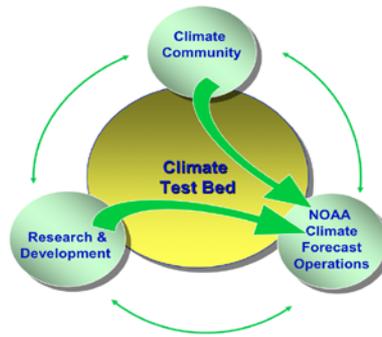


NCEP Climate Test Bed (CTB) Overview

Jin Huang

April 17, 2014

NOAA Testbeds Workshop



Mission: To accelerate the transition of scientific advances from the climate research community to improved NOAA climate forecast products and services.

<http://www.cpc.ncep.noaa.gov/products/ctb/>

Outline

- 1. CTB Overview**
- 2. Accomplishments and progress**
- 3. Performance Metrics/Protocol for CTB R2O Transition and Assessments**
- 4. How to make CTB R2O more effective?**
- 5. Summary**



NCEP Test Beds

Service – Science Linkage with the Outside Community:
Accelerating the R2O Transition Process



- **EMC** WRF Developmental Test Center (DTC)
Joint Center for Satellite Data Assimilation
- **CPC** **Climate Test Bed**
- NHC Joint Hurricane Test Bed
- HPC Hydrometeorological Test Bed
- SPC Hazardous Weather Test Bed with NSSL
- SWPC Space Weather Prediction Test Bed with AFWA
- AWC Aviation Weather Test Bed
- OPC IOOS Supported Test Bed



**Organization structure,
scope and funding
sources are different
for different test beds**

Advancing Operational Climate Prediction and Products

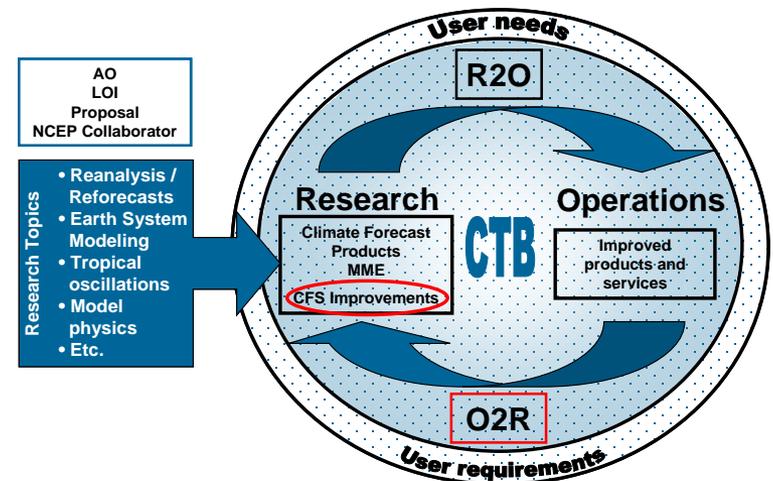
Climate Test Bed (CTB)

- Jointly established in 2004 by NCEP and CPO
- To accelerate **R2O** transition to improve NCEP operational climate projection
- To provide the climate research community with access to operational models, forecast tools and datasets (**O2R**)

• Focus Areas

- 1) *CFS Improvements*
- 2) *Multi Model Ensemble (MME)*
- 3) *Climate Forecast Products*

- **Competitive grants projects sponsored by OAR/CPO**



CTB Grants Projects

- **CTB's call for proposals is part of OAR/CPO research program and MAPP-CTB Partnership**
- **CTB priorities in the call for proposals are decided by CPO, mindful of NCEP operational requirements (via discussions and CTB Science Plan, NWS plans).**
- **Currently 3 ongoing CTB grants projects**
- **New FY14 projects are under review.**

Requirements to Select and Manage MAPP-CTB Projects

- MAPP-CTB proposals must include a section with **metrics** to be used to evaluate the outcomes of the project and assess readiness for transition into NCEP's operations.
- MAPP-CTB proposals must include co-PIs or collaborators from NCEP.
- MAPP-CTB proposals must include a **support letter from NCEP** (CTB, CPC and EMC).
- Post-Project Reviews

NCEP Infrastructure Support

Computer resources:

- Proposal based, i.e., no dedicated HPC

FTEs

- One dedicated FTE: CTB director
- Leveraging time from CPC and EMC directors
- Leveraging CPC and EMC FTEs, based on funded projects

CTB Priority (1): Multi-Model Ensembles

Goal: A multi model ensemble prediction system that leverages the best national and international models for improved predictions on intraseasonal-to-interannual time scales

NMME Phase-I: An experimental system initiated as a Climate Test Bed (CTB) research project supported by CPO/MAPP in FY11.

NMME Phase-II: An improved experimental system as a FY12-FY13 MAPP/CTB research project with additional support from NSF, DOE and NASA.

NMME Expansion Project in High Impact Weather Prediction Pilot (HIWPP) Project from Sandy Supplemental Fund

NMME (North American Multi-Model Ensemble)

An unprecedented MME system to improve intra-seasonal to interannual (ISI) operational predictions based on the leading US and Canada climate models.

Current NMME Forecast Providers

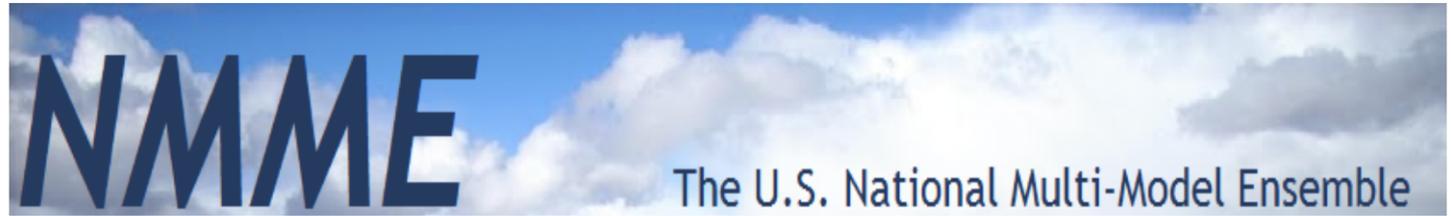
| Model | Hindcast Period | No. of Member | Arrangement of Members | Lead (months) | Model Resolution: Atmosphere | Model Resolution: Ocean | Reference |
|--------------|-----------------|---------------|---|---------------|------------------------------|-------------------------|--------------------------|
| NCEP-CFSv2 | 1982-2010 | 24(20) | 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-GEOS5 | 1981-2010 | 11 | 4 members every 5th days; 7 members on the last day of the previous month | 0-9 | 1x1.25deg L72 | MOM4 L40 1/4 deg at Eq | Rienecker et al. (2008) |

Upcoming new/upgraded models:

- NCAR-CCSM4: May 2014
- GFDL-FLOR: March 2014
- NCAR-CESM1: June 2014



[HOME](#) > NMME Forecasts of Monthly Climate Anomalies



Welcome to the National Multi-Model Ensemble home!

Data and Current Forecasts

NMME real-time seasonal forecast since August 2011 following CPC operational schedules

All participating models strictly follow the NMME protocol and re-run hindcast after model upgrades

- 3-month mean spatial anomalies
- 1-month mean spatial anomalies
- Niño3.4 Plumes
- International MME
- Experimental: Probability forecasts

[NMME Realtime Forecasts **Archive**](#)
[NMME Phase-I Hindcast Data](#)

About the NMME

- [Description of the NMME Phase-I Forecast Models](#)
- [CTB Activities & Documents](#)
- [Join the NMME mailing list](#)**

NMME Data Available to Users

1. Realtime forecasts from CPC website

- <http://www.cpc.ncep.noaa.gov/products/NMME/>

2. Phase-I Reforecast data in IRI website available now

- **Monthly Mean** of 30 year reforecast
- **8 variables** (P, T, SST, Z200, Tmax, Tmin Soil Moisture, Runoff)
- <http://iridl.ldeo.columbia.edu/SOURCES/.Models/.NMME/>

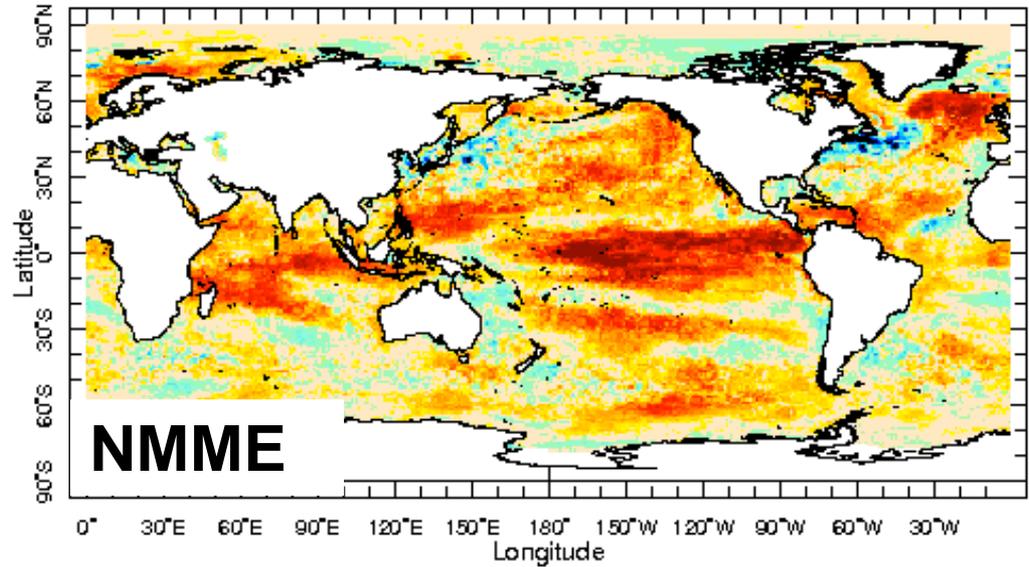
3. Phase-II Reforecast data in NCAR

- Complete monthly Mean of 30 year reforecast
- **Comprehensive daily reforecast data of selected (189) variables**
- <https://www.earthsystemgrid.org/search.html?Project=NMME>

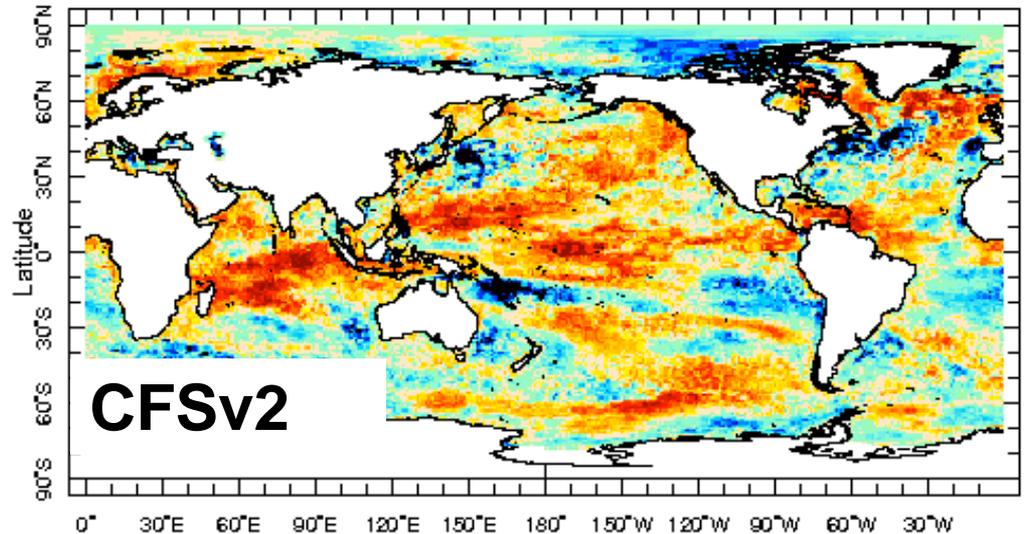
Comparison of CFSv2 skill vs NMME

July 1 start
DJF SST forecast
Ranked
Probability Skill
Score based on
30-year NMME
hindcast data

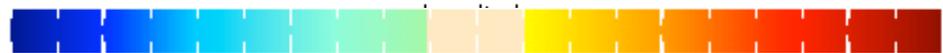
(B. Kirtman et al.)



lead 6.5 months S2 Jul

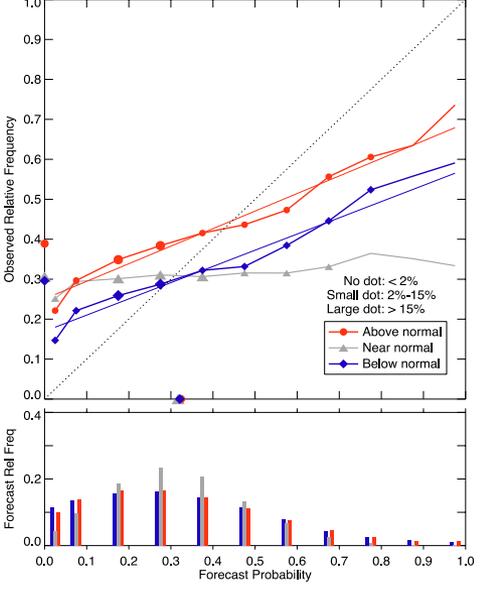
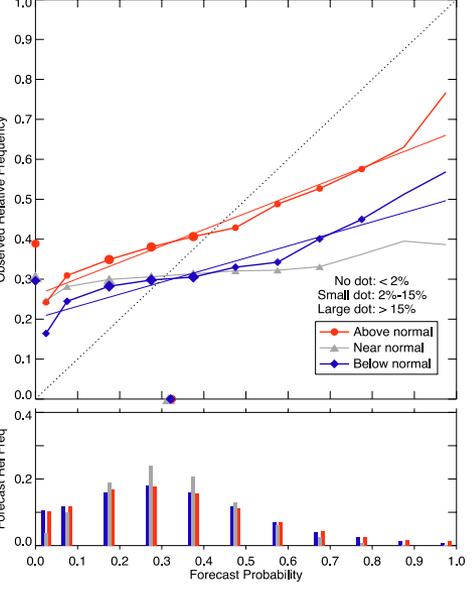
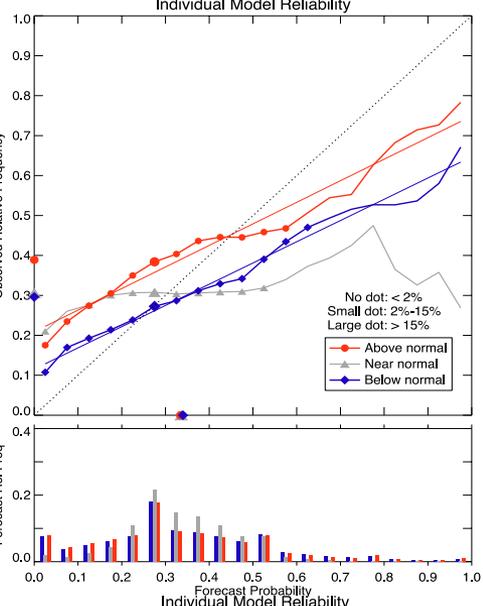
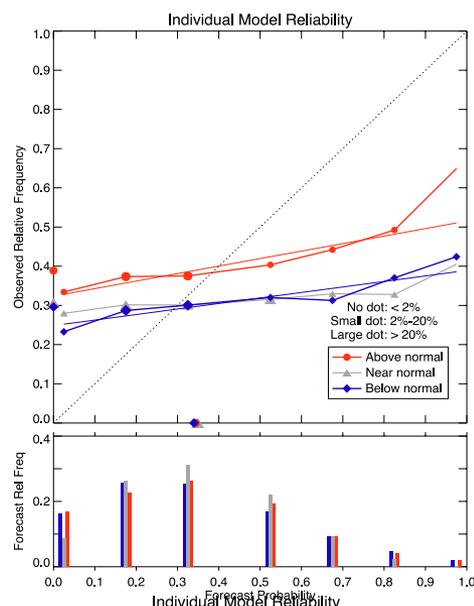
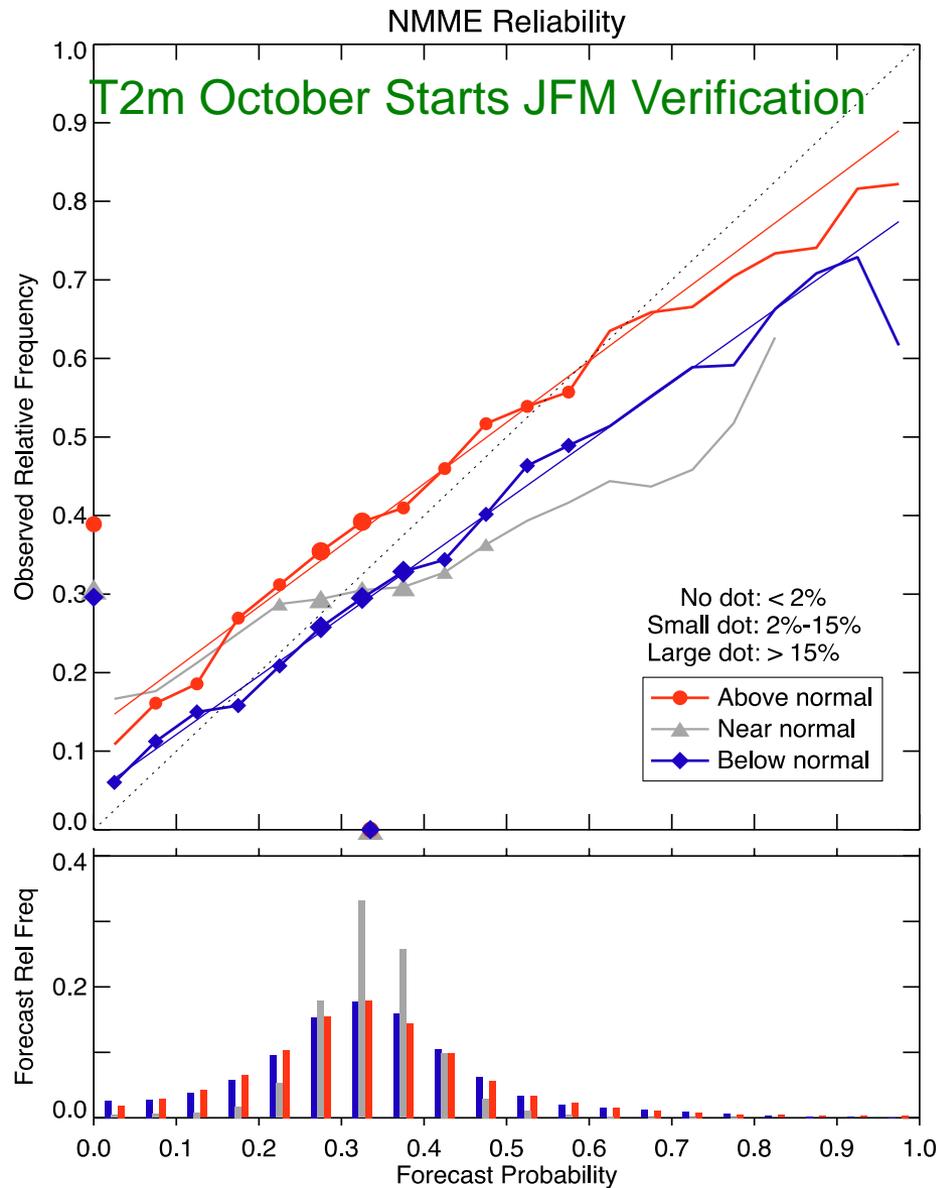


lead 6.5



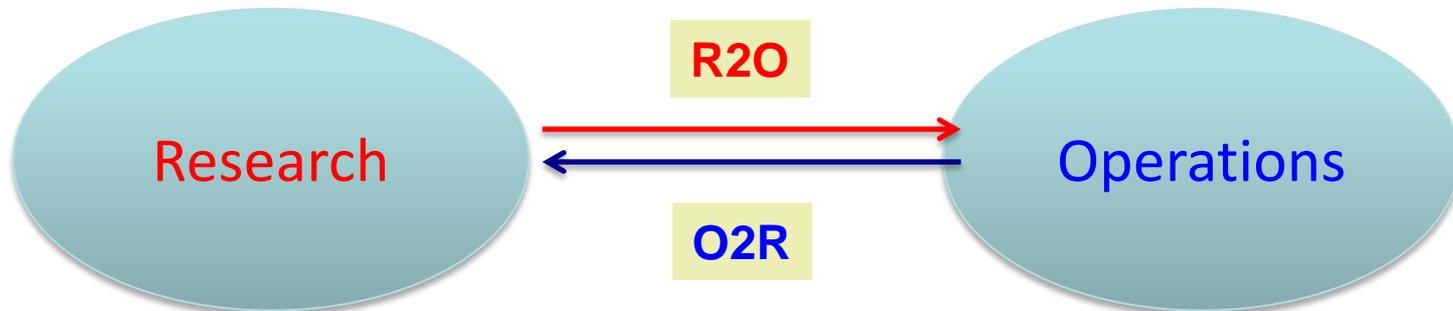
Ranked probability skill score

NMME Increases Forecast Reliability



What Can NMME do for NCEP Operations?

- **R2O to improve NCEP Operation:** NMME allows NCEP to continuously bring in model development advances and expertise from the research community



O2R to improve research:

- Openly distributed hindcast and real-time data to allow the community to look at climate predictability and predictions;
- Operational platform for model diagnosis and evaluations will also benefit participating research modeling centers.

Strategy to Operationalize NMME Seasonal Forecast System

- **NMME is currently funded as a R2O research project , which will end in July 2014**
 - **Post-project review in Sept. 2014**
 - **CPO plans to fund to sustain the experimental NMME system in FY14**
 - **“Operationalize NMME” has been submitted as a FY15 milestone**
- **Strategy to operationalize NMME**
 - **Concept of Operation has been developed**
 - **Need to i) develop/sign MOUs between operational agencies, ii) secure resources to support non-operational models centers, ii) develop transition path with NCO and CPC regarding data flow, post-processing, and data dissemination**
- **A community-wide NMME workshop early 2015 for future NMME enhancement (e.g., sub-seasonal capability**

CTB Priority (2): CFS Evaluation and Improvements

- To accelerate evaluation of and improvements to the operational Climate Forecast System (CFS) and to enhance its use as a skillful tool in providing NCEP's climate predictions and applications

(1) Provide grants funding to support R2O activities

- Test and evaluate new parameterizations, schemes, model components in NCEP operational models

(2) Engage the external community in planning for CFSv3

(3) Provide NCEP in-house support to facilitate R2O

A CPT for Improving Turbulence and Cloud Processes in the NCEP Global Models (FY13-16)

- U. of Utah: **Steven K. Krueger**
- NCEP: **Shrinivas Moorthi** and Fanglin Yang
- U. of Colorado: Robert Pincus
- CSU: David A. Randall
- NCAR: Peter A. Bogenschutz

To unify the representations of

- *turbulence and sub-grid scale cloud processes*
- **Sub-grid scale deep convective precipitation and grid-scale precipitation**

Cloud and Boundary Layer Climate Process Team (CPT) (FY13-16)

- NCEP: Jongil Han (PI), Ruiyu Sun
- GFDL: Chris Golaz (PI), Ming Zhao
- NASA/JPL: Joao Teixeira (PI), Marcin Witek
- U. Washington: Chris Bretherton (Lead PI), Chris Jones, Peter Blossey

The project is to improve NCEP GFS/CFS:

- Implement a moist Eddy-Diffusion Mass-Flux (EDMF) scheme
- Improve global cloud climatology of GFS+MOM through better cloud microphysical and macrophysical schemes
- Compare GFS-forecast clouds with versions of GFDL climate model run in initialized weather forecast model

Poster by Han

CTB Recent Efforts to Engage the Community in Development of next version CFS

- Organized **CFSv3 Planning Meeting** in August, 2011
- Organized **CFSv2 Evaluation Workshop** in April, 2012
- Developed **a CFSv3 Vision document**
- Coordinated **Special CFSv2 Collection** in Climate Dynamics
- Lead **MAPP Climate Model Development Task Force** with a focus to improve NCEP CFS in 2014-2016

CTB is leading MAPP Climate Modeling Task Force

- Synergize and coordinate with model development at NCEP and OAR labs
- Contribute to the development of the **next-generation operational CFS** via CTB

+40 Participants

- MAPP funded PIs from universities and Gov. agencies
- **CTB (Lead)**
- NCEP
- NOAA Labs: GFDL, ESRL
- COLA

NCEP in-house Support is needed to Facilitate R2O

- Recognized that NCEP cannot afford a community model, e.g., NCAR/CCSM.

However,

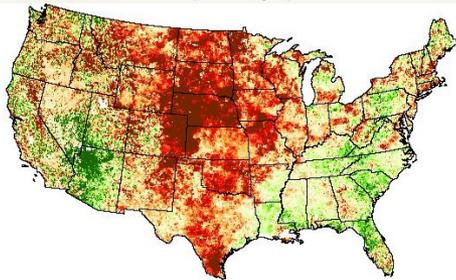
- External visitors and collaborators need NCEP O2R support to facilitate collaborations, e.g.,
 - More accessible model codes/scripts, documentation, experimental data
 - User technical support
 - Verification metrics and database

=> **Model Test Facility?**

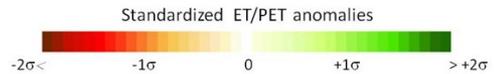
CTB Priority (3): Improving Climate Forecast Tools/Products

Goal: To provide reliable climate forecast products that are responsive to the needs of users and incorporate state-of-the-art science and research

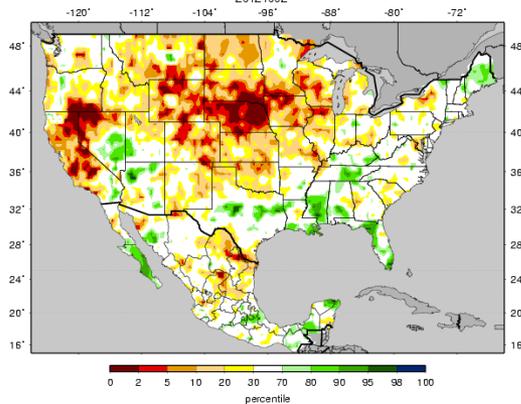
1 month composite ending September 26, 2012



Evaporative Stress Index
(Anderson, FY10)

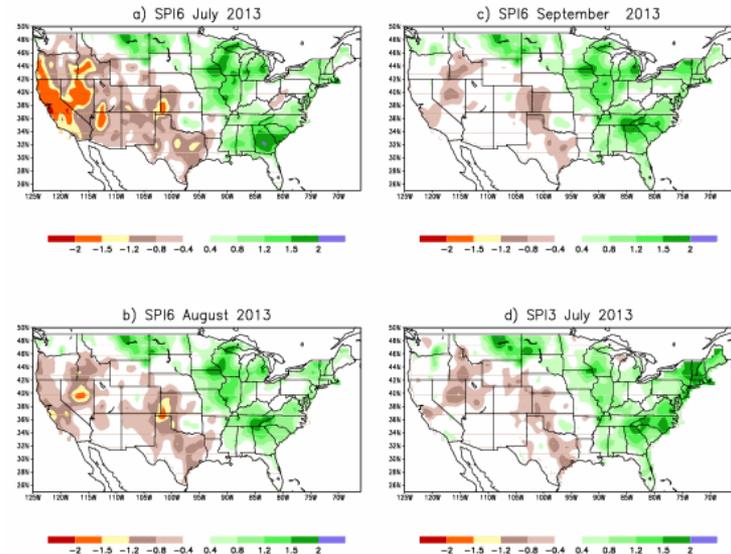


VIC Cumulative 3-Month Runoff Percentiles (w/1/ 1916-2004)
20121002



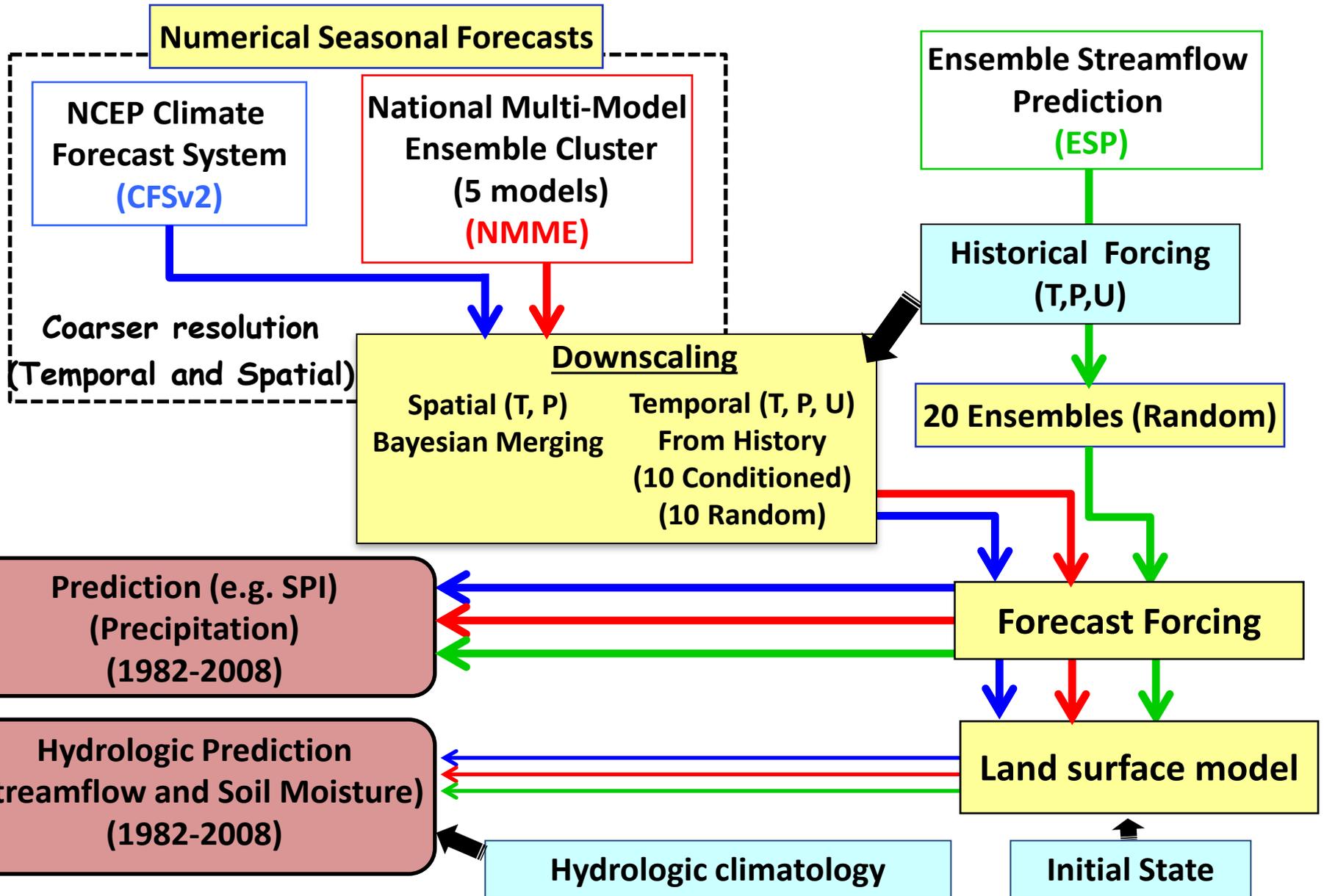
NMME-based drought forecast
(after Kintse Mo)

NMME SPI Fcst (ICs=July 2013)



Enhancing operational drought monitoring and prediction products
(Lettenmaier, Wood and Mo, FY10)

Princeton University's Hydrologic Forecast Methodology



Progress has been made to develop Performance Metrics/Protocol for CTB R2O Transition and Assessments

- 1. Metrics for Climate Model Evaluations**
- 2. Climate Forecast Evaluation Metrics and Protocol**
- 3. Metrics and Protocol for Assessment of Drought Monitoring and Forecasting Capabilities**

Assessing Drought Monitoring and Prediction Capabilities

CTB is leading the MAPP Drought Task Force Research to Capability (RtC) Assessment Effort.

- **Dedicated evaluation efforts are needed for building baseline systematic assessments**

| Key predictand (s) for drought variable (e.g., P, T, soil moisture, streamflow) | Metric(s) and skill scores comparing |
|--|---|
| Onset and recovery of drought condition | Lead time of prediction Error of identification |
| Duration and severity of drought condition | Error, bias, correlation (time, value) |
| Indication (detection, prediction) of drought condition: deterministic | Categorical metrics: Critical Success Index (CSI), Equitable Threat Score (ETC) Probability of Detection (POD), False Alarm Rate (FAR), and others. |
| Probability of drought condition: probabilistic | Brier Skill Score (binary); secondarily, Brier decompositions for reliability and resolution |
| Value, overall Value given drought occurring in the observed or forecast period | 1. Error, bias, correlation (of ensemble mean or median for probabilistic) 2. Ranked Probability Score (CRPS) |

Development of MAPP Drought Assessment Protocol

- Guidance for CPO/MAPP PIs to address the benefits of research
- Assessment metrics for drought monitor and forecast
- Verification data
- Verification period and case studies
- Baselines and benchmarking

NCEP Metrics for Climate Model Evaluations

(to be discussed/improved during CFSv3 development)

- **AMIP and CMIP Simulations Diagnosis:**
 - Mean bias (surface temperature; precipitation; T, u, v in the free atmosphere)
 - Modes of variability (PNA, NAO,...)
 - MJO; wind shear in Atlantic
 - ENSO tele-connection
- **Initialized predictions**
 - **Weather forecasts:** using EMC Verification Package
 - Anomaly correlations, biases, RMSE (u, v, T, P, SLP, q, cloud)
 - hurricane track and intensity errors
 - **ISI time forecast:** P, T and ENSO forecast skills.

Climate Forecast Evaluation Metrics and Protocol

Forecast Evaluation Protocol for monthly/seasonal forecasts

(following NMME Protocol):

Hindcast period:

- minimum 30 years (1982-2012)

Forecast lead time:

- 1- 9 months

Number of ensemble members:

- To be decided by the tool developer

Basic data:

- Monthly mean of T2m, Prate, Z200 and SST

Data requirements:

- Include each ensemble member and total uncorrected fields.
- Data format: Grid 1x1
- Domain: Global

Metrics:

Deterministic/Continuous :

- Anomaly Correlation (AC)
- Root Mean Square Error (RMSE)
- Mean Absolute Error
- Amplitude
- Biases

Categorical:

- Contingency Table
- Heidke Skill Score

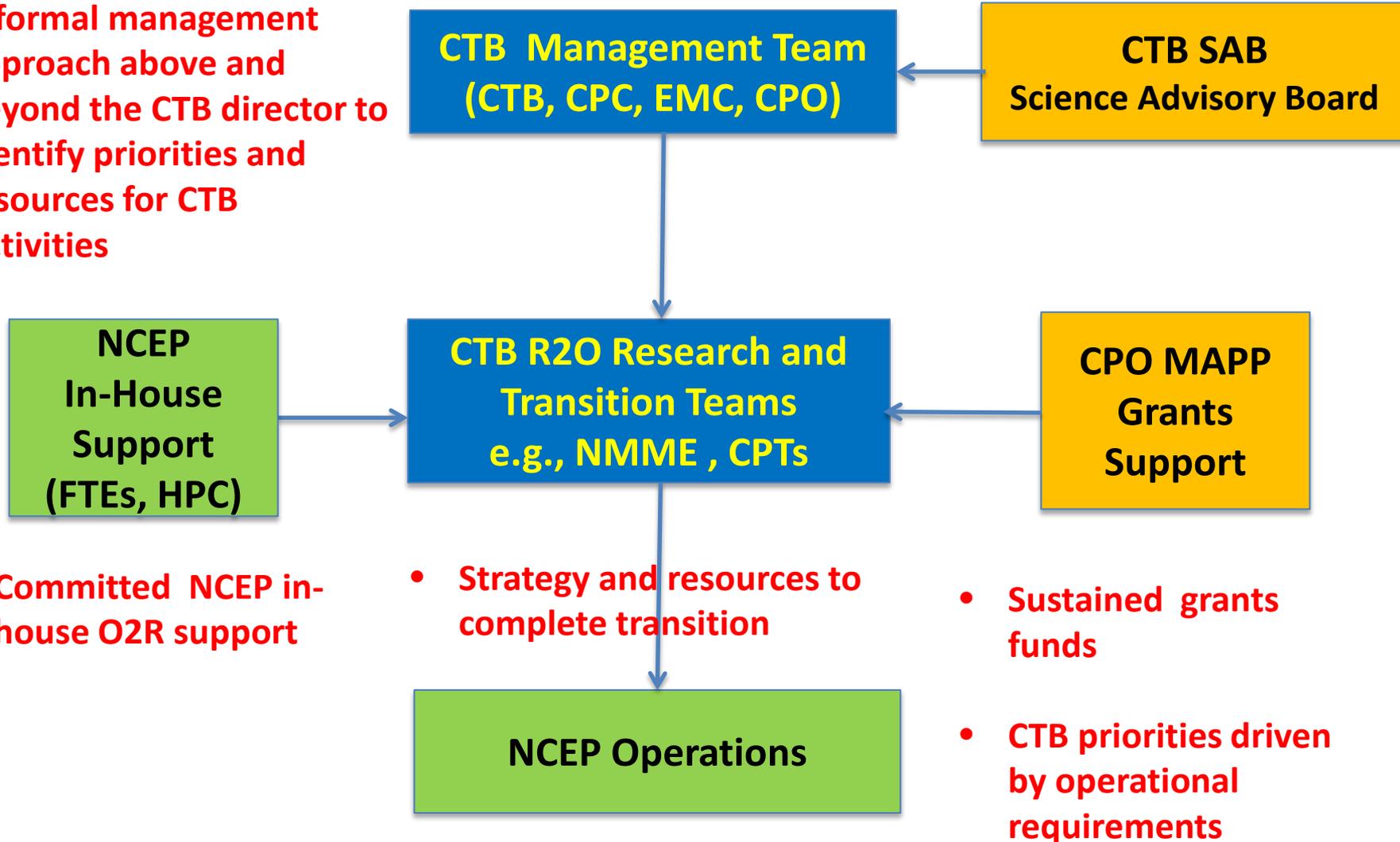
Probabilistic:

- Brier Skill Score (BSS)
- Rank Probability Skill Score (RPSS)
- Reliability

- Metrics could also be applied to existing operational tools/models for upgrades or phasing-out.

How to Make CTB Viable and Effective?

- A formal management approach above and beyond the CTB director to identify priorities and resources for CTB Activities



Summary

- **CTB is aimed at accelerating transitioning science advances to improved NOAA climate operations.**
- **CTB is jointly sponsored by CPO grants program and NCEP infrastructure (FTE, HPC) support**
- **CTB has contributed to NCEP operations**
 - 1) *CFS evaluations and improvements*
 - 2) *Multi-model ensembles*
 - 3) *Climate forecast tools and products*
- **Challenges/requirements for more effective R2O**
 - **A formal management approach above and beyond the control of the CTB director to identify priorities and resources for CTB R2O activities.**
 - **Sustained grants support for R2O projects driven by NCEP operational requirements**
 - **Committed NCEP O2R support to facilitate external collaborations**
 - **Resources to complete R2O transition after CTB R2O project is completed.**