A seamless approach to connecting science to decision

Rong Fu

Department of Atmospheric & Oceanic Science

COAA-SCC Fall Workshop

November 4, 2017, 10:30 am – 6:30 pm

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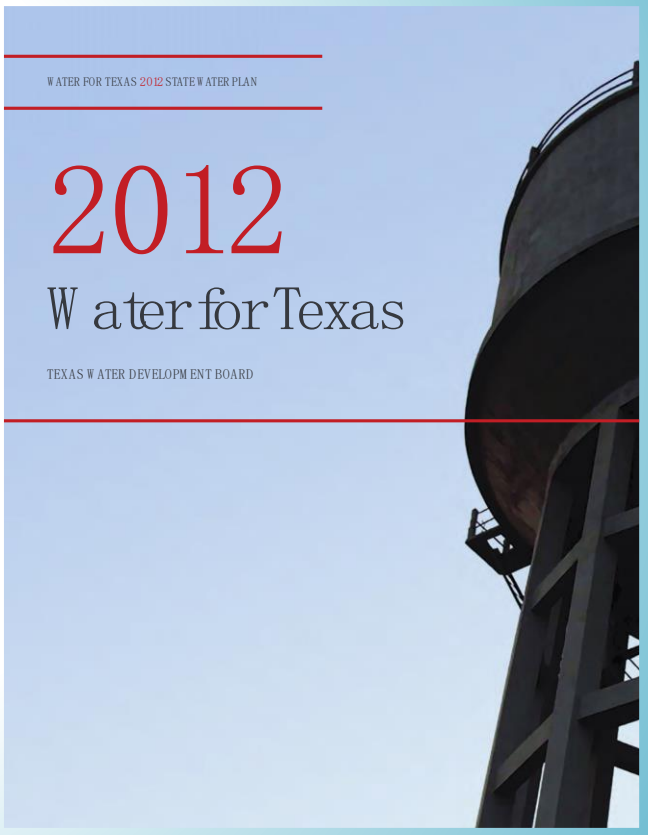
- ***How do we connect science to societal needs?***

Challenges:

- Scientists: Decision makers do not understand or appreciate science
- Decision makers: science is not relevant to decision

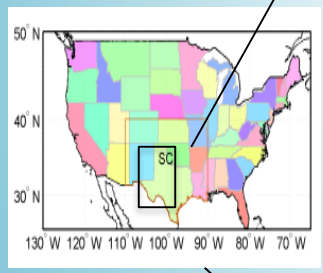
High Stakes of Water Resource Planning

- ***The economic loss: $116 billion should a drought of the 1950s occur around 2060.***
- ***The capital cost of implementing strategies to mitigate such a potential economic loss: $53B.***
- ***Future climate change information was considered.***



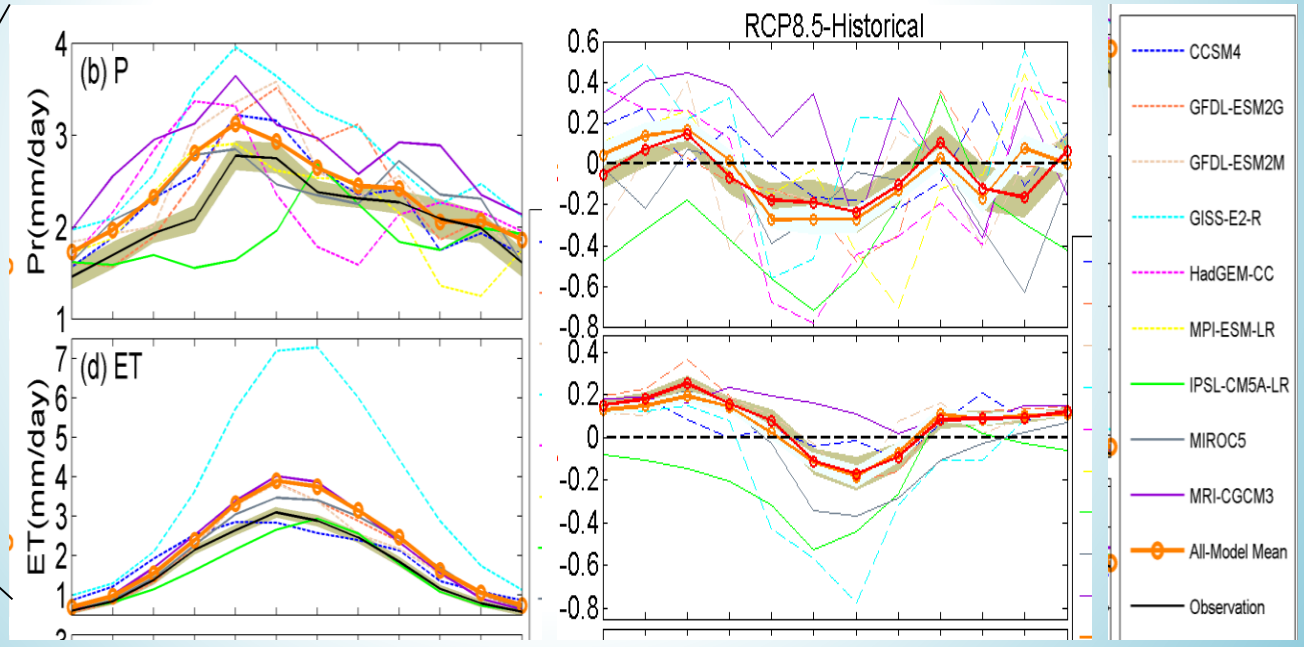
Climate projection is inadequate for future water resource planning.

IPCC AR5



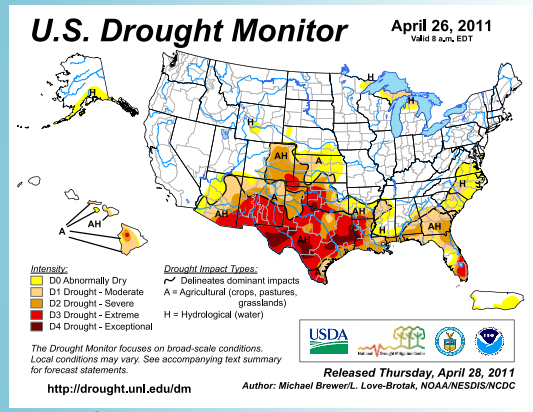
Historical (1979-2005)

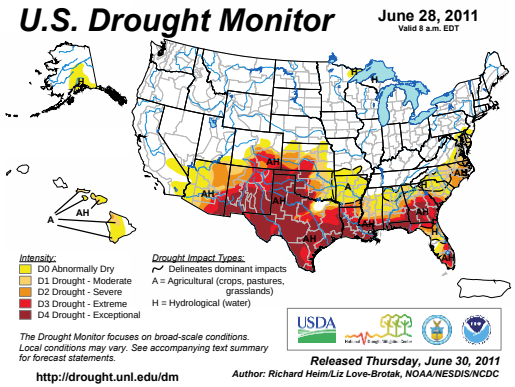
Projected changes RCP8.5



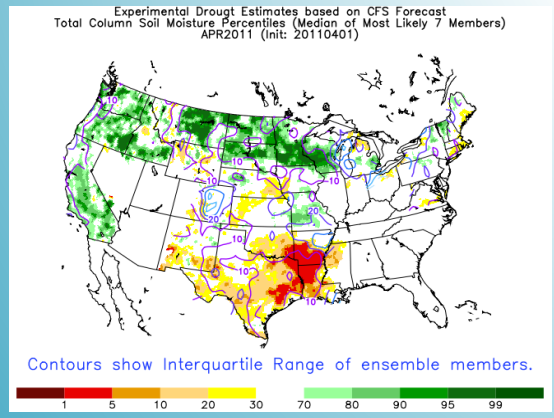
- ***Seasonal forecast unable to predict major summer droughts in recent years, and does not show more skill than autocorrelation over US Great Plains (Guan et al. 2012; Hoerling et al. 2013).***
- ***Decision makers have no reliable drought early warning.***

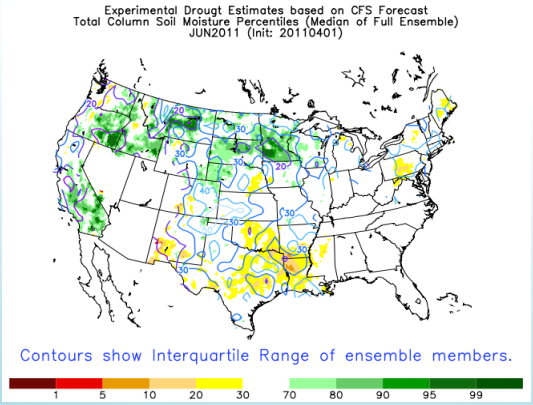
Observation





Prediction





- ***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

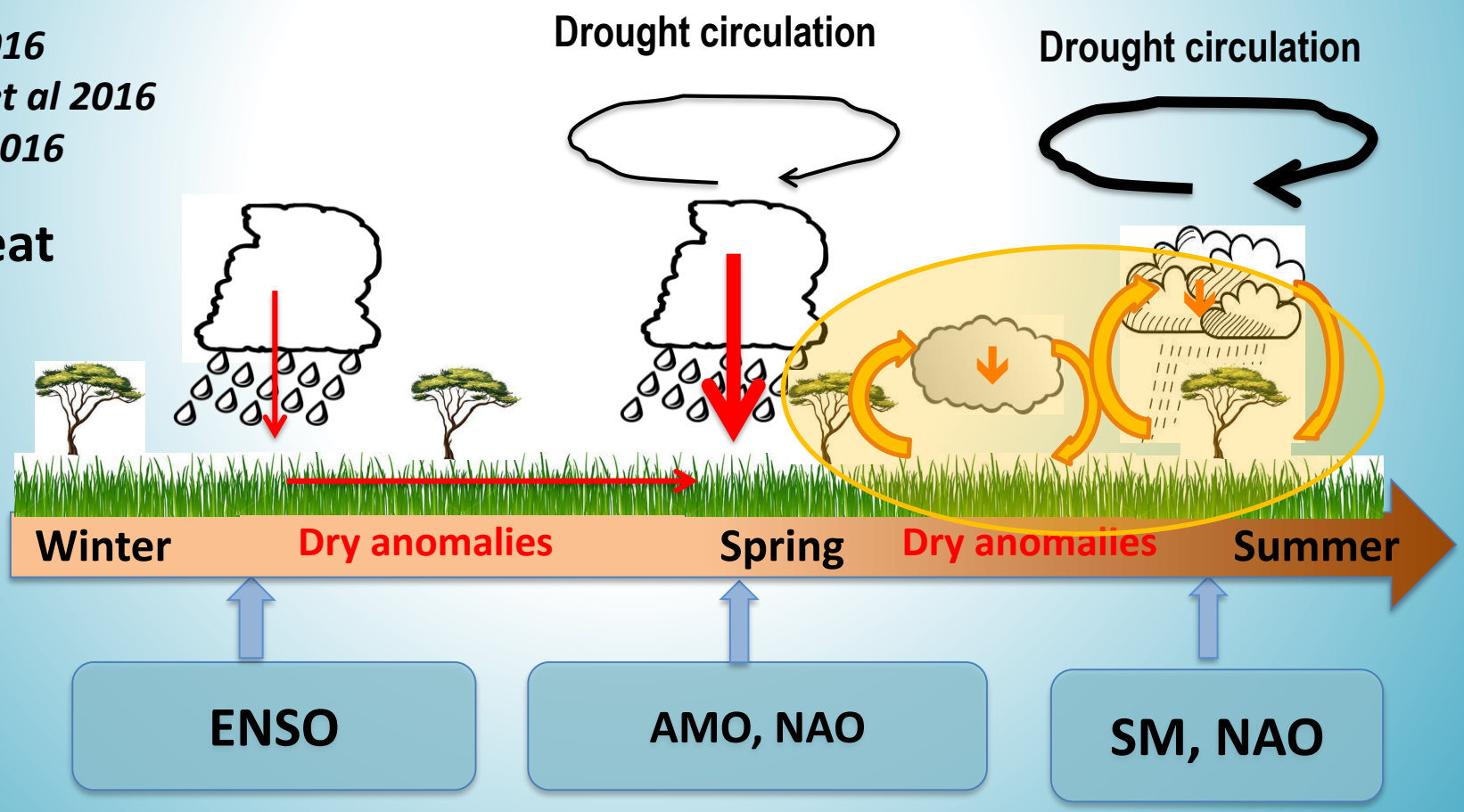
What cause the observed drought persistence (predictability) from spring to summer?

Key preconditions that trigger the persistent drought memory in spring:

- ***Anomalous mid-tropospheric geopotential high***
- ***Strong lower tropospheric inversion***
- ***Soil moisture deficit***

Pu et al. 2016
Fernando et al 2016
Sun et al. 2016

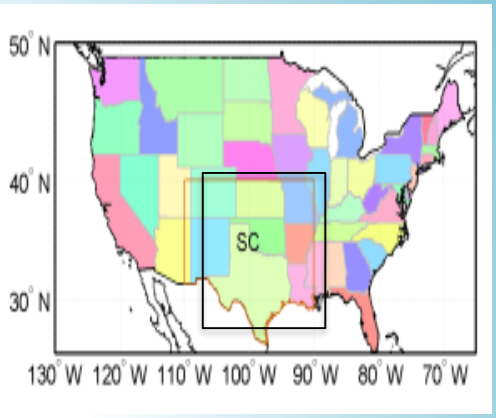
US Great Plains

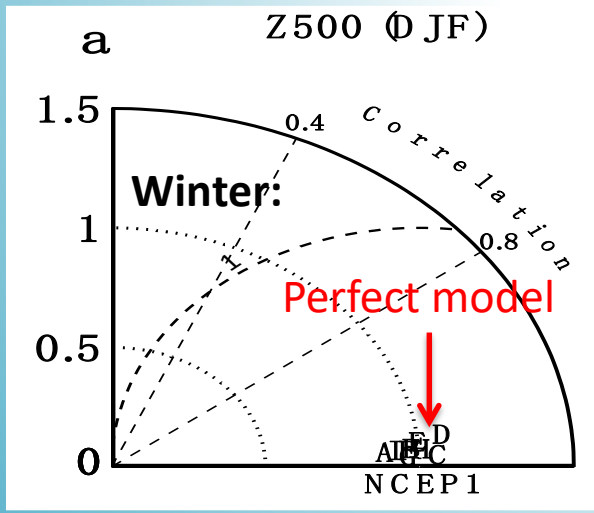


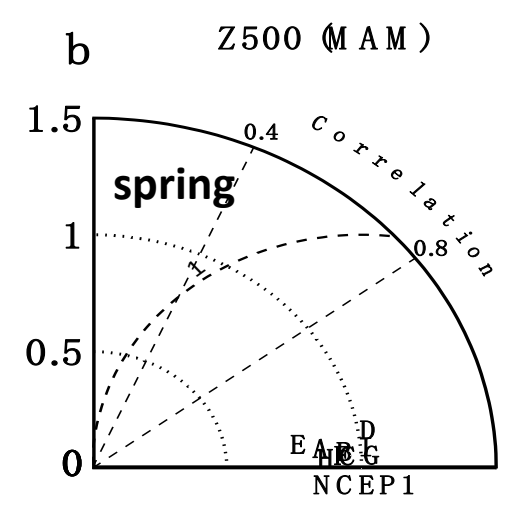
How can we use imperfect climate models to support societal decision?

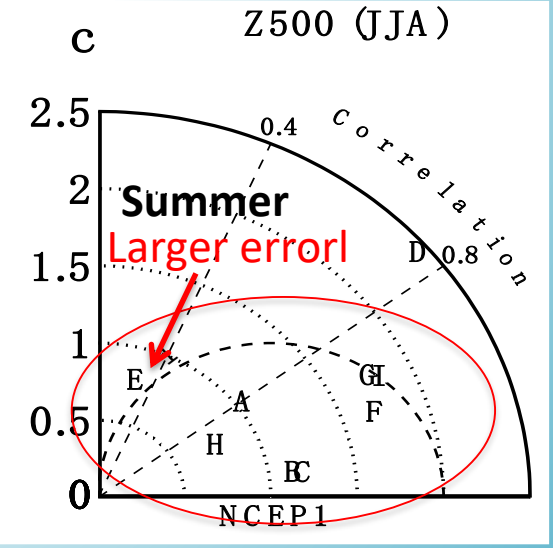
- ***Model Strength:*** ***Realistically capture large-scale circulation in winter and spring,***

- ***Model limitation:*** ***large uncertainty in representing summer large-scale circulation climatology in CMIP5 models***





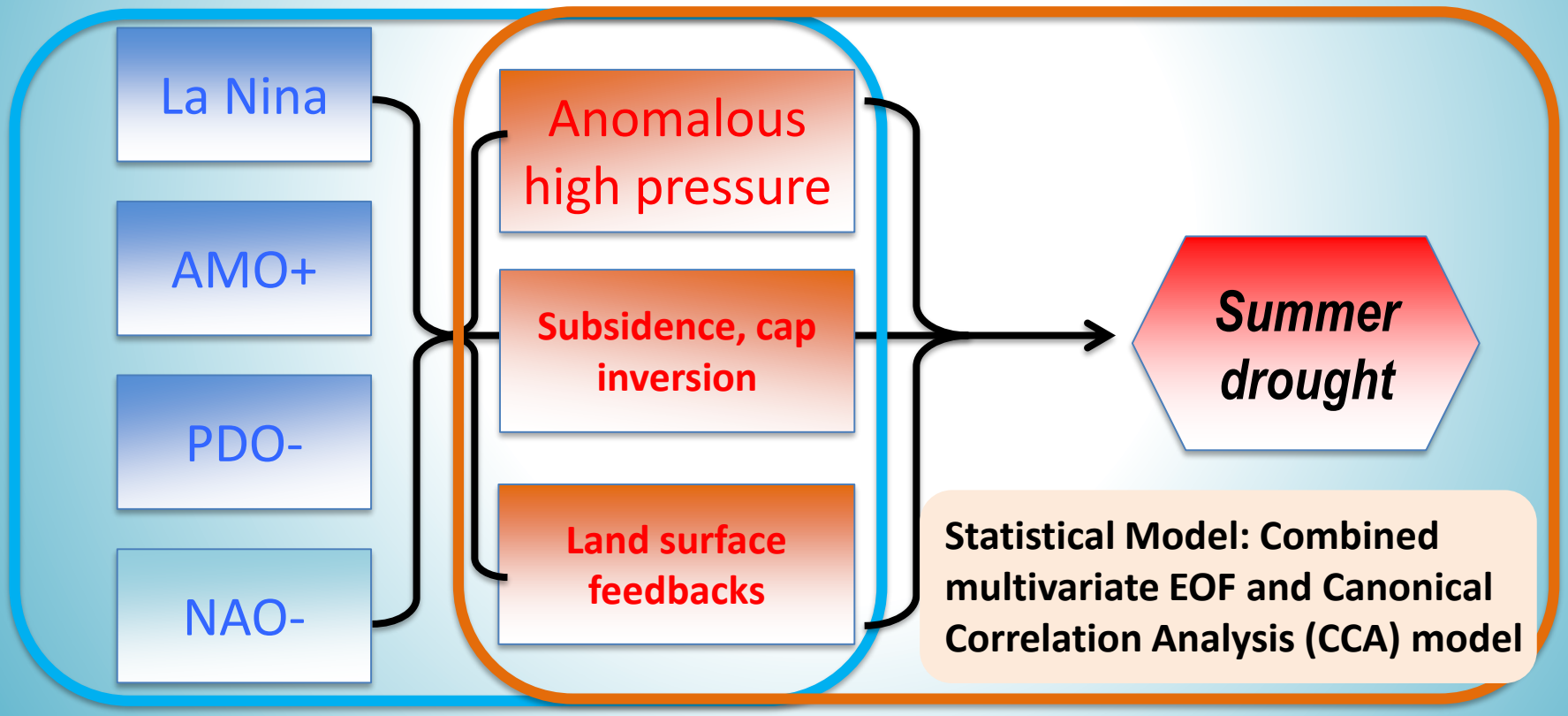




A hybrid physical-empirical model approach:

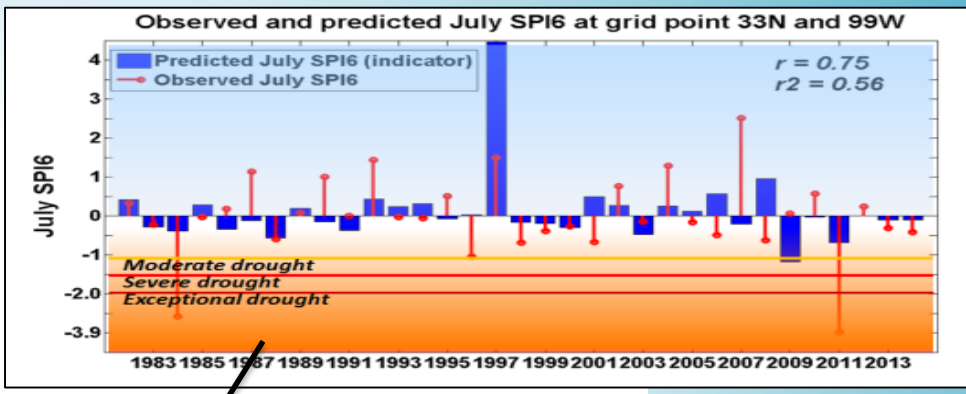
Winter → Spring: climate model prediction/projection

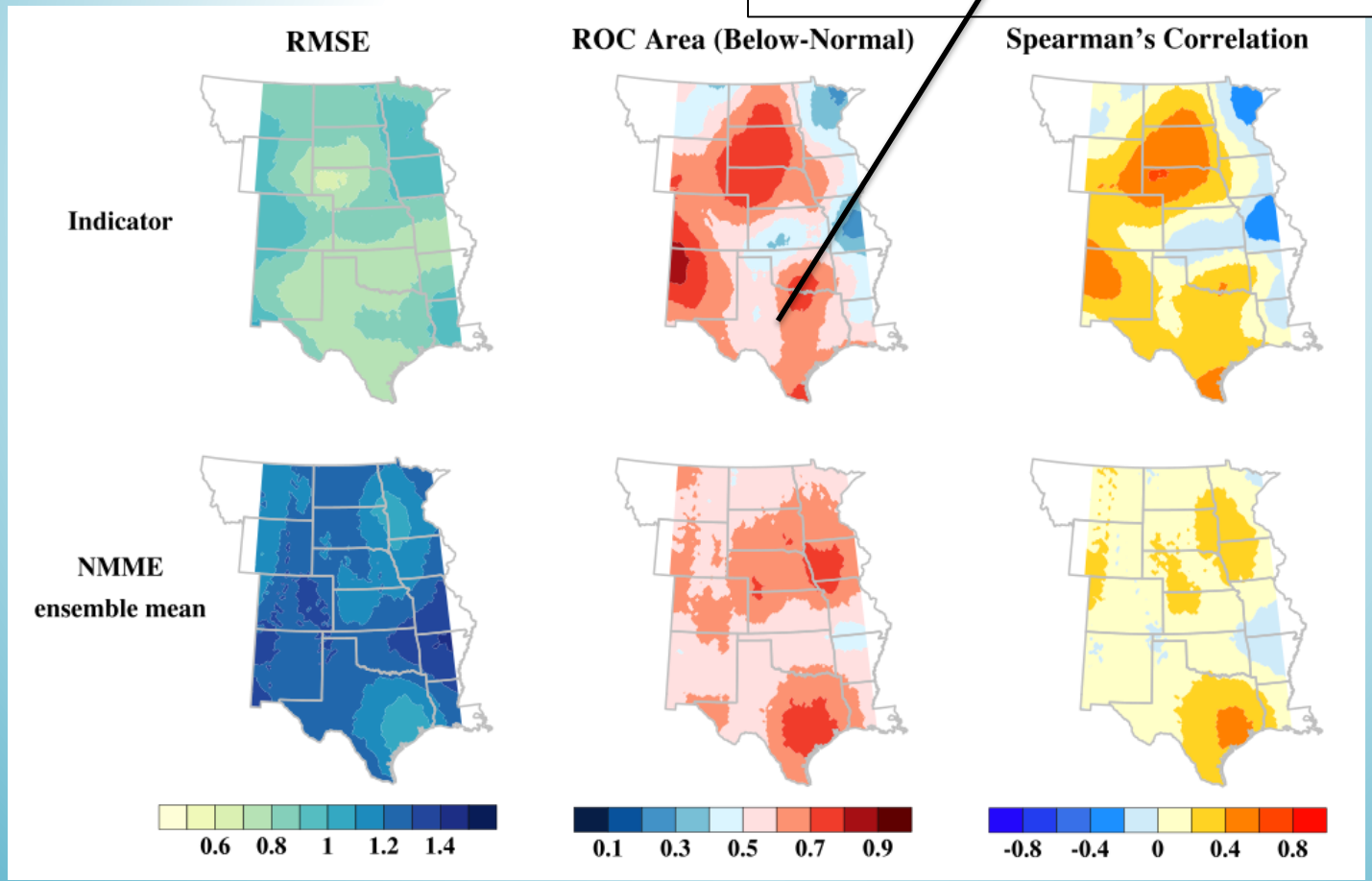
Spring →Summer: empirical model prediction/projection



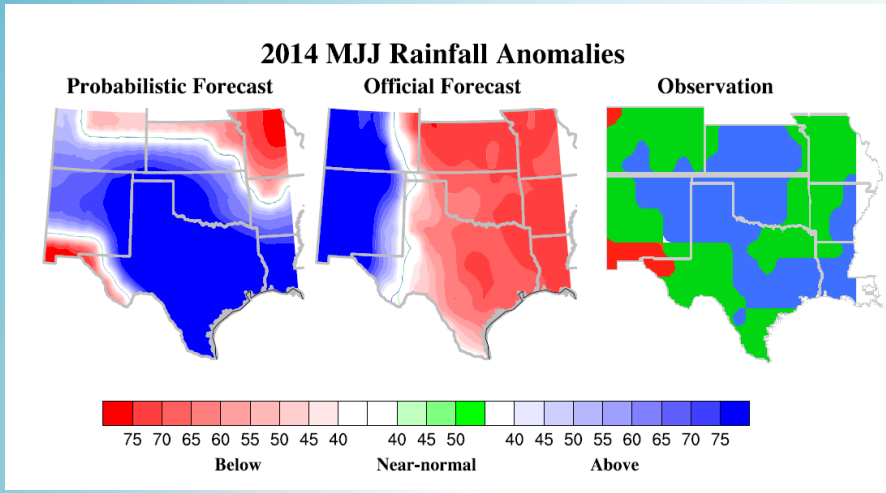
winter **spring** **summer**

- ***The statistic prediction out-performs the state-of-art dynamic prediction (NMME ensemble seasonal prediction for 1982-2013)***





Experimental prediction to support state government decision:

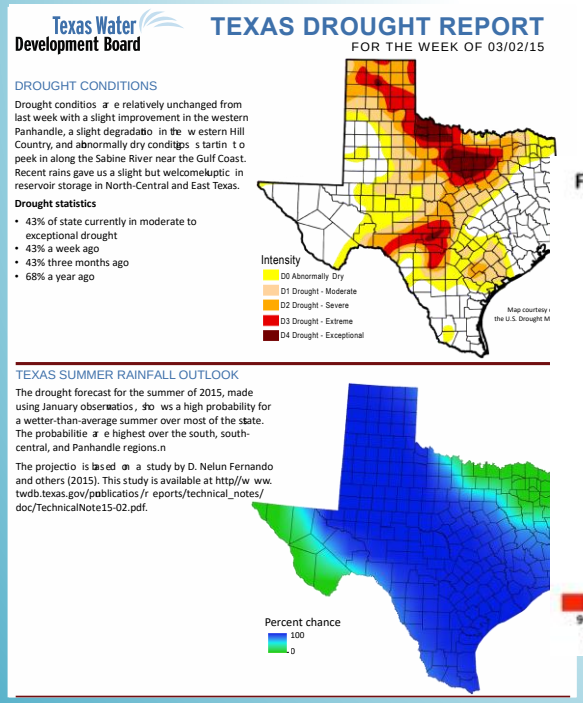


Texas Water Development Board publishes study on drought indicators

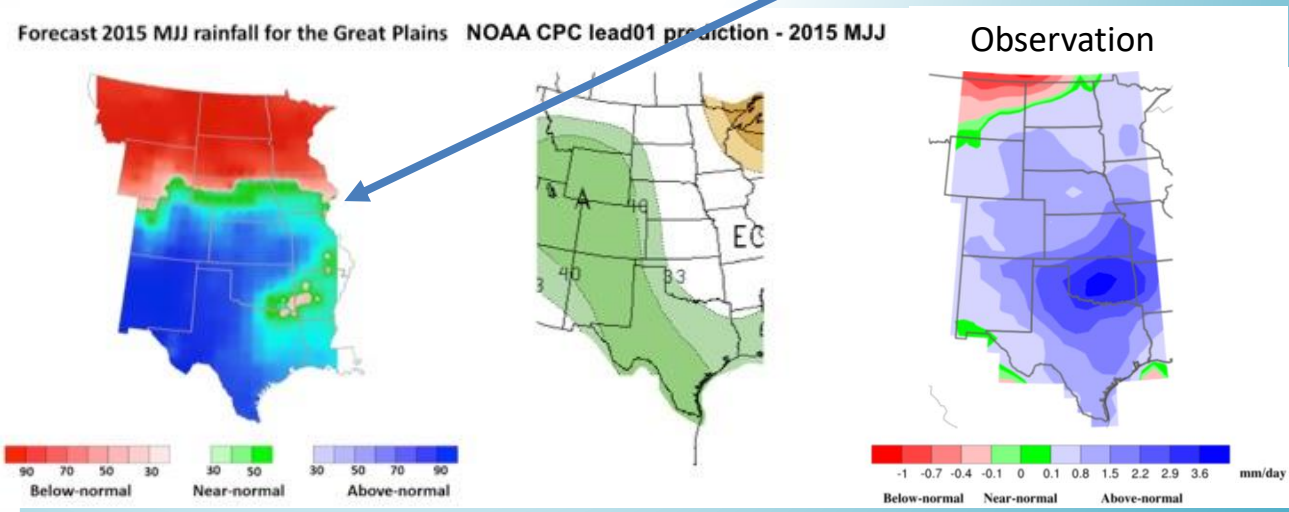
For immediate release. Contact: Kimberly Leggett at 512-463-5129

AUSTIN – (February 3, 2015) – The Texas Water Development Board (TWDB) in coordination with The University of Texas at Austin's Jackson School of Geosciences announces the publication of a study on indicators for the early warning of drought in Texas.

The study observed that certain climatic conditions in the spring, such as atmospheric pressure and soil moisture, can be used to better predict drought over Texas in the summer. The study participants developed a statistical model that is about 70 percent effective in predicting summer precipitation. The model successfully predicted rainfall conditions for last summer. "If we can predict summer drought in April, or as early as January, water providers have more time to prepare," explained the lead author of the study, Dr. Nelun Fernando of the Texas Water Development Board.



Collaboration with TWDB and JPL/SMAP



Explore more effective state drought policy based on improved drought/flood risk early warning information:

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**
  - 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.

Improving Projection of Future Summer Drought/Flood Risk for US Great Plains:

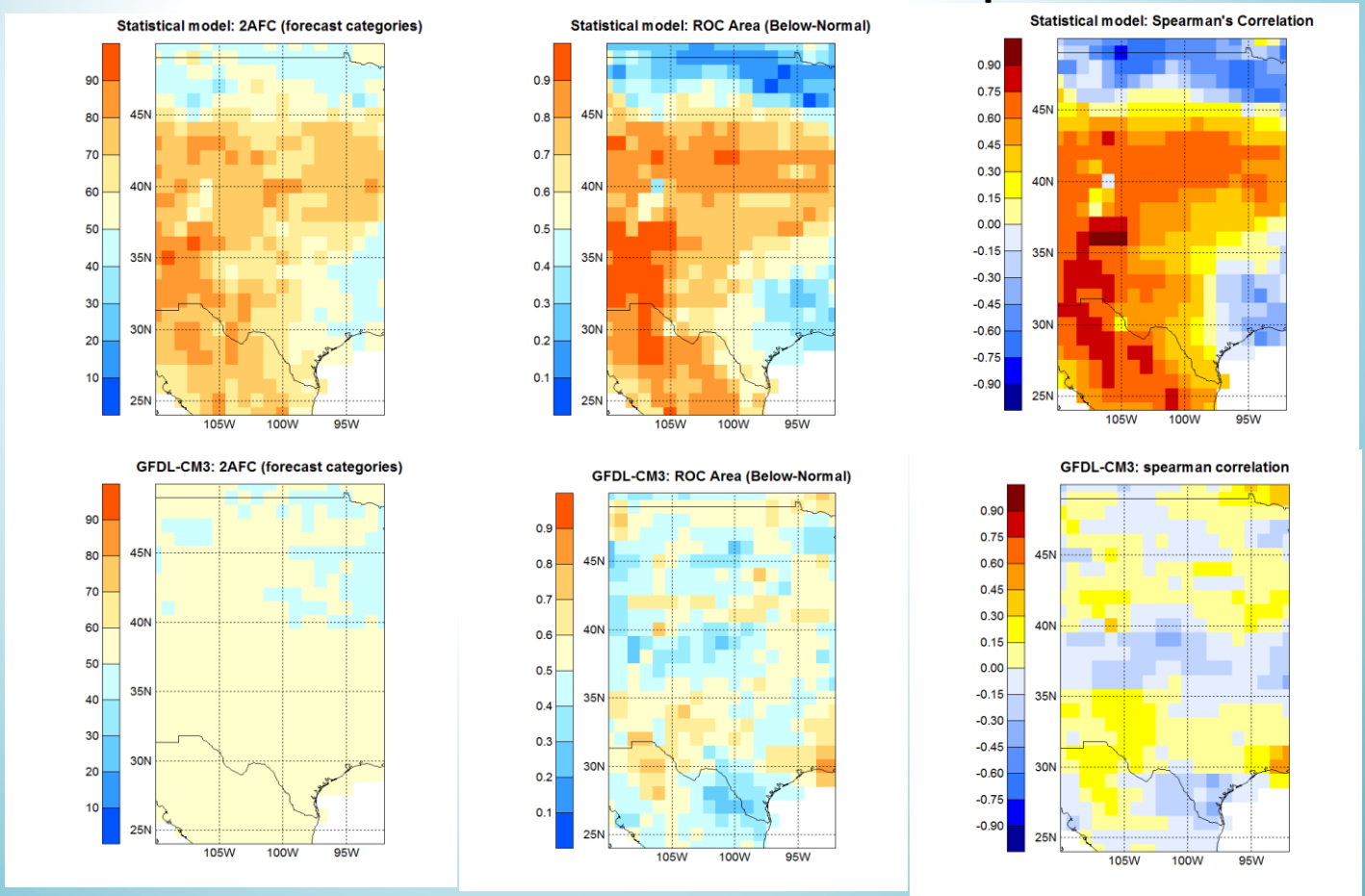
- ***An hybrid dynamic-empirical prediction with improved seasonal prediction skills and used by stake holders can provide a more trustworthy and meaningful climate projection.***

Prediction skills: **2AFC** **ROC** **Spearman's correction**

GFDL-CM3:

hybrid dynamic-empirical prediction skills

GFDL-CM3 Dynamic AMIP prediction skills



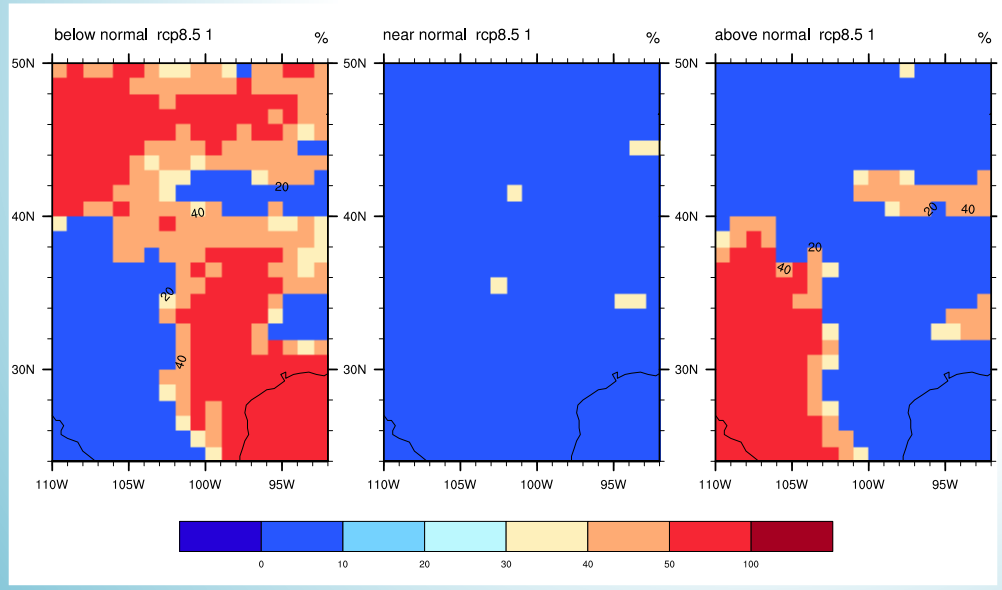
Projected May-July rainfall change for Mid-21st century for US Great Plains (2036-2065) – (1976-2005)

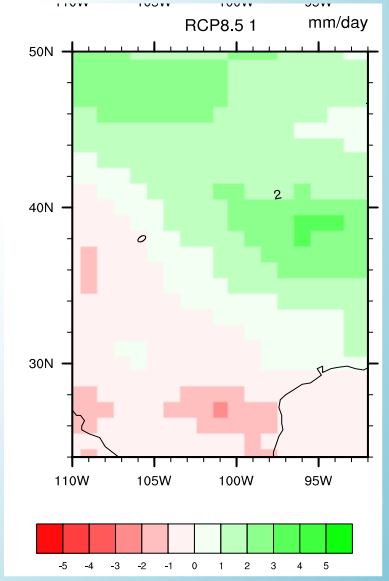
More trustworthy and actionable future climate information

Hybrid GFDL-CM3-statistical projection **original GFDL-CM3**

Below near Above

RCP8.5





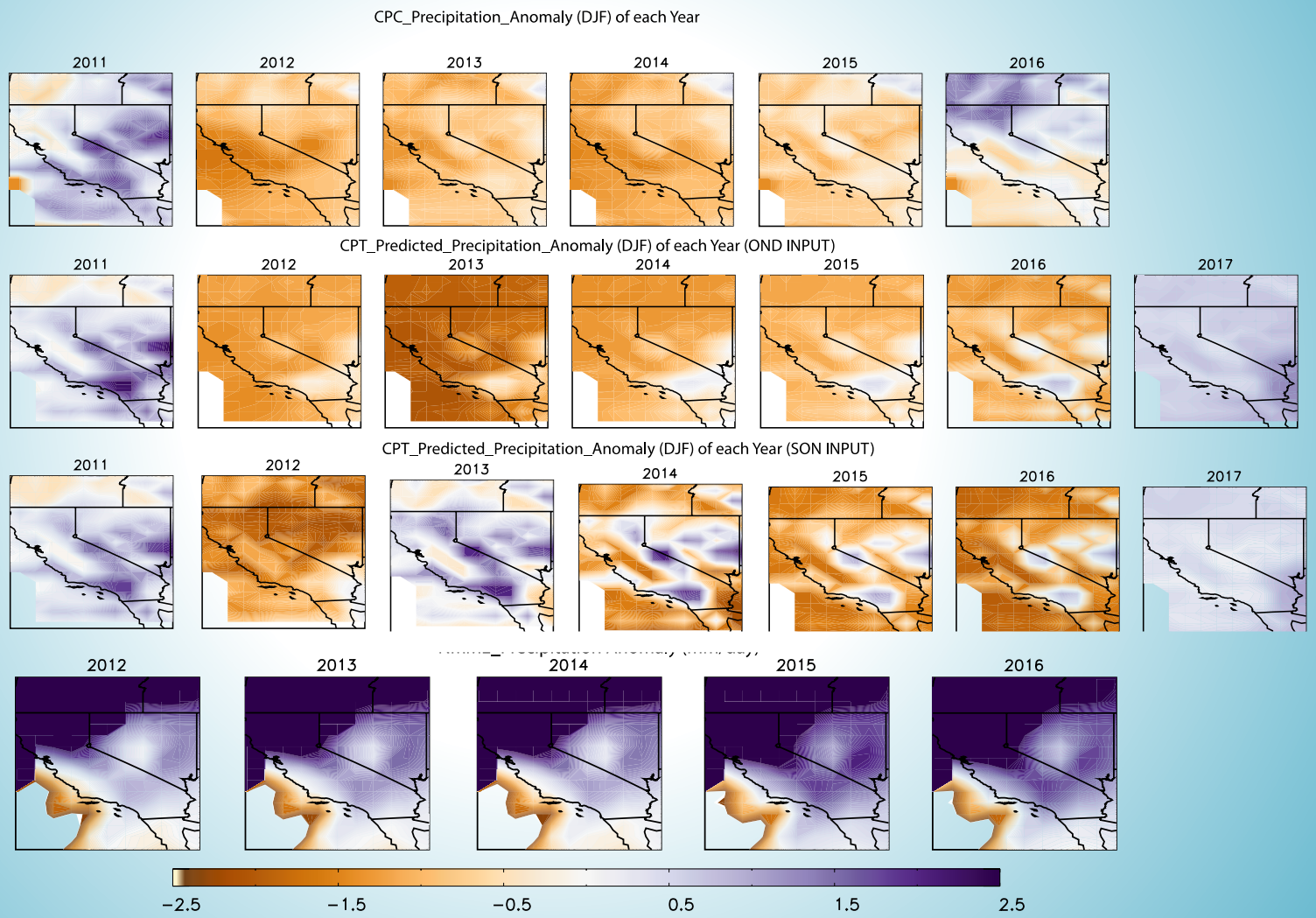
Preliminary results for winter rainfall anomalies prediction over the California/Nevada region:

CPC Precip

Statistical prediction 2-mons leadtime

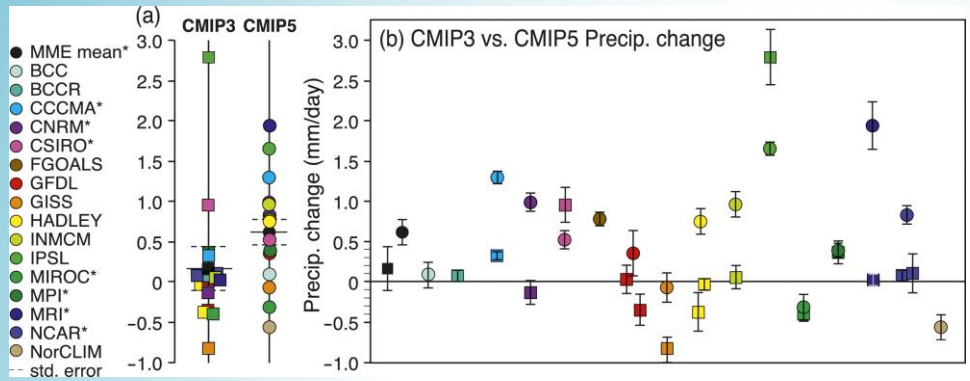
Statistical prediction 3-mons leadtime

NMME prediction 3-mons leadtime

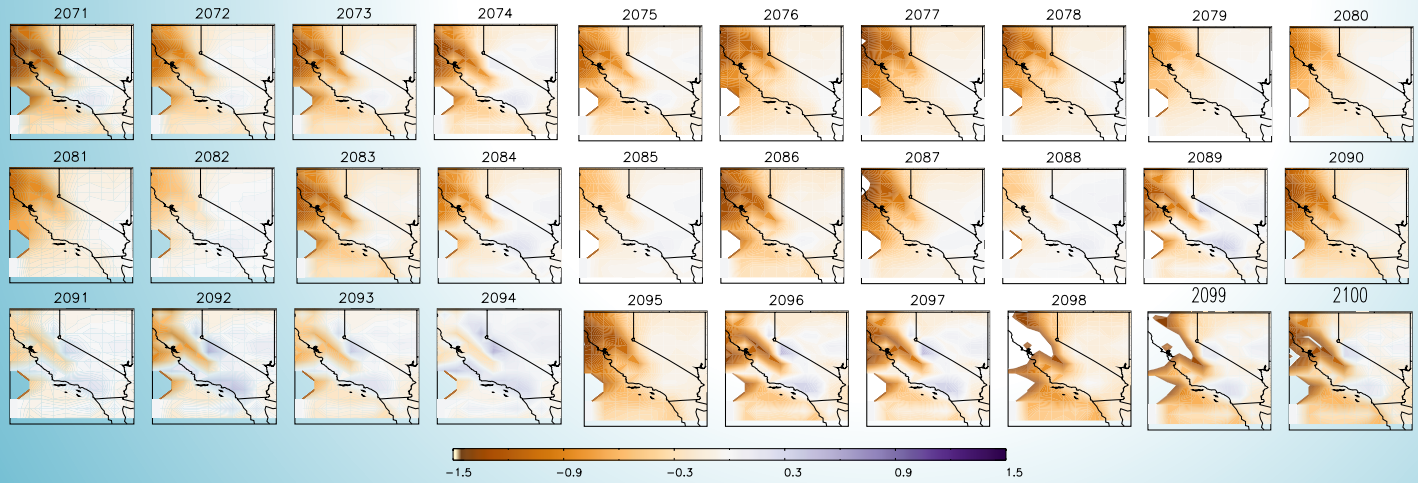


Standardized rainfall anomalies (1979-2010 climatology

A hybrid dynamic-statistical projection of future winter rainfall change (2050-2100)



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



Hybrid dynamic-statistical projection: Strong drying over northern California (2071-2100 relative to 1979-2010)

Figure 7. Anomalies (mm/day) in DJF precipitation of each year from 2051 to 2100 using RCP 8.5 scenario. Anomalies are calculated by subtracting mean precipitation between1979-2010 estimated by using CPC datasets from the predicted precipitation using RCP 8.5 scenario by CPT. Input parameters are Z850as well as Z250 over the [illegible]

Conclusions:

- *An improved understanding of drought mechanisms and climate models' uncertainty has enabled us to develop an hybrid physical-empirical climate prediction/projection to mitigate the uncertainty of imperfect climate models.*

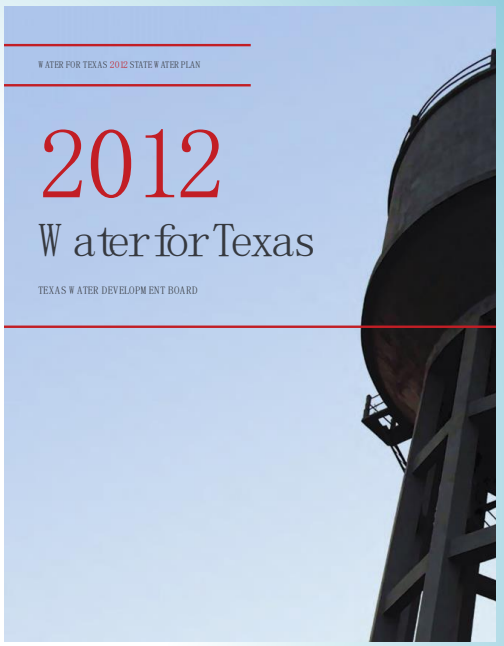
- *By improving seasonal rainfall prediction, we improve the trustworthiness of the climate projection in support society's adaption to future drought change.*

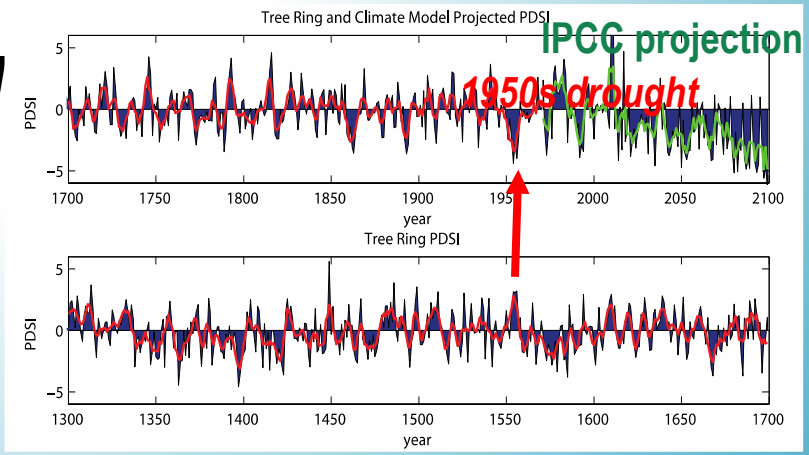
Final Remark:

- ***How do we connect science to societal needs?***
  - **An seamless approach to climate prediction/projection and application can be an effective way**
  - **Listen to stakeholders' needs and produce actionable climate information for decisions now can build trust and allow decision makers to calibrate their decisions for future climate change.**

High Stakes of Future drought Projection

- ***The economic loss: $116 billion should a drought of the 1950s occur around 2060.***
- ***The capital cost of implementing strategies to mitigate such a potential economic loss: $53B.***
- ***In response to the 2011 drought over Texas, the Texas Administrative Code § 358.1 (1) on Guidance Principles for the State Water Plan Development require all regional water plans to have a chapter dedicated to drought response.***





Banner et al. 2010

Projected May-July rainfall change for Late-21st centry for US Great Plains (2071-2100) – (1976-2005)

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original GFDL-CM3

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near

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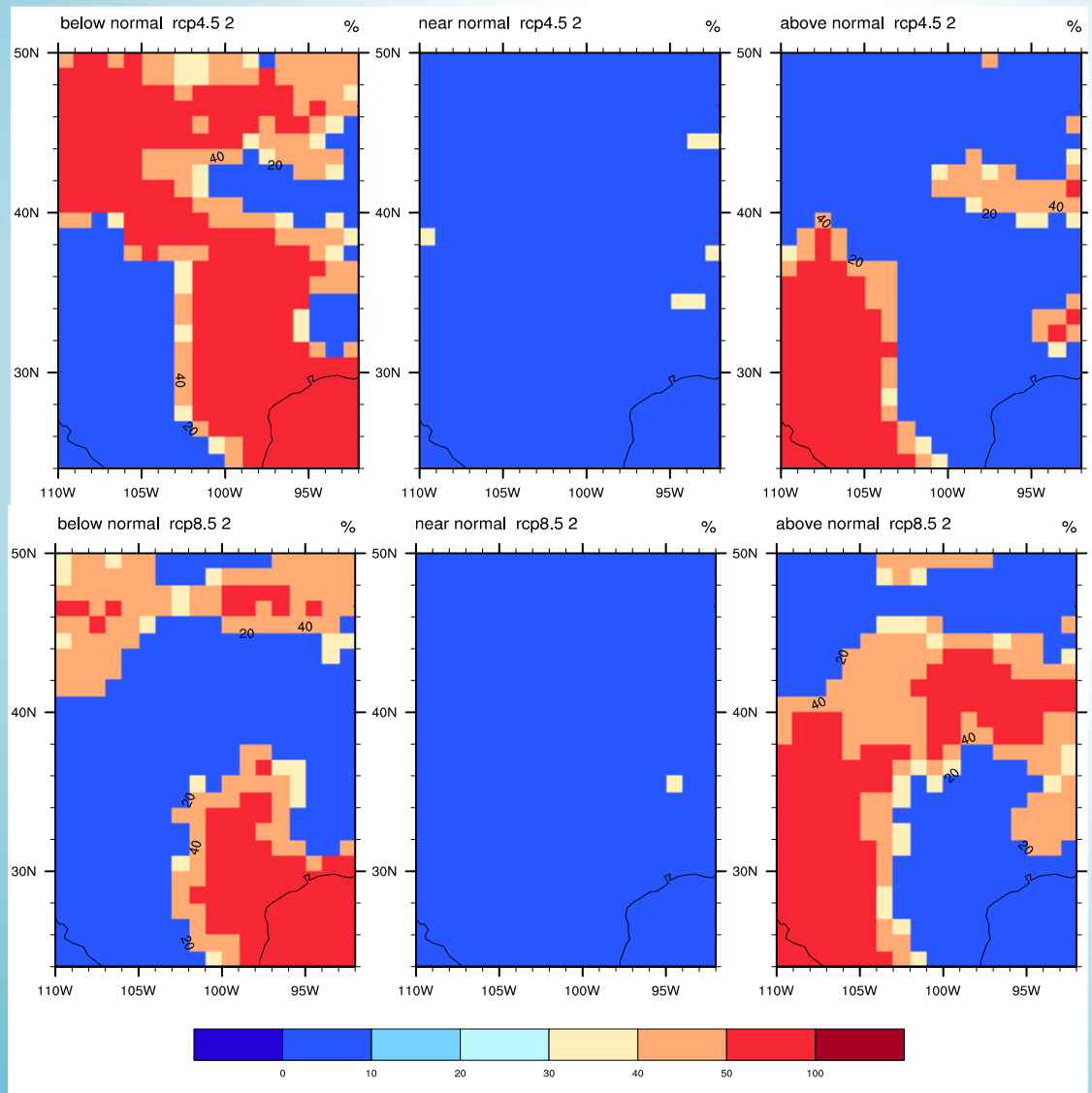
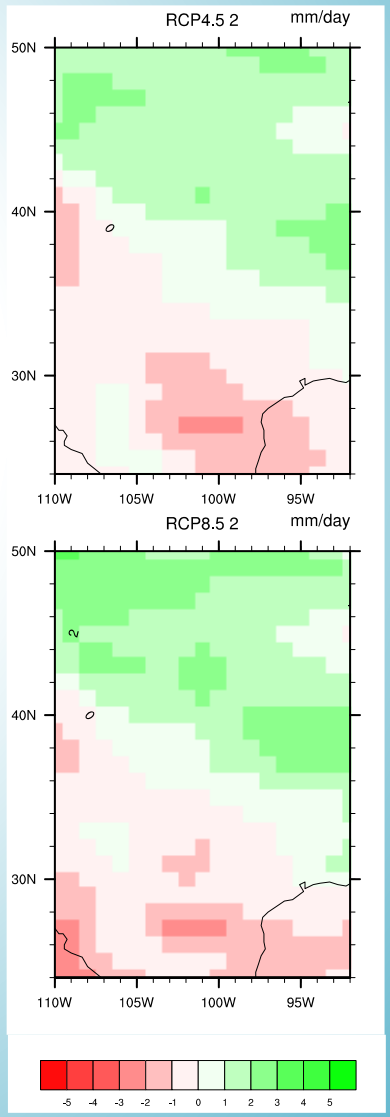
RCP4.5

RCP8.5





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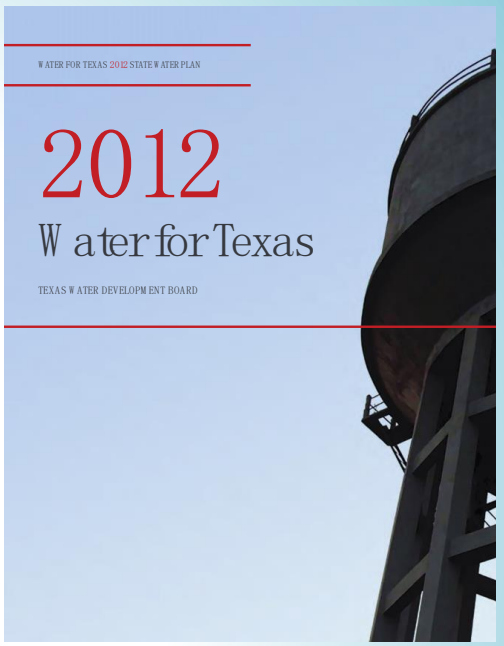

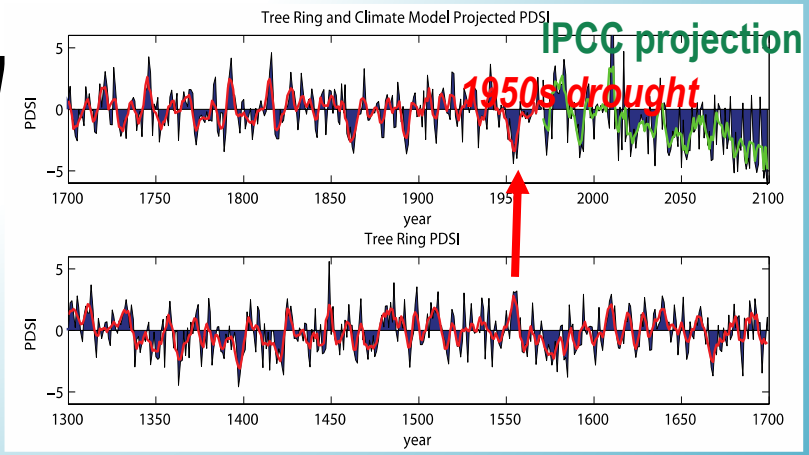

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