

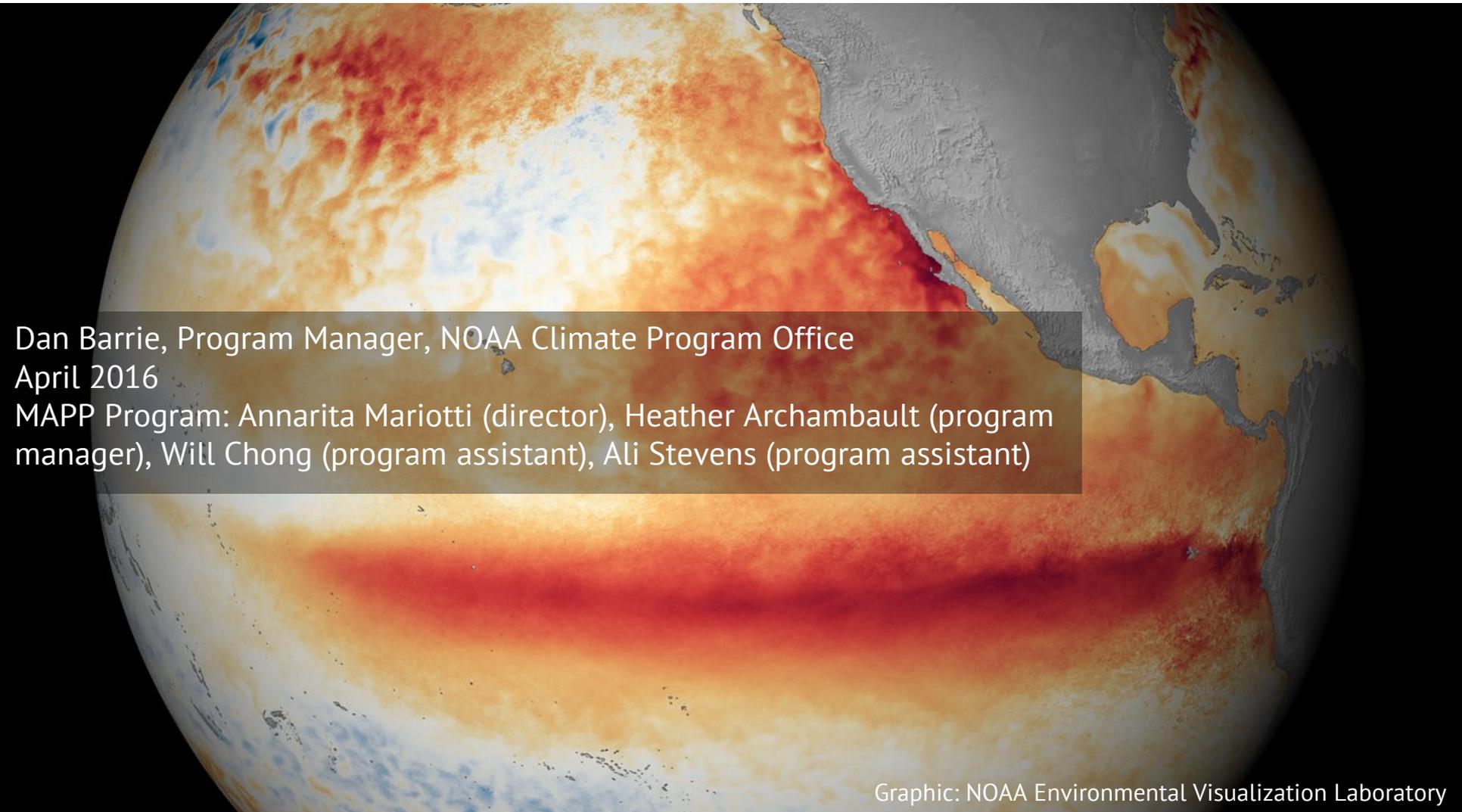


Climate Program
Office



MAPP
Modeling, Analysis,
Predictions, and Projections

OAR research on S2S predictability & prediction



Dan Barrie, Program Manager, NOAA Climate Program Office

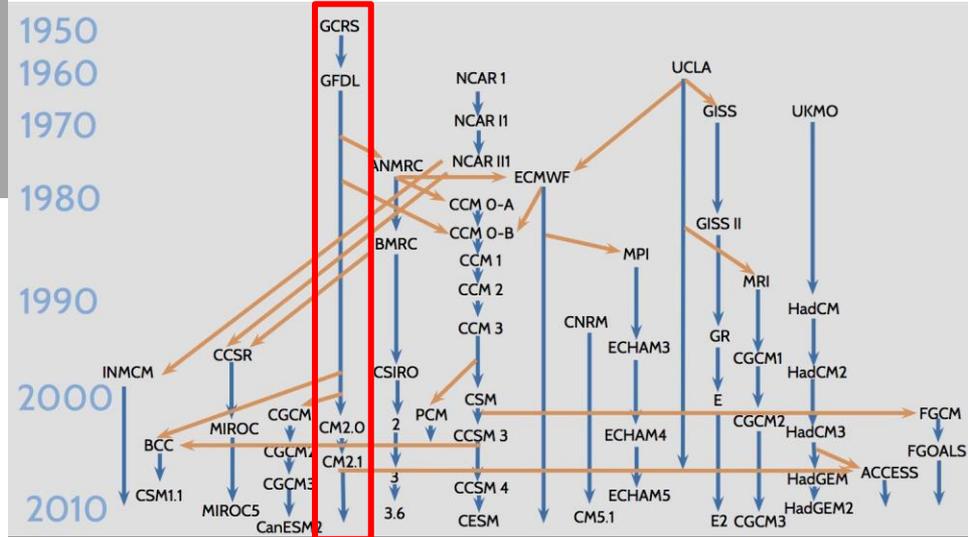
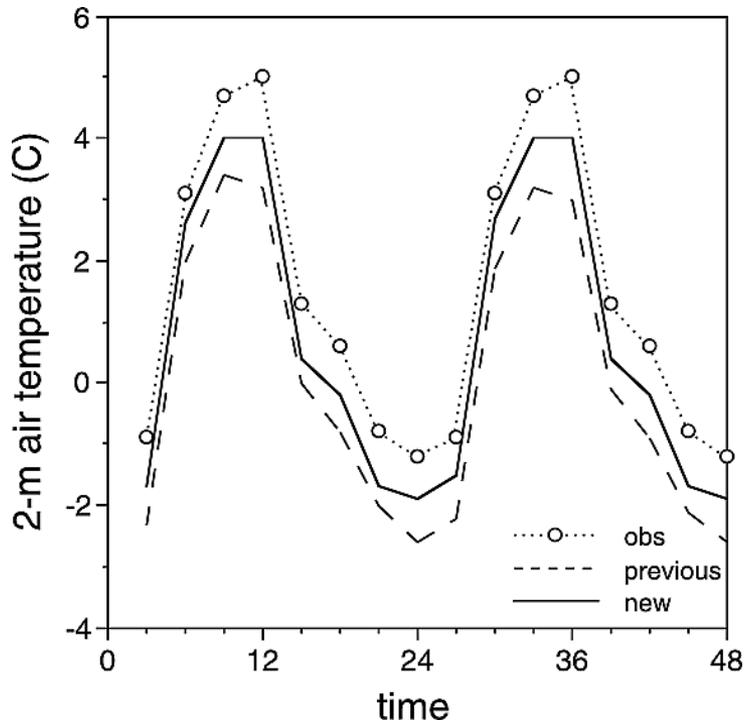
April 2016

MAPP Program: Annarita Mariotti (director), Heather Archambault (program manager), Will Chong (program assistant), Ali Stevens (program assistant)



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.



OAR Leadership Today

NGGPS Phase 1 Testing Project Summary Assessment

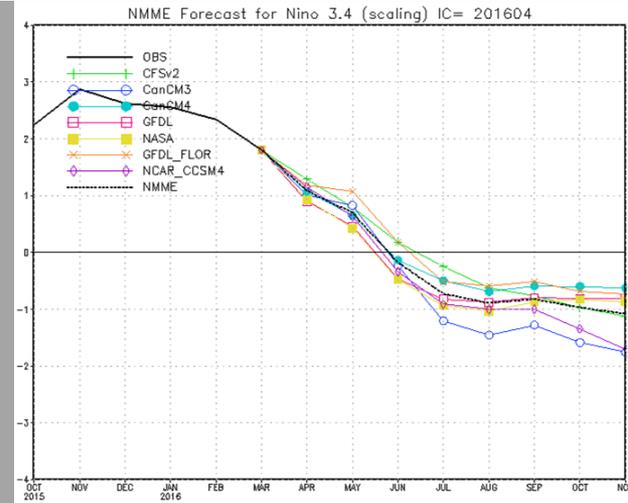
	Idealized Tests	3-km, 3-day forecasts	Performance	Scalability	Nesting or Mesh Refinement	Software Maturity
FV3	●	●	●	●	●	●
MPAS	●	●	●	●	●	●
NIM	●	●	●	●	●	●
NMM-UJ	●	●	●	●	●	●
NEPTUNE	●	●	●	●	●	●

- 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

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.

The screenshot shows the NOAA Earth System Research Laboratory (ESRL) Physical Sciences Division website. The main heading is "NOAA El Niño Rapid Response Field Campaign" for "JANUARY - MARCH 2016". It lists PSD Leads as Randall Dole and Ryan Spackman, and Media Relations as Theo Stein. A section titled "Image of the Day" features a photograph of a sunset over a body of water with a small boat. A link below the image says "Click image to enlarge and for more details. View Previous Images".

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.



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.

Forecasts of NINO3.4 SST Anomalies Initialized April 2016



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.



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.

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

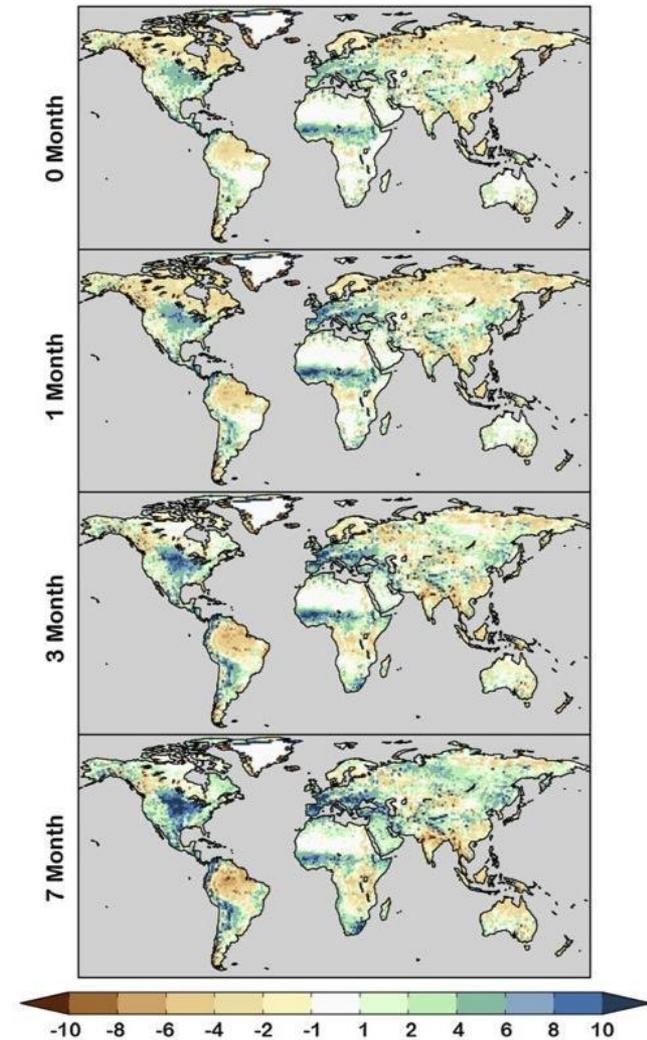
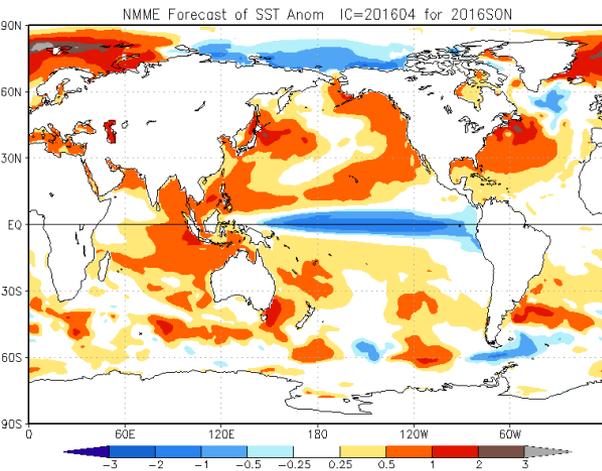


Fig. 3 As in Fig. 2 for JJA volumetric soil moisture (10–40 cm layer) forecast errors relative to CFS reanalysis



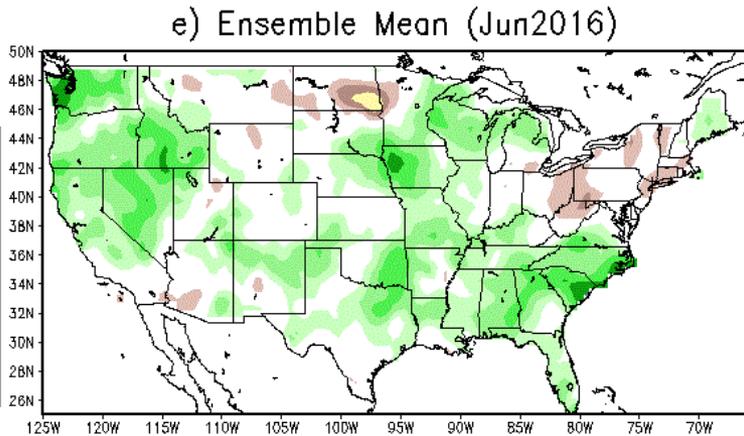
Transition to Operations

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

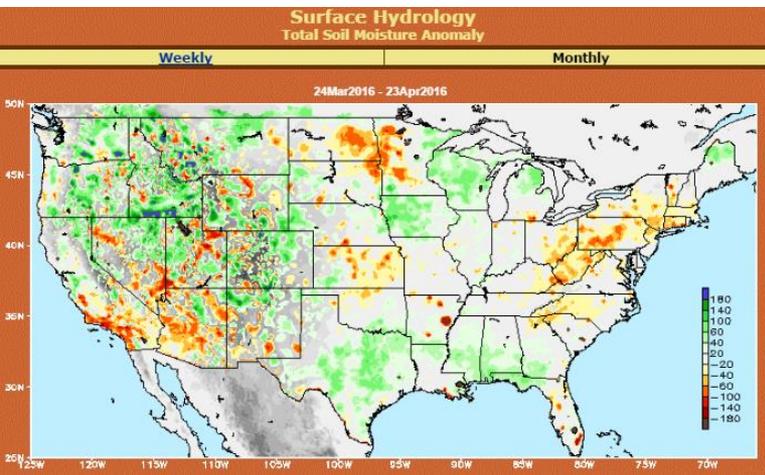


North American Multi-Model Ensemble

Standardized Precipitation Index forecasts derived from NMME



-2 -1.6 -1.2 -0.8 -0.4 0.4 0.8 1.2 1.6 2



North American Land Data Assimilation System

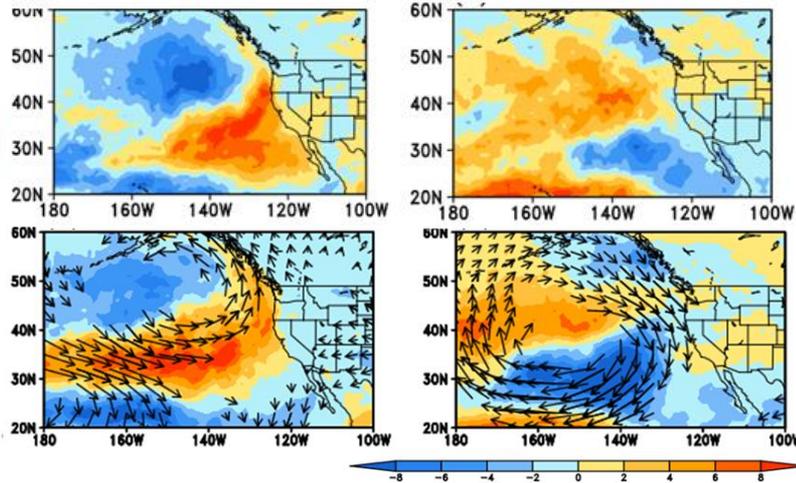
Recent Relevant MAPP Research

AR frequency anomaly

El Niño

La Niña

Prediction
(NCEP CFSv2)

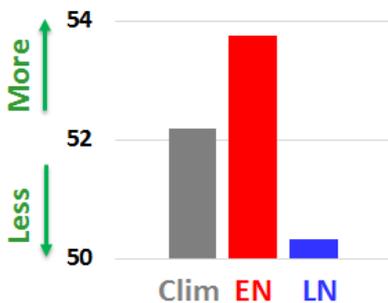


OBS (ERA-I)

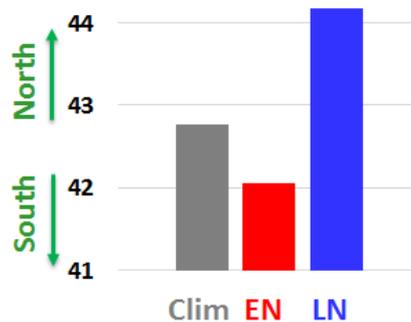
Hyemi Kim (Stony Brook University)

- 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 average landfall latitude, from:
 - 42 degrees (California/Oregon border; **El Nino**) to
 - 44 degrees (Central Oregon)

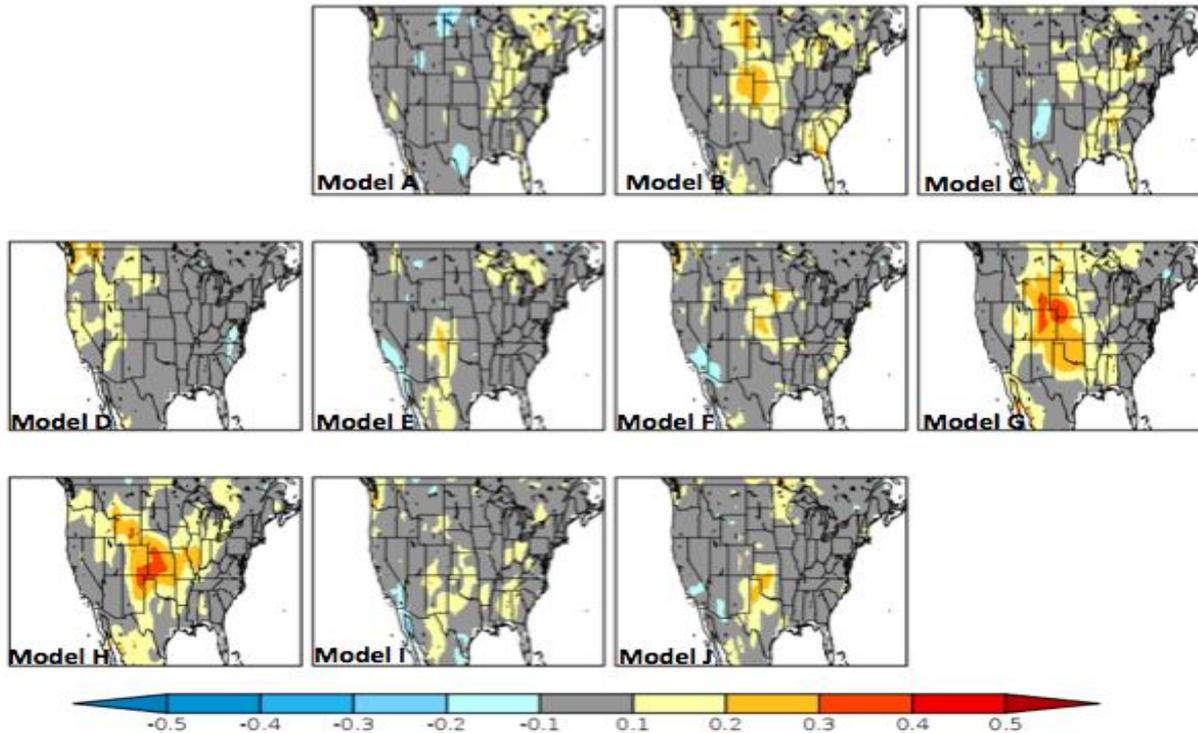
AR Landfall frequency (#/yr)



AR Landfall latitude (° N)



Recent Relevant MAPP Research

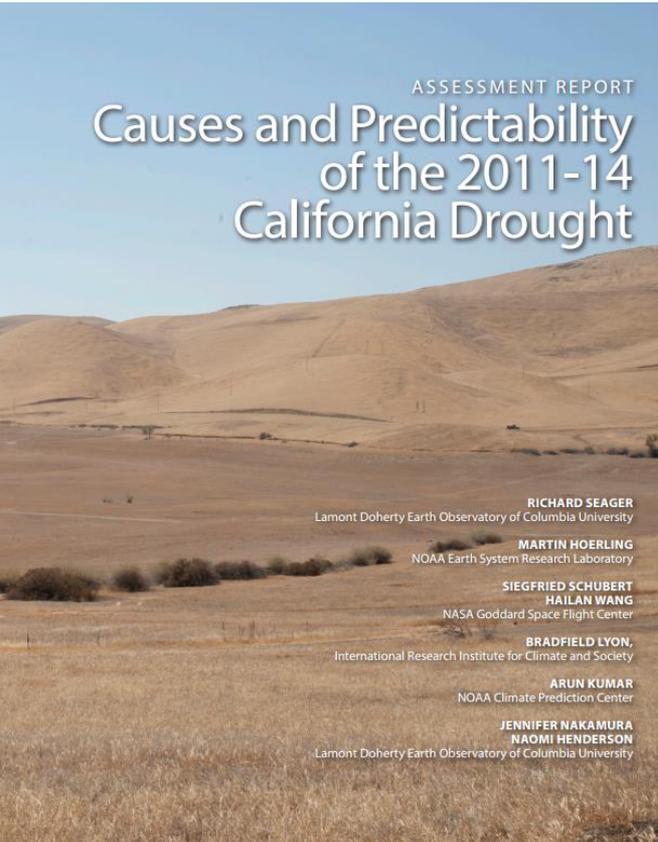
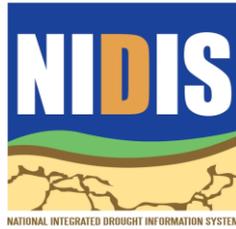


Kathy Pegion (George Mason University)

- 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?



Drought Task Force California Focus



ASSESSMENT REPORT Causes and Predictability of the 2011-14 California Drought

- RICHARD SEAGER**
Lamont Doherty Earth Observatory of Columbia University
- MARTIN HOERLING**
NOAA Earth System Research Laboratory
- SIEGFRIED SCHUBERT**
HAILAN WANG
NASA Goddard Space Flight Center
- BRADFELD LYON**
International Research Institute for Climate and Society
- ARUN KUMAR**
NOAA Climate Prediction Center
- JENNIFER NAKAMURA**
NAOMI HENDERSON
Lamont Doherty Earth Observatory of Columbia University

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.

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

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

What can drought-stricken California expect from the El Niño winter forecast?

A science assessment by a subgroup of the NOAA Drought Task Force



KEY POINTS

Recognizing the sensitivity of likely impacts on California winter precipitation to El Niño intensity, and also recognizing the spread of possible outcomes even for a very strong El Niño (see Fig. 3), the outlook must be expressed probabilistically. Nonetheless, this brief assessment leads to the following key points:

- ✦ Impacts are likely to be greater in late winter than early winter.
- ✦ Southern California has a stronger chance of wet conditions than northern California.
- ✦ In case of a very strong El Niño, heavy precipitation is more likely across the entire state.

During 2011-15, California experienced the driest four successive winters since 1895. Dry conditions have been widespread and, according to the U.S. Drought Monitor for August 2015, all of California is in severe to exceptional drought. Recent research⁴ has demonstrated that sea surface temperature (SST) anomalies - cool conditions in the central to eastern equatorial Pacific and warm conditions in the west Pacific and Indian Ocean - were important factors contributing to the drought. This SST pattern has now changed. A developing El Niño, with strong warming of the east equatorial Pacific and cooling of the tropical west Pacific and North Pacific, reverses many of the anomalies prevailing during 2011-15. This El Niño ranks among the strongest in the historical record for this time of year and forecast models predict it to last into 2016.

How does El Niño alter risks for wet and dry winters over California? Is El Niño's impact over northern and southern California different? Do very strong El Niños (of which only 1982/83 and 1997/98 have occurred since 1895) exert effects distinct from more typical El Niños? The NOAA Drought Task Force (DTF) report noted that statewide wet California winters since 1895 (top 15%) tend to occur during El Niño events but here, to address the questions above, two analyses are presented: observed historical relationships between El Niño and California rain and climate simulations of those relationships. The latter has the attribute that many more samples of California precipitation during very strong El Niños are created using ensemble methods. On the basis of these diagnoses and the current SST forecast, an indication for the range of winter precipitation that can be expected for the upcoming 2015/16 winter is provided.

Southern California has stronger chance of wet conditions than northern California: Fig. 1 at right shows anomalies of SST, 200mb

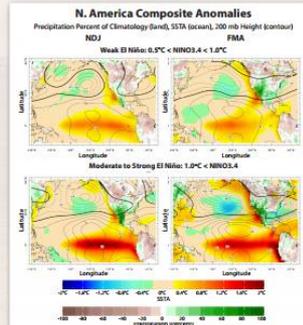


FIG. 1. Anomalies of SST (colors), ocean NOAA ERSSTv4, and precipitation (contours), land GPCP % of average and 200mb geopotential heights (contours); NOAA 20th Century Reanalysis) for weak (top) and moderate-strong (bottom) El Niños. All relative to a 1901-2015 climatology. El Niño strength is evaluated with the NINO3.4 index SST anomaly averaged over 5°N to 5°S and 170°W to 120°W with weak El Niño defined as between 0.5°C and 1°C and moderate-strong El Niño as greater than 1°C.

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*NOAA Climate Prediction Center, College Park, Maryland

*Wang and Schubert 2013; Seager et al. 2014; NOAA Drought Task Force report, <http://go.noaa.gov/mapp/california/droughtreport>



New FY16 Subseasonal to Seasonal Research Funding

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

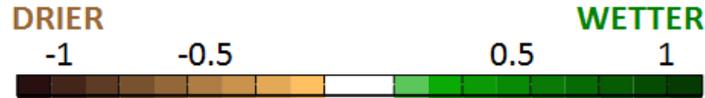
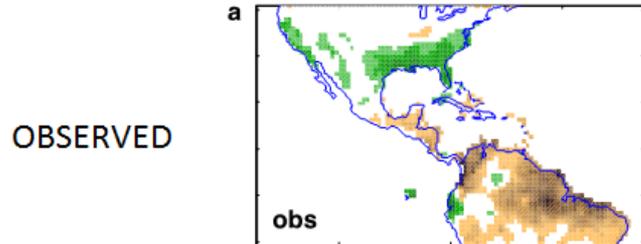
- SubX - Experimental multi-model subseasonal ensemble prediction
- Improving LSMs and DA for better representation of snow and other biases
- New drought products more relevant to water managers
- Statistical techniques to improve teleconnection response over North America

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

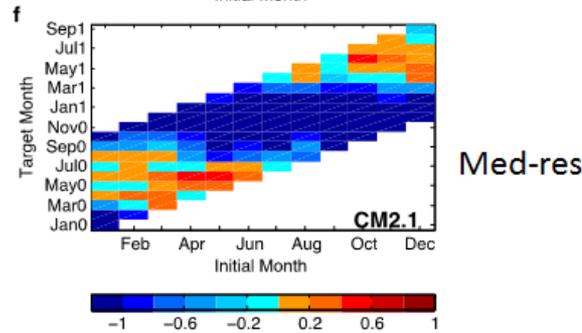
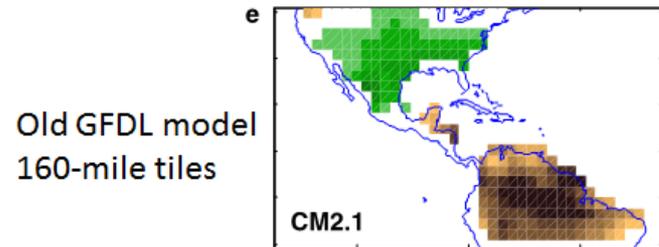
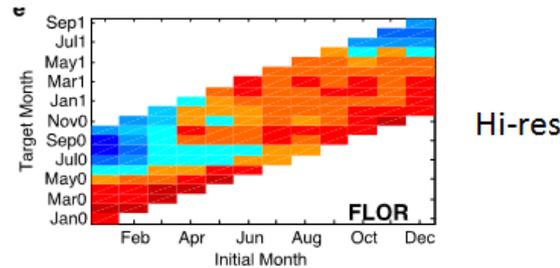
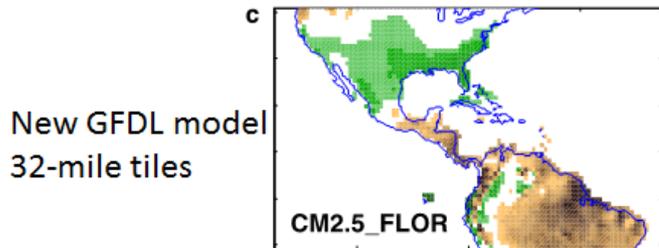
- Statistical and other approaches (linear inverse modeling) to find new and less-expensive sources of improved forecast information
- Work on blocking and atmospheric rivers work
- Improvements in North American precipitation prediction from multi-model data



GFDL Research



Most predictable precip pattern (inches/month)



Skill (SESS) of 1981-2012 predictions of ENSO precip

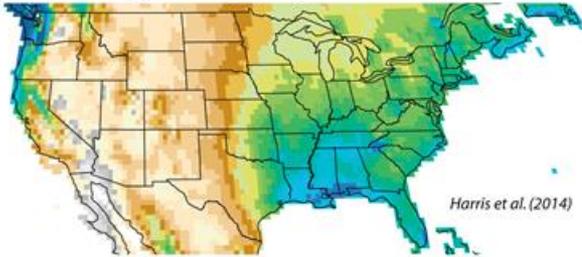
- GFDL FLOR system shows significant improvements for ENSO prediction
- Data is available - 33 years, 12 start months, 12 ensemble members
- CM2.5 and FLOR models are publically available.

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

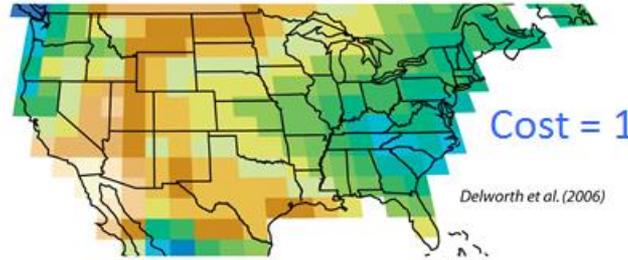


GFDL Research

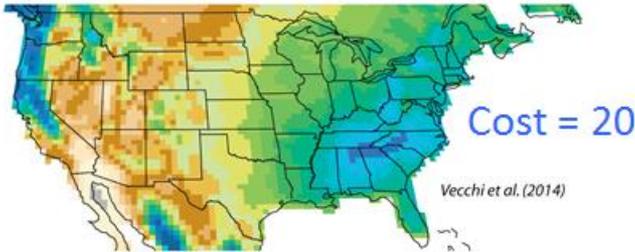
Rain gauge estimates
(U. East Anglia CRU 3.22)



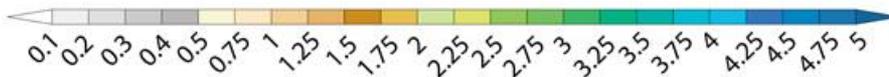
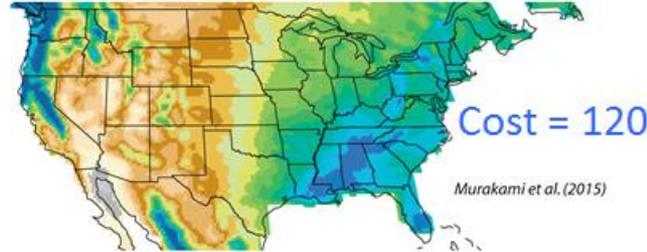
Real-time seasonal prediction model
160-mile "tiles": CM2.1 (vintage-2006)



Real-time seasonal prediction model
30-mile "tiles": FLOR (vintage-2014)



Prototype seasonal prediction model
16-mile "tiles": HiFLOR (vintage-2015)

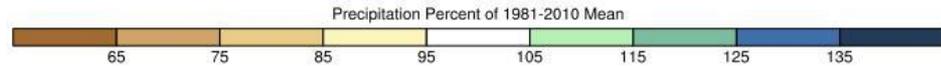
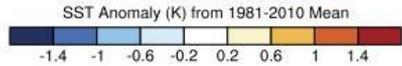
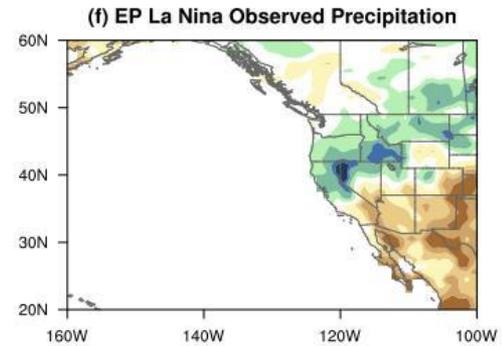
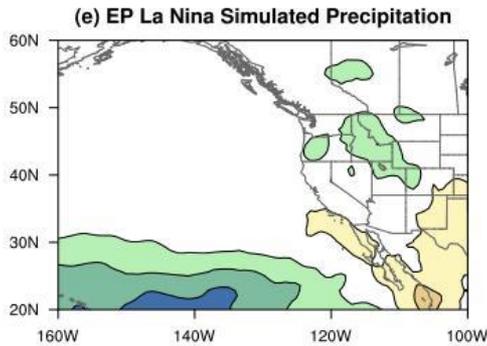
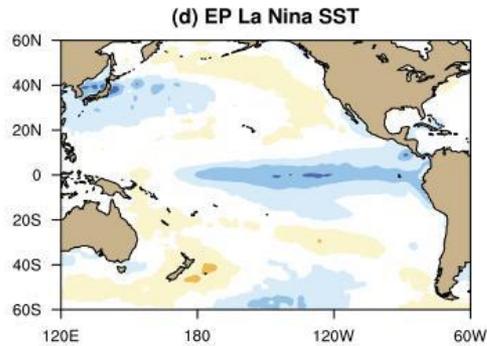
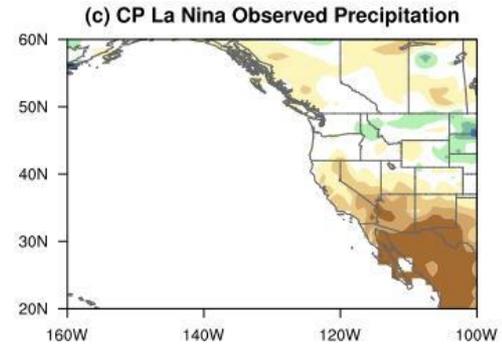
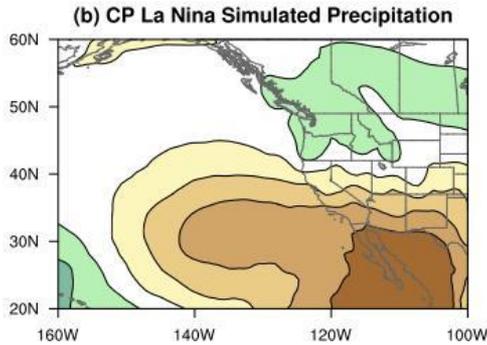
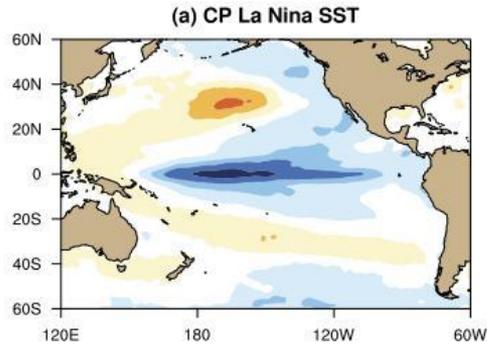


Annual Average Precipitation (mm/day)



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

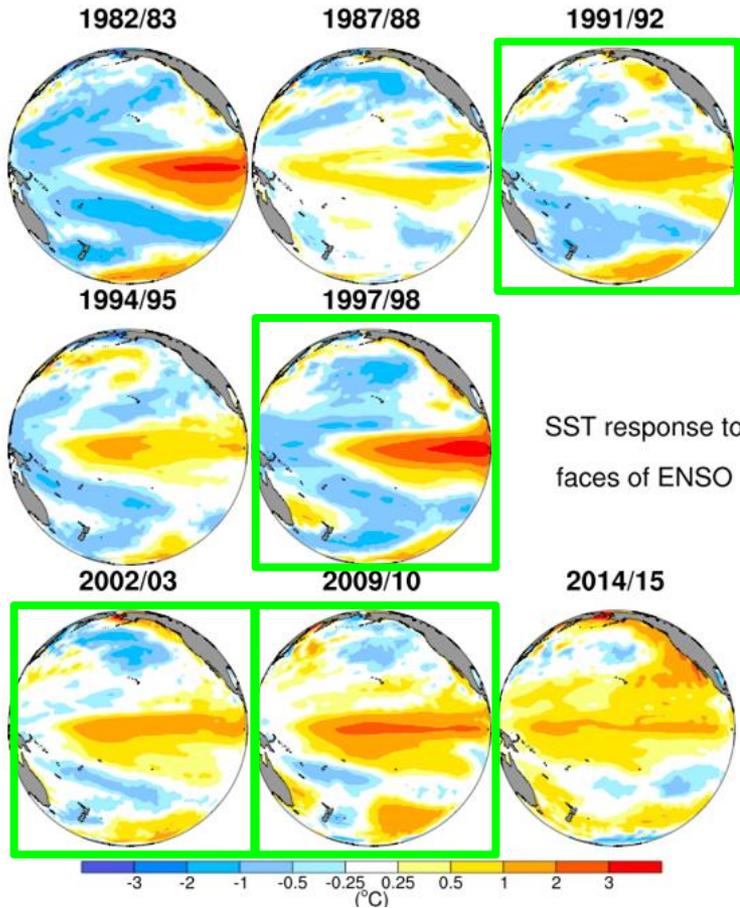
ESRL Research



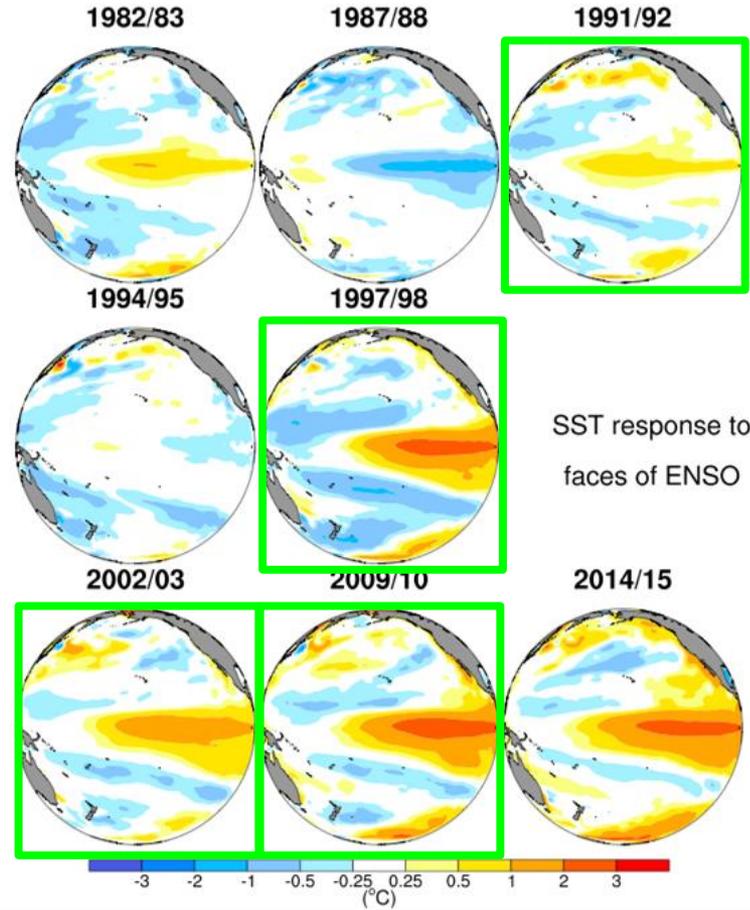
- With possibility of 2016-2017 La Niña, ESRL is looking at precipitation impacts
- Models agree with Observations for Central Pacific-oriented La Ninas -- dry in west.
 - EP model-obs. disagreement: only four events in obs. record (nine for CP)
 - Assuming models are correct, small precip. impact for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

ESRL Research

CFSv2 reforecast, 1 month lead, 16-member ensemble



CFSv2 reforecast, 9 month lead, 16-member ensemble



- 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
- **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

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?

