NMME Plans for Subseasonal Forecasts

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40th Climate Diagnostic and Prediction Workshop

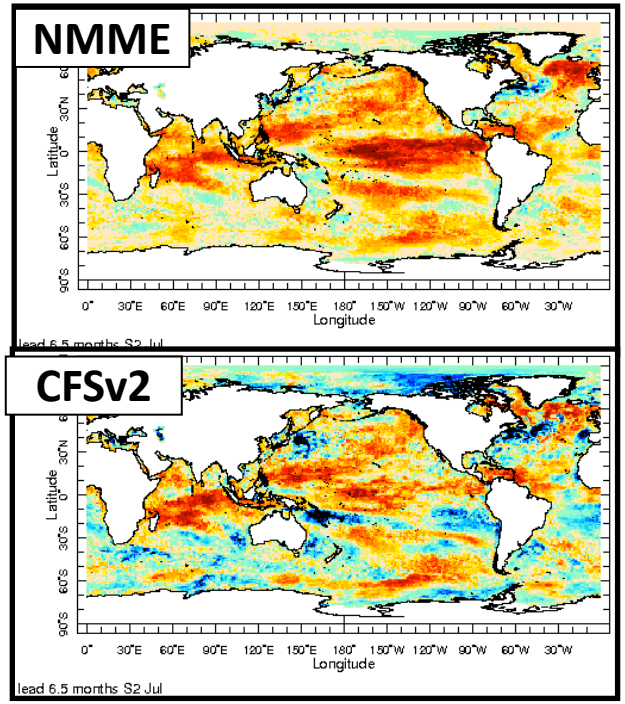
Outline

- What learned from the NMME **seasonal** forecast experiment
- Opportunities and requirements for sub-seasonal forecasts
- Plans for the NMME subseasonal forecast experiment
  - NMME subseasonal forecast Protocol
  - FTY16-17 MAPP-CTB demonstration project

NMME Overview

NMME (North-American Multi-Model Ensemble) is to improve subseasonal to interannual predictions based on ensemble of major US and Canada models augmenting CFS predictions

- Initiated as an experimental system as a Climate Test Bed (CTB) research project in 2011.
- Supported by CPO/MAPP program with contributions from NSF, DOE and NASA.
- Tested forecast reliability and forecast skills based on 30-year hindcasts and real- time forecasts since Aug 2011
- The NMME **Seasonal** Forecast System became operational in September 2015.

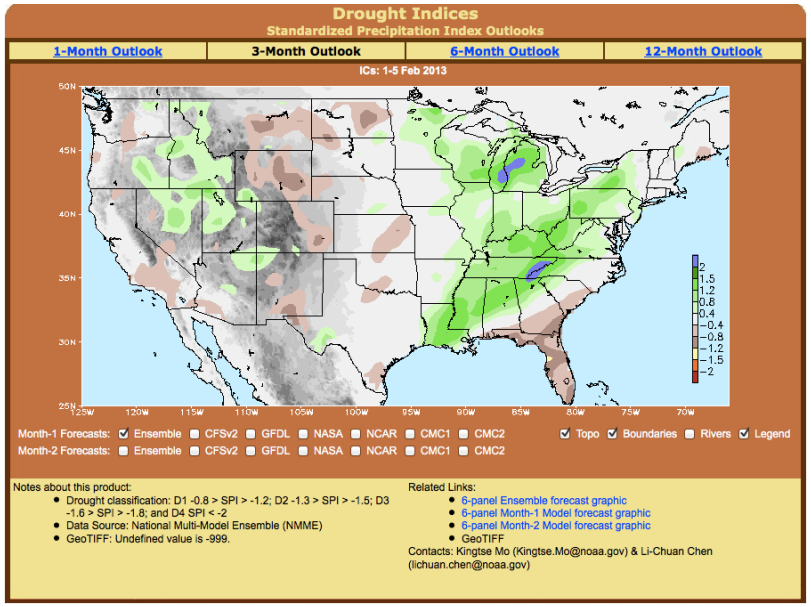


NMME and CFSv2 skills based on 30-year hindcasts (July 1 start DJF SST forecast Ranked Probability Skill Score, after Ben Kirtman)

NMME: widely used in NCEP Operations and Applications

- **Provided real-time forecasts following the CPC operational forecast schedule since August 2011**

- **Critical input for a host of CPC applications e.g.,**
  - Monthly and Seasonal P and T Outlooks
  - CPC African Desk
  - Drought outlooks
  - Hurricane outlook
  - ENSO Diagnosis Discussions



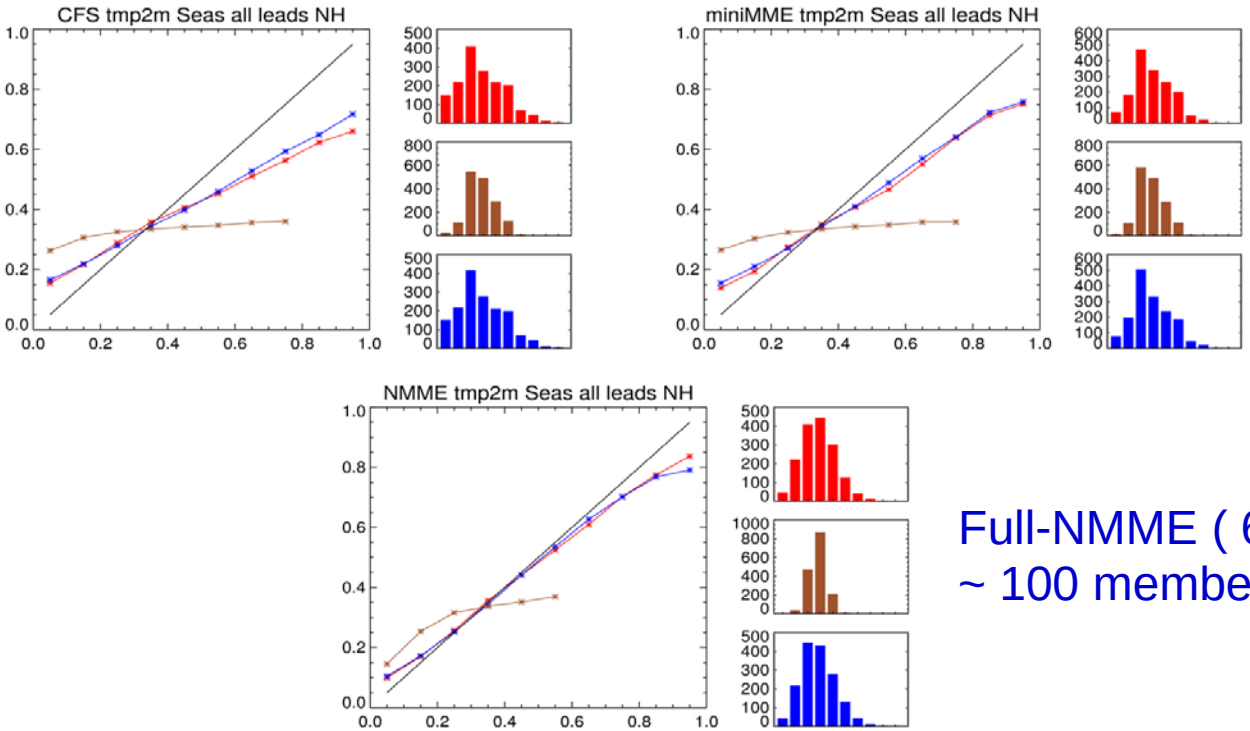
CPC NMME-Drought Products (Li-Chuan Chen, Kingtse Mo)

How to best combine models in NMME and how to best combine dynamic models and statistical tools are still ongoing research

NMME Improves Forecast Reliability

CFS (1 model, 24 members)

Mini-NMME (6 models, 24 members)

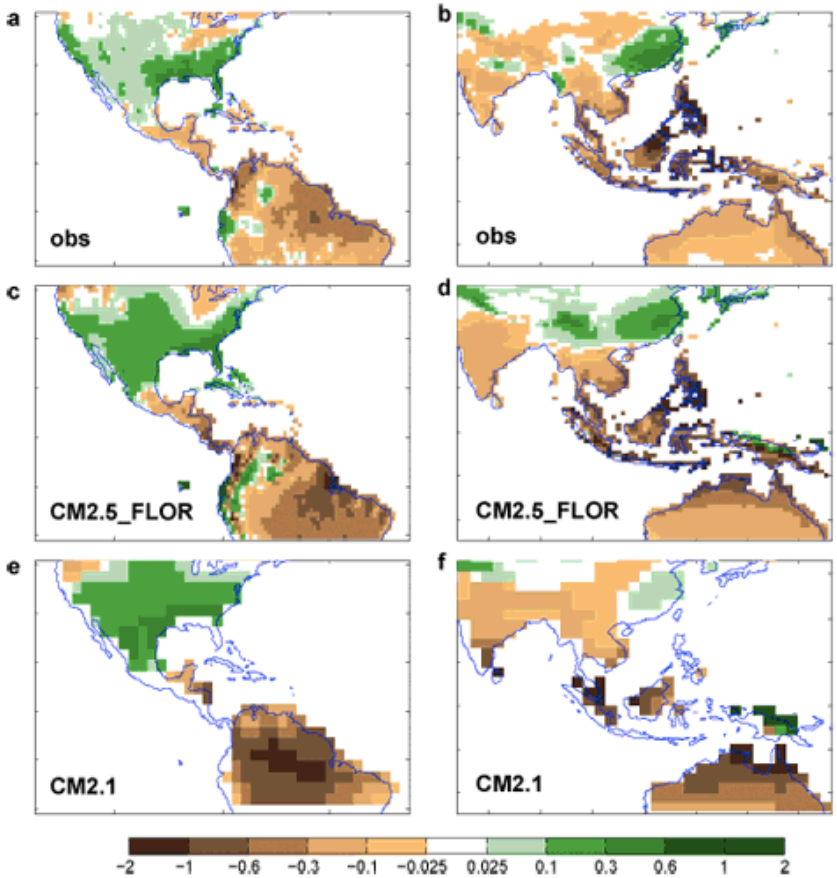


Full-NMME (6 models, ~ 100 members)

Figure 7: Reliability diagram for T2m Northern Hemisphere land (23N-75N). Upper left is CFSv2, upper right is the results from the mini-NMME and the bottom is the full NMME. Histograms are given for each panel. Red corresponds to above normal, brown for near normal and blue for below normal.

NMME increases forecast reliability due to both ensemble size and model diversity (van den Dool)

NMME serves both operation and research



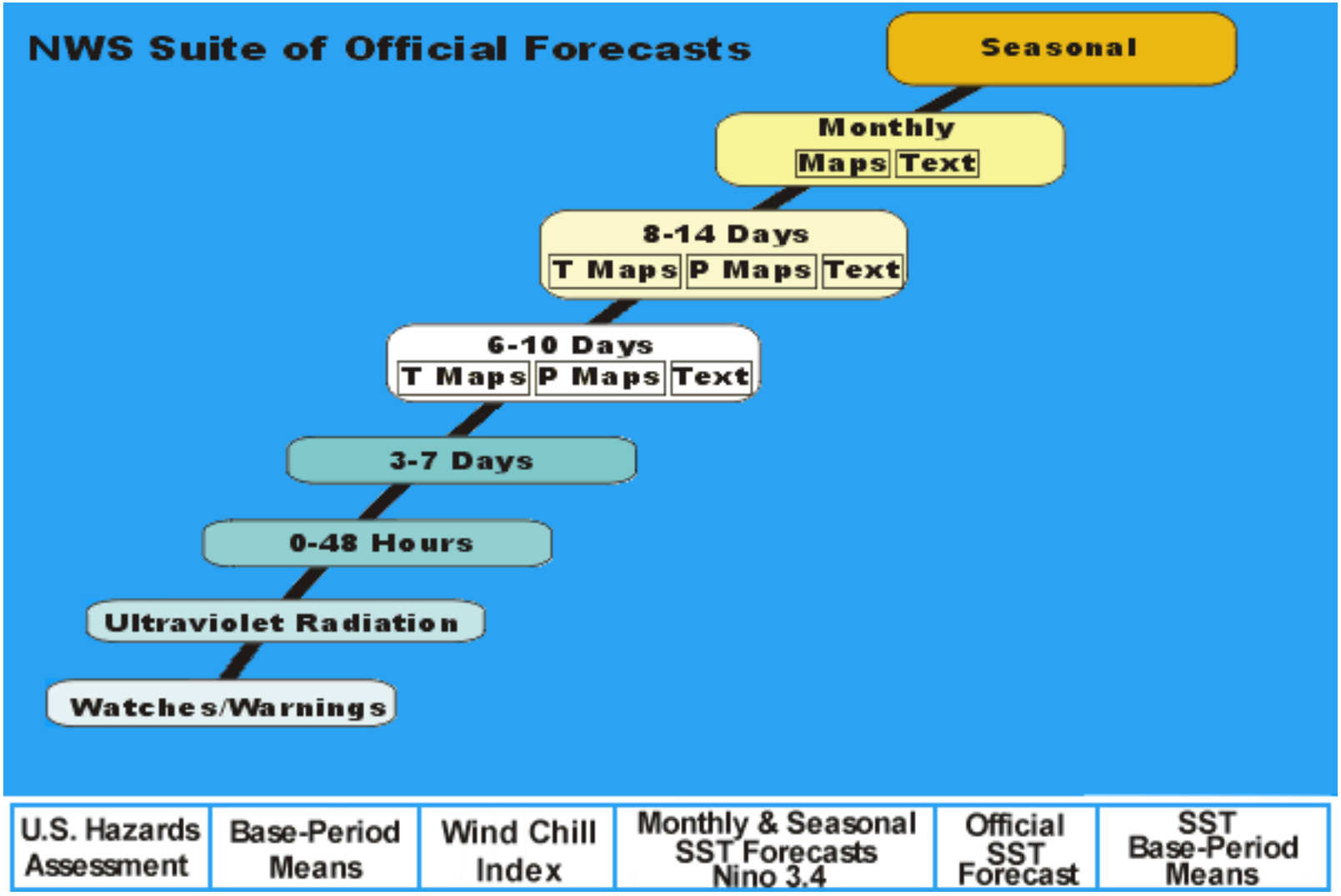
- **NMME allow NCEP operation to benefit from model upgrades (e.g., GFDL model upgrades from CM2.1 to FLOR, Liwei Jia)**

- The **NMME data (**hindcast and real-time) accessible by the public has stimulated an impressive body of research and applications including peer-reviewed papers **(50 journal papers as of Sept. 2015**)

  http://www.nws.noaa.gov/ost/CTB/nmme.htm

- NMME real-time forecasts and verification/diagnoses, and monthly telecons allow close **interactions between operational forecasters and external researchers**
  - Predictability and attributions
  - Model biases and performances

There is a Gap in NWS Suite of Official Forecasts at weeks 3-4 timescales

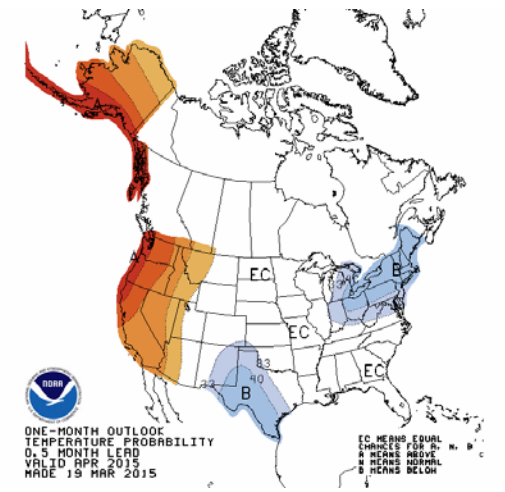


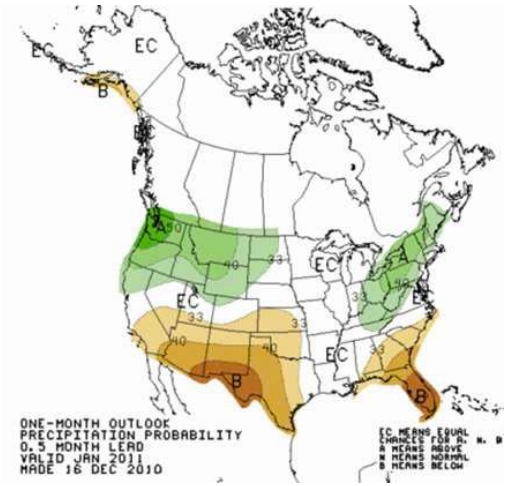
NCEP/CPC Subseasonal Outlook Products

In 2015, CPC team started to produce **experimental week 3-4 probabilistic temperature and precipitation outlooks**

- released once per week, similar in style to current CPC monthly outlook.
- combined empirical techniques and dynamical model guidance
  - Constructed analogue,
  - Dynamic models from operational centers (NCEP, JMA, ECMWF)

Question: What can NMME contribute to the NCEP operational subseasonal Forecasts?





NMME Sub-seasonal Forecast System Exploratory Workshop

NCWCP, College Park, MD
March 30–31, 2015

Workshop Purpose:

- To explore scientific opportunities and feasibility to evolve the current NMME seasonal forecast system to enable sub-seasonal forecasts
- To assess operational and stakeholder needs for future testing and implementation
- To design a coordinated reforecast protocol for a potential NMME sub-seasonal forecast system

Organizers: NOAA CTB and CPO

- Jin Huang (NOAA CTB)
- Annarita Mariotti (CPO/MAPP)
- Kathy Pegion (George Mason University)
- Ben Kirtman (University of Miami)

Workshop Participants

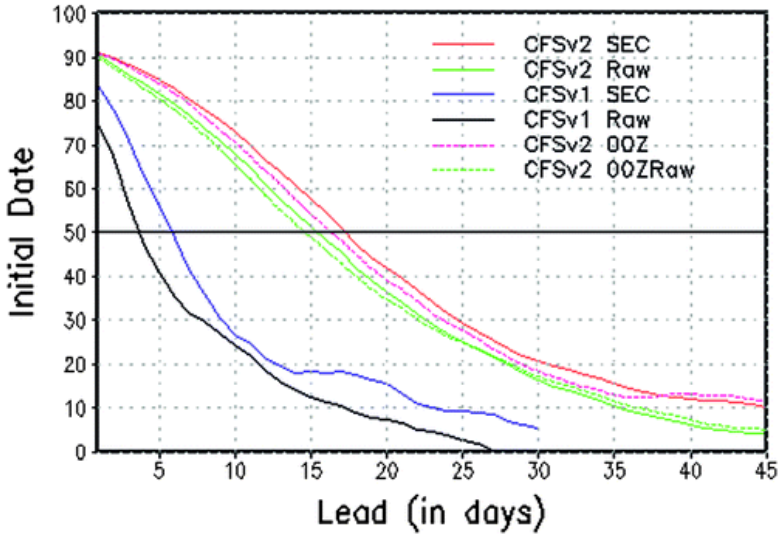
- **US Agencies**:
  NOAA, NASA, Navy, Air Force
- **International**:
  Environment Canada, ECMWF, UK Met Office, Korea/APCC
- Universities
- US/NRC S2S Study members

Opportunities for sub-seasonal forecasts

Improved understanding of key sources of predictability for sub-seasonal timescales.

- Sea surface temperature
- Sea ice
- Land surface (snow, soil moisture, vegetation)
- Madden Julian Oscillation
- Stratospheric variability
- Atmospheric dynamical processes (Rossby wave propagations, blocking)

Improved skills in dynamic model forecasts (Zhang and van den Dool)



Increased demand from applications and decision making

- e.g., food and water security, public health, emergency management

WCRP/WWRP S2S Project

	Time-range	Resol.	Ens. Size	Freq.	Hcsts	Hcst length	Hcst Freq	Hcst Size
ECMWF	D 0-32	T639/319L91	51	2/week	On the fly	Past 20y	weekly	5
UKMO	D 0-60	N216L85	4	daily	On the fly	1996-2009	4/month	3
NCEP	D 0-45	N126L64	4	4/daily	Fix	1999-2010	4/daily	1
EC	D 0-35	0.6x0.6L40	21	weekly	On the fly	Past 15y	weekly	4
CAWCR	D 0-60	T47L17	33	2/week	Fix	1981-2013	6/month	33
JMA	D 0-34	T159L60	25	2/week	Fix	1979-2009	3/month	5
KMA	D 0-60	N216L85	4	daily	On the fly	1996-2009	4/month	3
CMA	D 0-45	T106L40	4	daily	Fix	1992-now	daily	4
Met.Fr	D 0-60	T127L31	51	monthly	Fix	1981-2005	monthly	11
CNR	D 0-32	0.75x0.56 L54	40	weekly	Fix	1981-2010	6/month	1
HMCR	D 0-63	1.1x1.4 L28	20	weekly	Fix	1981-2010	weekly	10

- Useful dataset for R2S predictability and prediction research
- 3-week embargoing of real-time data
- Participating models don’t follow the same protocol
- Operational models only

Workshop Spin-off:
Experimental Sub-seasonal Forecast Protocol

General Requirements:

- **Reforecasts**: minimum 1999-2015
- **Ensemble members**: minimum 4
- Models and procedures including initial conditions for real-time forecasts and reforecasts should be the same
- **Forecast Length**: minimum of 32 days.
- One-year of real-time forecasts is required

Requirements Specific for Real-time:

- All forecasts (& hindcasts) must be sent to **CPC 5pm ET each Wednesday**
- **Output data for real-time forecast** include: T2m, Precip, Z500, Z200, SST, SM

Initialization Requirements:

- **Initialization Frequency**: once a week
- Forecast providers are encouraged to **use the most recent observations to initialize** real-time forecasts.
- **Initialization of the atmosphere and land surface is required**; Initialization of the ocean is required for coupled O-A models; Other models should use the time evolving predicted (and/or persisted) ocean state.

Output Data Requirements:

- Data will be output on a **1x1 grid**
- **Total fields**, not anomalies, must be provided.
- **All ensemble members**, not the ensemble mean, must be provided.
- **Daily means** of the variables should be output (and reforecasts will include more variables than real-time)

Key differences between subseasonal and seasonal protocols

Subseasonal

- **Reforecasts**: minimum 1999-2015
- **Forecast Length**: minimum of 32 days.
- **Forecast frequency**: once a week
- **atmospheric-ocean coupled model is NOT required**
- **Initialization of the atmosphere and land surface is required**
- All forecasts (& hindcasts) must be sent to **CPC 5pm ET each Wednesday**

Seasonal

- **Reforecasts**: minimum 1981-2010
- **Forecast Length**: minimum of 9 months
- Forecast frequency: once a month
- **atmospheric-ocean coupled model is required**
- **Initialization of the atmosphere and land surface is NOT required**
- All forecasts (& hindcasts) must be sent to **CPC 5pm ET 8th of each month**

Common requirements in NMME subseasonal and seasonal protocols

- All participating models need to strictly follow the forecast protocol
- Models and procedures including initial conditions for real-time forecasts and reforecasts should be the same
- Need to re-generate hindcasts if models are upgraded.
- Output Data Requirements:
  - Data will be output on a 1x1 grid
  - Total fields, not anomalies, must be provided.
  - All ensemble members, not the ensemble mean, must be provided.

NMME Subseasonal Forecast Experiment in FY16-17

- MAPP-CTB demonstration proposals are submitted to the CPO FY16 call
- Subject to panel reviews and CPO fund availability

- Purpose: Test a multi-model system for subseasonal climate prediction

- All participating models (7 models proposed to participate)
  - Must follow the NMME subseasonal protocol
  - Need to demonstrate the model capability for sub-seasonal forecast and deliver real-time forecast
    - Generate 1999-2015 hindcasts
    - Perform 1-year real-time forecast
    - Provide realtime data to CPC to produce MME products

NMME Subseasonal Forecast Experiment – con't

- A **core team** will
  - organize and coordinate the multi-model experiment
  - develop rigorous techniques to combine the multi-model predictions into probabilistic forecasts,
  - comprehensively evaluate the skill of the forecasts
  - develop products utilizing the model ensemble system;
  - refine the design of the multi-model system; and
  - support timely and effective sharing of reforecast and forecast data

- **Post-project review** (if the project is funded…)
  - within 3 months of the end of the project (~Fall 2018)
  - An ad hoc review panel will evaluate the benefits and feasibility of the experimental system
  - NCEP management will make decision on operational deployment based on panel recommendations

Ongoing MAPP & CTB Funded Research involving NMME

- **“**Developing an Optimum Multimodel ENSO Prediction”, Barnston et al.
- “Improved probabilistic forecasts for the NMME seasonal forecast system ”, Barnston et al.
- “**Subseasonal** NMME Forecasts: Skill, Predictability, and Multi-model Combination ”, Del Sole et al.
- “Bridging the gap in NOAA's extended and long range prediction systems through the development of new forecast products for **weeks 3 and 4**”, Johnson et al.

Summary

- The NMME **seasona**l forecast system became operational in Sept. 2015

- Increased opportunities and requirements for subseasonal forecasts

- Plan to test the feasibility to evolve the NMME seasonal forecast system to enable subseasonal forecasts
    - A MAPP-CTB demonstration project is proposed to conduct a NMME subseasonal forecast experiment in FY16-17

- Potential contributions to operational forecast and research
    - Improve operational forecast skills and reliability
    - Test the design for the subseasonal forecast system
    - Test methodology to optimally combine multiple models
    - Open data enabling predictability and prediction research and inform model development