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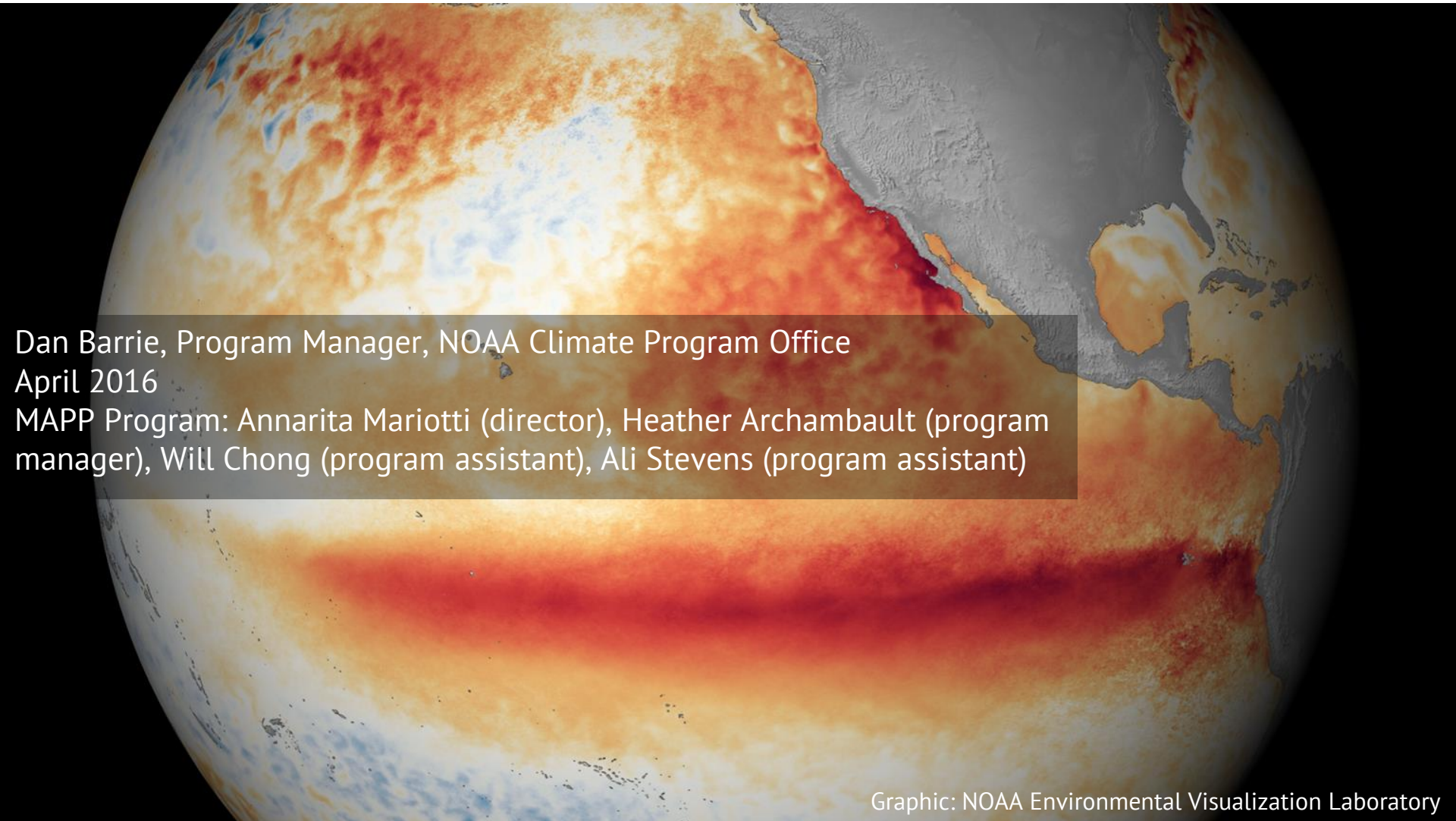
MAPP Modeling, Analysis, Predictions, and Projections

OAR research on S2S predictability & prediction



Dan Barrie, Program Manager, NOAA Climate Program Office
April 2016
MAPP Program: Annarita Mariotti (director), Heather Archambault (program manager), Will Chong (program assistant), Ali Stevens (program assistant)

Graphic: NOAA Environmental Visualization Laboratory

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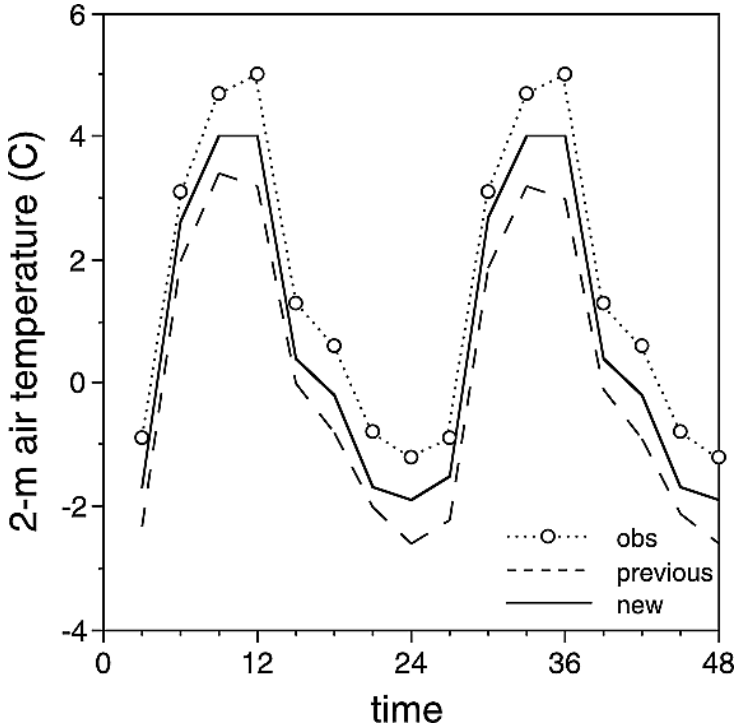
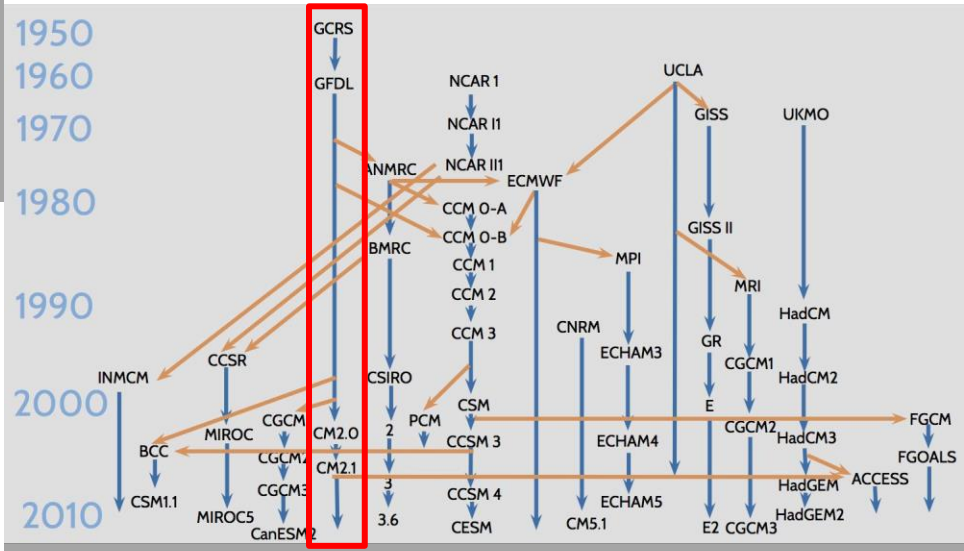
OAR Leadership in Subseasonal to Seasonal Prediction Research

Climate Program Office (CPO) and predecessor Office of Global Programs (OGP) initiatives have targeted prediction system improvements for 20 years. The figure below from Ek et al. (2003) shows improvements in T2m resulting from an upgraded land model





GFDL's predecessor, the Weather Bureau's General Circulation Research Section (GCRS), consolidated model development activities into a focused effort in the 1950s.

Model genealogy figure from Ben Sanderson (NCAR)

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OAR Leadership Today

NGGPS Phase 1 Testing
Project Summary Assessment

	Idealized Tests	3-km, 3-day forecasts	Performance	Scalability	Nesting or Mesh Refinement	Software Maturity
FV3						
MPAS						
NIM						
NMM-UJ						
NEPTUNE						

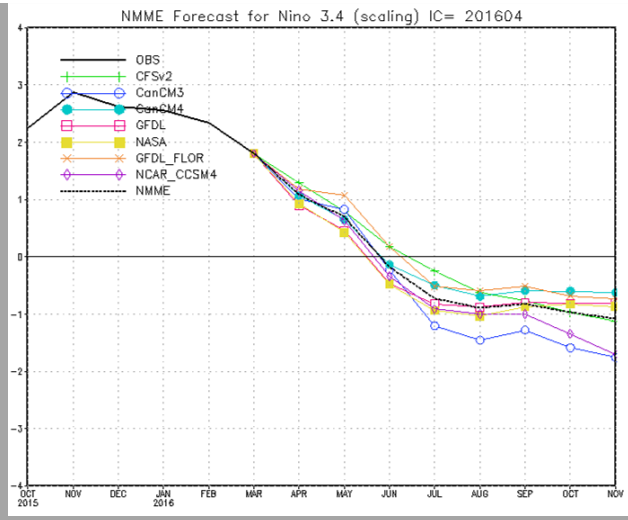
Meets or exceeds readiness for needed capability
Some capability but effort required for readiness
Capability in planning only or otherwise insufficiently ready

Recommendation (strongly endorsed by NWS) is to perform phase 2 testing with only MPAS and FV3

28

GFDL's modeling leadership continues – the GFDL dynamical core is one of two finalists to serve as the core of the next-generation NWS prediction system.

ESRL led an El Niño rapid response experiment to collect an unprecedented high-resolution data set of observations of tropical conditions and the extratropical response. This data set will be critical to better understanding El Niño and to improving models and forecasts, amongst other outcomes.



CPO, through the OAR-NWS Climate Test Bed, led the development of the North American Multi Model System, a major interagency effort, which includes input from 7 research and operational climate models.

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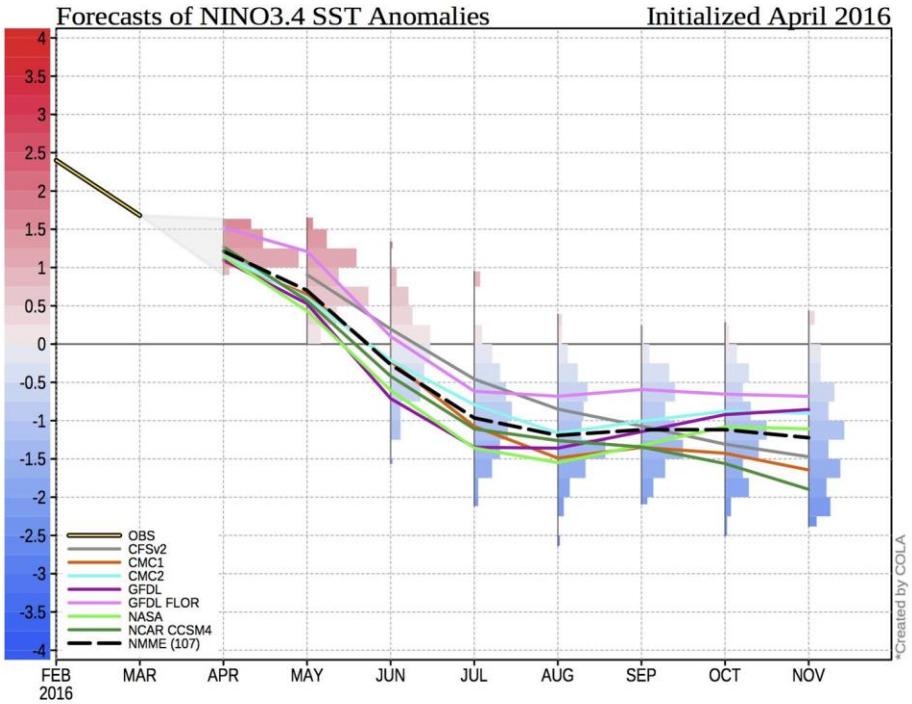
CPO prediction research



The MAPP and Climate Variability and Predictability programs are the current flag bearers for 20 years of CPO/OGP support for seasonal prediction research.

Foci areas:

- advancing statistical and dynamical modeling, including multi-model ensemble prediction systems
- understanding model biases, and improving model processes and physics
- developing novel climate reanalysis techniques
- improving data assimilation and monitoring systems

CPO involved in:

- Supporting past GEWEX efforts and establishment of new GEWEX-US office.
- Coordination with international, interagency, laboratory, and operational center partners.

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MAPP efforts to improve predictions

MAPP Notables:

- Development and support for NMME (research and real-time).
- Development of the Climate Forecast System, version 2.
- Drought Task Force - NIDIS link
- Climate Prediction Task Force
- Reanalysis research
- Data assimilation
- Predictability and prediction research at the Center for Ocean-Land-Atmospheres (George Mason University)
- $3M+ in new subseasonal to seasonal research investments in FY16, including transition to operations work. With co-support from NWS NGGPS, NESDIS, and Navy.
- Targeted improvements to model atmospheric physics.

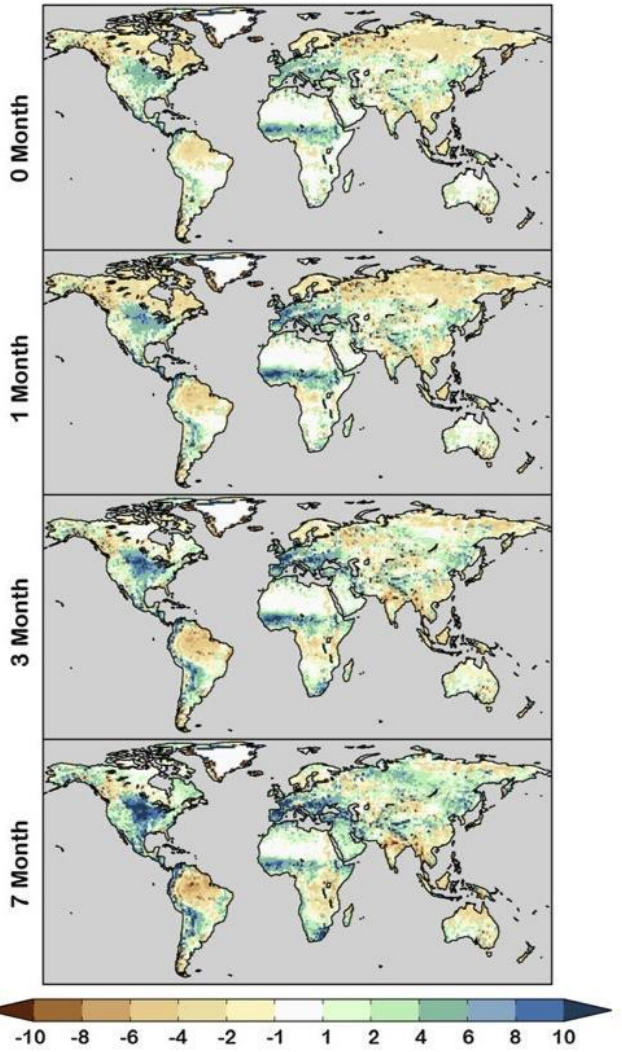

Fig. 3 As in Fig. 2 for JJA volumetric soil moisture (10–40 cm layer) forecast errors relative to CFS reanalysis

Evaluation of soil moisture biases with lead time in the CFSv2 reforecasts (Dirmeyer, CFSv2 Topical Collection (2013)

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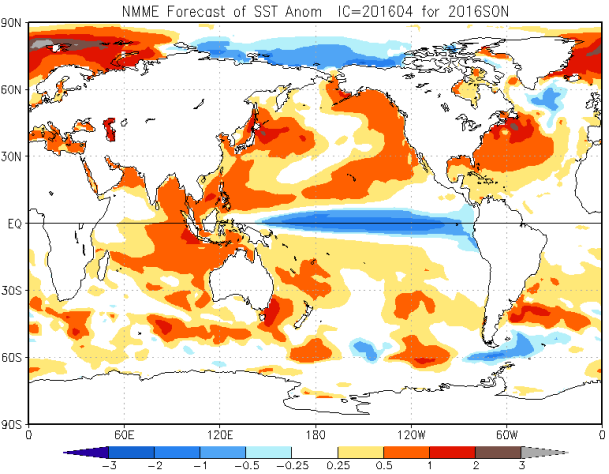
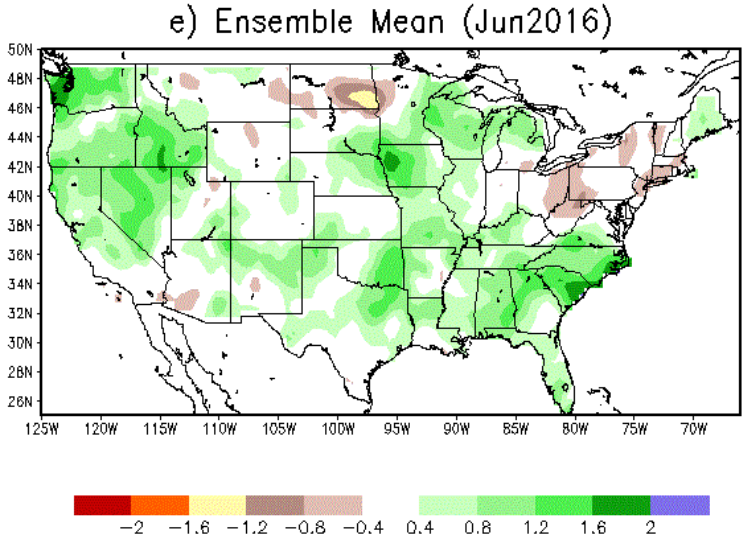
Transition to Operations

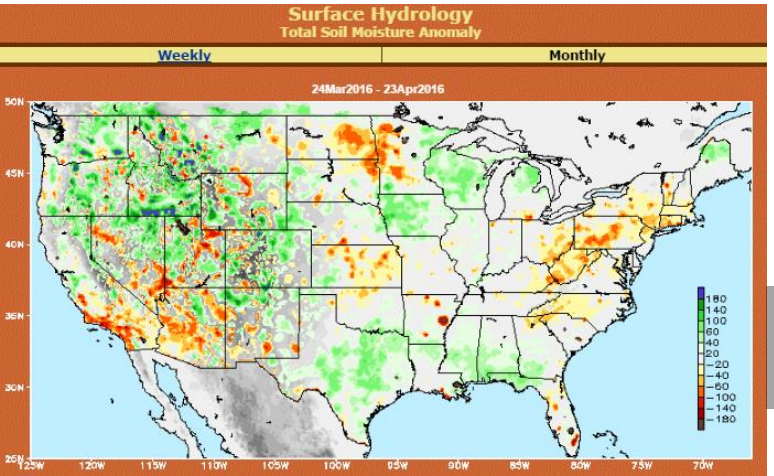
The **Climate Test Bed** is a joint effort of NWS and OAR/CPO, focused on enabling the transition of research into operations



North American Multi-Model Ensemble

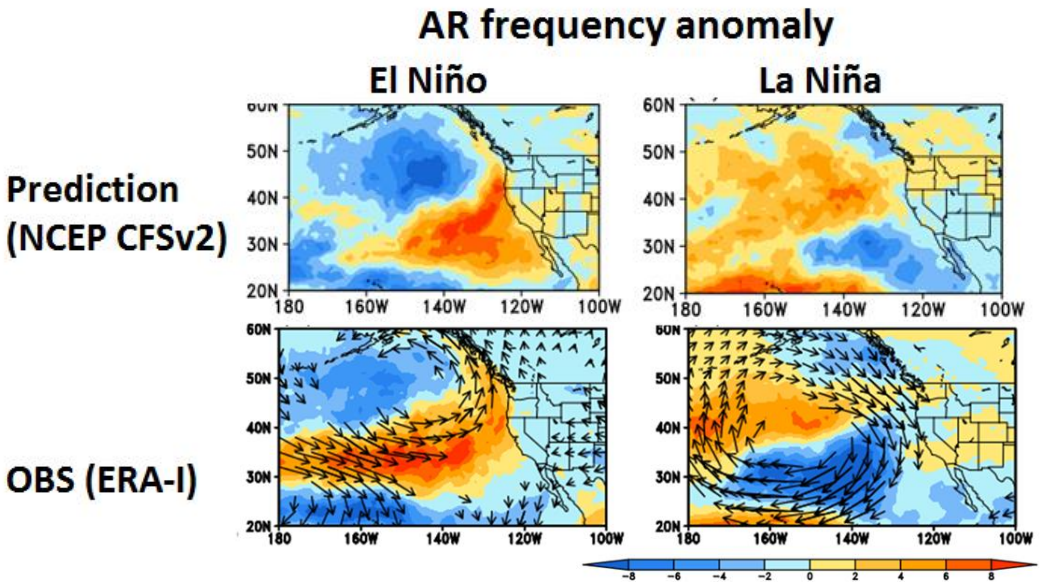


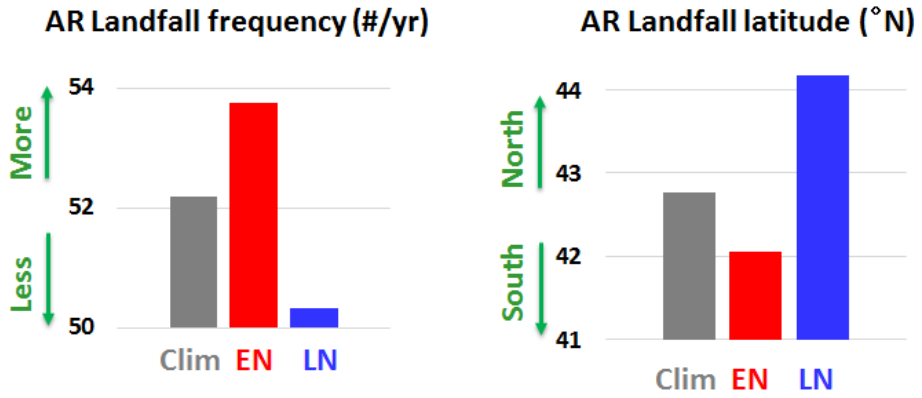
Standardized Precipitation Index forecasts derived from NMME



North American Land Data Assimilation System

Recent Relevant MAPP Research



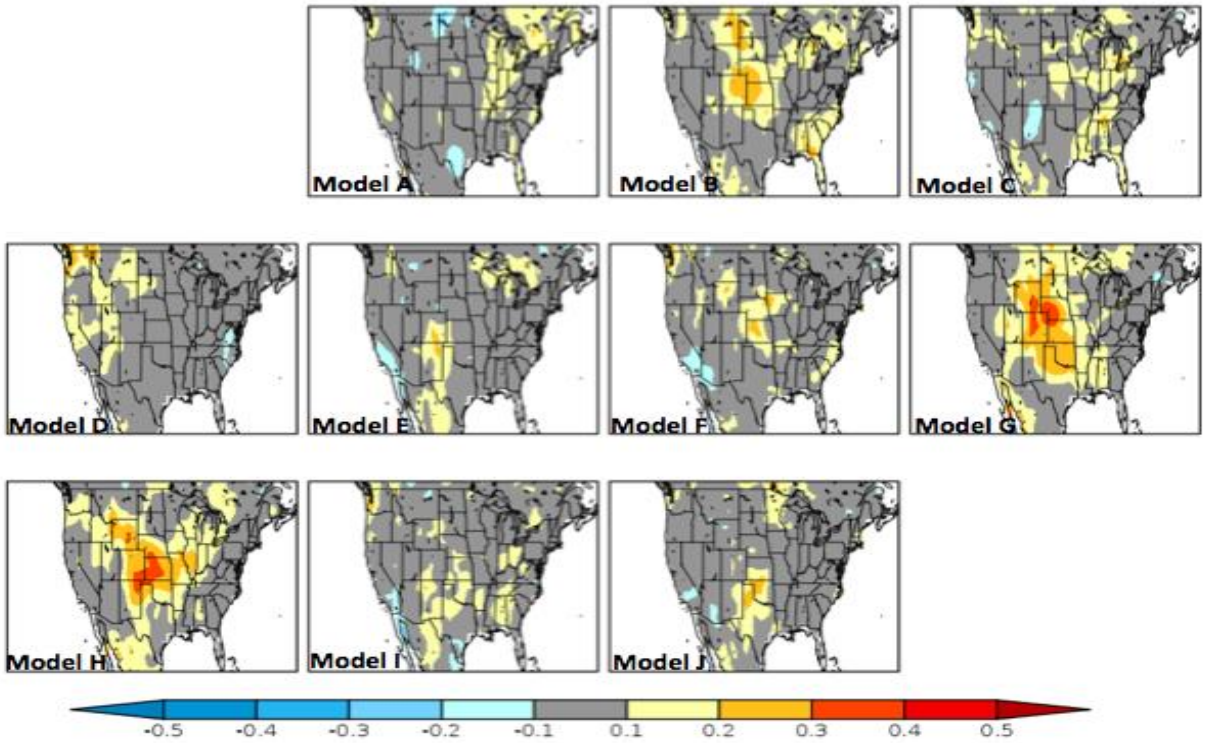


Hyemi Kim (Stony Brook University)

- Looking at seasonal prediction of AR events
- CFSv2 does a good job simulating ENSO-AR variability in lead-1 DJF forecast (left top and middle)
- ENSO modulates both AR frequency and and average landfall latitude, from:
  - 42 degrees (California/Oregon border; **El Nino**) to
  - 44 degrees (Central Oregon

Figures courtesy Hyemi Kim

Recent Relevant MAPP Research



Kathy Pegion (George Mason University)

- Using approach of perfect model predictability to highlight areas where there is additional predictability, according to the models
- Varies with model errors; which models are most trustworthy? Are intelligent weights possible?

Figure courtesy Kathy Pegion

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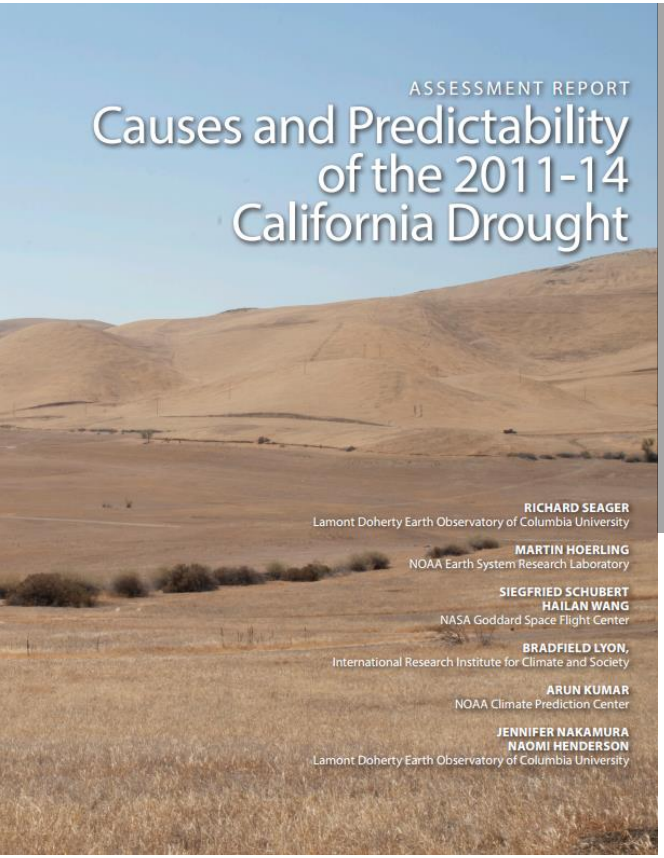
NIDIS NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

Drought Task Force California Focus



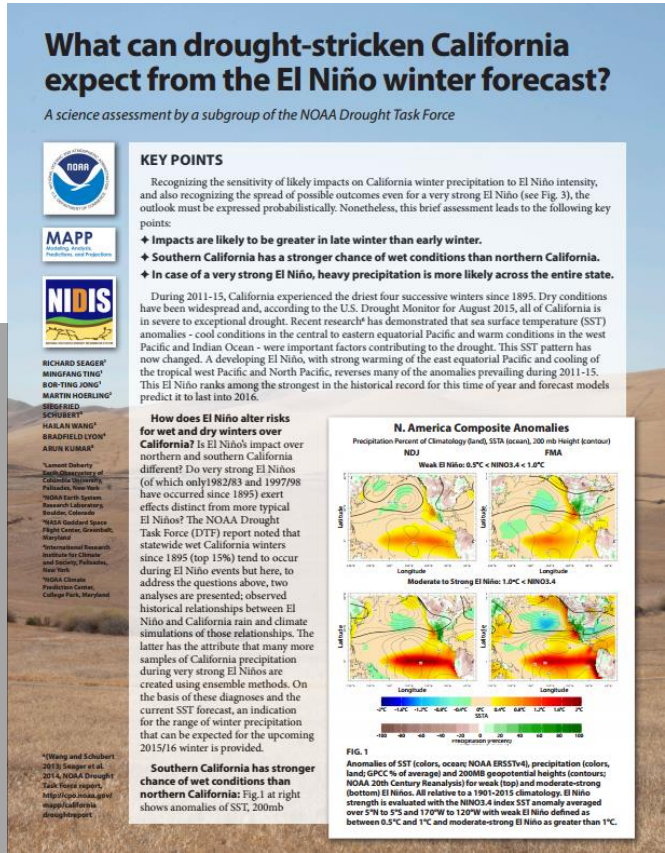
Scientific assessment of the 2011-2014 period of the drought. Causes:

- Weather conditions -- high pressure ridge off West Coast diverted storms
- Response to SST forcing
- La Nina in first year, then continued ocean influence.

- **Continuing questions:**
  - Winter 2015-2016 forecast evaluation
  - Impact of temperature and ET on the drought

Scientific assessment of El Nino impacts on California winter precipitation

- Impacts of El Nino typically greater in late winter
- Southern California higher odds of wet than Northern California



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New FY16 Subseasonal to Seasonal Research Funding

MAPP, with co-support from the NWS NGGPS program, ONR, and NESDIS, has recommended a number of new, relevant transition projects for funding starting in FY16:

- SubX - Experimental multi-model subseasonal ensemble prediction
- Improving LSMs and DA for better representation of snow and other biases
- New drought products more relevant to water managers
- Statistical techniques to improve teleconnection response over North America

With co-support from the NWS NGGPS program, MAPP has recommended for funding a number of new projects targeting S2S timescales:

- Statistical and other approaches (linear inverse modeling) to find new and less-expensive sources of improved forecast information
- Work on blocking and atmospheric rivers work
- Improvements in North American precipitation prediction from multi-model data

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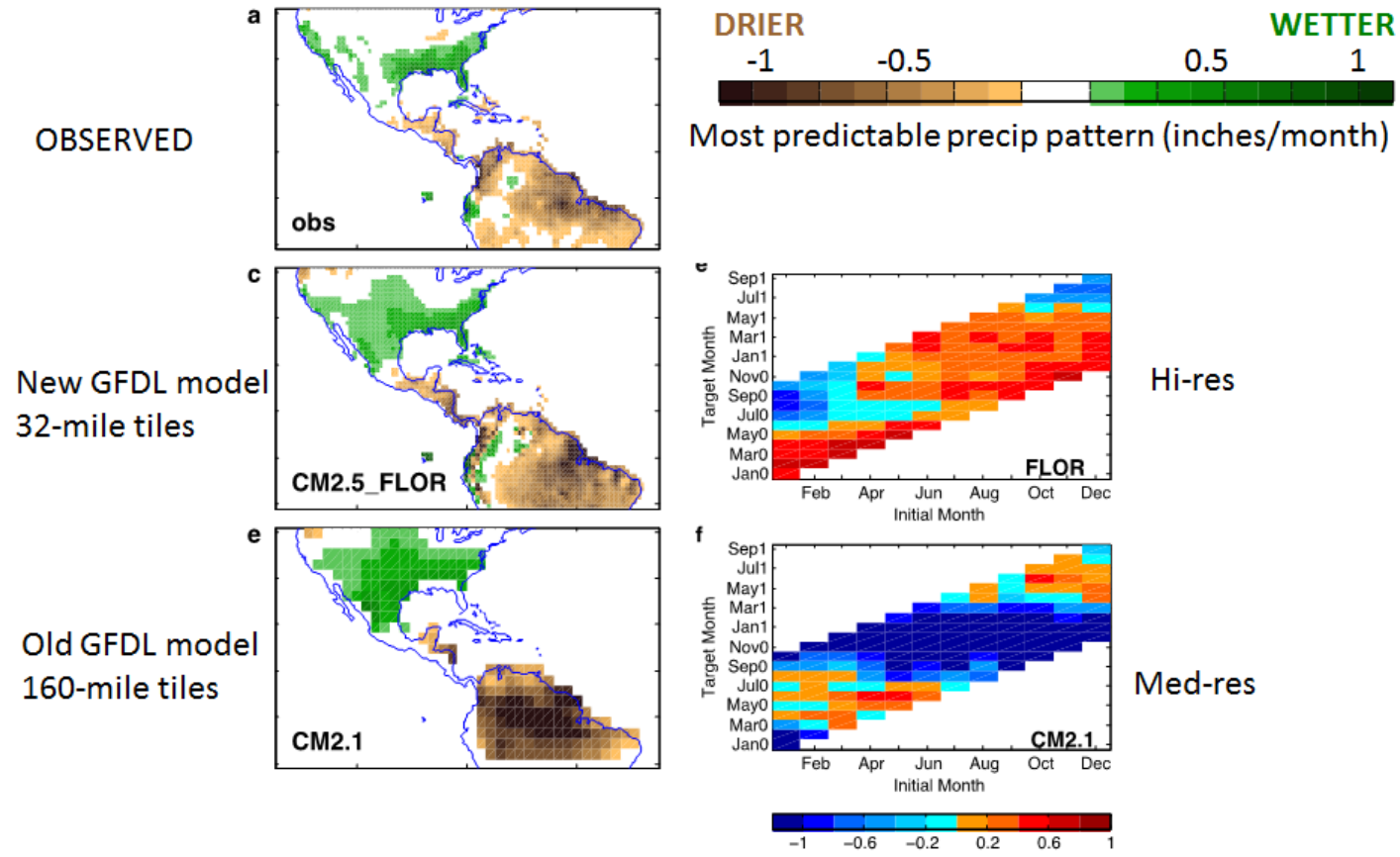
GFDL Research

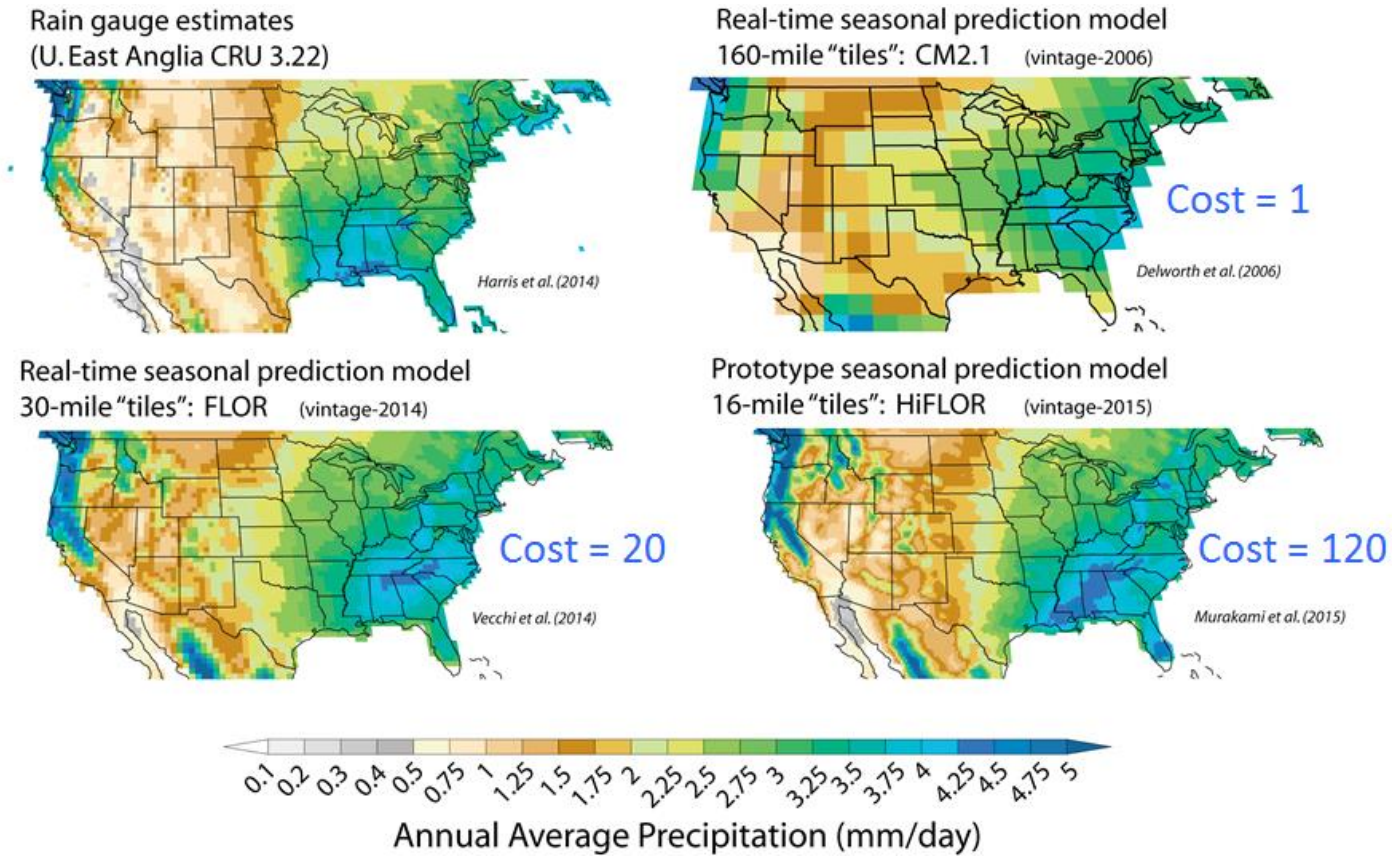


(Adapted from Jia et al. 2015, J. Clim.)

Geophysical Fluid Dynamics Laboratory GFDL NOAA

- GFDL FLOR system shows significant improvements for ENSO prediction
- Data is available -- 33 years, 12 start months, 12 ensemble members
- CM2.5 and FLOR models are publically available.

GFDL Research



- Smaller grid spacing improves simulation and allows phenomena (e.g., mountain snow) to be better represented
- Lots of data for HiFLOR

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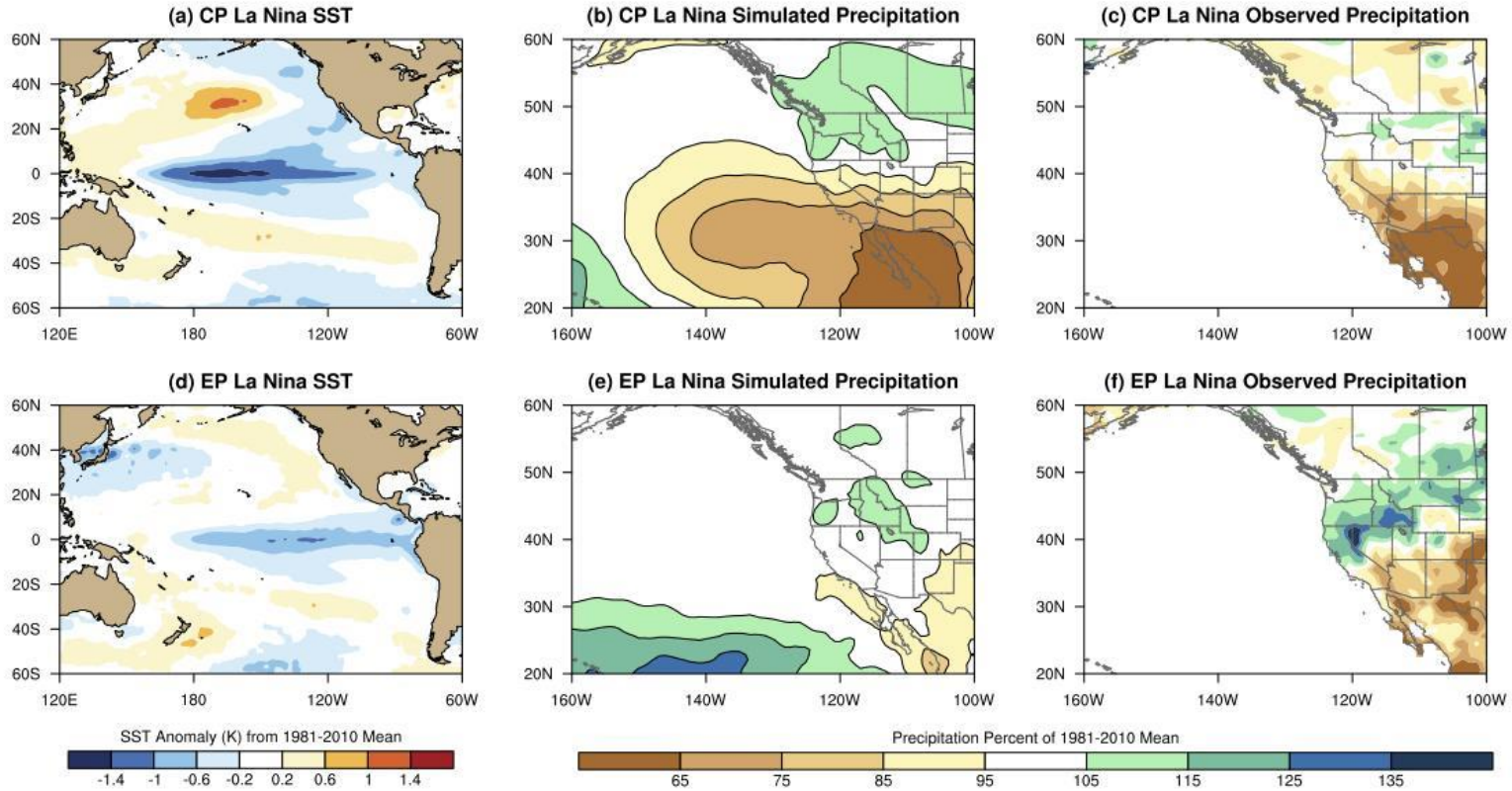
ESRL Research



- With possibility of 2016-2017 La Nina, ESRL is looking at precipitation impacts
- Models agree with Observations for Central Pacific-oriented La Ninas -- dry in west.
  - EP model-obs. disagreement: only four events in obs. record (nine for CP)
  - Assuming models are correct, small precip. impact for EP La Nina
- Both moderate and strong La Ninas impact precipitation in the West

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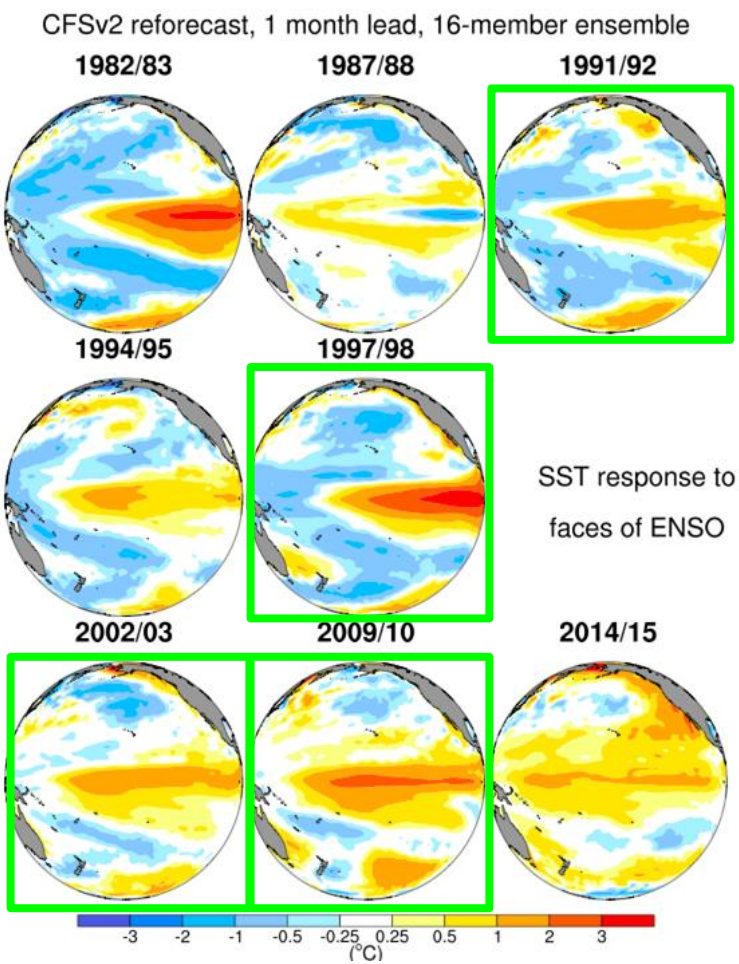
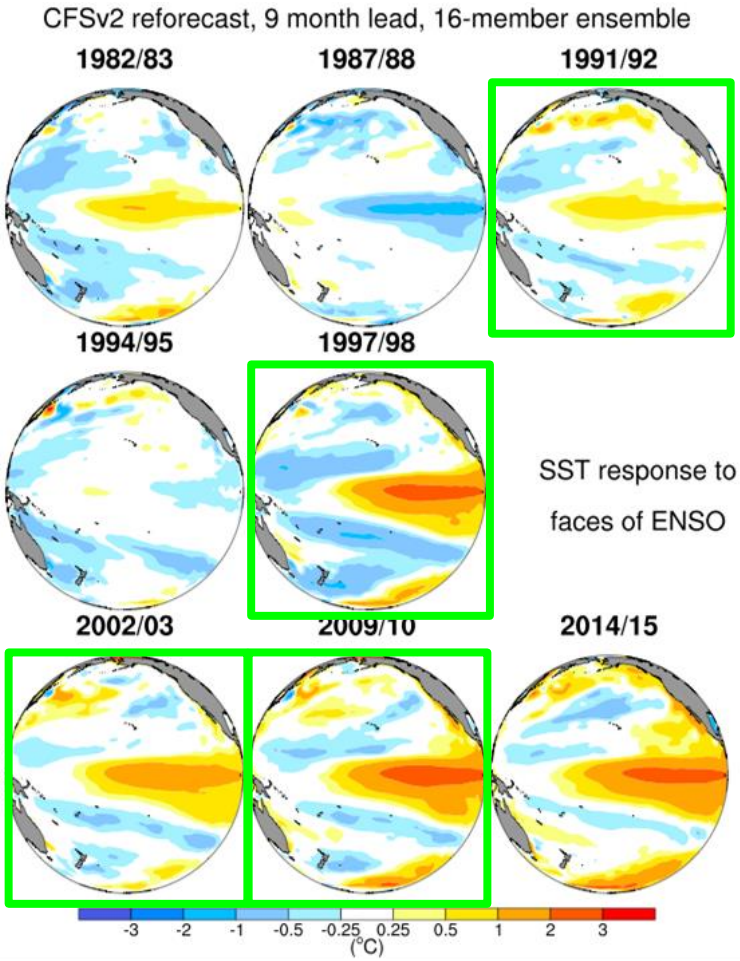
ESRL Research





- Examining skill loss from 1-month lead (left) to 9-month lead (right)
  - Why do some verify while others don't?
  - What about the atmospheric response?

Focus Areas/Needs - Modeling and Prediction

- **Better representation** of precipitation and related processes in global climate models
- Which prediction systems deliver the best representation of **predictability sources**?
- Better predictions of **land water dynamics**: e.g. snowpack, soil moisture, and streamflow
- Target **forecasts of opportunity**
- Improve **data assimilation techniques** for initialization
- Experimentation at **high resolution**

Focus Areas/Needs - Observations and Other

- Understand the **seasonal predictability** of precipitation
- Better understanding of **drought** causes, onset, amelioration, and predictability
- Better understanding of regional storms and their influence on precipitation (**events driven approach**)
- Improve two-way communication with **stakeholders** to feed back on the development and interpretation of climate models results into water resource predictions
- **Integration of available observations** for validation, and reanalysis
- Sustained **observational systems**
- **Human capacity** for doing analysis, quality control, and data

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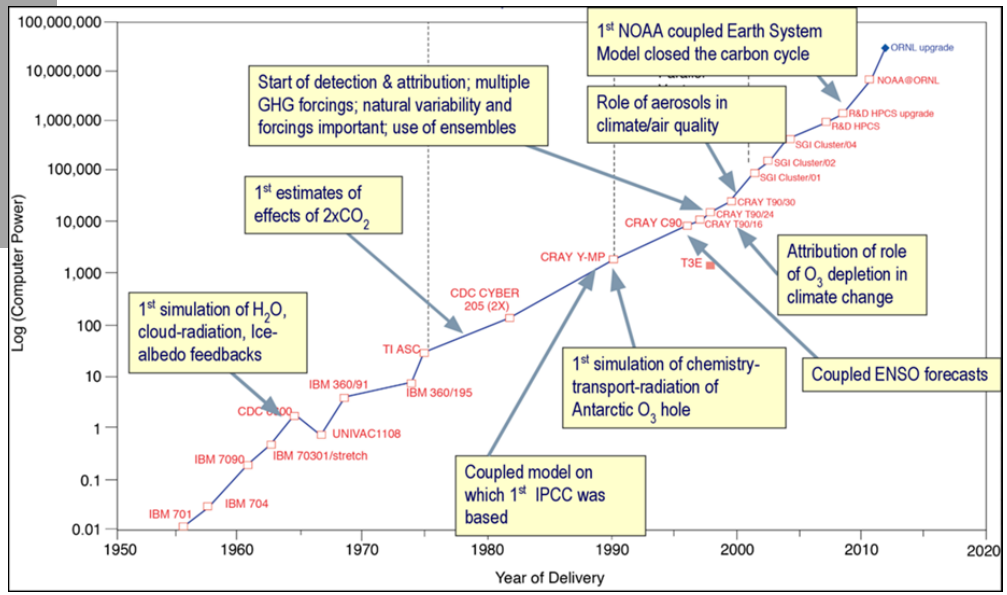
Major Challenge -- Computing

- Research HPC very limited
  - Need order-of-magnitude increases, not maintenance
- What increased HPC would accomplish:
  - Decisively explore S2S prediction at global high resolution in the ocean/atmosphere/land
  - Have scale-aware physics that supports such experimentation
  - Initialize the prediction systems at appropriate spatial scales
  - Increase number of ensemble members to properly sample variability.



- **Major challenge pt. 2:**
  - How low is the natural limit of seasonal precipitation predictability?