Background And Framework for Establishing a Seasonal Precipitation Forecast Improvement Project (SPFIP)

Outline

- Vision
- Motivation for establishing the program
- Definitions
- Foundational documents
- State of seasonal forecasting skill including gaps
- Science goals
- Framework for a SPFIP

Vision

Vision: Development of a holistic program to improve seasonal forecast skill through improved understanding of known sources of predictability, exploration of new sources, and improvement of the representation of these processes in our models.

Realizing this vision will require a substantial and sustained commitment of resources and need to leverage all members of the short-term climate prediction community including operational centers, federal labs, and academic partners!

Motivation for Improving Seasonal Precipitation Forecasts

The National Climatic Data Center has recorded droughts in the United States having severe economic impacts (more than $1 billion in damages) during 16 of the 21 years from 1980 to 2011, with an estimated annual average direct drought loss of $9.5 billion (adjusted to 2011 dollars; Smith and Katz, 2013)).

Definitions

For purpose of this discussion:

1. Seasonal forecast refers to first 3 month season and includes the first month's forecast.
2. Although focus is on precipitation it should be recognized that work to be undertaken will also benefit seasonal temperature forecasts.
3. Predictability is used qualitatively to describe the extent to which the representation of a physical process contribute to prediction skill. Estimates of the lower-bound on predictability are obtained from the skill of current forecasts.

Foundational Documents

Assessment of Intraseasonal to Interannual Climate Prediction and Predictability (NRC, 2010).

Sub-Seasonal to Seasonal Prediction Research Implementation Plan (WMO, 2014)

California Drought Service Assessment (Werner et al., 2015)

Prospects for advancing drought understanding, monitoring, and prediction. (Wood et al., 2015)

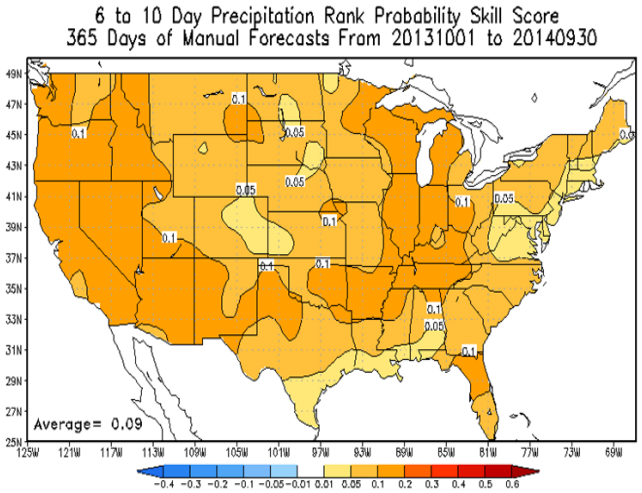
Causes and Predictability of the 2011-2014 California Drought. (Seager et al., 2014).

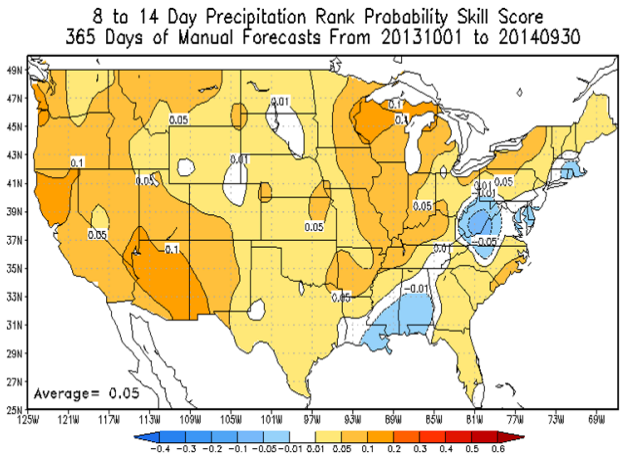
State of Seasonal Climate Forecasting

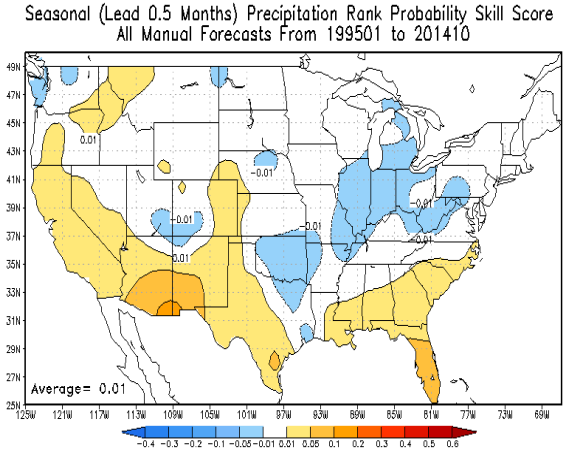
- CPC Seasonal Outlooks
- Skill level of current seasonal forecast tools
- Footnote on ENSO and its role in Seasonal Forecasts for the US
- Examples of where our most skillful tools don't perform well indicating gaps in our knowledge or limited predictability or both
  - 1 Month JFM 2015 NMME forecast
  - Greatly reduced skill of NMME in predicting SST variability outside of central and eastern Tropical Pacific

Improving Skill of Extended Range Precipitation Forecasts Is One of the Most Difficult Problems in Earth-System Modeling

Precipitation Forecast Skill Rapidly Decays with Lead-Time







Day 6 to 10

Day 8 to 14

First Season

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

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

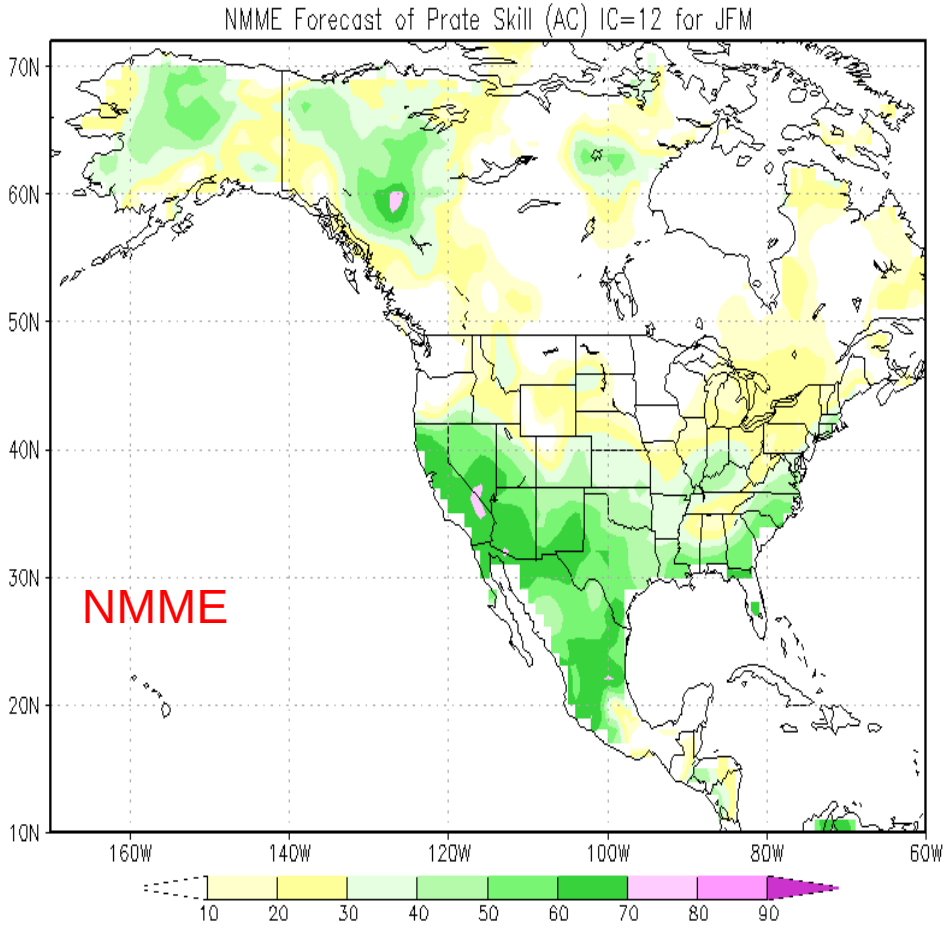
- Allows representation of model uncertainty.
- Possibility of complementary skill between models.
- Skill of MME is frequently higher than that from the most skillful member in the ensemble (though if one model is dominantly better this is not always true).

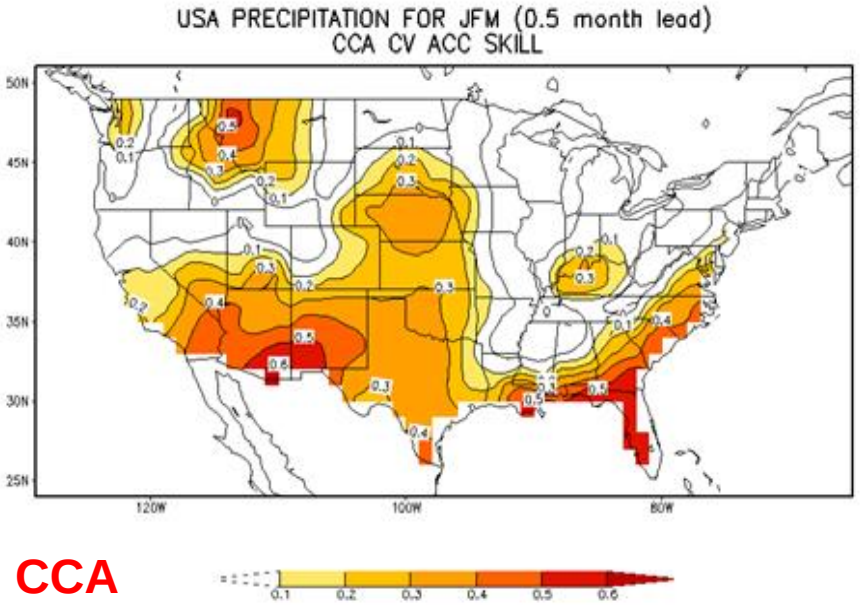
NMME is frequently our most skillful tool but there is still room for improvement.

Models/Groups Participating in NMME

Organizations	Models
NOAA/NCEP	CFSv2
NOAA/GFDL	CM2.1 FLOR (March 2014)
NASA/GMAO	GEOS5
Environment Canada	CMC1-CanCM3 CMC2-CanCM4
NCAR	CCSM3.0 CCSM4.0 (July 2014)
NCAR	CESM1.0 (Mar. 2015)

Lead 1 Precipitation Forecast Skill for JFM from Two State of the Art Forecasting Tools: NMME and CCA





Users perspective on the skill level of these forecast tools and hence their utility will vary.

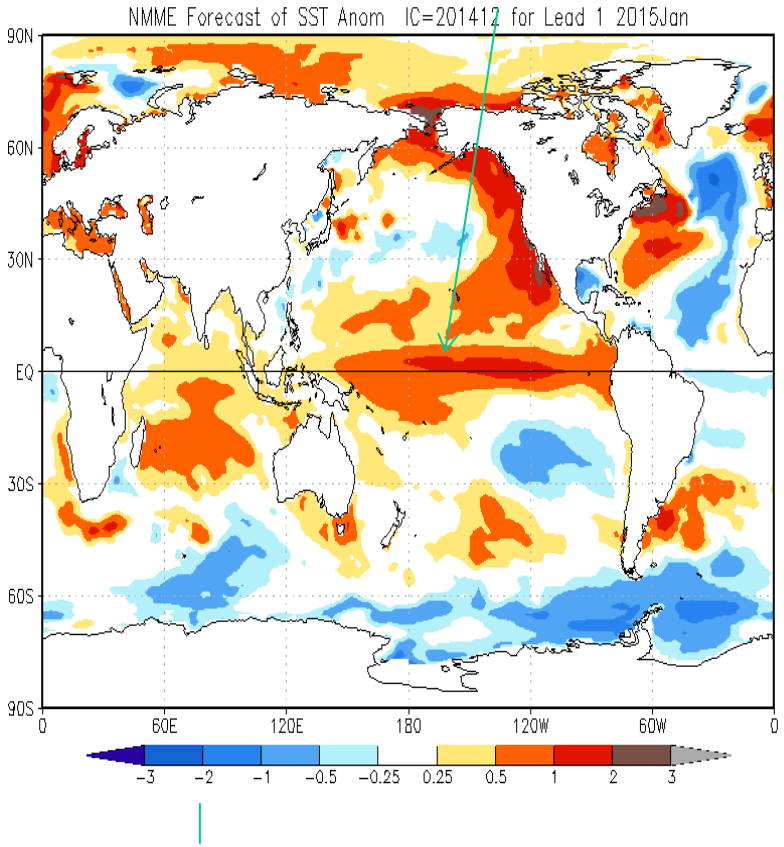
Footnote on ENSO and Seasonal Prediction Over the US

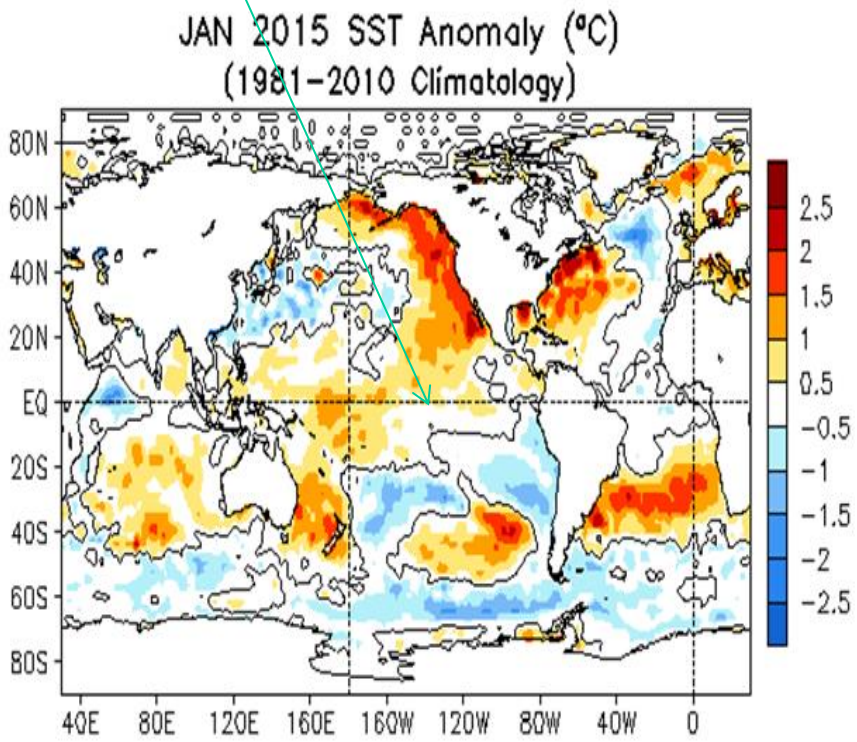
ENSO isn't the only factor controlling the seasonal distribution of precipitation over the US.

However, it is commonly accepted that accurate forecasts of ENSO and its associated teleconnections are a necessary but not sufficient condition for accurate seasonal precipitation forecasts.

Lead 1 NMME SST Forecast for January 2015

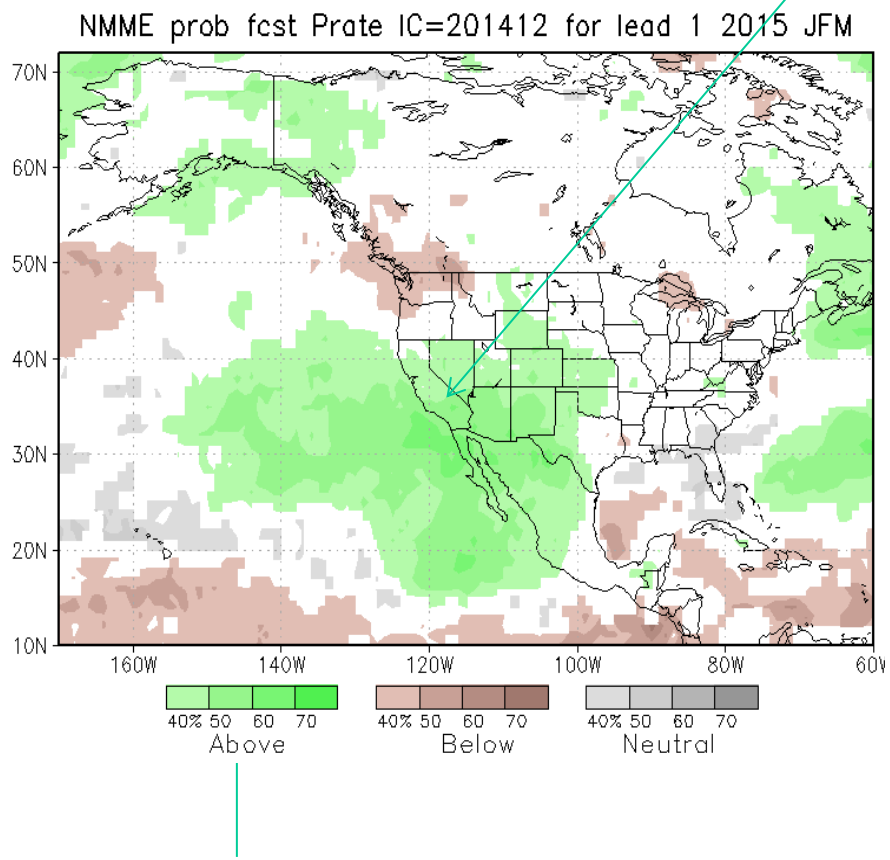
1 month lead NMME forecast calls for moderate cannonical El-Nino while observed anomalies were confined to western Pacific

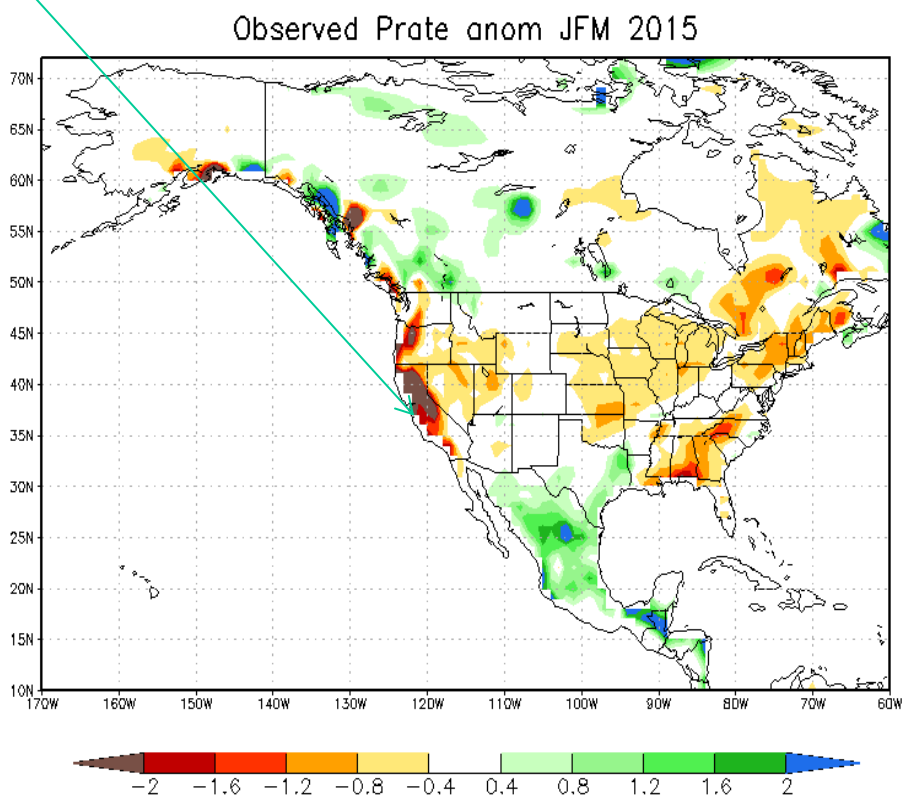




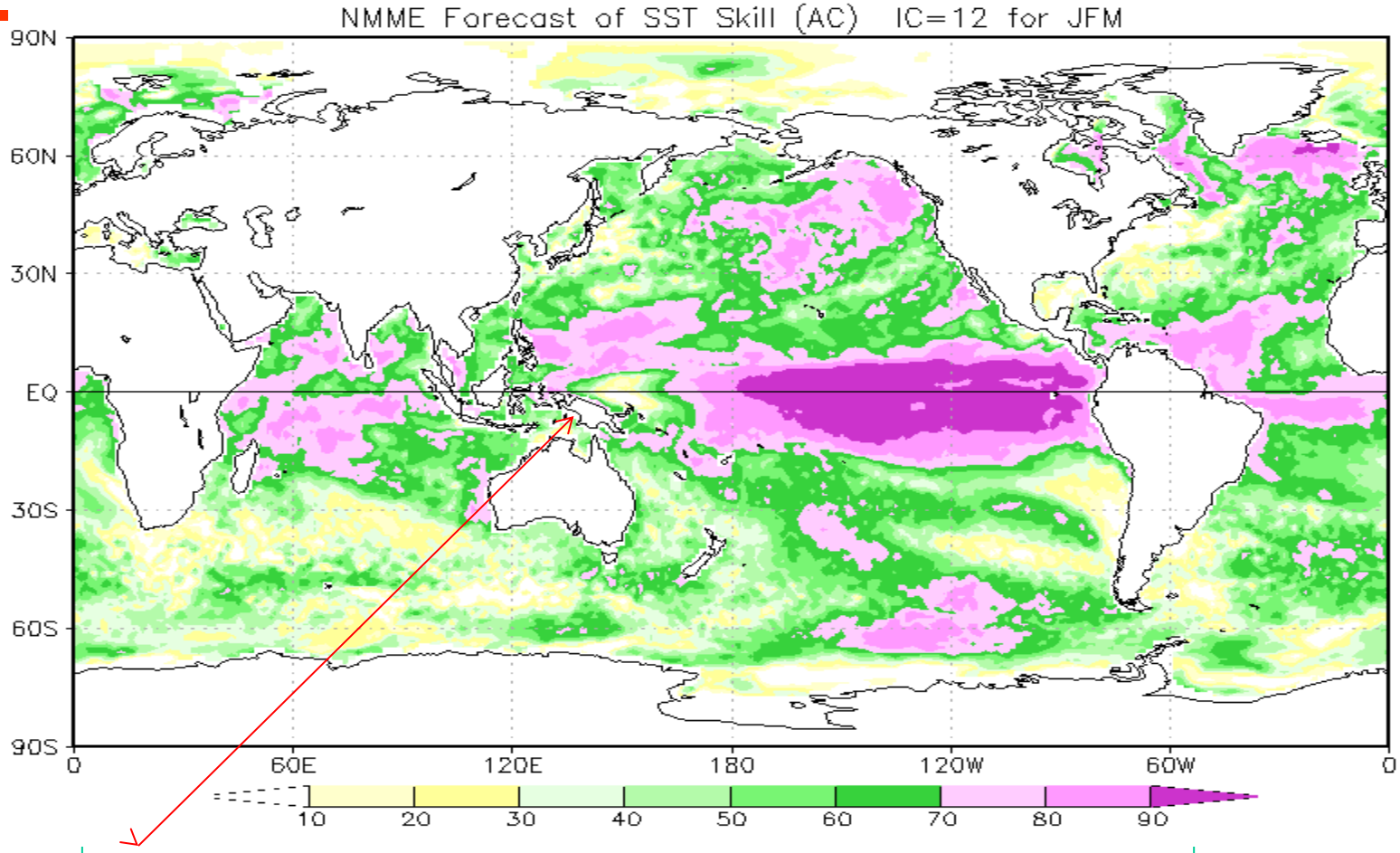
Lead 1 NMME Precipitation Forecast for JFM 2015

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



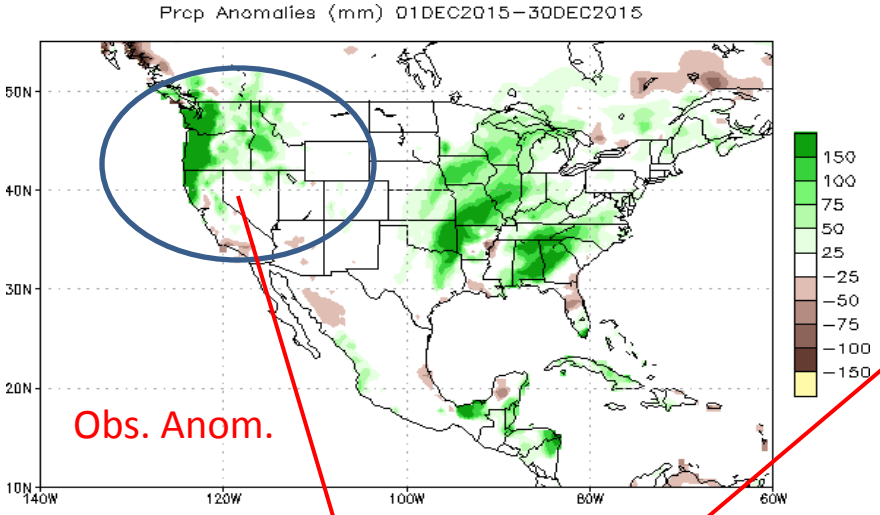


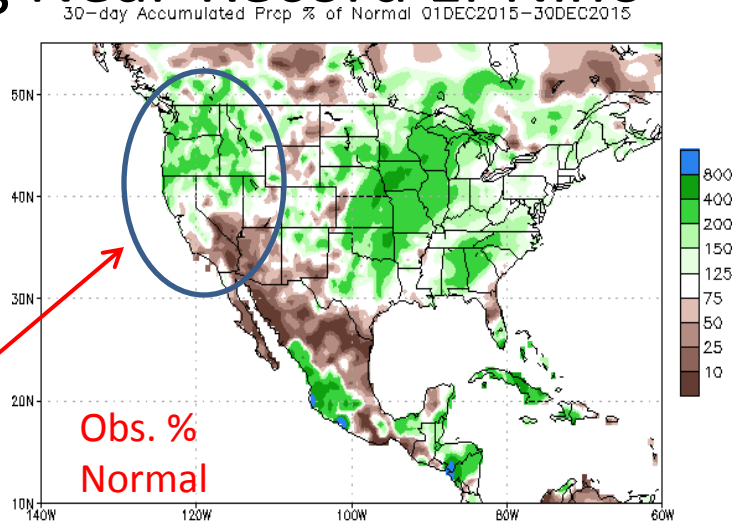
Retrospective Forecast Skill of Lead 1 NMME SST Forecast for JFM from NMME

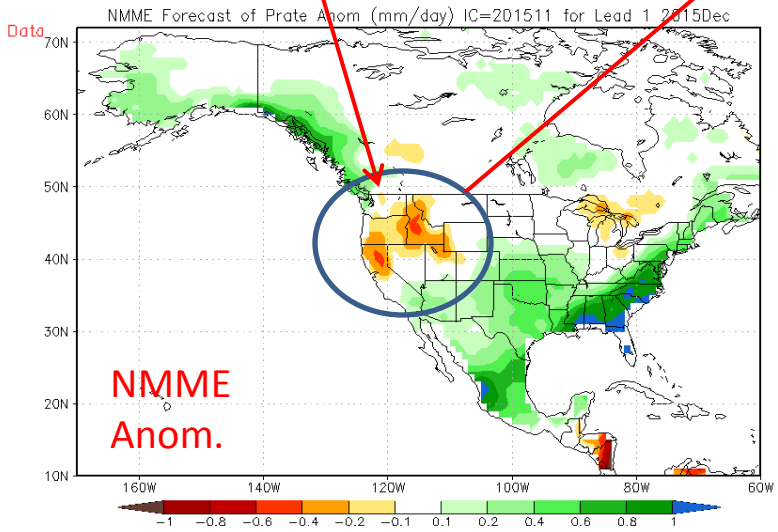


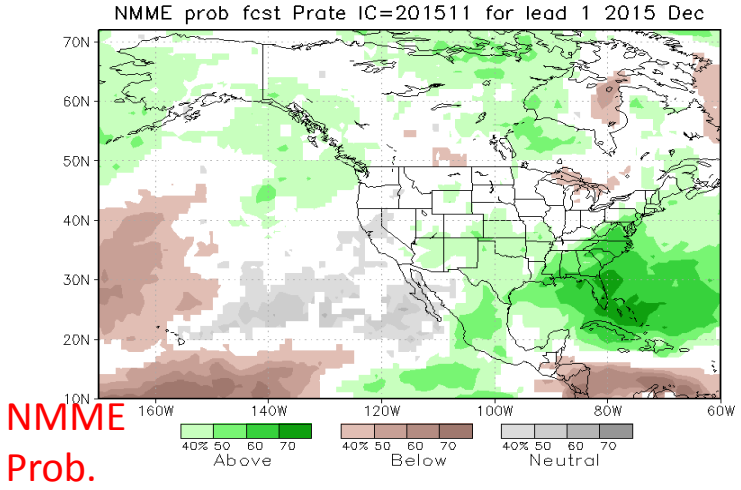
State of the Art MME Dynamical Forecast System has Low Skill in Predicting Near-Equatorial Western Pacific SST. If SST in this region drove the large-scale pattern past two years there is an issue.

NMME Precipitation Forecast for December 2015 at One Month Lead During Near-Record El-Nino









State of the art NMME misses major precipitation anomalies in Western US despite Strong El-Nino.

Key Science Issues that Need to Be Addressed to Improve Seasonal Forecast Skill

Borrowing heavily from the collective recommendations made in the foundational documents especially the NRC Report on Intraseasonal to Interannual Prediction and Predictability

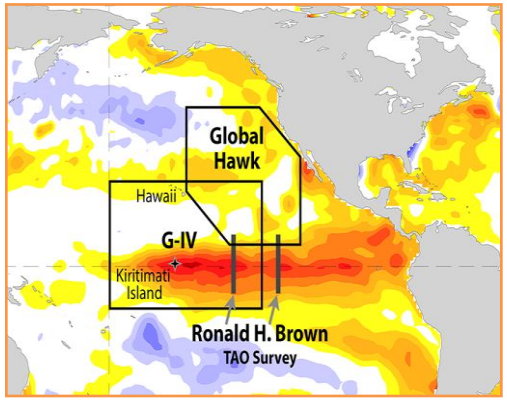
National Academy Assessment of State of Interaseasonal to Interannual Climate Prediction and Predictability (2010)

Main Conclusions:

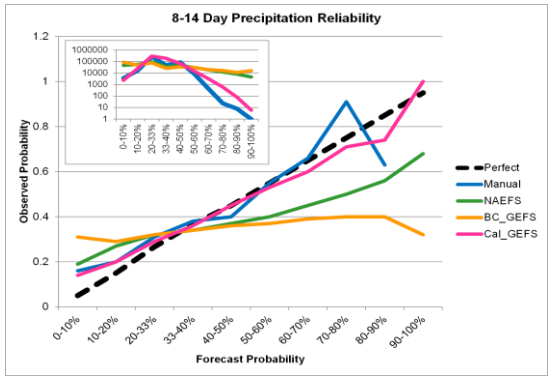
- There are no “silver bullets;” there is no single action that will lead to a revolutionary leap forward in ISI predictions.
- Incremental increases in ISI forecasting quality are to be expected as the building blocks of ISI forecasts are improved and we increase knowledge of sources of predictability.

NOAA Projects Targeted Toward: Increased Understanding and Exploitation of Sources of Predictability

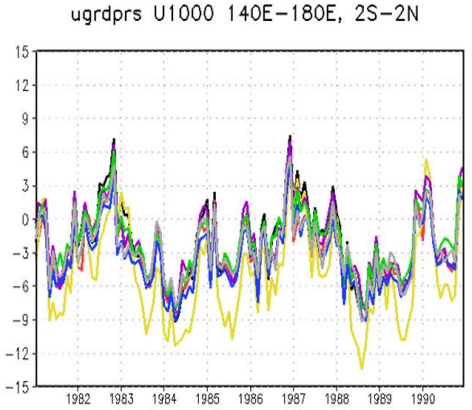
El-Nino Rapid Response Field Campaign



Maximizing Value of Dynamical Model Ensembles



New Multi-Decadal Climate Reanalysis



Improved Understanding of:

* Tropical-Extratropical Teleconnections
* Model Systematic Errors

Increased Skill Through:

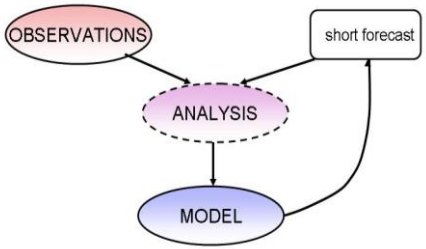
* Calibration using reforecasts
* Hybrid Dynamical-Statistical Techniques

Improved Diagnostic Studies Through:

*Updated Dynamical Models
*More Sophisticated Assimilation Techniques

NOAA Projects Targeted Toward Improve the ISI Prediction "Building Blocks

Upgrade Data Assimilation Systems

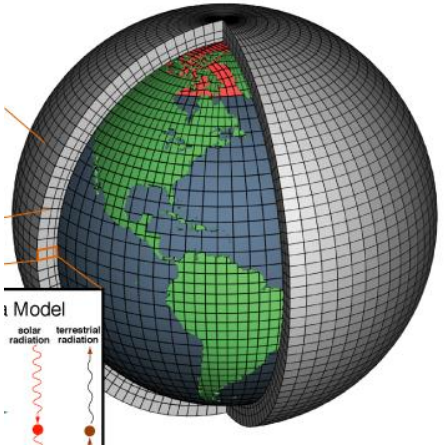


- 4D-Hybrid Atmosphere
- ENKF-based Ocean Assimilation
- Assimilation of Salinity

Enhance Observational Networks

-JASON Altimetry
-GOES-R
-JPSS

Reduce model errors through improved dynamics and physics



NGGPS Dynamic Core
NGGPS Physics
Week 3-4

SPFIP Science Goal 1: Improved Understanding and Modeling Sources of Seasonal Predictability

- Madden-Julian Oscillation
- Stratosphere-Troposphere Interactions
- Ocean-atmosphere coupling (including ENSO)
- North Atlantic Oscillation (NAO)/Arctic Oscillation (AO)
- Land-atmosphere feedback
- Polar Sea-Ice
- Atmospheric Rivers
- Pacific Decadal Oscillation
- Role of SST forcing versus internal variability?

SPFIP Science Goal 2: Improved Seasonal Prediction Tools

Identify cause reduce systematic errors in coupled atmosphere-ocean general circulation models (CGCMS):

- Double intertropical convergence zone
- Excessively strong equatorial cold tongue
- Weak or incoherent intraseasonal variability and associated teleconnection
- Failure to represent multi-scale organization of tropical convection
- Poorly represented cloud processes, especially low-level clouds

Increase model resolution to better resolve physical processes and orographic variations

SPFIP Science Goal 2: Improved Seasonal Prediction Tools

Improved Representation of physical process in CGCMS:

- Deep and shallow convection
- Planetary boundary layer in the atmosphere and the ocean
- Sea ice
- Soil moisture
- Snow cover

Exploration of new statistical techniques and hybrid dynamical-statistical techniques

- Need to ensure rigorous cross-validation to estimate true forecast skill

Framework for an SPFIP

1. Need to recognize the difficulty of the problem and ensure adequate resources are obtained.
2. Essential components:
   - Grants program supporting mission-driven research on understanding sources of predictability
   - Support to modeling centers for model improvements
   - Grants program on tailoring products for end users
   - Support infrastructure for testing new tools and transitioning to operations
   - High-performance computing augmentation
3. Key partners:
   - Academic community
   - Within NOAA: NWS (NCEP, NWC), OAR (GFDL, ESRL, CPO); NESDIS (NCEI)
   - Other willing federal agencies

SPFIP Concept Paper: Status

Currently being updated to reflect recently released NAS S2S report. Primary authors are close to finalizing and will release it once it is done.