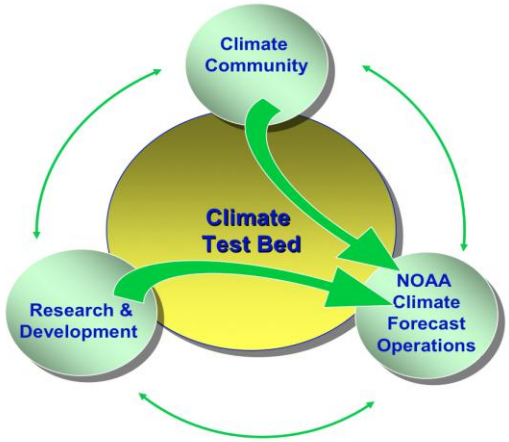
NCEP Climate Test Bed (CTB) Overview

Jin Huang

April 3, 2013



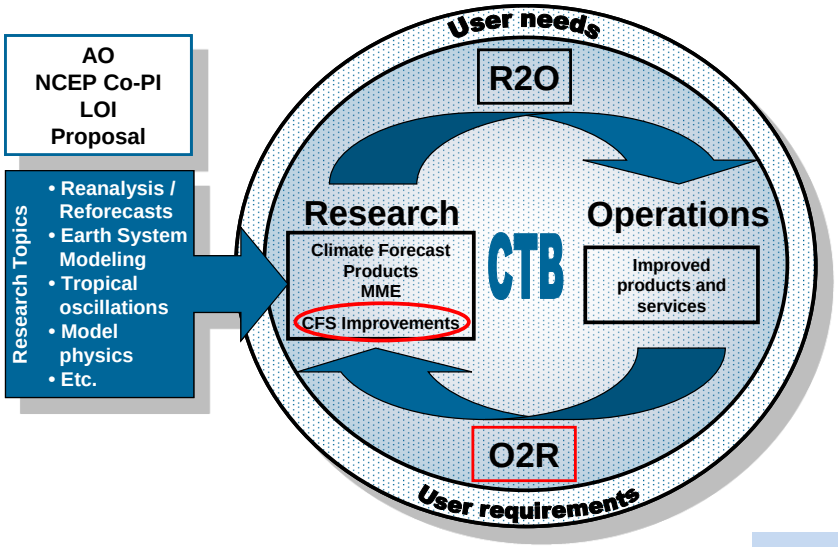
Mission: To accelerate the transition of scientific advances from the climate research community to improved NOAA climate forecast products and services.

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

Outline

1. **CTB Overview**
2. **Progress and future activities**
3. **Issues and plans to improve R2O transition**
4. **Summary**

NCEP Climate Test Bed



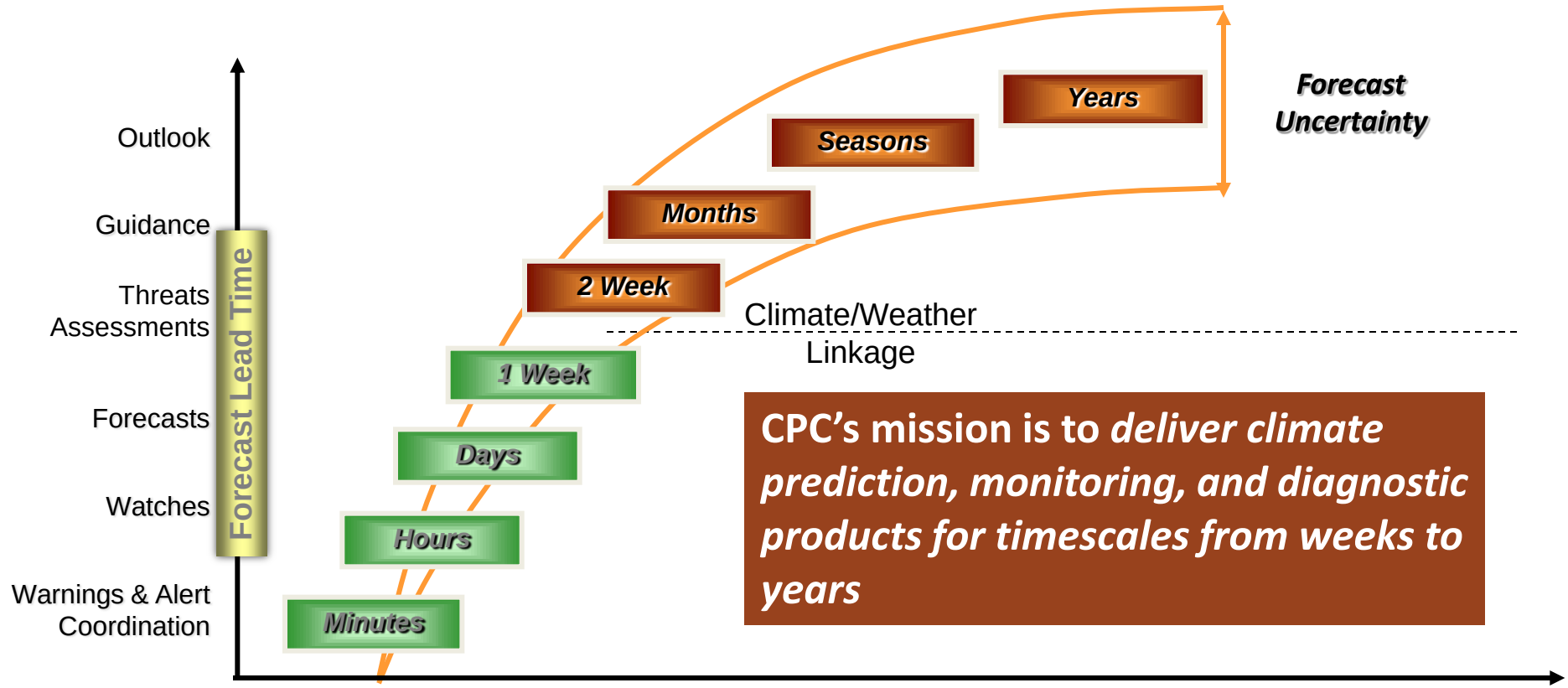
Mission

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

- Joint NCEP-CPO facility @ NCEP
- CTB Science Advisor Board (SAB)
- Established in 2005
- Serves as conduit between the operational, academic and research communities

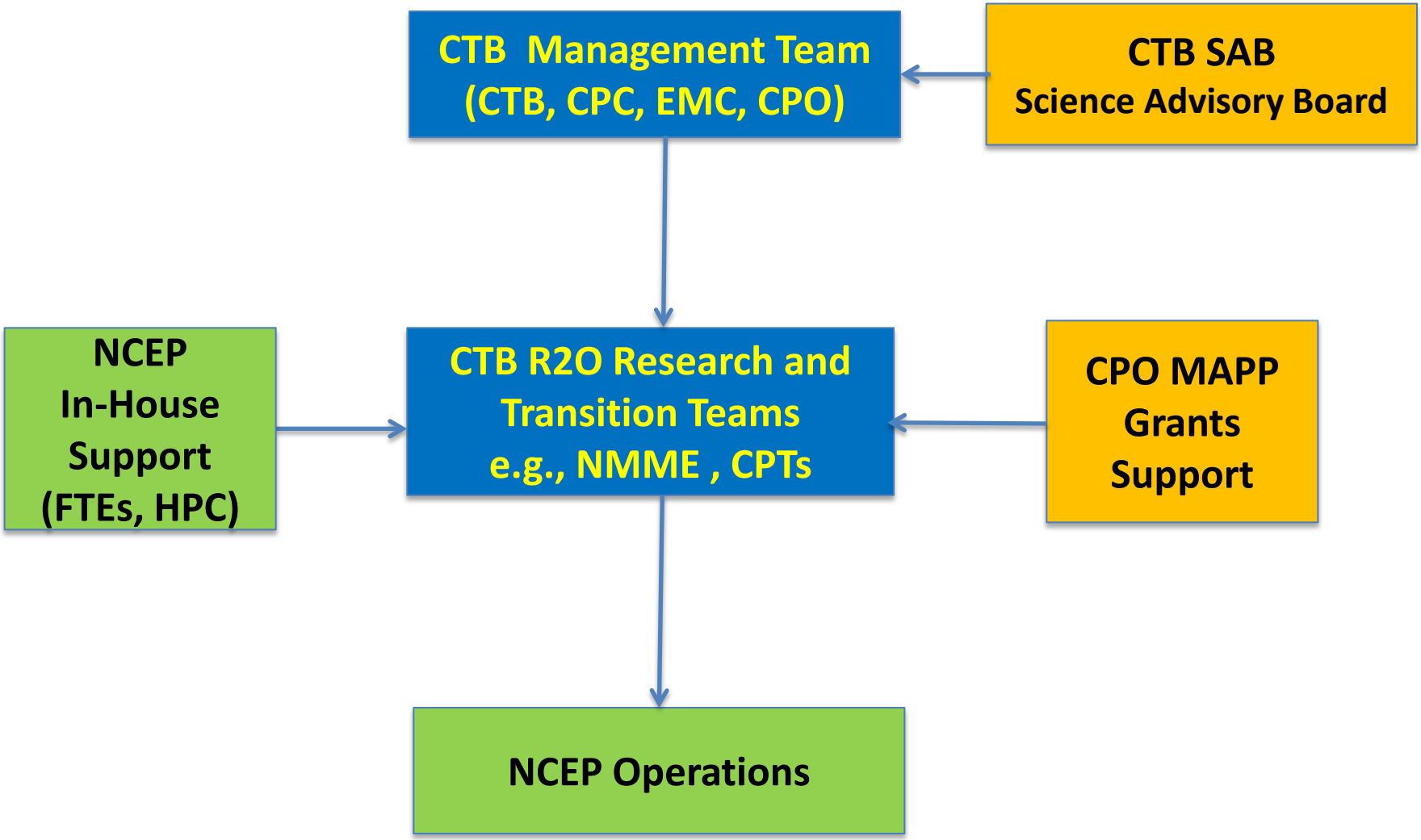
- CTB embraces *the R2O and O2R paradigms*
- *Grants projects sponsored by Climate Program Office*
- CTB emphasizes three science activities
  - *CFS improvements*
  - *Multi-model ensembles*
  - *Climate forecast products*
- CTB supports both CPC and EMC

CTB Contributions to NOAA Seamless Suite of Forecast Products



- **CTB's mission is to improve *climate forecast products and service on timescales from weeks to years by accelerating R2O transitions.***
- **CTB priorities are driven by the requirements of NOAA operational forecasts**

How Does CTB Function?



CTB Science Advisor Board (SAB)

provides independent scientific advice, broad direction and endorsement of ongoing and planned activities

Current CTB-SAB Members:

1. T. Barnston (IRI)
2. T. Busalacchi (U. Maryland, Chair)
3. E. Harrison (PMEL)
4. M.Harrison (UK)
5. J. Kinter (COLA)
6. R. Koster *(NASA)
7. K. Redmond (DRI)
8. T. Rosati (GFDL)
9. S. Sorooshian * (U. California at Irvine)
10. J. Tribbia (NCAR)

* new member

NCEP – CPO MOU

Respective Roles of CPO and NCEP in Advancing Intraseasonal-to-Interannual Climate Modeling and Prediction

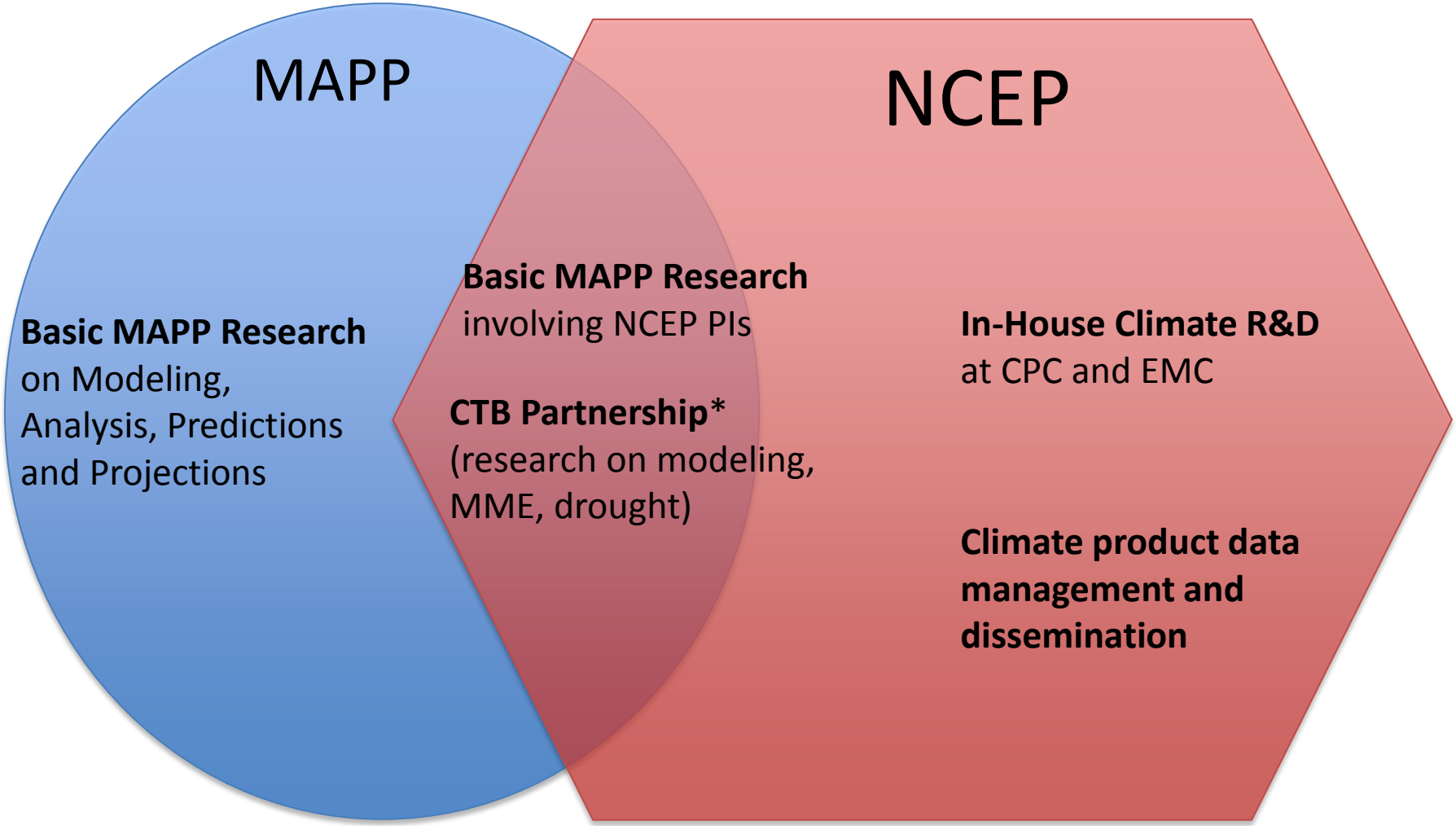
- **CPO provides and manages support for research (R**) to both the extramural community and NOAA labs / centers participating in the ISI climate arena.

- **NCEP delivers operational (O)** national and global weather, water, climate and space weather guidance, forecasts, warnings, and analyses to its partners and the external user communities.

- **The CTB executes end-to-end transition activities** with grant support from CPO and infrastructure support from NCEP.

- CPO provides funding to research activities of mutual interest and of high priority identified by CPO, mindful of the priorities stated by NCEP in its strategic plan and related documents

CPO/MAPP Program and NCEP



*MAPP- NCEP CTB Partnership, next slide..

New Additional 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.
  - CPC and CTB are developing the evaluation metrics and R2O protocols
- 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:

- FY06 - FY10: dedicated HPC (1/3 Vapor)
- FY11 – FY13: proposal based

FTEs

- CTB Management (CTB, CPC, EMC)
- Leveraging CPC and EMC FTEs

Climate Test Bed
Past Funded Projects

- **FY06**
  - Using Initial tendency errors to reduce systematic errors, identify model errors, and construct stochastic parameterizations (DelSol)
  - Development of neural network emulations of model physics components for improving the computational performance of the NCEP seasonal climate forecasts (Fox-Rabinovitz)
  - The Ocean Component of the NCEP ENSO CFS (McPhaden/Xue/Behringer)
- **FY07**
  - System-wide advancement of user-centric climate forecast products (Hartmann/O'Lenic)
- **FY08**
  - Recalibrating and Combining Ensemble Predictions (Goddard et al)
  - Probabilistic forecasts of extreme events and weather hazards over the United States (Jones/Gottschalck)
  - Enabling the Transition of CPC Products to GIS Format (Doty/Silva/Halpert)
  - Generation and Evaluation of Long-Term Retrospective Forecasts with NCEP Climate Forecast System: Predictability of ENSO and Drought (Cane/Wang/Xue)
  - Multi-Model Ensemble Climate Prediction with CCSM and CFS (Kirtman/van den Dool
  - Development of an Extended and Long-range Precipitation Prediction System over the Pacific Islands (Annamalai/Kumar)
  - New Tools for North American Drought Prediction (Lyon/Kumar)

Climate Test Bed Funded Projects

- **FY09**
  - CFS Stratosphere Improvement, Perlwitz, Long, Alpert & Iredell
  - Development of Subseasonal Ensemble Forecast Techniques, Schubert et al.
  - A GOES Thermal-based Drought Early Warning Index For NIDIS, Anderson, Mo,et al
  - Multi-model Ensemble Reanalysis System (MERS) Using the 4D-Local Ensemble Transform Kalman Filter (4D-LETKF), Ide, Kalnay, Miyoshi & Wang
- **FY10**
  - Incorporating Scale and Predictability Information in Multi-model Ensemble Climate Predictions, DelSole, Tippett & van den Dool
  - Multi-Model Ensemble Forecast of MJO, Wang & Waliser,
  - Enhancing operational drought monitoring and prediction products through synthesis of N-LDAS and CPPA research results, Wood & Lettenmaeir
  - Improved Extended Range Prediction through a Bayesian Approach Exploiting the Enhanced Predictability Offered by the Madden-Julian Oscillation. Xie, Johnson, L'Heureux, Collins & Gottschalk
  - Seasonal Prediction for Ecosystems and Carbon Cycle Using NCEP/CFS and a Dynamic Vegetation Mode, Zeng, Kalnay & Kumar
  - CPT for Improving the Representation of the Stratocumulus to Cumulus Transition in Climate Models, Bretherton, Mechoso, Park & Teixeira
- **FY11**
  - National Multi-Model Ensemble (NMME) Prediction System – Phase I
- **FY12**
  - National Multi-Model Ensemble (NMME) Prediction System – Phase II

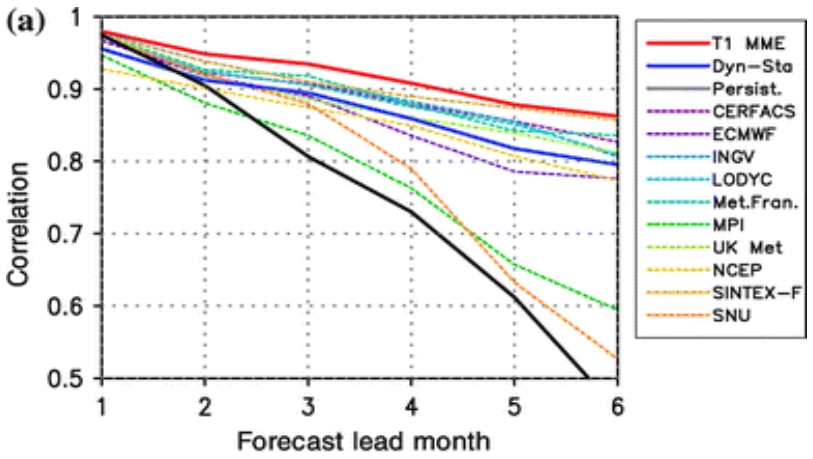
CTB Priority (1): Multi-Model Ensembles

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

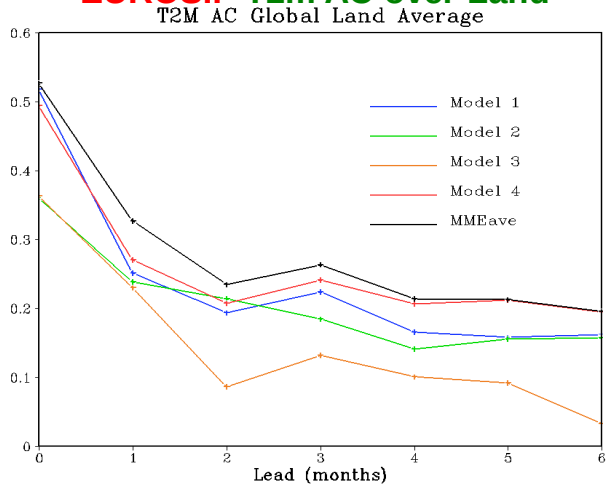
Why NMME?

- Probabilistic seasonal predictions requires moderately large ensembles
- Although ad-hoc, multi-model techniques have proven to be a pragmatic approach to increasing ensembles size and to improve the resolution of the forecast probability over any single model
- CTB supported several more research focused projects on verification and consolidations during FY08-10
- EUROSIP (International MME) is beneficial to operational forecasts, but data is not open to the research and user communities

ENSEMBLE ENSO Prediction



EUROSIP T2m AC over Land



NMME - Phase I

NCEP Climate Tests Bed (CTB) NMME Workshops February 18, April 8, 2011

- Establish Collaboration
- Developed Protocol for Experimental Real-time Multi-Model Prediction

Distributing Hindcast and Forecast Data to NOAA and the community

- Public Dissemination via IRI Data Library

Became Real-Time in August 2011

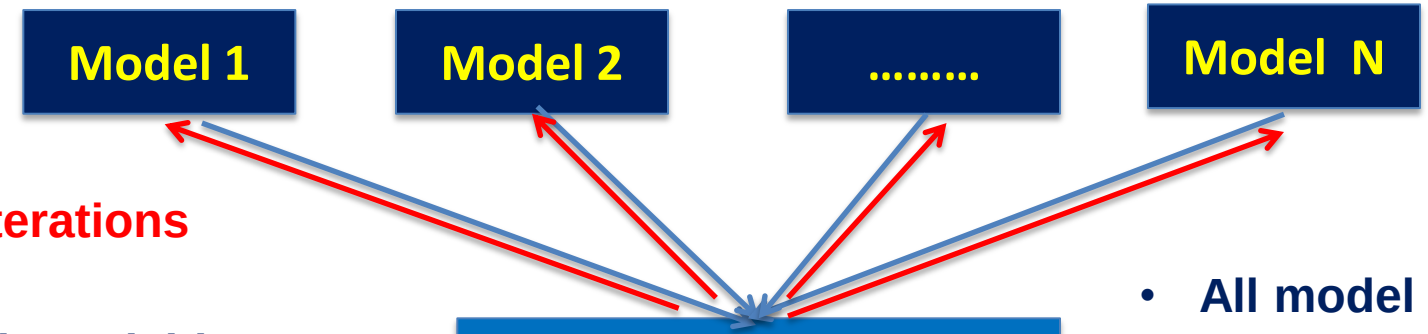
- Adhering to NOAA Operational Schedule

NMME Partners

- **University of Miami**
- **COLA**
- **NCAR**
- **IRI**
- **U of Colorado – CIRES**
- **NASA – GMAO**
- **NOAA/NCEP**
- **NOAA/GFDL**
- **Princeton University**
- **Canada**

Funded by NOAA/CPO/MAPP Program in FY11

NMME Real-time Forecast Process



QC Iterations

Monthly Variables:
- SST, P and T
- Tmax, Tmin, Z200, soil moisture, runoff

NCEP/CPC

- **Consolidation**
- **Forecast products**
- **Verifications**

- **All model hindcast and real-time forecast need to be in CPC by the 8th of each month**
- NMME Telecon 1st Thursday of each month or before the 8th

http://www.cpc.ncep.noaa.gov/products/NMME or google NCEP NMME

CPC Real-Time Seasonal Forecasting Tools

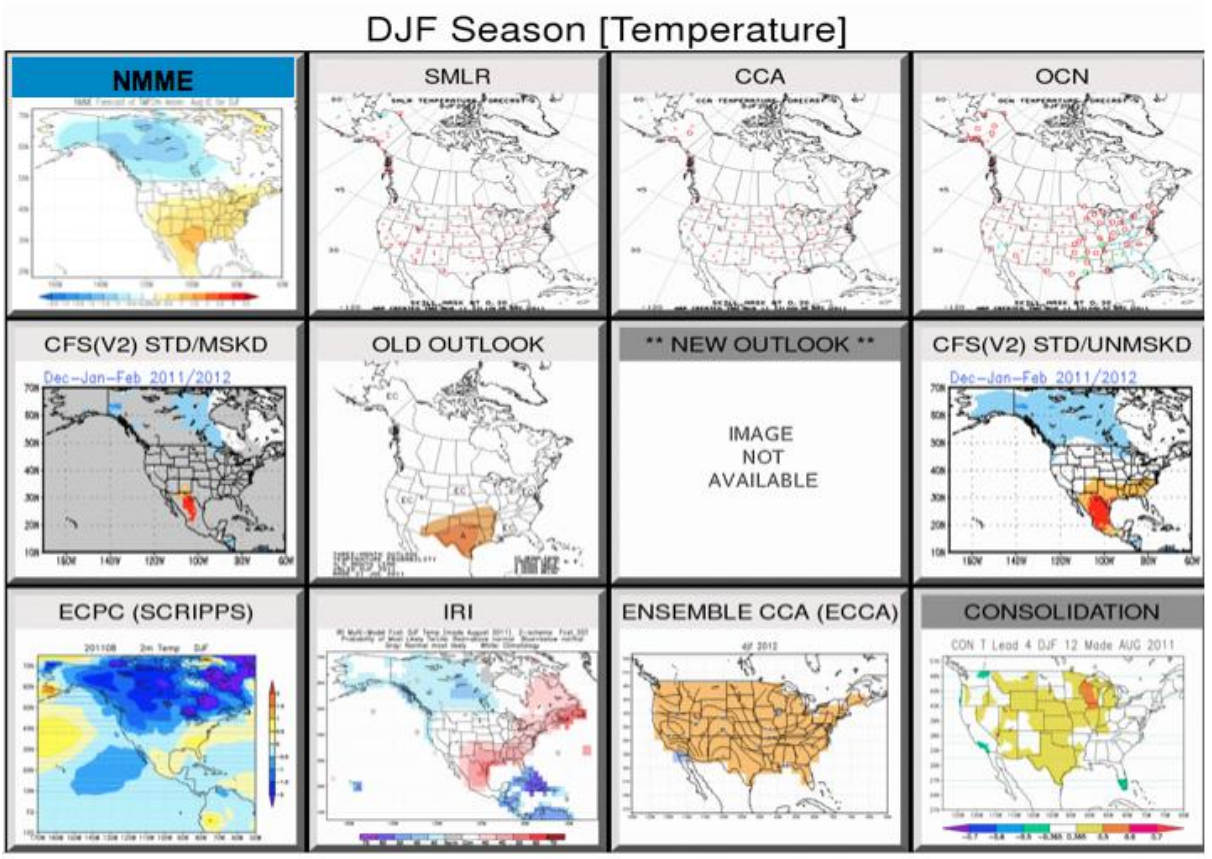
NMME applications:

Operational CPC Forecasts

Monthly Ocean Briefing

Monthly Drought Briefing

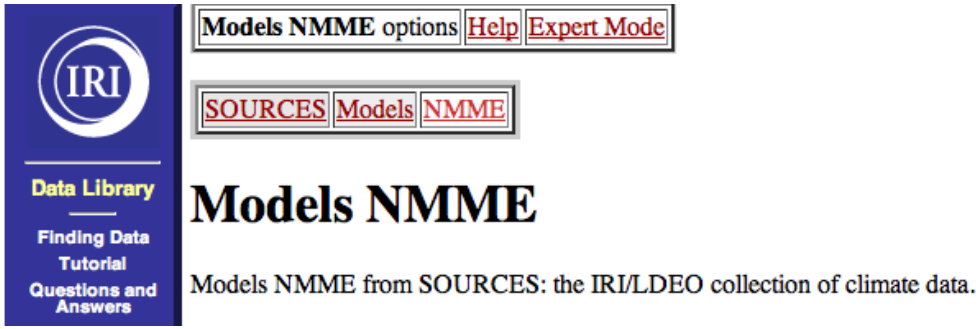
African Desk



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 …"

NMME Phase-1 Hindcast Data



http://iridl.ldeo.columbia.edu/SOURCES/.Models/.NMME/

- Download files
  - Binary, netcdf, etc
- Read data directly into clients
  - ferret, GrADS, matlab, NCL, R
- Sub-setting and averaging (+ a lot more)
  - Select regions, start months, lead
  - Seasonal averages

NMME – Phase II

Main Goal: A more "purposeful" MME Experiment with improved models and an optimal experimental design to address key research questions

Funded by NOAA/MAPP, NSF, DOE and NASA

Tasks during FY12 and FY13

- **Continue Real-Time Experimental Predictions**
- **Enhance Current NMME Capabilities with model upgrades**
  Model Improvements: GFDL-CM2.5 (20 km AGCM), CCSM4, CESM1
- **Assess Forecast Quality**
  Consolidation techniques
  Drought Assessment: soil moisture, runoff, evaporation
- **Sub-Seasonal Assessment**
  Forecast Protocols
- **Initial Condition Sensitivity Experiments**
  Ocean, Land
- **Phase-II data will distributed at NCAR**
- **Phase-I Enhanced data (additional variables) will be continued at IRI**

Proposed Long-term Distributed Operational NMME System

- All participating modeling centers generate model reforecasts on their own and provide real-time forecasts to NCEP following NCEP's operational launch schedule

- Benefits:
  - Leveraging R&D at the participating centers
  - Stable funding from the sponsoring agencies for the modeling centers
  - Greater flexibility for R2O and O2R transitions

- Requirements:
  - MOUs between NCEP and participating modeling centers
  - Budget support for operations and continuous improvements
    - Reforecasts and real-time forecasts for each model
    - The external NMME producers and users via Climate Test Bed
    - Data archive, access and management

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**

Past Supported CTB Projects:

Data Assimilation Methodology

- 150-yr Coupled ocean data assimilation (Cane, FY08)
- Hybrid data assimilation for reanalysis (Ide, FY09)

Model Physics Improvement

- Stratosphere (Perlwitz, FY09)
- CPT (Bretherton, FY10)

Empirical and Stochastic Parameterizations

- Stochastic perturbation (Delsole, FY06)
- Neural Network (NN) Emulation of model radiation (Fox-Rabinovitz, FY06)

FY13 Funding Opportunity:

- **MAPP Priority #2: Climate Process and Modeling Teams**

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

Team efforts of NCEP, CPO, and the external community:

- **Organized CFSv3 Planning Meeting in August, 2011**
- **Organized CFSv2 Evaluation Workshop in April, 2012**
  - Document improvement from CFSv1 to CFSv2
  - Identify model biases and deficiencies in CFSv2
  - Identify research directions for the development of CFSv3
- **Developed a CFSv3 Vision document**
- **Coordinate Special CFSv2 Collection in Climate Dynamics**

NCEP CFS Strategy

1. **NOAA requirement for a CFS**
   - CFS is the operational model for seasonal forecast
   - CFSv2 needs improvement
2. **Developing a vision for NCEP CFS**
   - How bold and far-reaching should the vision be?
   - Should NCEP embrace a fully weather-climate modeling strategy?
   - Should CFS be a community model?
   - Should reanalysis be de-coupled from CFS model upgrades?
3. **Collaborative research and development process**
   - Initiate a fully unified weather-climate modeling strategy
   - Establish an NCEP Climate Modeling Team (NCMT)
   - Make NOAA collaboration with the external community more effective
   - Improve NCEP infrastructure, modeling framework and rewarding system
   - Accelerate the CFS development cycle and implementation cycle

What can CTB do for CFS Evaluation and Improvement?

(1) Engage the external community in planning for CFSv3

- **Workshops;**
- **Future CFS implementation plan**

(2) Provide grants funding to support R2O activities

- **Test and evaluate new parameterizations, schemes, model components in NCEP operational models**
- **Form Joint NCEP-External Modeling Teams**

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

- **Support to external visitors and collaborators**
  - Model code, documentation, data, and technical support
- **Provide model testing environment that mimics NCEP operations**

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

Goal

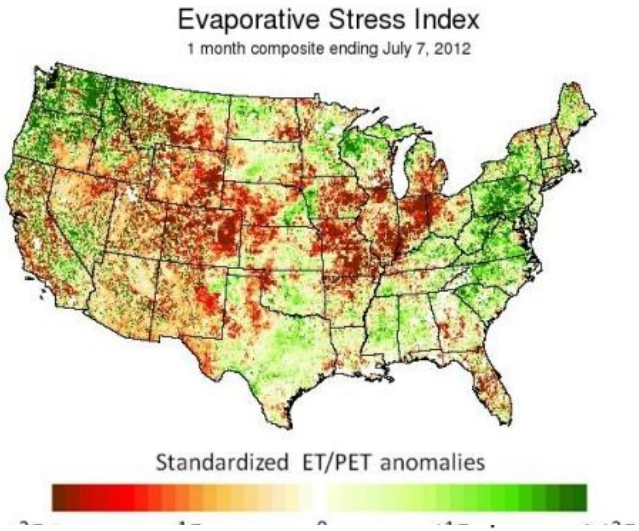
To provide reliable climate forecast products that are responsive to the needs of users and incorporate state-of-the-art science and research

CTB Funded Activities to Improve Drought Products

- Drought is a leading natural disaster for the United States.
  - Recent droughts caused more than 10 Billion economic and property damages.
  - Losses of crops and livestock during the 2011 Texas drought caused 7.6 billion dollars .
  - The Texas drought also exposed the vulnerability of the electricity generatio
  - Improve monitoring and prediction of drought in near real time can lead to better planning and to reduce the damages caused by drought .

- The projects from the Climate Test Bed improve the ability of CPC to monitor and predict drought on seasonal time scales.

The evaporative Stress Index for drought monitoring (PI: Martha Anderson , USDA)

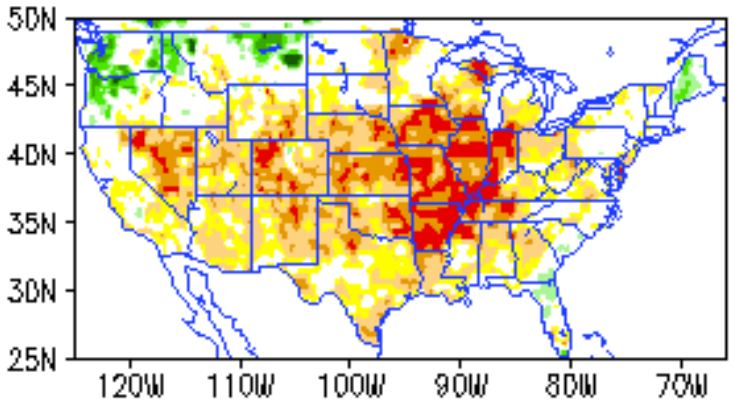


Evaporative Stress Index (ESI) developed within a thermal remote sensing energy balance framework for monitoring.

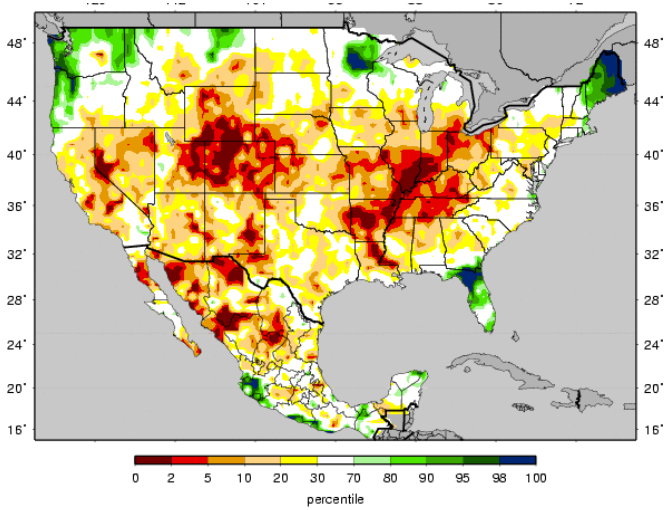
Advantages:

- Independent on land models
- Sensitive to vegetation and is good to monitor quick drought onset
- Compares well with the U. S. Drought Monitor and the North American Data Assimilation System

NCEP SMP

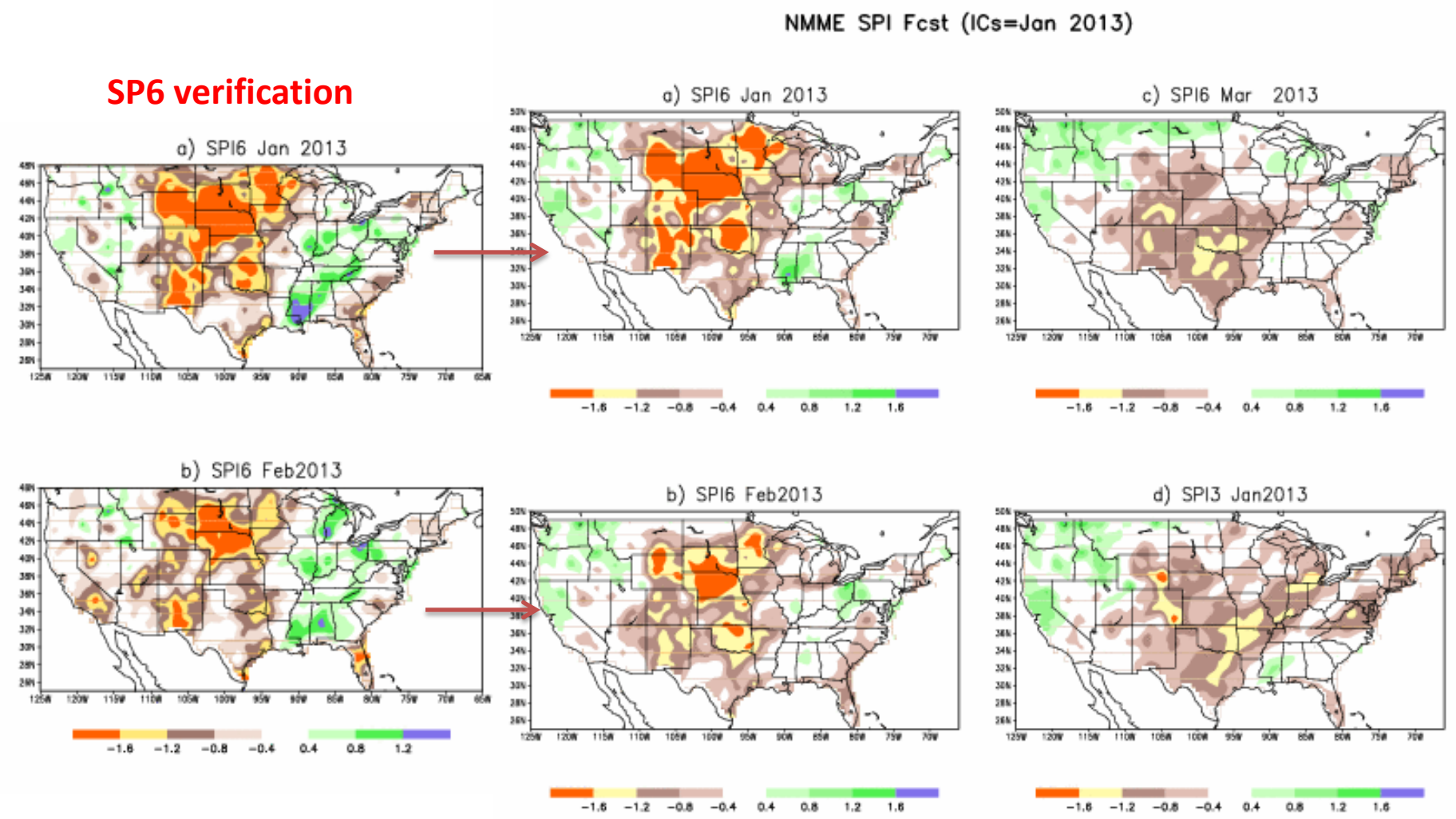


University of Washington NLDAS SMP



Standardized Precipitation Index (SPI) Based on NMME

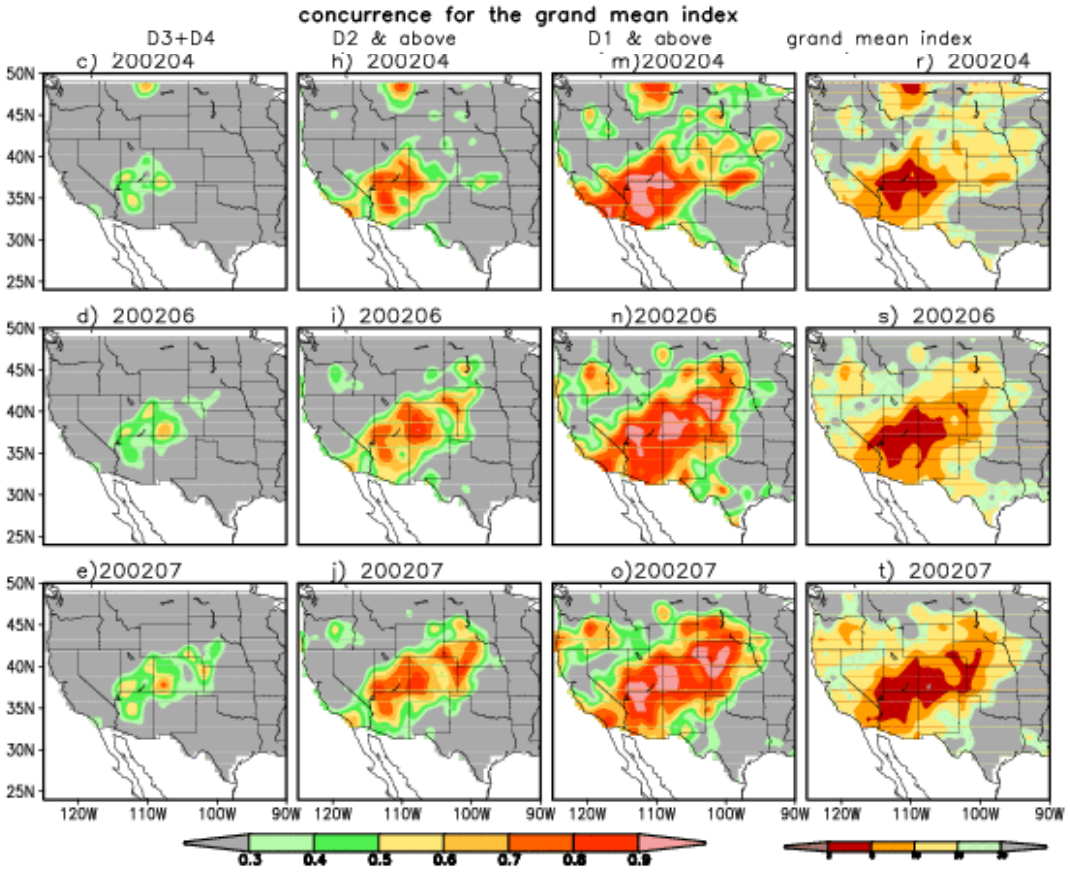
(PIs: Eric Wood Princeton University; Brad Lyons IRI)



Standardized Precipitation Index (SPI) is the index to monitor the meteorological drought.

Probabilistic Drought Classification

(PIs: Lettenmaier and Mo)

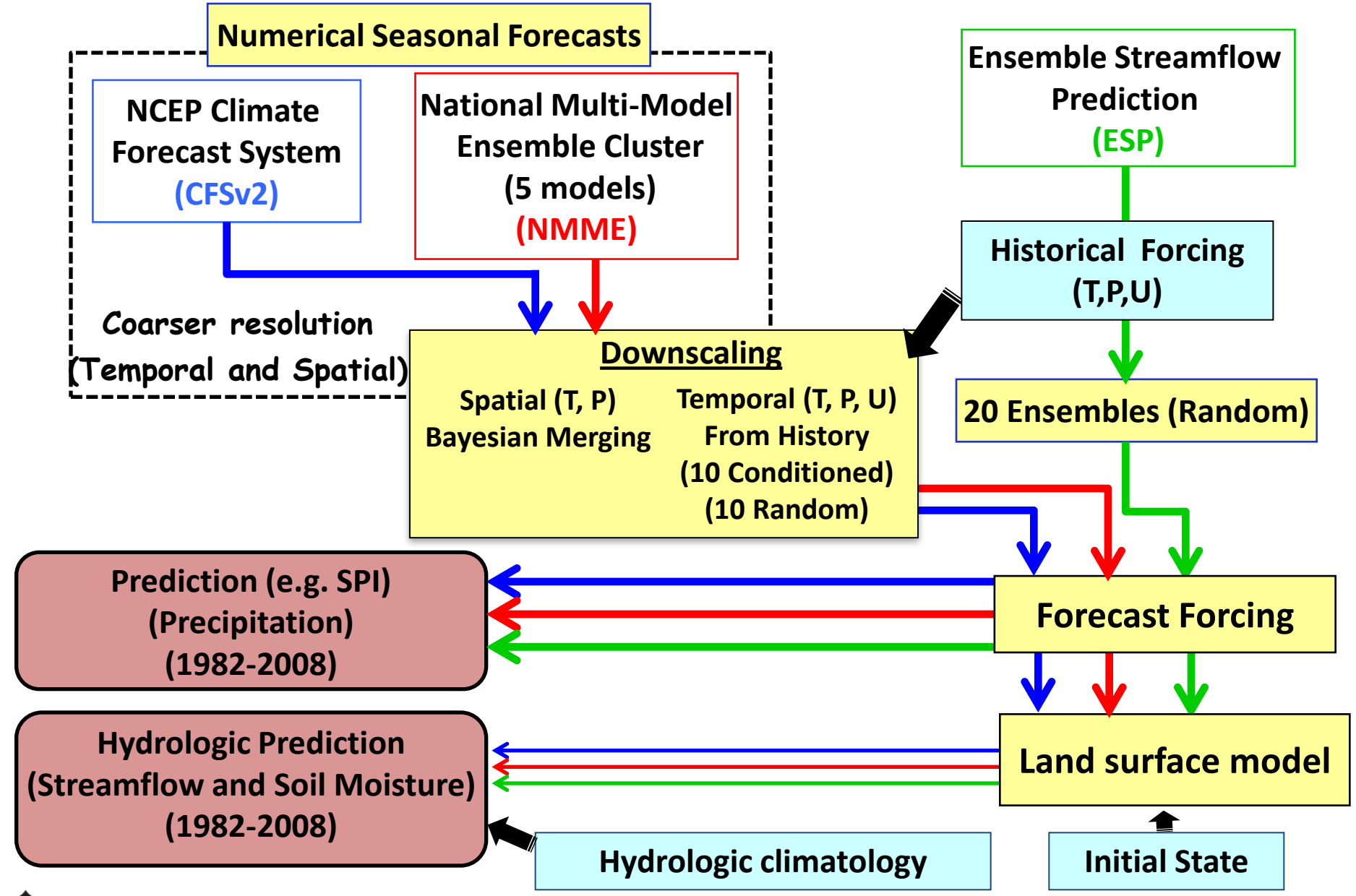


- At the peak of drought in 2002 summer, the concurrence measure of the drought occurrence indicates that there is a 40-50% probability for drought in the D3/D4 category.
- There is still a 20-30% chance for the drought in the D2 category

Motivation and Procedure:

- Differences among different drought indices are often too large to classify drought into D0 to D4 categories.
- Probabilistic approach to address the uncertainties in drought classification.
- The grand ensemble mean of 6-month SPI (SPI6), SMP and 3-month SRI(SRI3) from different NLDAS systems is used for drought classification
- The uncertainties of the grand mean index are assessed by using the drought concurrence measure defined as the percentage of indices in each drought category (D0 to D4)

Princeton University's Hydrologic Forecast Methodology



PRINCETON UNIVERSITY

Key Elements for Successful R2O Transition

- **The project objectives are NCEP requirement driven and R2O focused.**
- **Required "applied research" have been supported by other research programs**
- **Close involvement/partnership from NCEP is critical**
- **NCEP In-house O2R support is critical.**

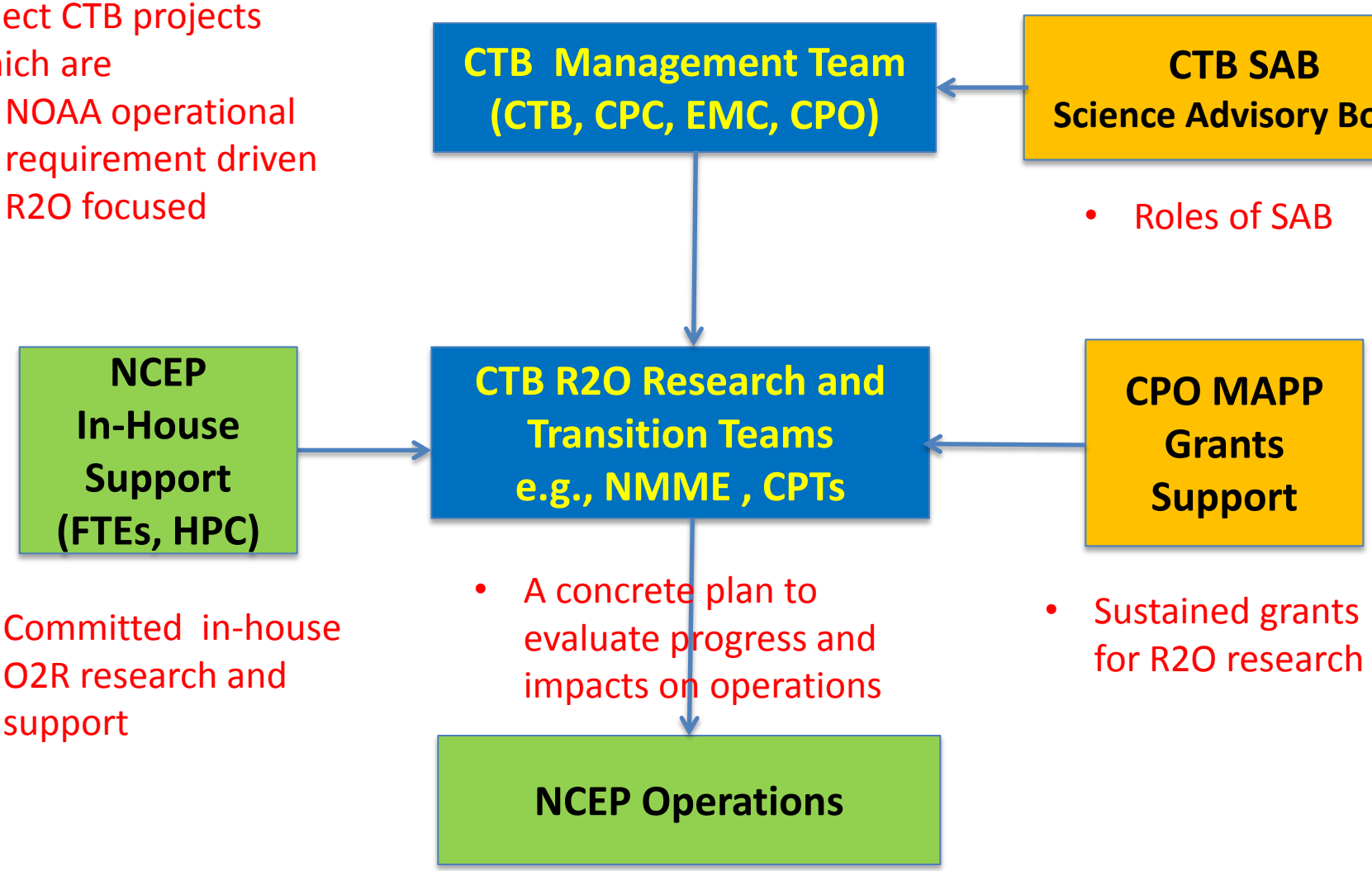
Reasons for Failing R2O Transition

- **Negative testing results**
- **Insufficient support from NCEP (model access, data, collaborators)**
- **Software incompatibility**
- **Less focused on R2O. Some projects have demonstrated potentials, but need additional time/effort/funding to test in an operational environment or for the upgraded model system**

How to Make CTB Function?

Select CTB projects which are

- NOAA operational requirement driven
- R2O focused



- Roles of SAB
- Committed in-house O2R research and support
- A concrete plan to evaluate progress and impacts on operations
- Sustained grants for R2O research
- Strategy and resources to sustain the operations

Summary

- **CTB is aimed at accelerating transitioning science advances to improved NOAA climate operations.**

- **CTB is jointly sponsored by NCEP and Climate Program Office (CPO)**
  - CTB grants projects sponsored by CPO/MAPP Program
  - NCEP provides personnel and computer

- **CTB current science priorities**
  1) ***CFS evaluations and improvements***
  2) ***Multi-model ensembles***
  3) ***Climate forecast tools and products***

- **CTB Monthly Seminar Series**