Prototype statistical seasonal prediction for CA/NV winter precipitation

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DWR Winter Outlook Workshop, Scripps Institute of Oceanography

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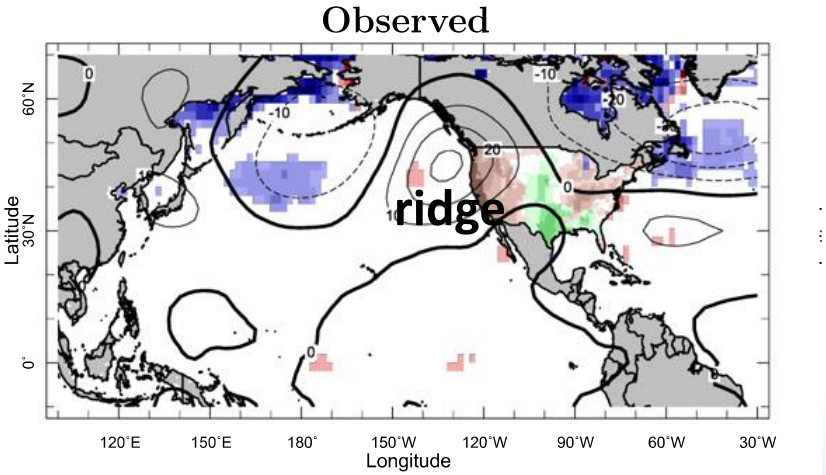
What control California Winter Rainfall?

- *Middle and upper tropospheric ridge/trough in NE Pacific*
  - *ENSO, PDO (e.g., Cayan et al. 1999; Dettinger et al. 1998; Mason & Goddard 2001; Gershunov and Cayan 2003; Wang and Schubert 2014; Seager et al. 2015)*
- *Atmospheric river, contribute 30-50% of total rainfall over US west coast (e.g., Ralph et al 2004; Dettinger 2013)*
- *Warmer surface temperature (e.g., AghaKouchak et al. 2014)*
- *Sea Ice melting (e.g., Lee et al. 2015; Sewall and Sloan 2004*

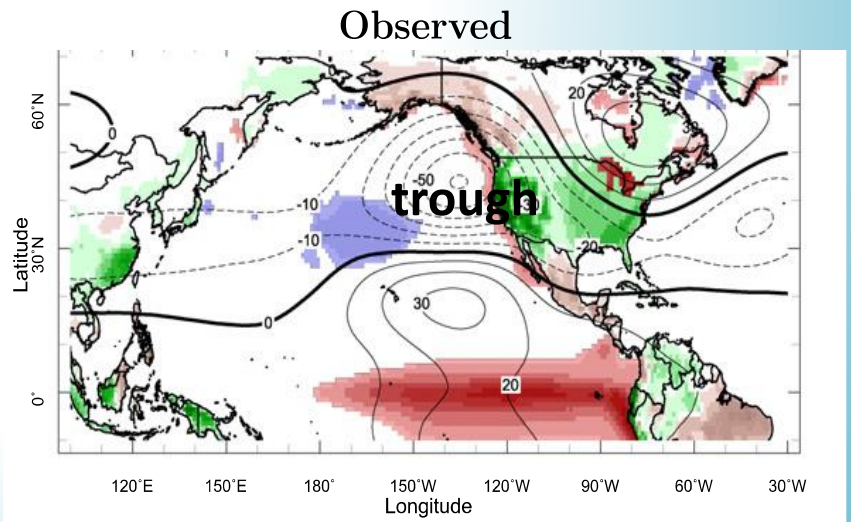
Anomalous patterns of the Large scale upper-level (200 Pa) circulation associated with the drier and wetter winters over California

- ***Drier winters: Ridge over the NE Pacific***
- ***Wetter winters: trough over the NE Pacific***

Composite for 15% driest winter



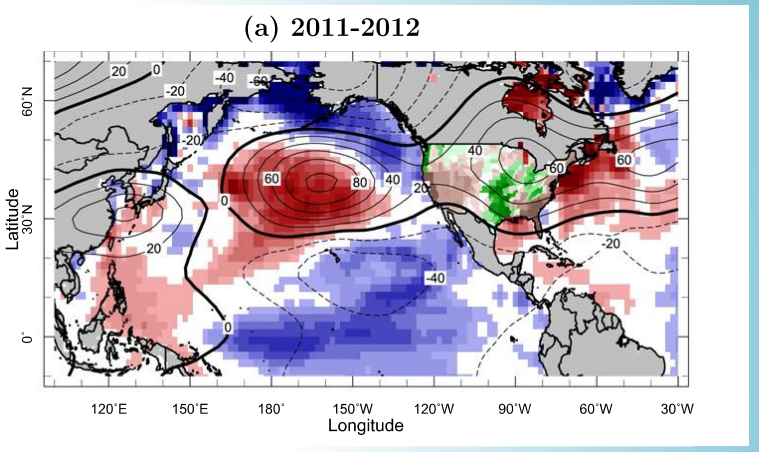
Composite for wet winters

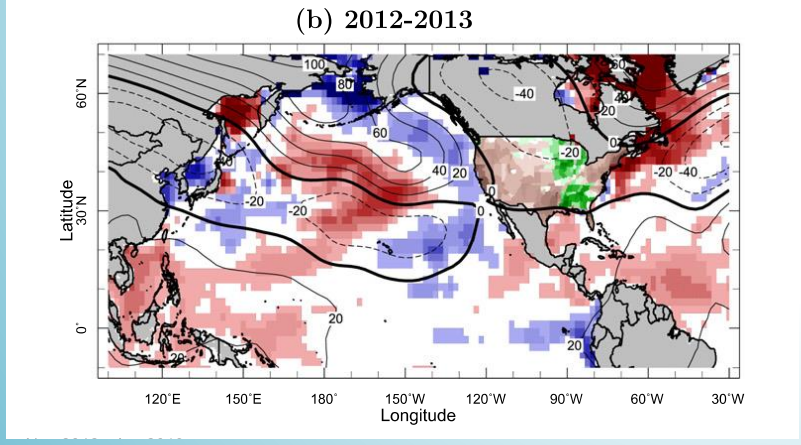


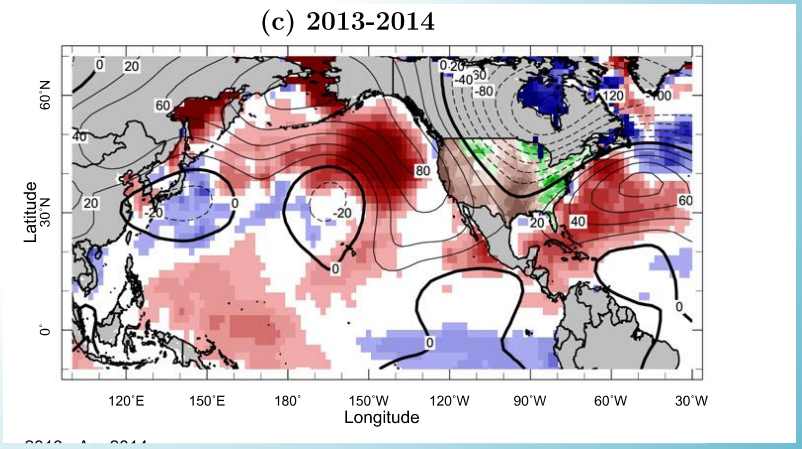
Seager et al. 2015

Tang & Branstator 2017: extreme ridges originate from mid-latitude atmospheric internal variability. Tropical diabatic heating anomalies are not essential, but can double the probability of the extreme ridges.

Extreme ridges can vary in structure, instead of following classical PNA pattern, as we expect from the ENSO influence





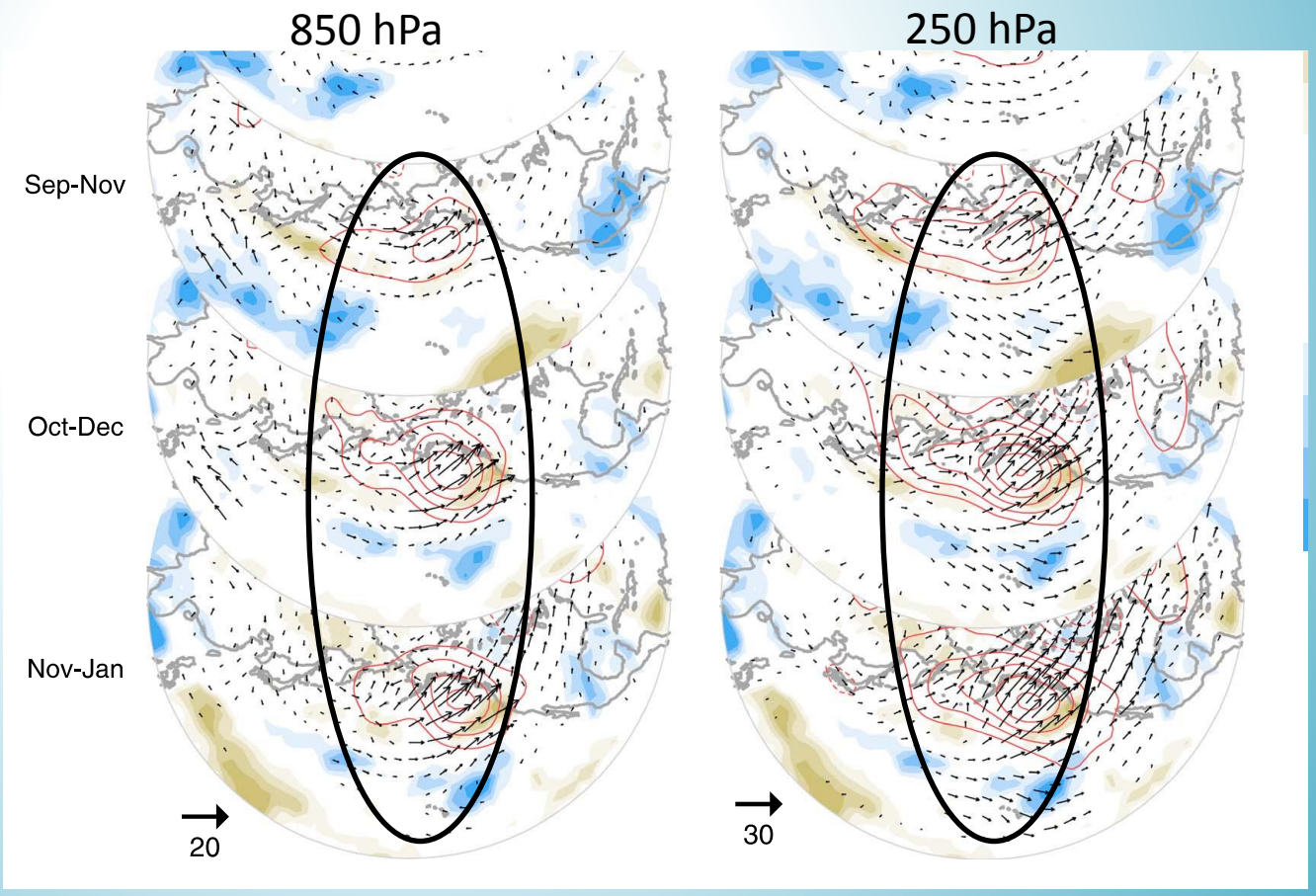


Seager et al. 2015

Are there pre-cursors for the anomalous ridge or trough over the NE Pacific?

- ***Wang et al. 2014: The anomalous ridge over the NE Pacific began in fall (Sept-Nov) in 2013 (a pre-cursors of El Nino, instead of a result of El Niño).***

2013-2014 anomalies of geopotential height (contours), OLR (shades) and wave fluxes (vectors)

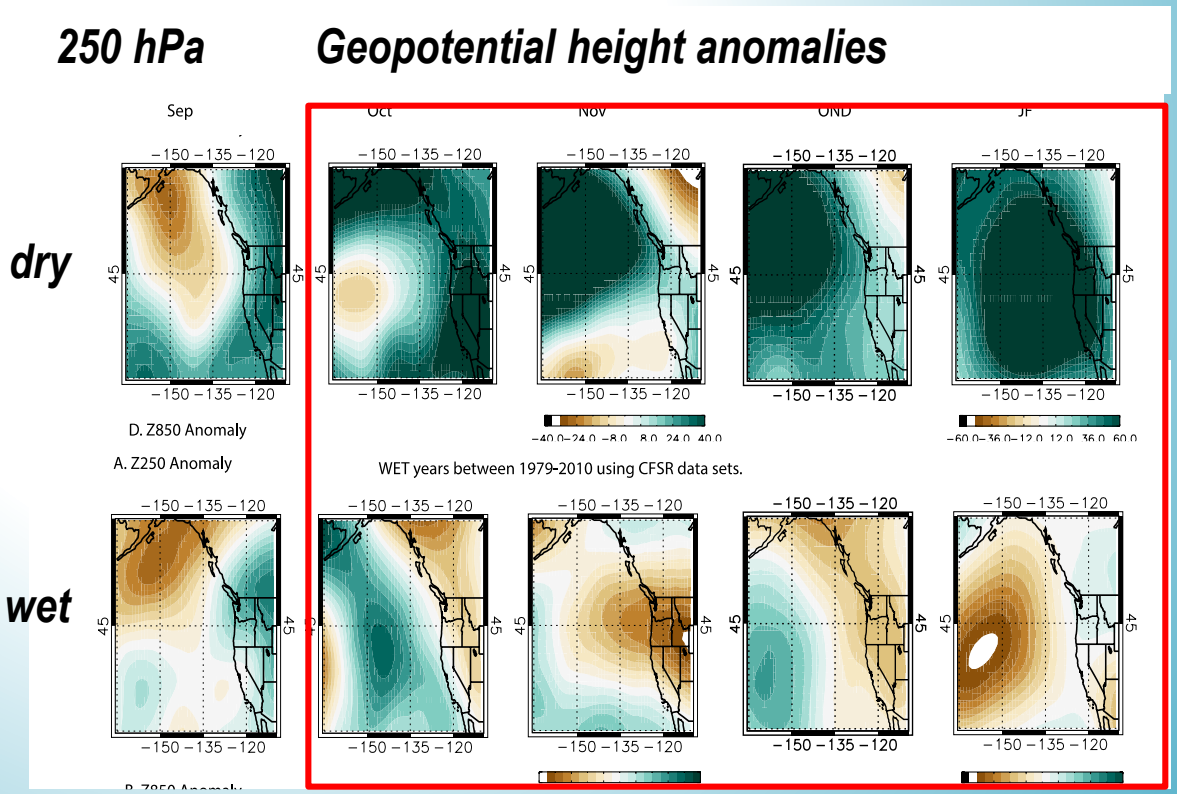


Observed pre-conditions in fall preceding the dry and wet winters, respectively, over the California/Nevada region

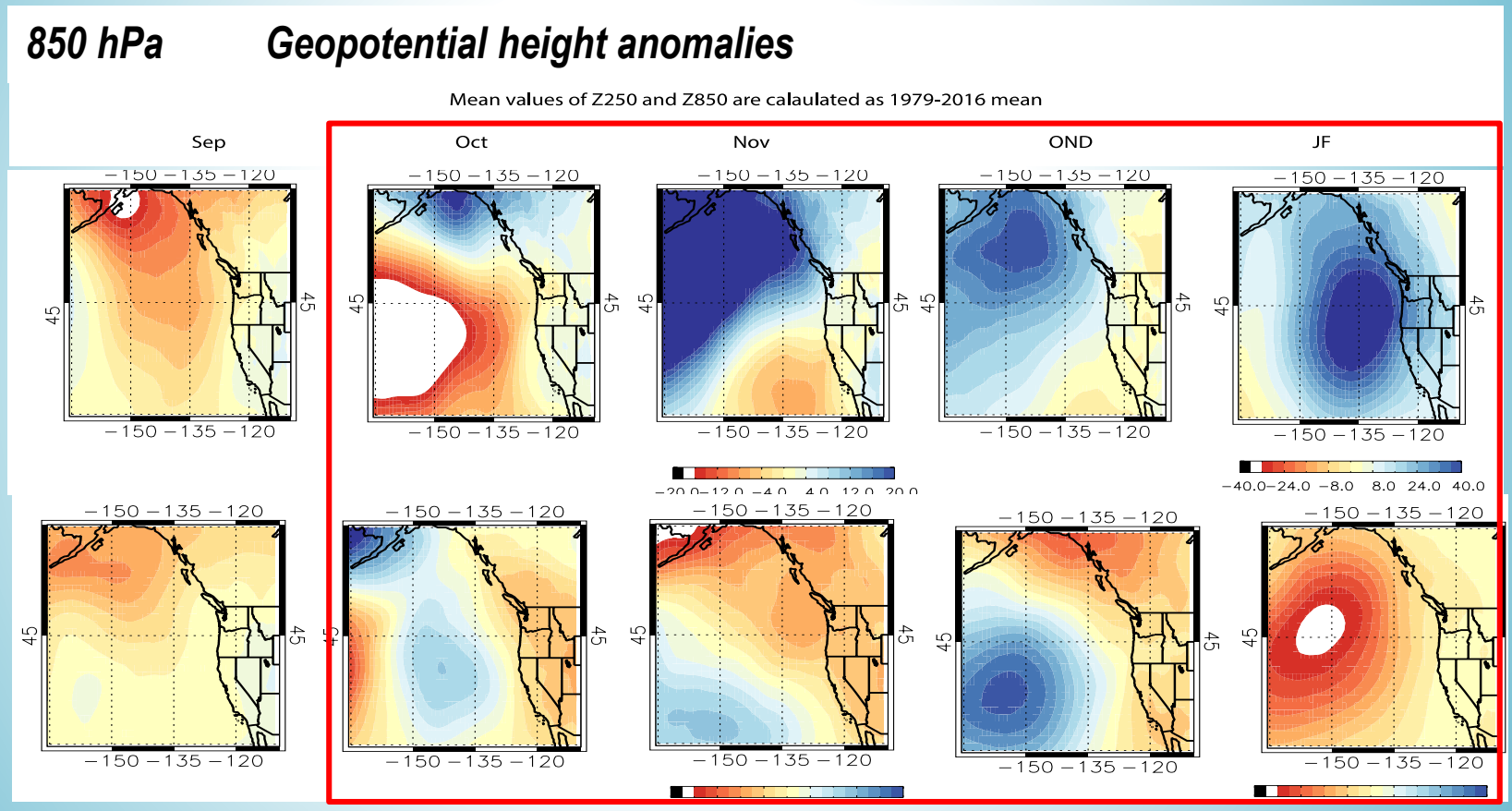
- *The anomalous upper tropospheric circulation patterns between the anomalous dry and wet winters (December-February) become clearly distinguishable in October and afterward.*

Dry winters: persistent ridge and anomalous high pressure center off the North American west coast starting in November.

Wet winters: alternation between anomalously high and low pressure centers related to propagating planetary waves from Sept to February.



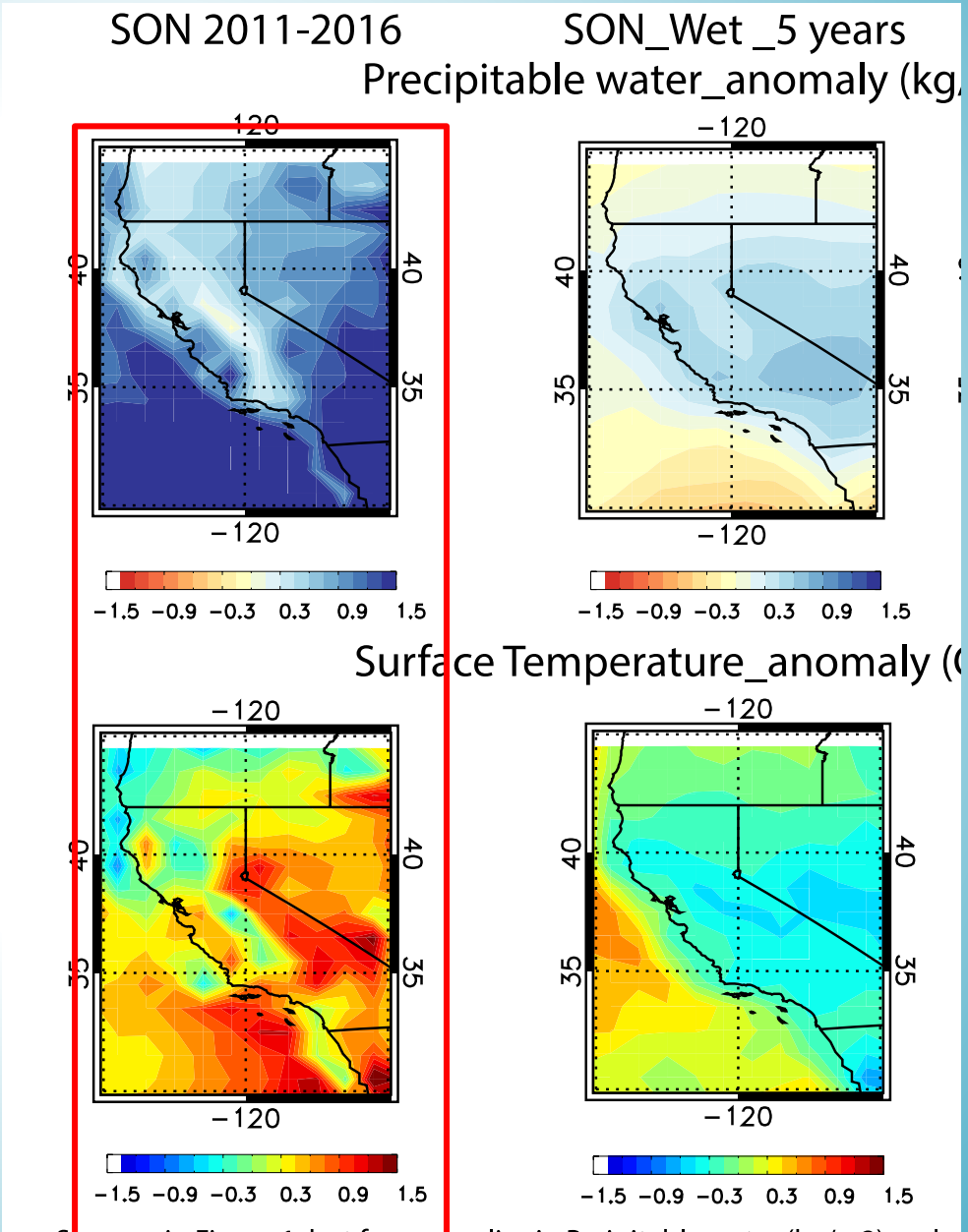
- ***The lower tropospheric anomalous circulation patterns between the anomalous dry and wet winters (December-February) also become clearly distinguishable in October and afterward.***



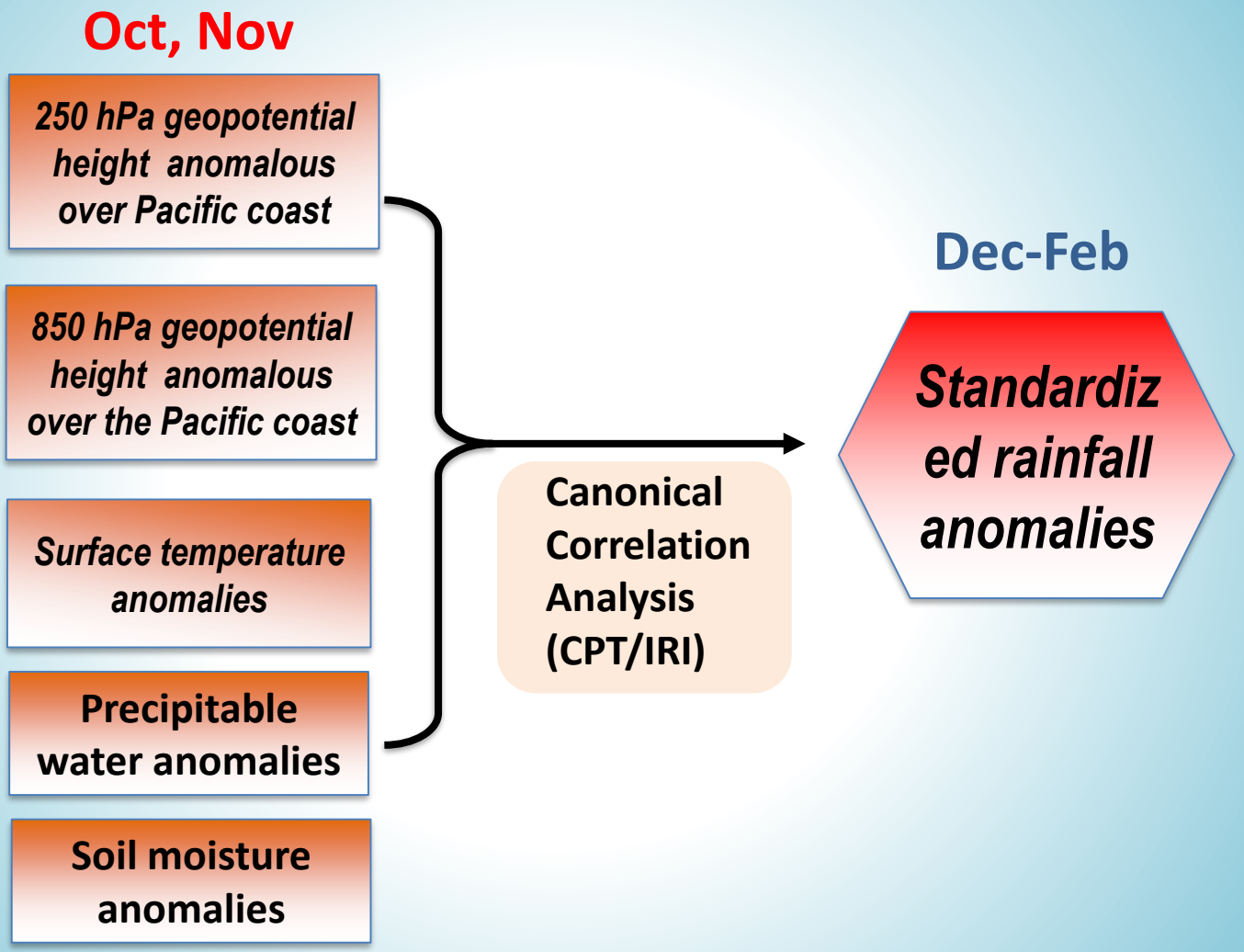
Observed pre-conditions in fall for drier and wetter winter

Dry winters: preceded by higher sea surface temperature and moisture in the atmosphere off the coast of S. California, and warmer surface temperature over CA/NV except over the central valley in Fall (Sept-Nov).

Wet winters: preceded by cooler surface temperature and high humidity over CA/NV, lower humidity over ocean off coast of S. California in fall.

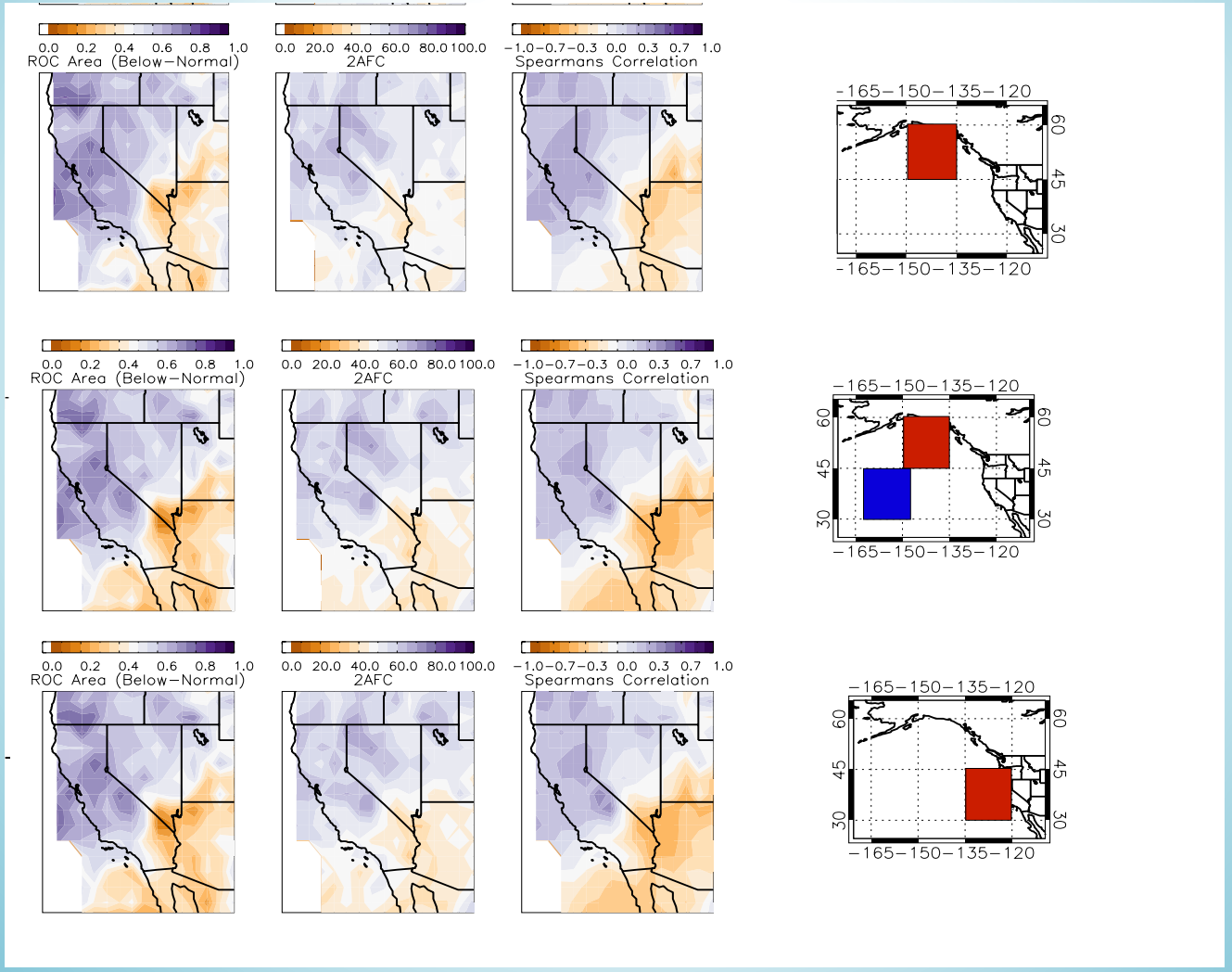


The statistical prediction model



Trained by CFSR and CPC rainfall data for the period of 1980-2010
CFSv2 realtime forecast after 2010.

- ***The NE Pacific domain for large-scale circulation predictor provides the best overall prediction skill***



Prediction skills for various lead times:

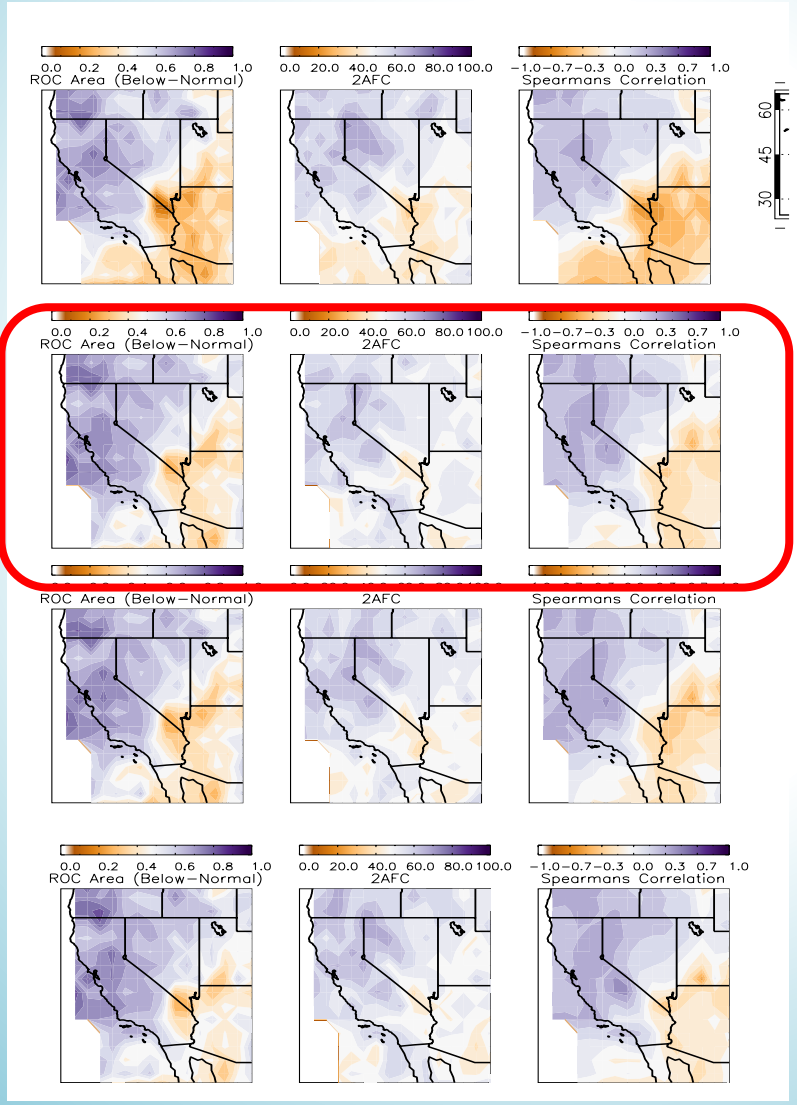
ROC ***2AFC*** ***Correlation***

Inputs: SON

Inputs: Oct

Inputs: Nov

Inputs: Oct-Nov

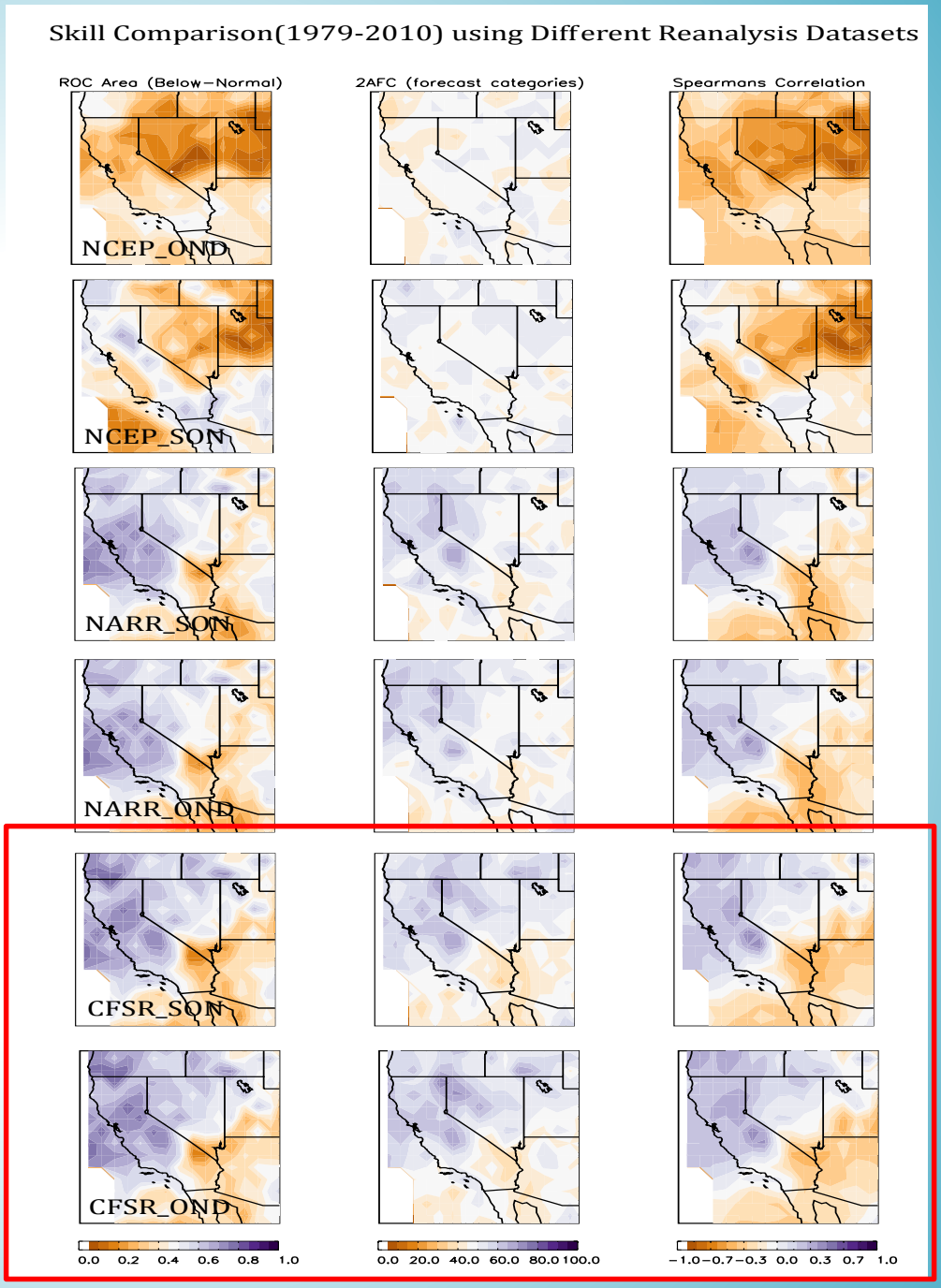


Can potentially provide prediction of Dec-Feb rainfall in the first week of Nov, 6-7 weeks before Christmas time to support mid-year adjustment decision

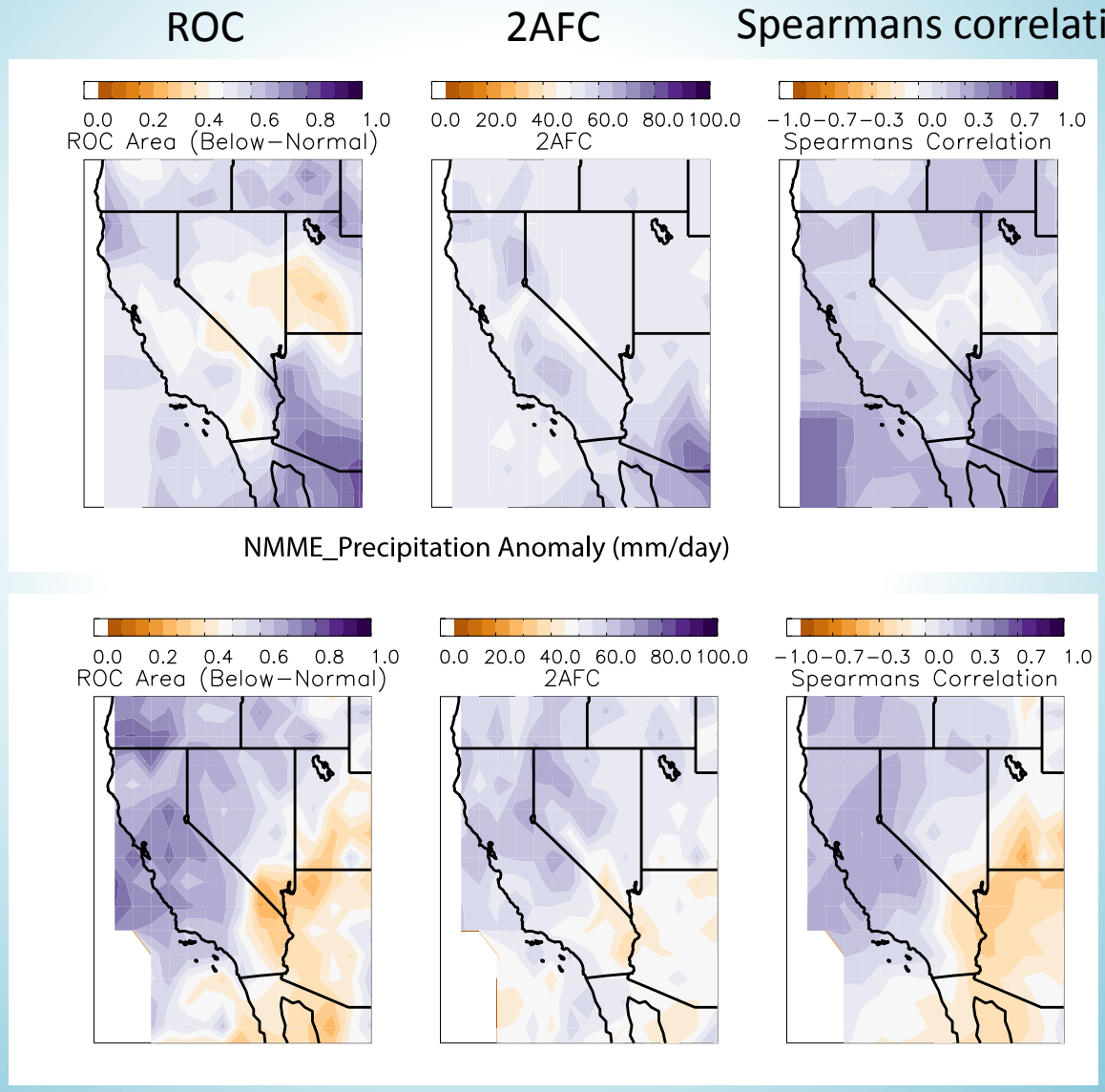
Relative to 1979-2010 climatology
3 point cross-validation

Sensitivity of the prediction skills to inputs data

- *CFSR as input provides the highest prediction skills*
- *CFSv2 realtime forecast will be used for seasonal prediction*



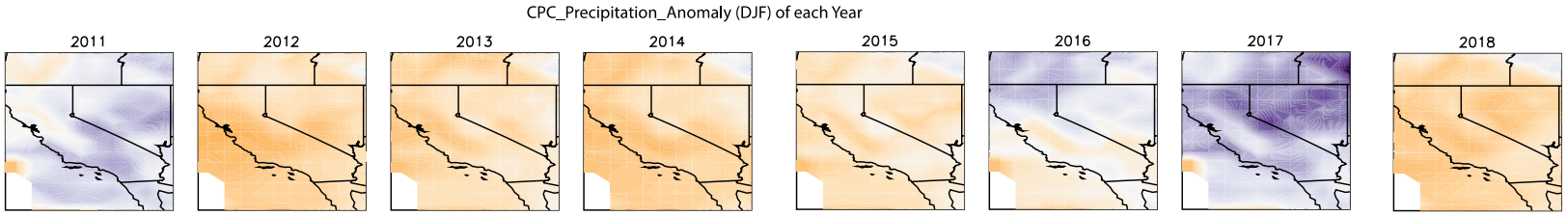
Compare to NOAA NMME prediction skills (initialized in Oct, for Dec-Feb standardized rainfall anomalies)



Hindcasts for 2012-2017 winter rainfall anomalies using Nov input vs. Oct input

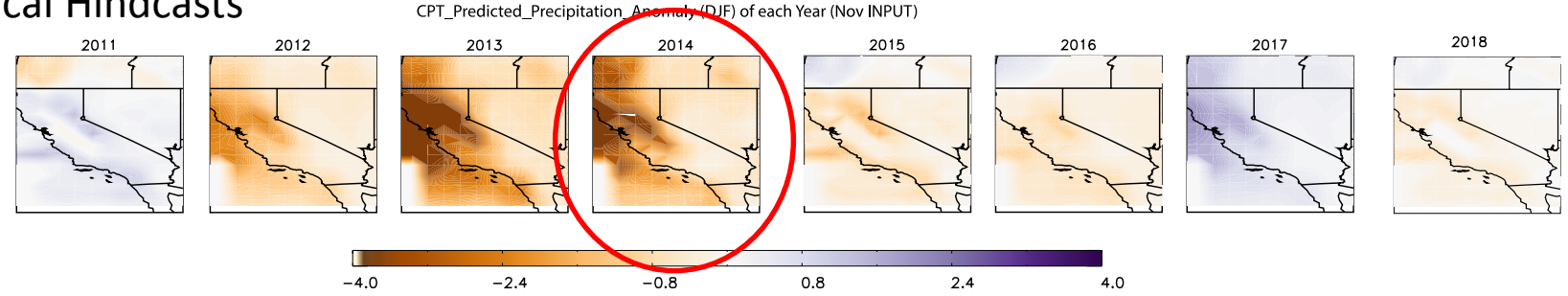
- Using Nov input can improve prediction from that using Oct input
- Thus, provides updated prediction based on Nov input in early December can improve the accuracy of the winter rainfall prediction

OBS

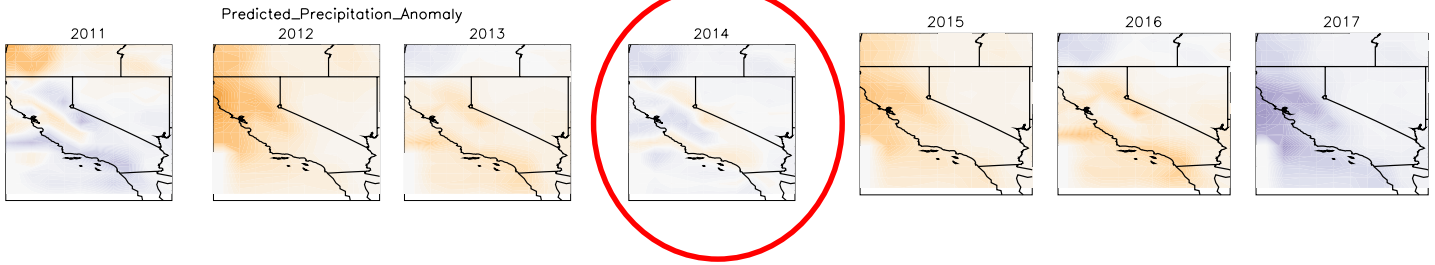


Statistical Hindcasts

Nov input



Oct input



Using seasonal prediction to quantify the skill and calibrate climate projections on multidecadal to centennial scales

The San Diego Union-Tribune

Climate change could make California wetter, study finds

SAN DIEGO, CA.-Jan. 20, 2017 - File photo of urban flooding pooled on University avenue drenching businesses and cars. (JOHN GIBBINS/Union Tribune)

LA Times

Climate scientists see alarming new threat to California

By EVAN HALPER
DEC 05, 2017 | WASHINGTON

In June 2014, Lake Shasta was at 37% of capacity due to the long California drought. (Allen J. Schaben / Los Angeles Times)

Large uncertainty!

UCLA Newsroom

ENVIRONMENT + CLIMATE

Study forecasts a severe climate future for California

UCLA research predicts dramatic shifts between extreme dry and extreme wet weather by end of 21st century

David Colgan | April 23, 2018

Facebook 80 Twitter LinkedIn Email Print

Michael J. Nevins/U.S. Army

The New York Times

In a Warming California, a Future of More Fire

The recent cycle of drought and deluge in California led to major fire risk. Climate change makes that cycle worse.

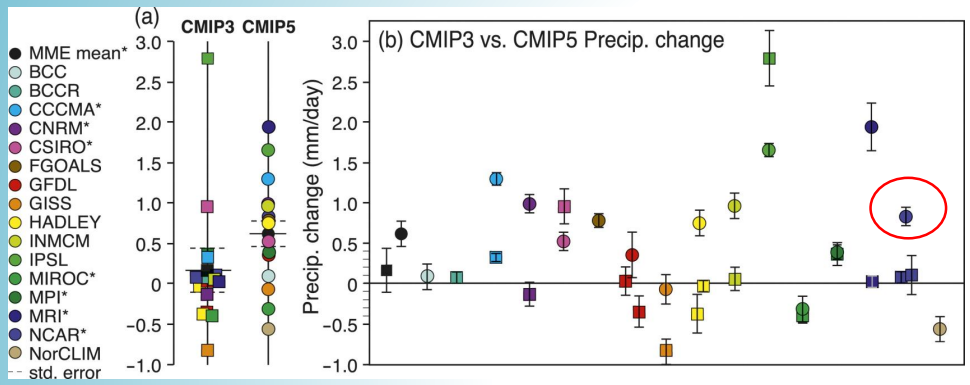
By Henry Fountain

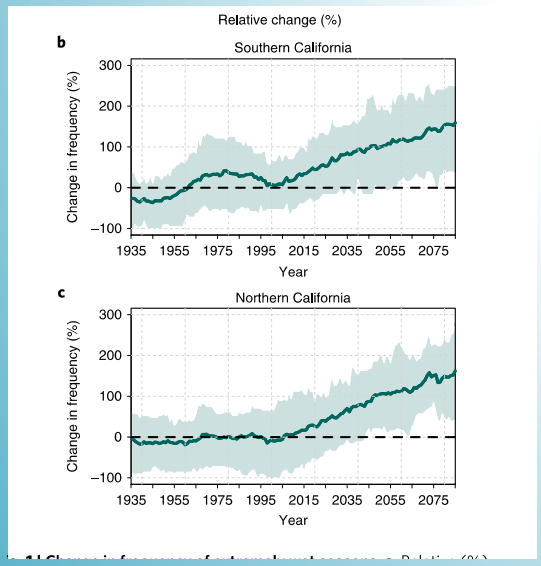
Dec. 7, 2017

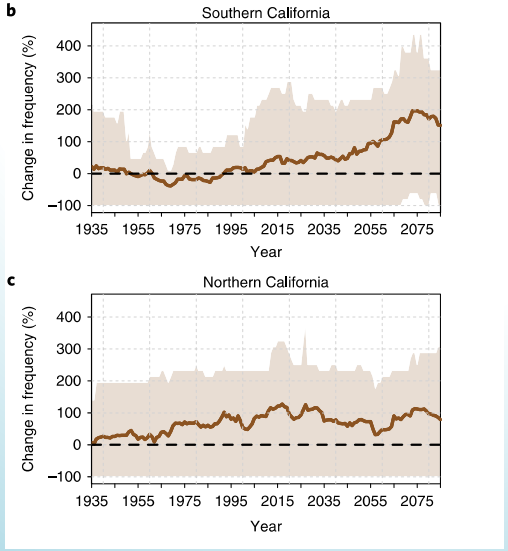
Want the latest climate news in your inbox? You can sign up here to receive ***Climate Fwd:****, our email newsletter.*

Severe wildfire seasons like the one that has devastated California this fall may occur more

Projection of future winter rainfall change (2050-2100)







IPCC AR5 dynamic models' projections:

Neelin et al. 2013: CMIP3 and CMIP5 project a slightly wetter winter over California during 2070-2099 relative to 1979-2005.

Swain et al. 2018: increases of both wet and dry extremes

- ***If you cannot predict droughts a few months in advance, how can we ask state legislature to pay billions of dollars based on your projection of 50 years in the future?***

  - Director, Surface Water Resource Division, TWDB

TOWARD SEAMLESS PREDICTION

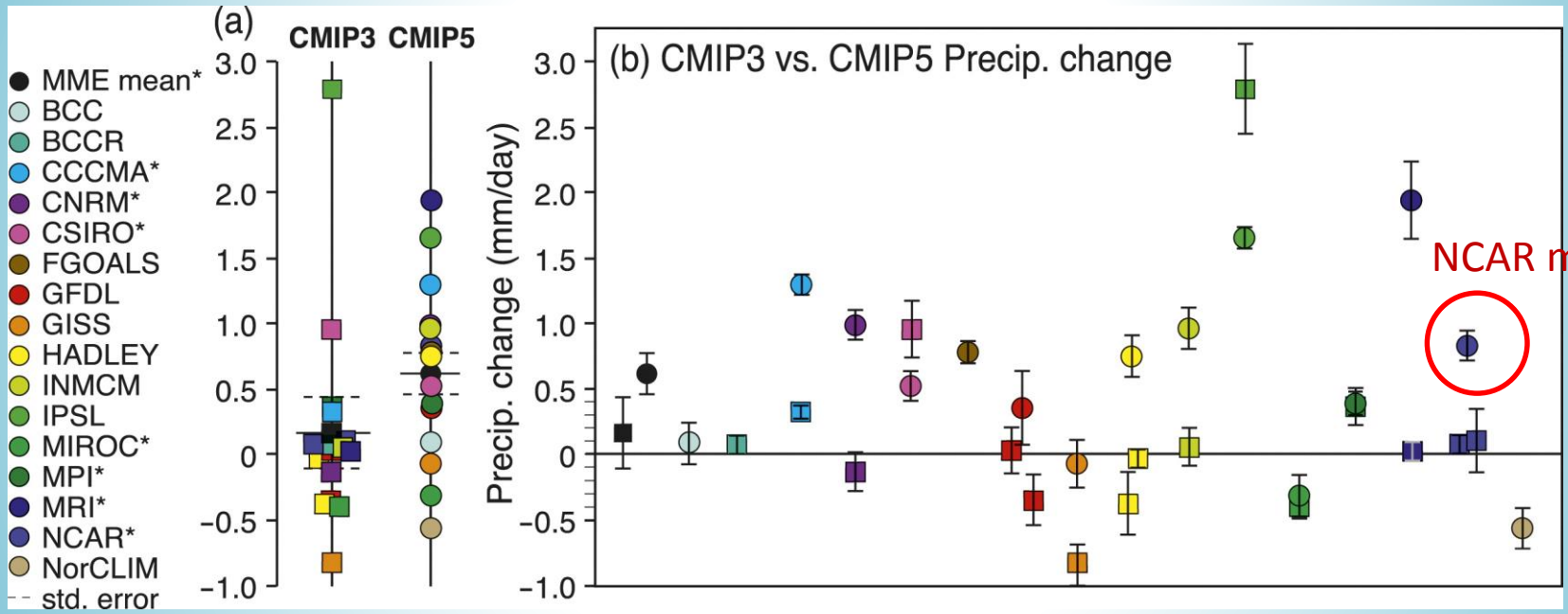
Calibration of Climate Change Projections Using Seasonal Forecasts

BY T. N. PALMER, F. J. DOBLAS-REYES, A. WEISHEIMER, AND M. J. RODWELL

In a seamless prediction system, the reliability of coupled climate model forecasts made on seasonal time scales can provide useful quantitative constraints for improving the trustworthiness of regional climate change projections.

Palmer et al. 2008, BAMS

By improving seasonal rainfall prediction, we improve the trustworthiness of the climate projection in support society's adaption to future droughts.


(a)
CMIP3
CMIP5
MME mean*
BCC
BCCR
CCCMA*
CNRM*
CSIRO*
FGOALS
GFDL
GISS
HADLEY
INMCM
IPSL
MIROC*
MPI*
MRI*
NCAR*
NorCLIM
std. error
3.0
2.5
2.0
1.5
1.0
0.5
0
−0.5
−1.0
(b) CMIP3 vs. CMIP5 Precip. change
Precip. change (mm/day)
NCAR model

A hybrid dynamic-statistical projection of future winter rainfall change (2050-2100, RCP8.5)

- *Much stronger drying than wetting, especially in N. California*

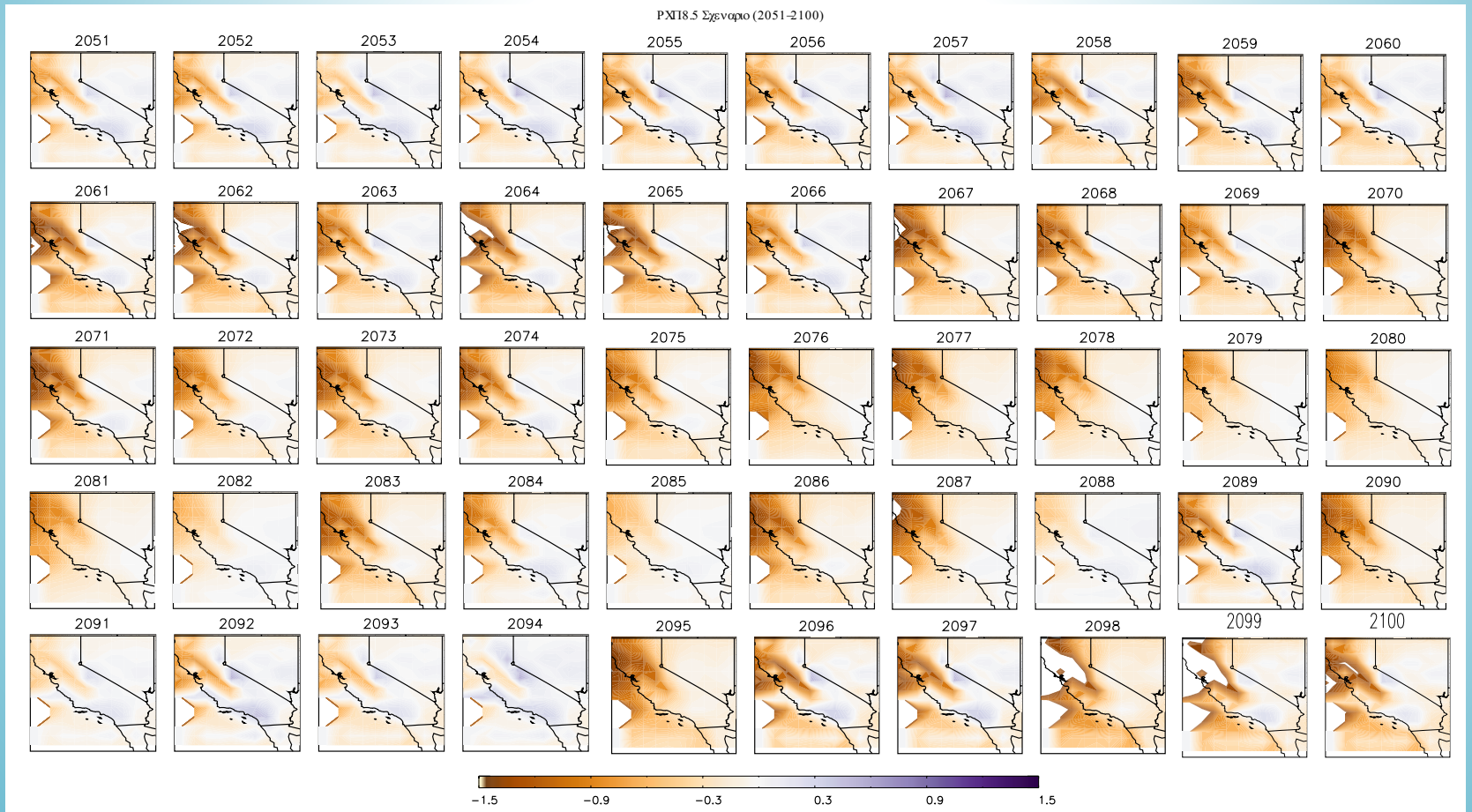
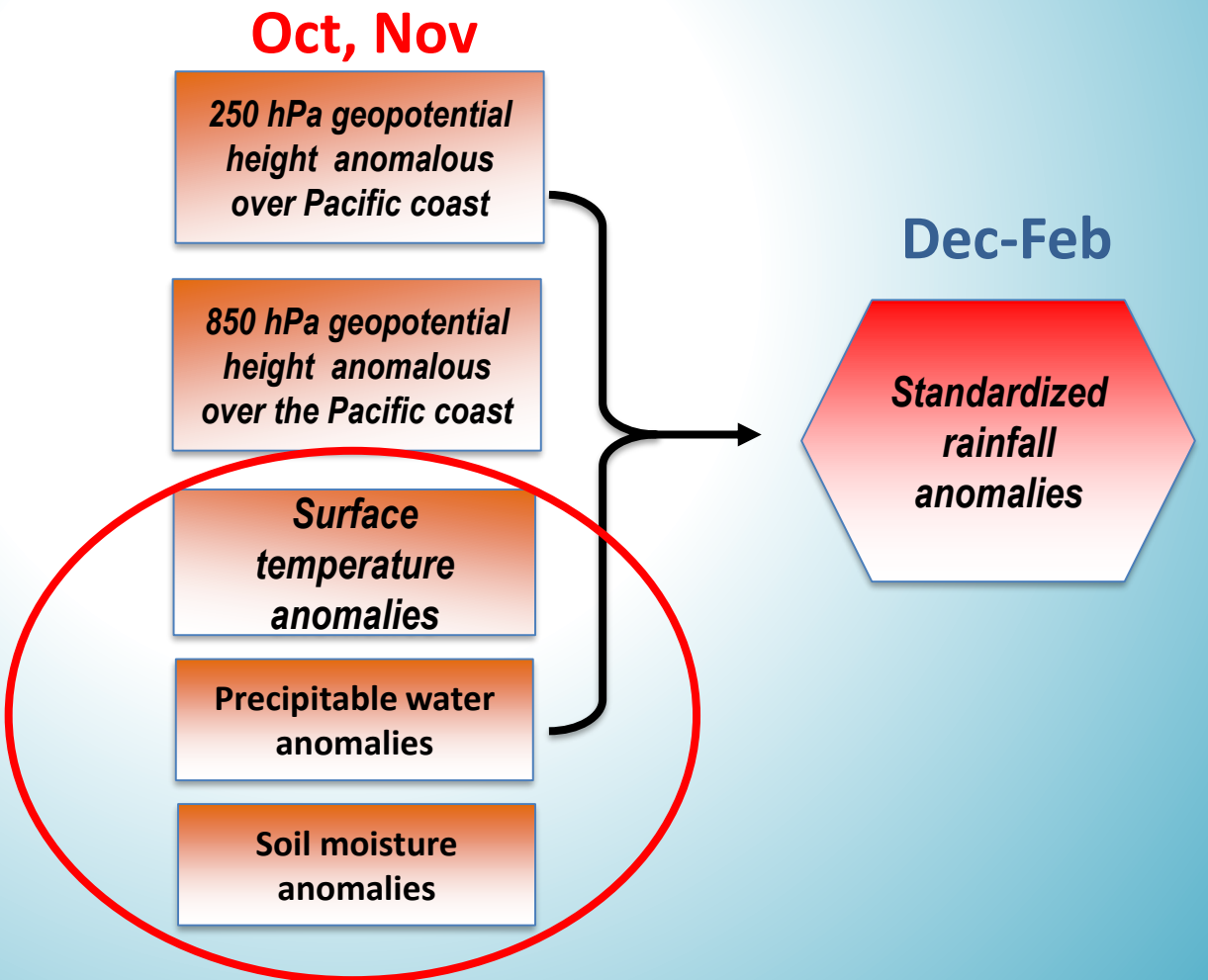


Figure 7. Anomalies (mm/day) in DJF precipitation of each year from 2051 to 2100 using RCP 8.5 scenario. Anomalies are calculated by subtrating mean precipitation between1979-2010 ex stimated by using CPC datasets from the predicted precipitation using RCP 8.5 scenario by CPT. Input parameters are Z850as well as Z250 over the παχι χοασταλρεγιονσανδ σοιλμ οιστυρε ασωελλασσυρφαχε τεμ περατυρε δαταασετσοπερ της δομ αιν βετωεεν της περιοδ οφΣεπτεμ βερ-Νοπεμ βερεαχη ψεαρ

Why is the statistical prediction different from the dynamic prediction?

Our hypothesis: our input fields are highly sensitive to climate change



Future work

Improve the seasonal prediction model:

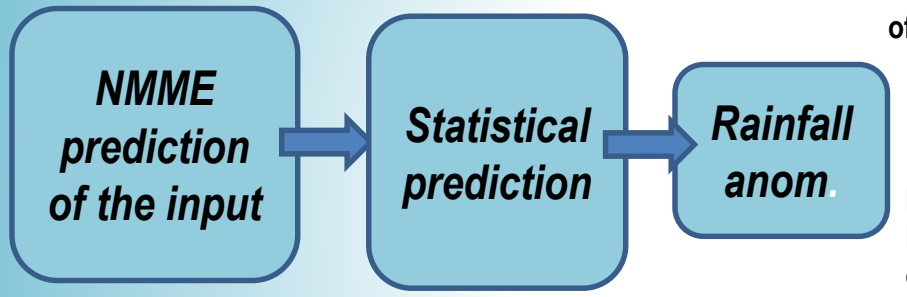
- ***Further testing the statistical model to improve the skills.***
- ***Evaluate hindcasts to determine the capability and limitation of this seasonal prediction system***
- ***Explore extended seasonal forecast (4-5 months leadtime)***
- ***Determine the sources of the predictability***
- ***Understand the reasons behind the projected strong drying in future***

Improve the usefulness of the seasonal prediction system

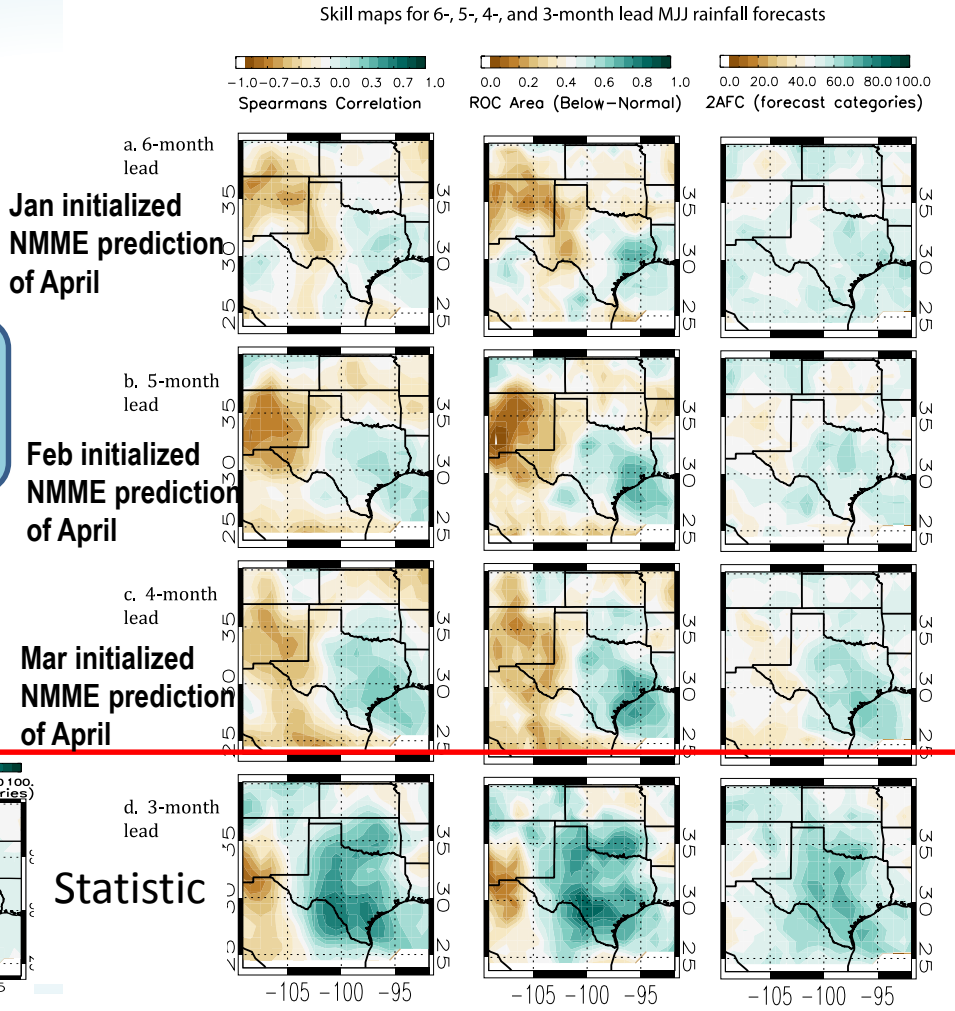
- ***Seeking opportunities to work with DWR, CA/NV DEWS, and Western weather & water extremes***
- ***Contribute to the state winter rainfall seasonal prediction effort***

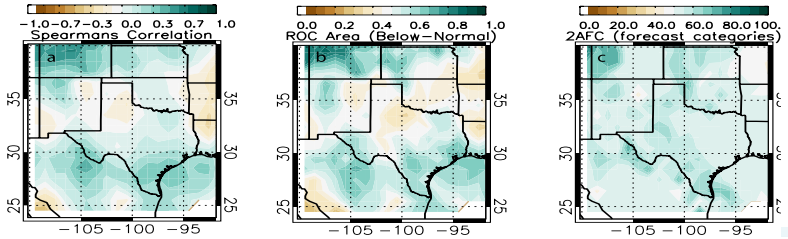
Explore extended seasonal prediction of winter rainfall anomalies for CA/NV

Extended seasonal prediction for Texas Water Development Board



Hybrid NMME-statistical prediction skills





NMME

Statistic

Prediction of MJJ rainfall anomalies initialized by CFSv2 real time forecast in April

Figure 5. Skill comparison maps for MJJ rainfall anomalies using (a) January-April (6 months lead), (b), February-April (5 months lead), (c) March and April (4 months lead), and (d) April (4 months lead) initial conditions.

Fernando et al 2018, in review

Extended seasonal forecast (3-4 months leadtime)

Texas Water Development Board

TEXAS DROUGHT REPORT

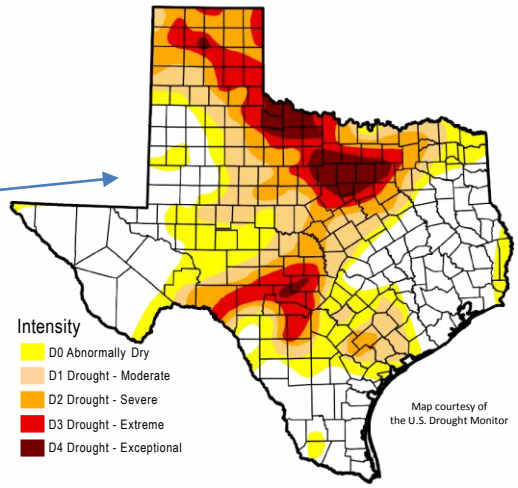
FOR THE WEEK OF 03/02/15

DROUGHT CONDITIONS

Drought conditios ar e relatively unchanged from last week with a slight improvement in the western Panhandle, a slight degradatio in the w estern Hill Country, and abnormally dry conditigps s tartin t o peek in along the Sabine River near the Gulf Coast. Recent rains gave us a slight but welcomeluptic in reservoir storage in North-Central and East Texas.

Drought statistics

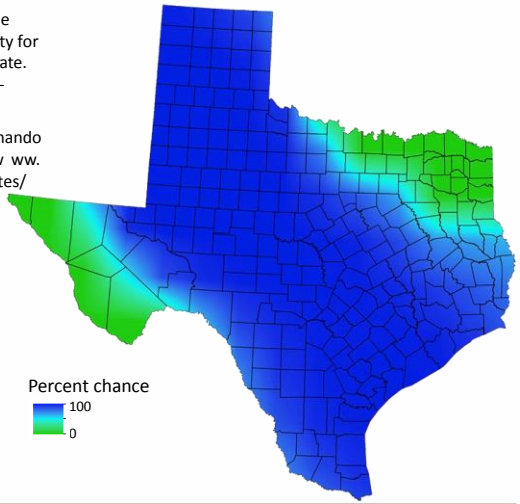
- 43% of state currently in moderate to exceptional drought
- 43% a week ago
- 43% three months ago
- 68% a year ago



TEXAS SUMMER RAINFALL OUTLOOK

The drought forecast for the summer of 2015, made using January observatios, sho ws a high probability for a wetter-than-average summer over most of the state. The probabilitie ar e highest over the south, south-central, and Panhandle regions.n

The projectio is based on a study by D. Nelun Fernando and others (2015). This study is available at http//w ww.twdb.texas.gov/publicatios/r eports/technical_notes/doc/TechnicalNote15-02.pdf.



Hindcasts, May-July rainfall anomalies (training period 1982-2005)

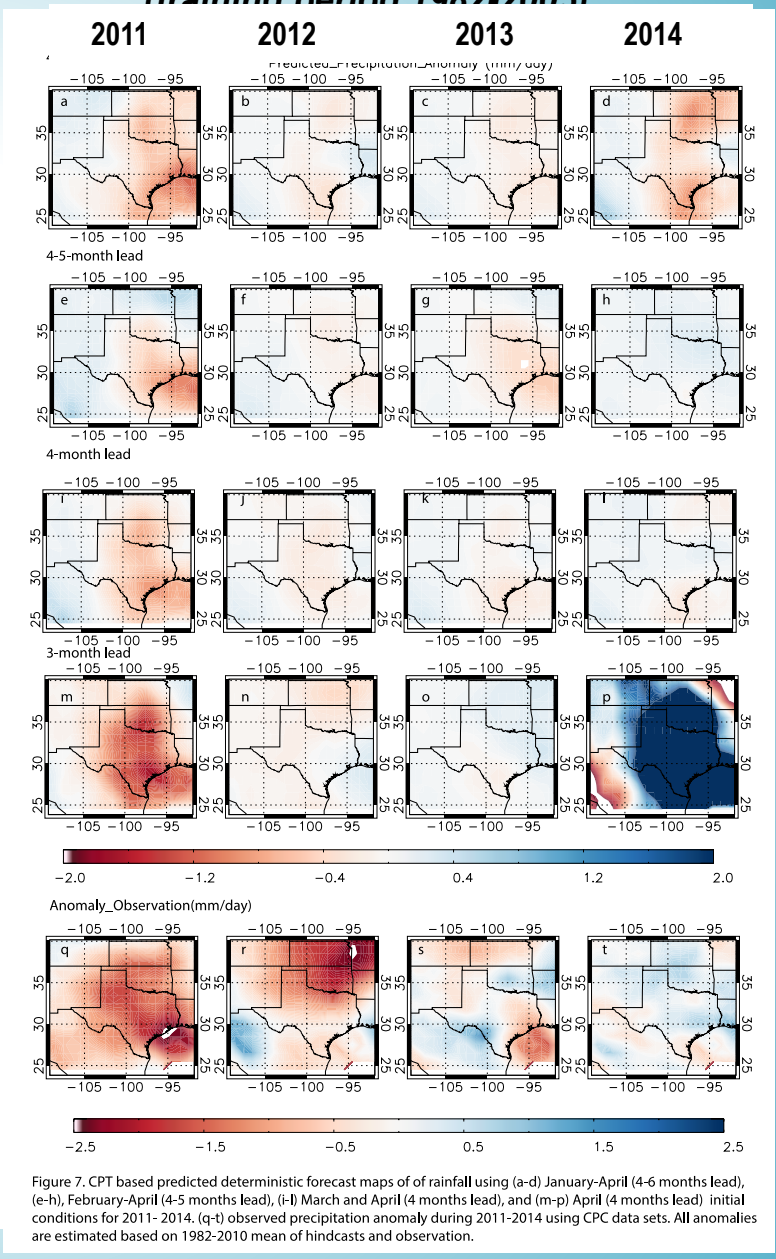
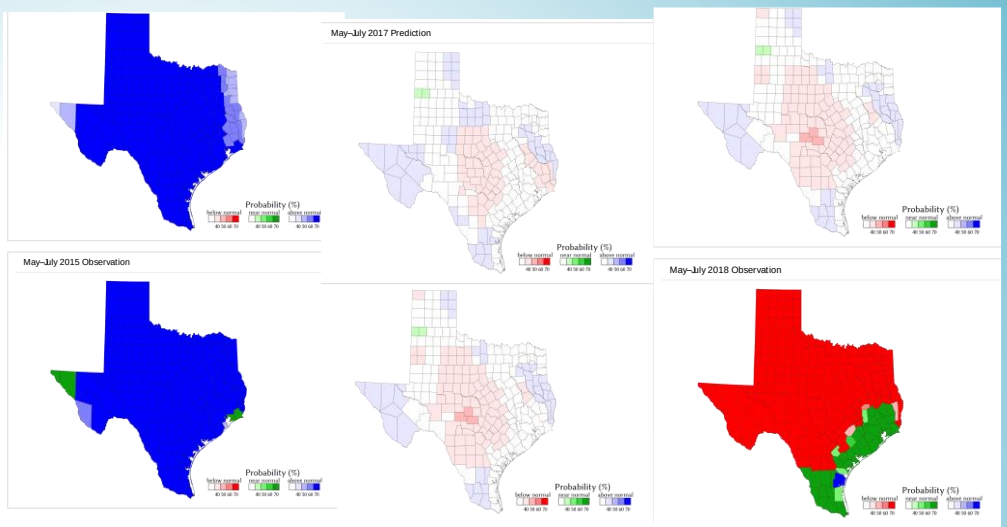


Figure 7. CPT based predicted deterministic forecast maps of of rainfall using (a-d) January-April (4-6 months lead), (e-h), February-April (4-5 months lead), (i-l) March and April (4 months lead), and (m-p) April (4 months lead) initial conditions for 2011- 2014. (q-t) observed precipitation anomaly during 2011-2014 using CPC data sets. All anomalies are estimated based on 1982-2010 mean of hindcasts and observation.

- ***Enable users to assess the prediction skills, i.e., making prediction and verification readily available online.***
- ***Incorporate new data to improve the prediction skills***

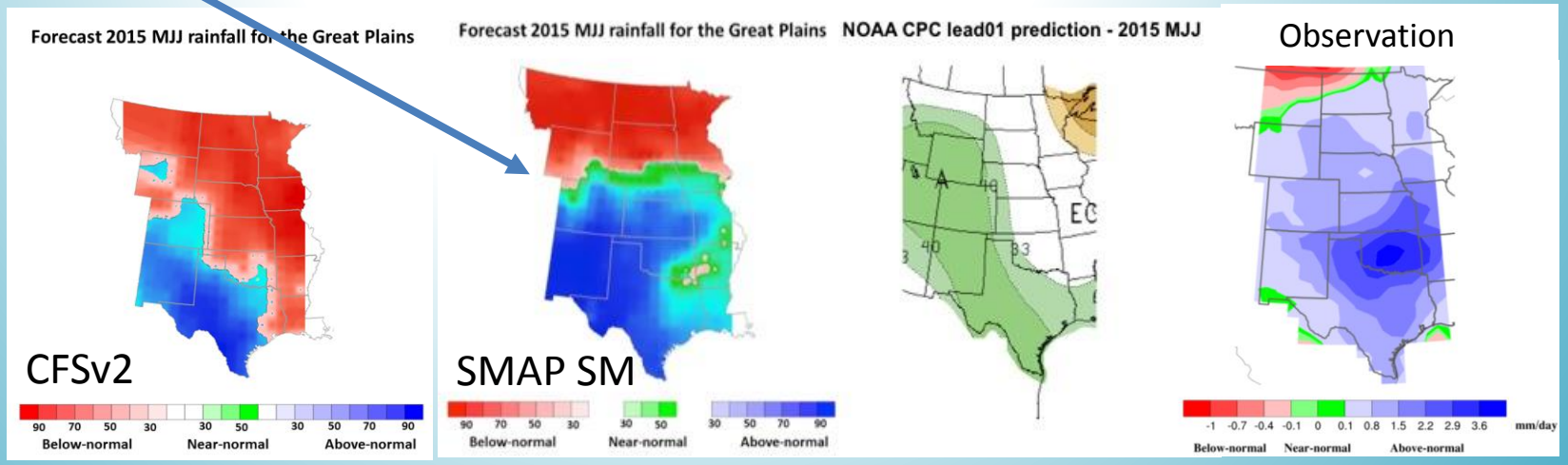
May-July 2015 **May-July 2017** **May-July 2018**



Available at https://waterdatafortexas.org/drought/past-rainfall-forecasts

Collaboration with JPL/SMAP & TWDB

Statistical prediction ***NOAA CPC Prediction***

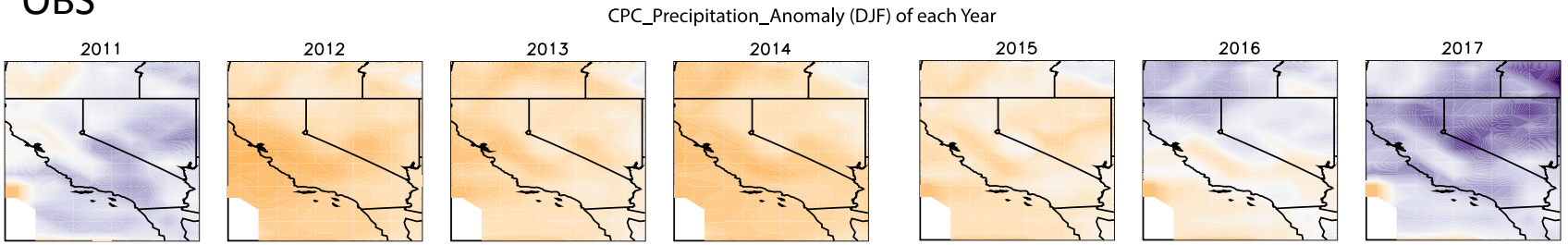


Summary

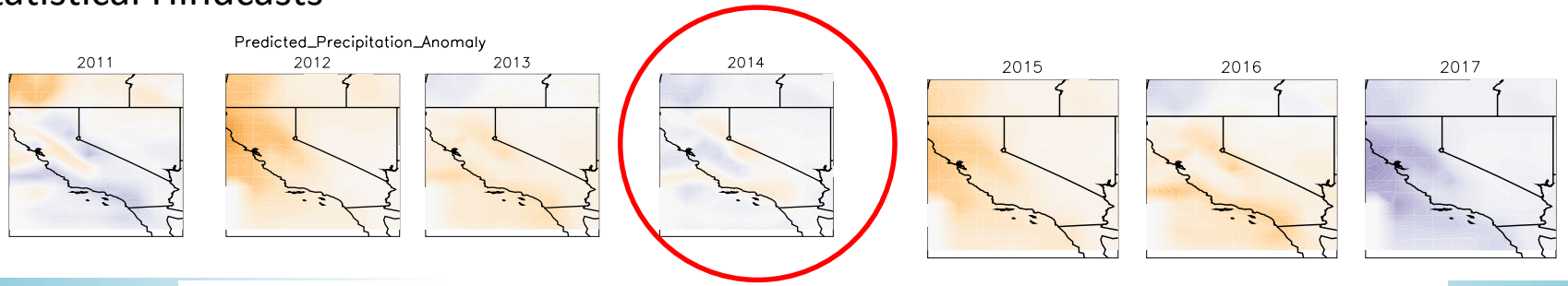
- ***Preliminary statistical seasonal prediction system shows a higher skill in predicting winter rainfall anomalies over the CA/NV than that of the dynamic seasonal prediction.***
- ***This statistical seasonal prediction system can be trained to incorporate new data and to provide rainfall related parameters for improving the skill and usefulness of the prediction.***
- ***This statistical prediction system can potentially calibrate the climate projection for future winter rainfall anomalies over the CA/NV region, to improve the trustworthiness of the projection of winter rainfall in future climate.***

Hindcasts for 2012-2017 winter rainfall anomalies using Oct inputs

OBS



Statistical Hindcasts



NMME

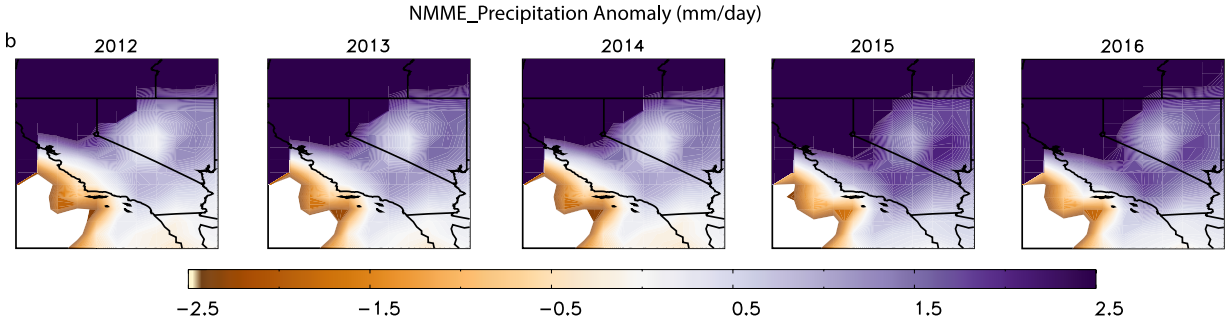


Figure 5. a) Skill maps and b) anomalies of DJF rainfall from NMME in mm/day from NMME CMC1-CanCM3 FORECAST MONTHLY prec, NMME CMC2-CanCM4 FORECAST MONTHLY prec , NMME COLA-RSMAS-CCSM3 MONTHLY prec], NMME GFDL-CM2p1-aer04 MONTHLY prec , NMME GFDL-CM2p5-FLOR-A06 MONTHLY prec.

Using the statistical seasonal prediction to support state drought preparedness

Funding Opportunity Announcement No. R15AS00046

WaterSMART:
Drought Resiliency Project Grants for Fiscal Year 2015

U.S. Department of the Interior
Policy and Administration
Bureau of Reclamation
Denver, Colorado

May 2015

- *US Bureau of Reclamation Drought Resiliency Project awarded to TWDB: Tool for the early warning of impending summer drought over Texas*

  Nelun Fernando (PI), Rong Fu (collaborator)

  - *Water user groups in Texas are required to have a strategy for reducing water use when water sources reach certain drought response trigger levels. By providing early warning of drought probability, early response measures may be taken to mitigate the impacts of drought and to reduce the need for more severe use restrictions. The forecasts will be updated on a bi-weekly basis and made accessible to water managers across the state through the Water Data for Texas website.*