



**Developing a summer drought early
warning indicator to support regional
resilience to extreme climate events over
the US Great Plains**

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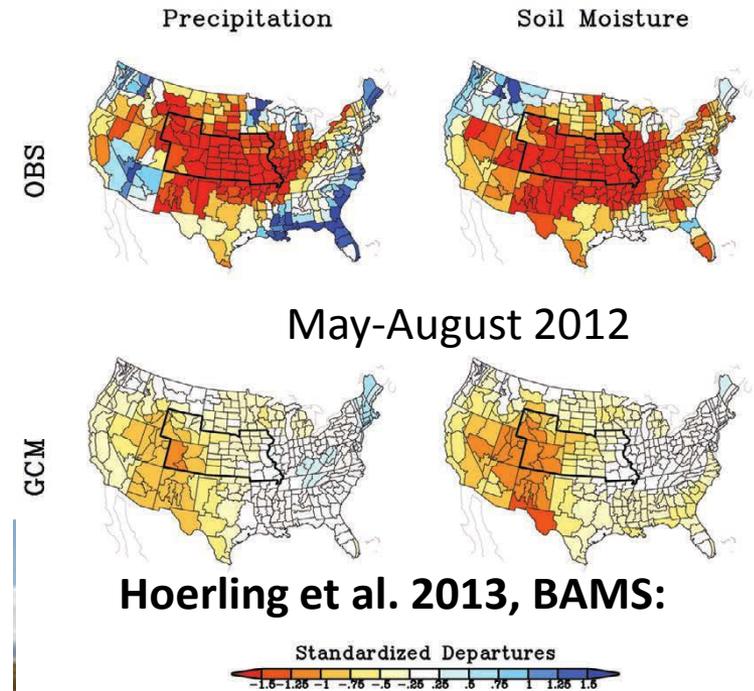
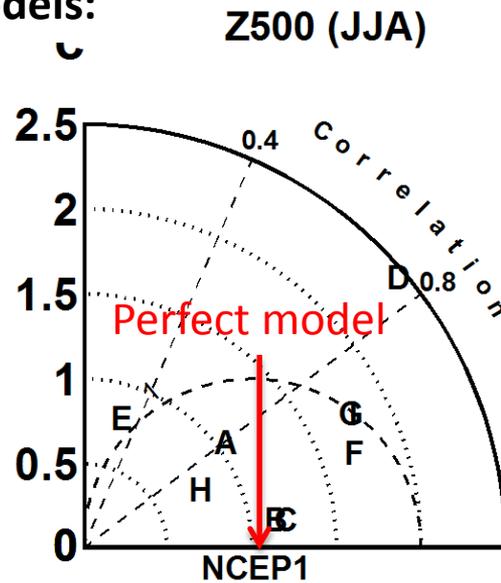
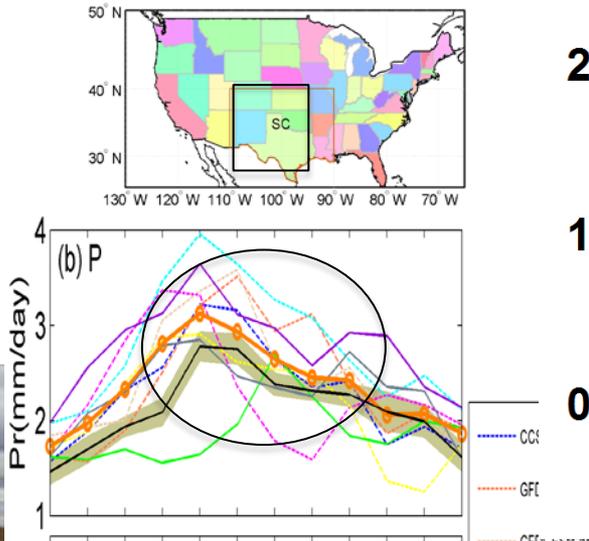


- ***Extreme summer droughts are one of the most costly natural disasters over US and world wide (e.g., in US, \$11.3B in 2011, \$14B in 2012).***
- ***US Great Plains have significant impact on global food security (e.g., 6% global food price increase in July 2012).***
- ***Develop early warning of extreme droughts is the highest priority of NIDIS-Phase 2 (Drought Information Act of 2013, S. 376; 113th Congress)***

Challenges:

- 2012 IPCC Special Report on Extreme Climate shows **low to medium** confidence on projected changes of droughts over US Great Plains (Field et al. 2012).
- CMIP5 models have shown large uncertainty in simulating summer rainfall, land surface conditions and even large scale circulation over US Great Plains.
- Seasonal forecast unable to predict major summer droughts in recent years, and does not show more skill than autocorrelation (Guan et al. 2012).

Fu et al. 2014, CMIP5 models:



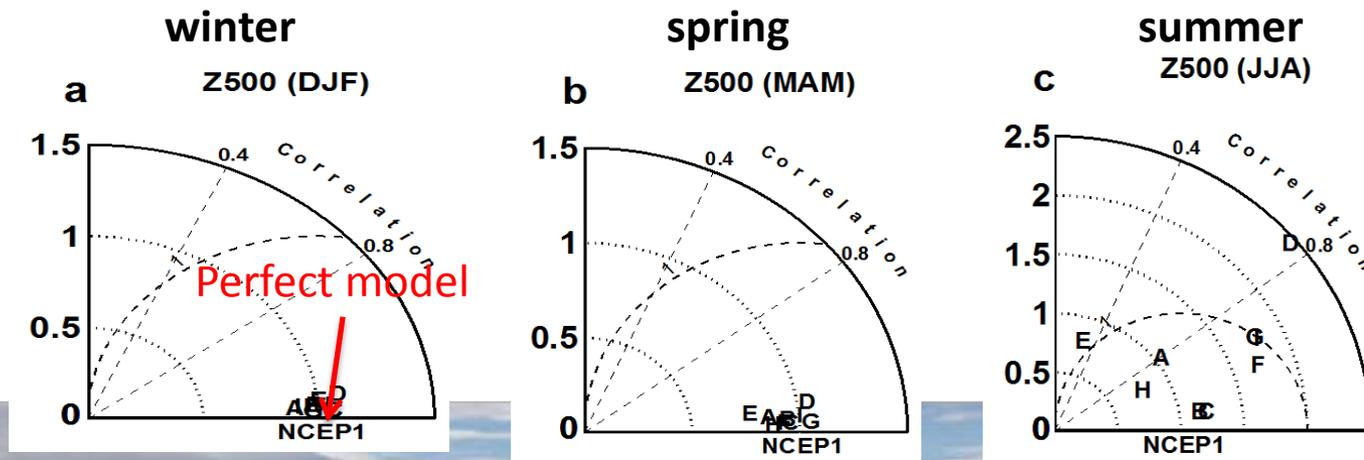
Objectives:

- Provide early warning about the risk of flash droughts in **summer** based on its observed relationship with the large-scale circulation and land surface conditions in **winter** and **spring**.
 - Mitigate the influence of models' weakness on summer drought prediction.
 - Provide clear and concise actionable information about the drought.



Rationale for an observational-process based summer drought early warning indicator

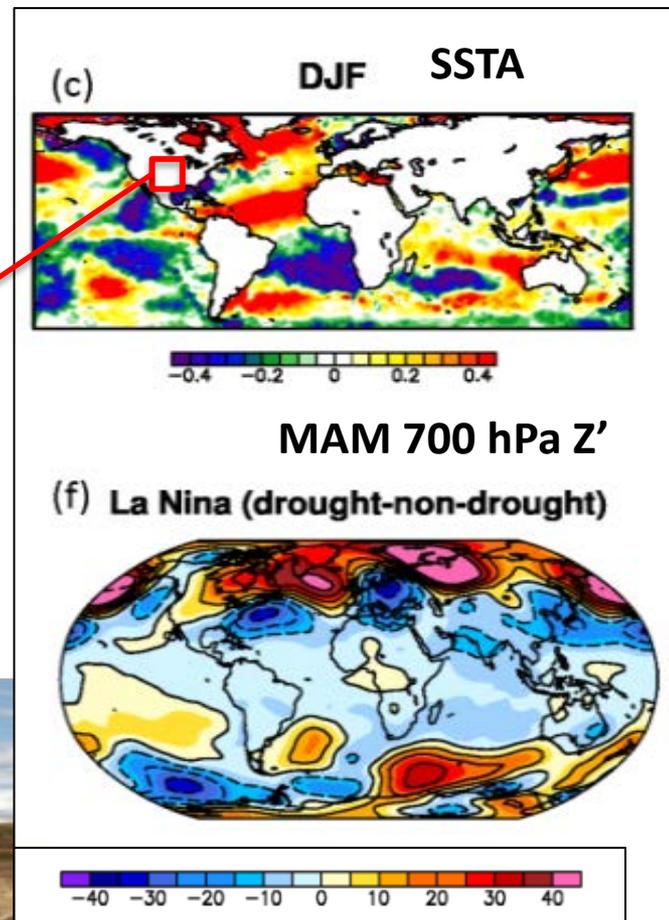
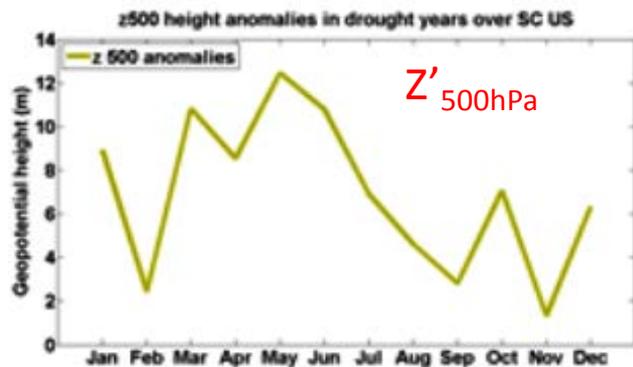
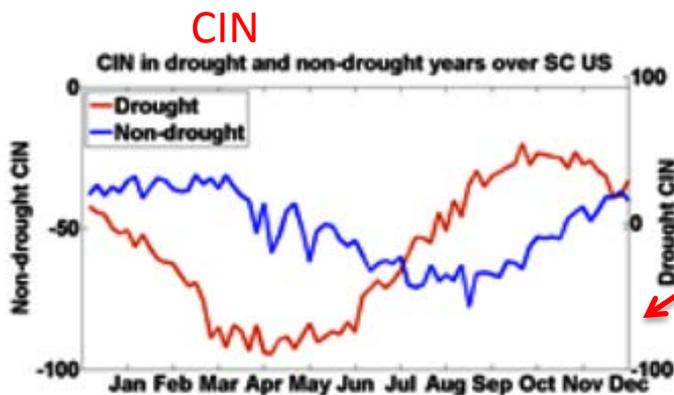
- CMIP5 climate models more realistically simulate the winter and spring large-scale circulation over US Great Plains than that in summer.
- Climate predictions show high skills for winter and spring seasons, than for late spring and summer for US (e.g., Guan et al. 2012, Hoerling et al. 2012).
 - To mitigate the summer droughts in **summer** based on its observed relationship with the large-scale circulation and land surface conditions in **winter** and **spring**.



Fu et al. 2014

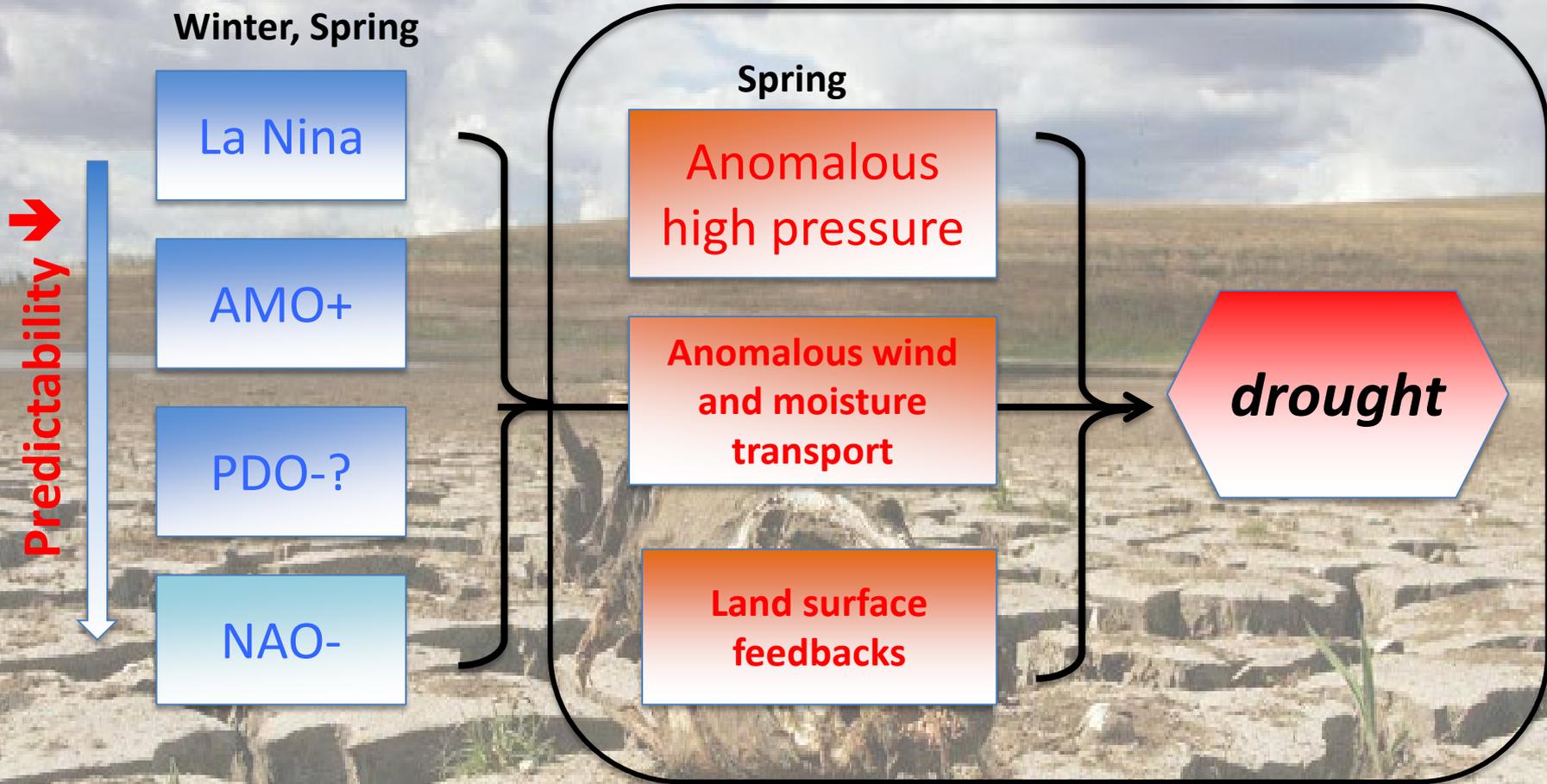
Scientific basis:

- Summer extreme droughts can be linked to distinctive anomalous circulation pattern, strongly enhanced lower tropospheric thermodynamic stability and surface dryness in spring (Fernando et al. 2014).



Composite DJF SSTA and MAM 700 hPa Z' for La Nina with subsequent summer droughts (3) and the La Nina without summer droughts (15) over SGP for the period of 1901-2012.

Construct the drought early warning indicator:



Statistical model:

1. **Originally proposed local (areal averaged) drought early warning indicator: Partial Least Square regression (PLSR)**

$$SPI6_{i+3} = A dZ^*_{500hPa,i} + B d(T_{700hPa} - T_d)_i + C dSM_i + \text{residual} \quad (\text{F-1})$$

Term 1: April geopotential height anomalies

Term 2: Anomalies in the difference between temperature at 700 hPa and surface dewpoint in April (proxy for CIN)

Term 3: Anomalies in land surface moisture)

A, B and C are the regression coefficients determined by PLSR.

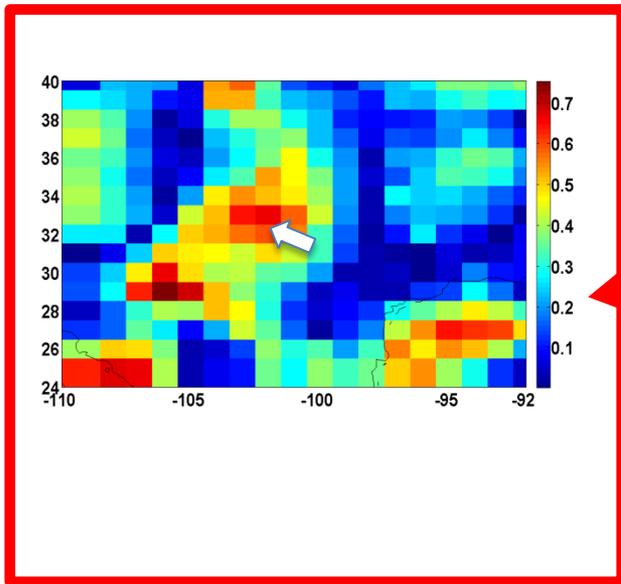
2. **New Multivariate Principal Component Regression model: Identify the leading EOFs of the inputs and predicted fields; apply multivariate regression to the PCs to obtained relationship between the predicted and input fields; and construct a spatial field of the drought early warning indicator using the Climate Predictability Tool (IRI, Columbia University).**

4. **Use data during 1982-2005 for training the model and 2006-2013 for validation.**

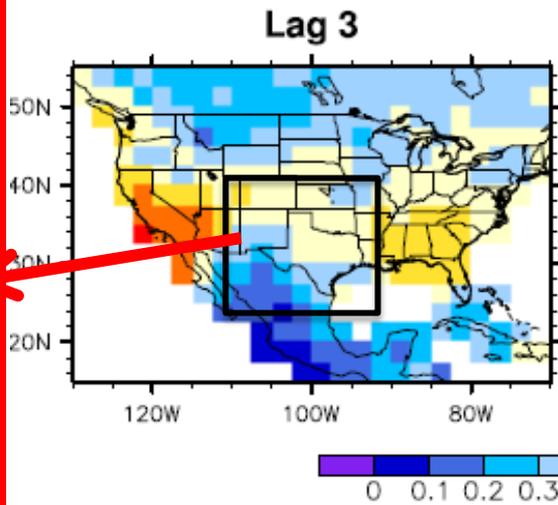


- The drought early warning indicator shows higher skill than the baseline and the dynamic prediction.*

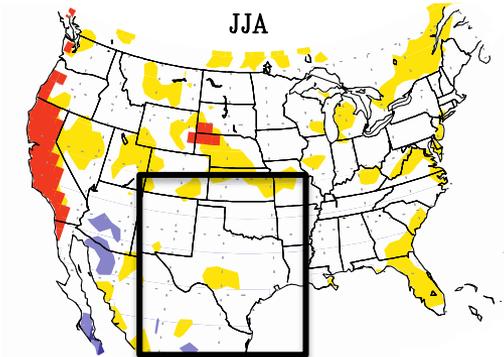
Correlation between observed and predicted July SPI6



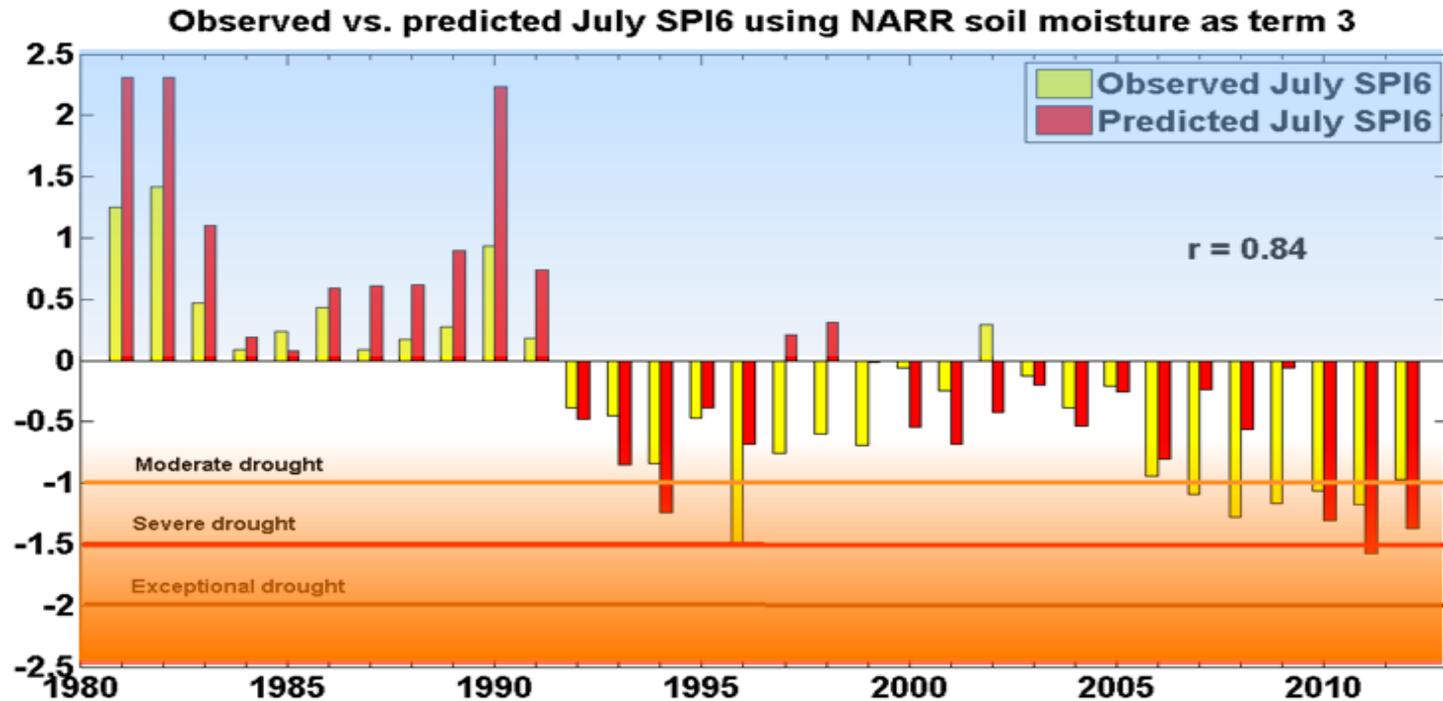
Baseline, autocorrelation of the observed SPI6, Lyon et al 2012



NOAA CFSV2 Dynamic prediction, Quan et al 2012



More detailed information about past performance (hindcasts) of the Indicator at each location



Hindcasts qualitatively capture the general pattern of the 2011 and 2013 summer drought

July 2011 predicted

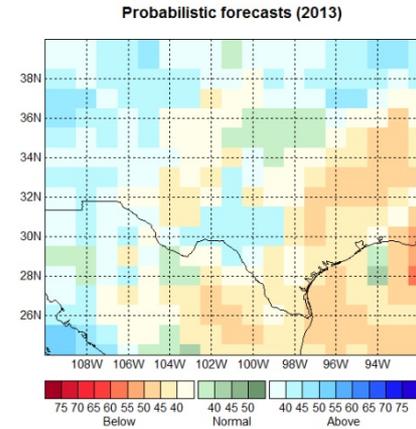
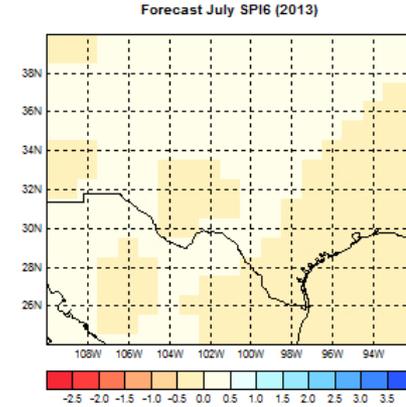
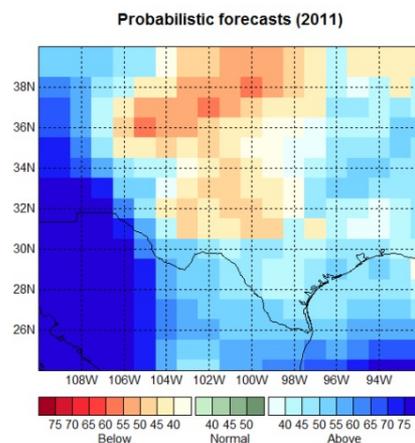
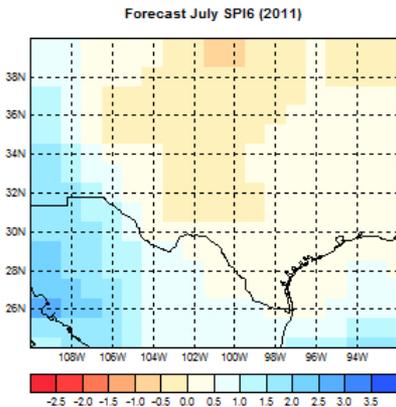
SPI6 actual values

SPI6 probabilistic

July 2013 predicted

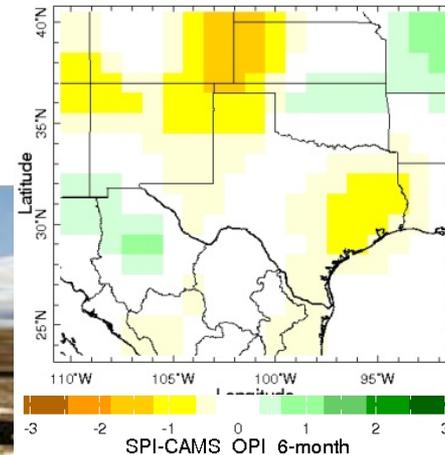
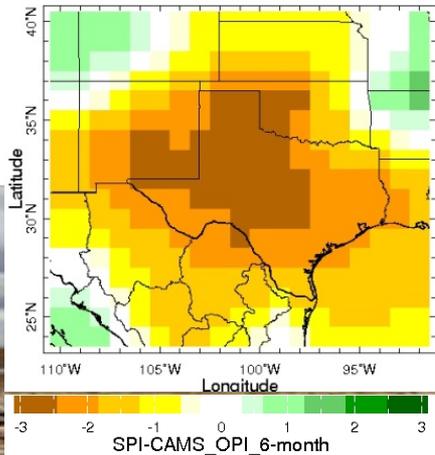
SPI6 actual values

SPI6 probabilistic



Observed SPI6

Observed SPI6



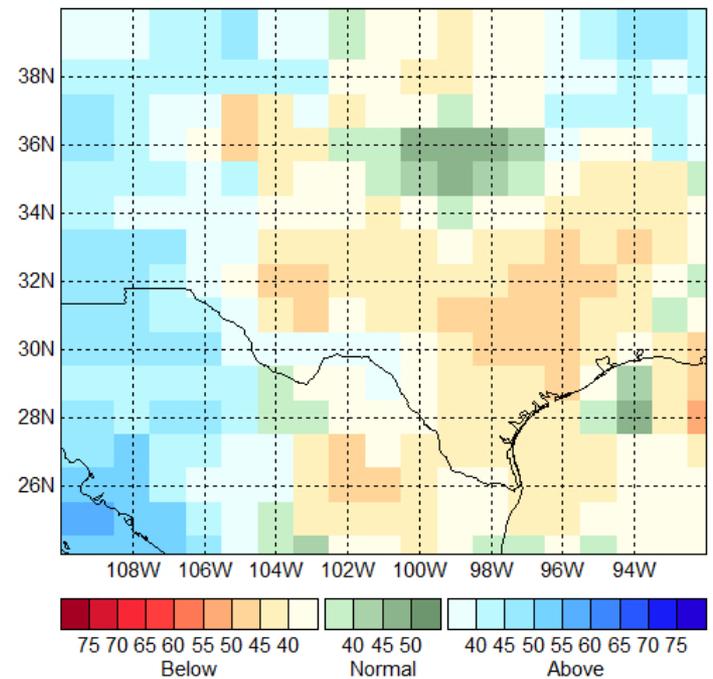
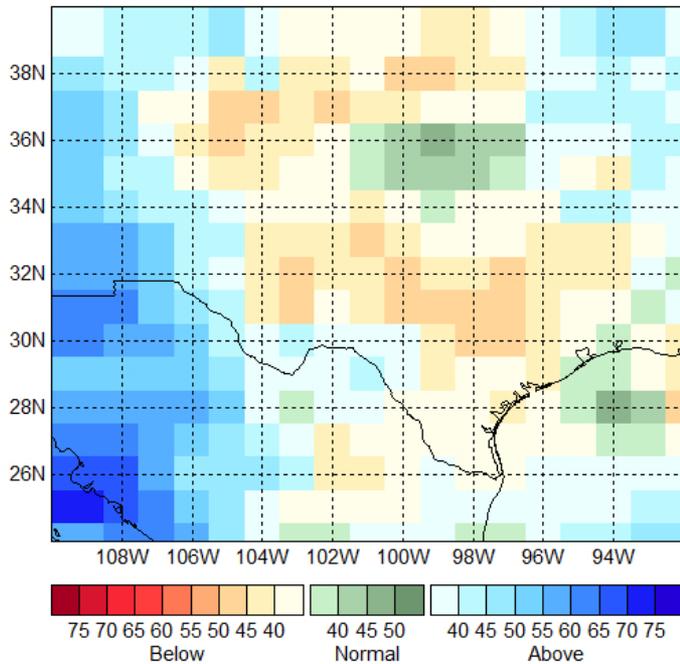
Predicted Summer drought risk in 2014

**With February 2014
initial conditions
from CFSv2**

**With March 2014
initial conditions**

Probabilistic forecasts (2014)

Probabilistic forecasts



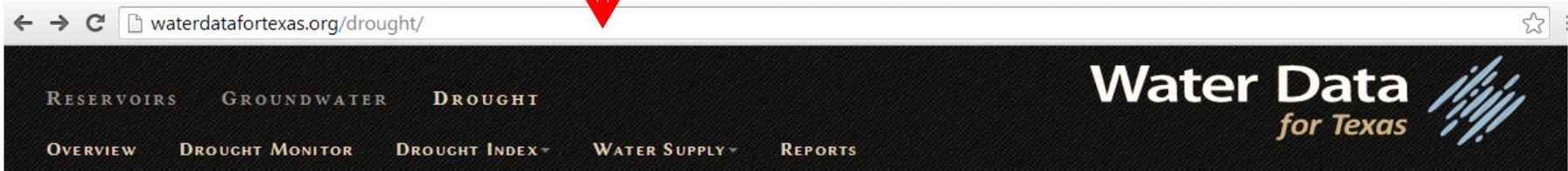
Communicating the Indicator to Users:

- *Through TWDB website and network to reach broad users in the states*

TWDB:

- *Tasked with preparing the state water plan with a 50 year planning horizon and providing funds for water projects*
- *Member of the Texas Drought Preparedness Council and the Emergency Drinking Water Task Force*
- *Provides all manner of water related information to public*

- *State legislature and voters approved allocation of US\$ 2 billion from the Texas Rainy Day Fund to fund water projects in response to 2011 exceptional drought.*



Drought in Texas

Texas is no stranger to drought. The seven-year drought of record in the 1950s was a turning point in Texas history that led to the formation of the Texas Water Development Board. Since then, Texas has faced several droughts including the most recent and most severe drought that began in 2011. This website brings together relevant resources, links, data and analyses to provide updated information on drought in Texas.

Texas is a big place and we don't always get to see what is happening in different regions of our great state. Texas Parks and Wildlife (TPWD) and the TWDB invite the public to help us capture what the drought looks like for folks across the state by sharing drought-related photographs on [Flickr](#).

Next Step:

Scientifically integrity (large to regional scale, limitation of the predictability)



Stakeholder's need (high spatial resolution, 6 months lead time)

- Further improve the skill of the indicator using NASA model and satellites data products (e.g., MERRA, GRACE, MODIS, NLDAS and ESA soil moisture);
- Explore downscaling and bias correction for climate model simulations and projections for droughts.
- Explore the limit of the indicator
- Communicate to the users through TWDB website and the state drought preparedness council.
- Share results with NIDIS

Explore collaborations with the indicators PIs: e.g., Alex Ruane, Chris Potter, Jim Collatz, Daniel Tong)



Summary and Next Step:

- *Progress:*
 - *The drought early warning indicator based on anomalous climate conditions in spring for US Southern Great Plains has better skill than the dynamic prediction on seasonal scale, and potentially more creditable assessment of future summer droughts than the original projection by the CMIP5.*
- *Next Step:*
 - *Refine and clarify the uncertainty of this drought early warning indicator based on users' feedbacks*
 - *Use NASA data as inputs*



