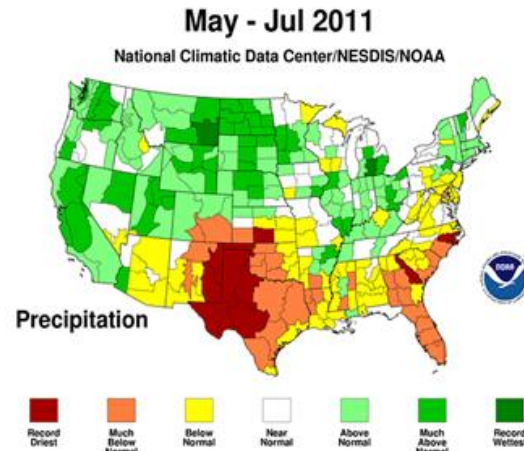
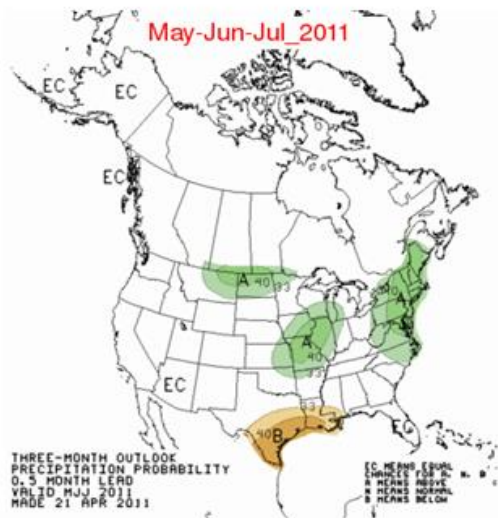


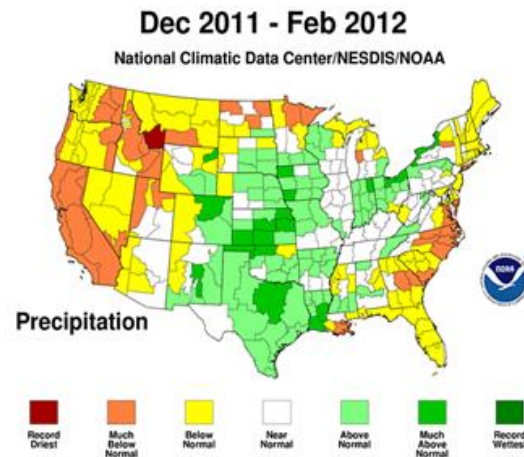
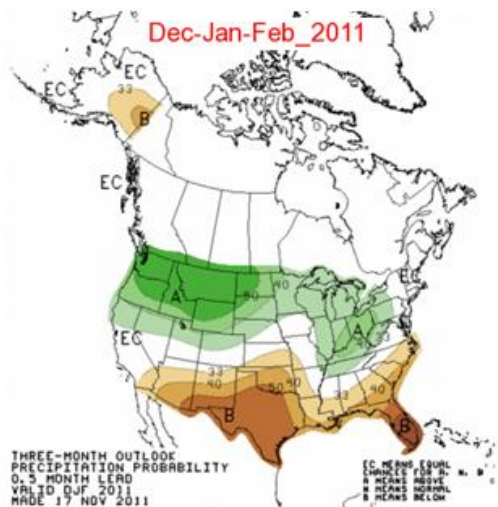
***Statistical forecasts of May–July seasonal  
rainfall over Texas  
and  
the use of S2S climate information by the  
Texas Water Development Board***

*Nelun Fernando, Ph.D.*

# 2011: record drought; double-dip La Niña



**Spring intensification not forecast**



**Drought conditions forecast for Dec-Feb 2011/2012 based on La Niña**

**Positive NAO resulted in more moisture transport from the Gulf > ended meteorological drought**

# Background on drought in Texas

- Strong summer droughts are characterized by the rapid intensification in the spring/early-summer
- 92% of strong summer droughts (going back to 1895) had anomalously low rainfall in the spring
- Dry springs lead to an anomalously high atmospheric pressure system over Texas > subsidence and a reduction in rainfall
- Once set up, the high pressure system tends to persist (i.e. hotter, less rainfall, even hotter, etc.) through the summer

*Reference: Fernando et al. (2016), What caused the spring intensification and winter demise of the 2011 drought over Texas?. Climate Dynamics, pp.1-14.  
(doi:[10.1007/s00382-016-3014-x](https://doi.org/10.1007/s00382-016-3014-x))*

# Seasonal rainfall forecast tool

- **We\*** developed a process-based statistical model to predict May–July (MJJ) rainfall over the south central US (110W–92W; 24N–40N)
- Key processes active in the spring (**April**) that drive summer rainfall deficits:
  - *Geopotential height at 500 hPa (~3 km above land surface)*
  - *Convective inhibition energy (prevents convective rainfall processes)*
  - *Soil moisture*

\* TWDB (Water Science and Conservation Division) and Rong Fu's research group at the Univ. of Texas at Austin (funding from: CPO MAPP and NASA Indicators for the NCA Program)

Reference:

[http://www.twdb.texas.gov/publications/reports/technical\\_notes/doc/TechnicalNote15-02.pdf](http://www.twdb.texas.gov/publications/reports/technical_notes/doc/TechnicalNote15-02.pdf)

# Seasonal rainfall forecast tool (cont.)

- Model trained using reanalysis (CFSR, Saha et al., 2010) data
- Hybrid dynamical-statistical forecasts using 3- to 1-month lead forecasts of April predictor fields from CFSv2 (Saha et al., 2014).
- Model created using Canonical Correlation Analysis with the Climate Predictability Tool developed by IRI  
(<http://iri.columbia.edu/our-expertise/climate/tools/cpt/>)

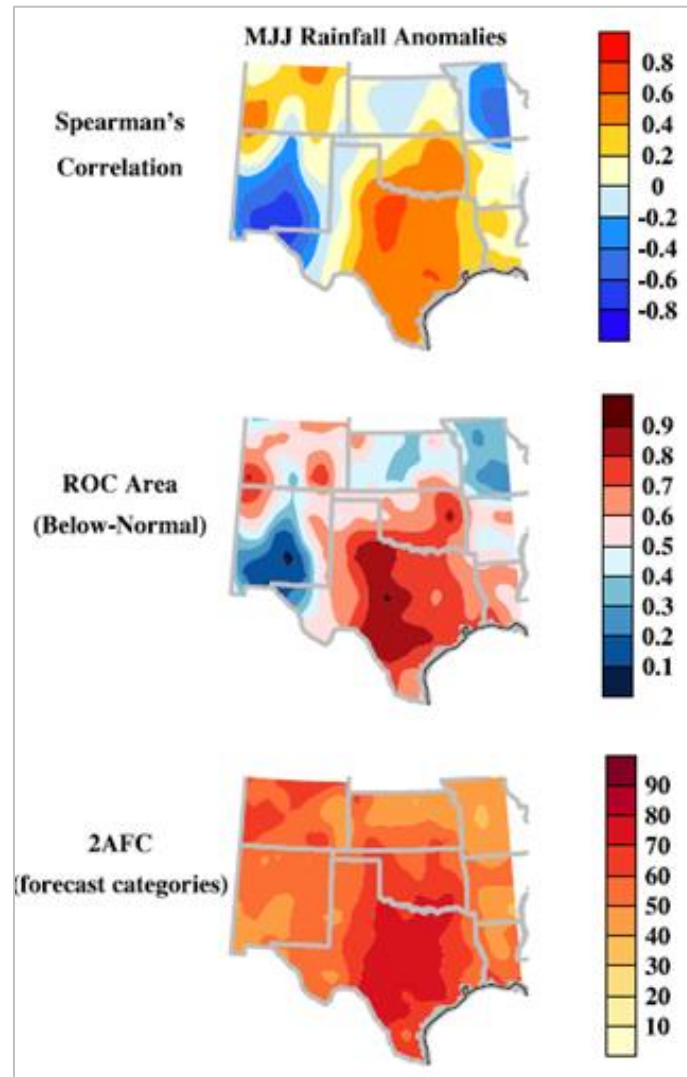
## References:

[http://www.twdb.texas.gov/publications/reports/technical\\_notes/doc/TechnicalNote15-02.pdf](http://www.twdb.texas.gov/publications/reports/technical_notes/doc/TechnicalNote15-02.pdf)

*Fernando et al. (in-prep), WRR*

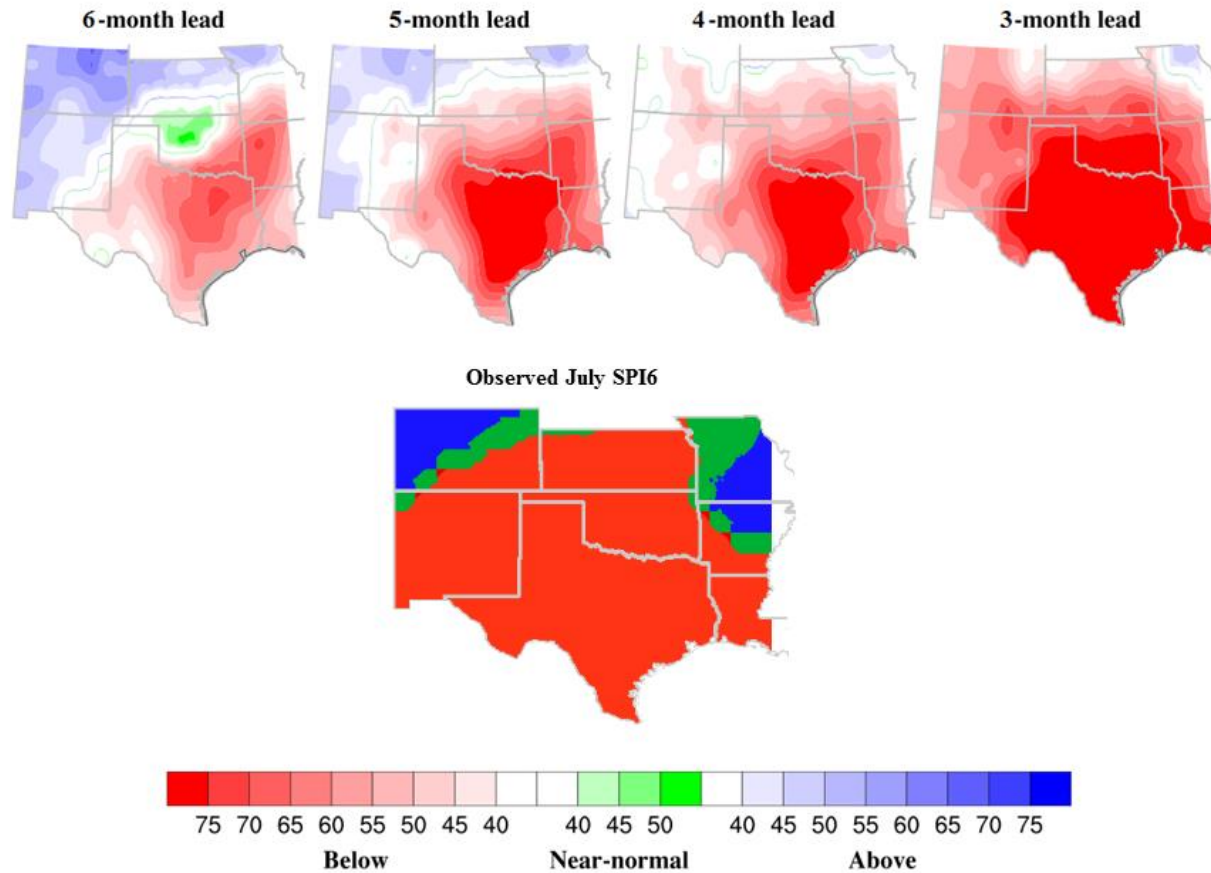
# Skill of the rainfall forecasts

Forecast skill level exceeds skill due to persistence (i.e. autocorrelation) over most of Texas and Oklahoma.



# Hindcast of summer 2011

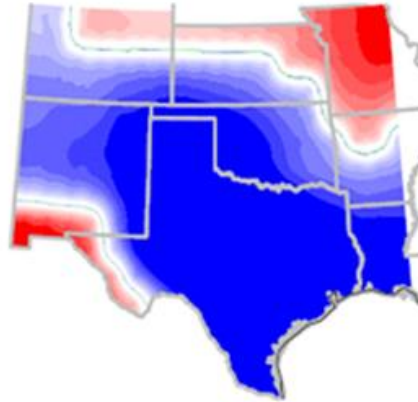
6-,5-,4- and three-month lead probability forecasts of July SPI6, 2011





# Skill in capturing past dry/wet events

## TWDB/U. Texas forecast 2014 MJJ rainfall

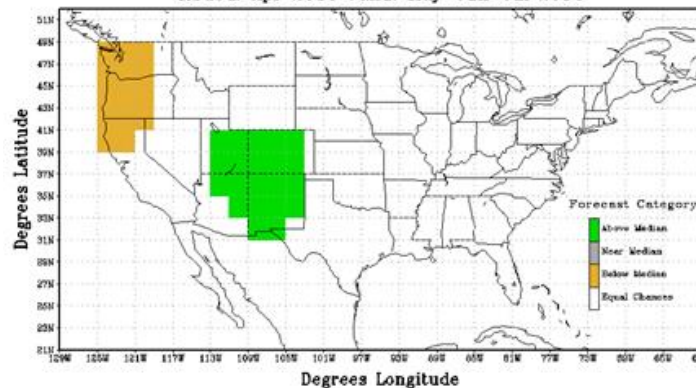


Below

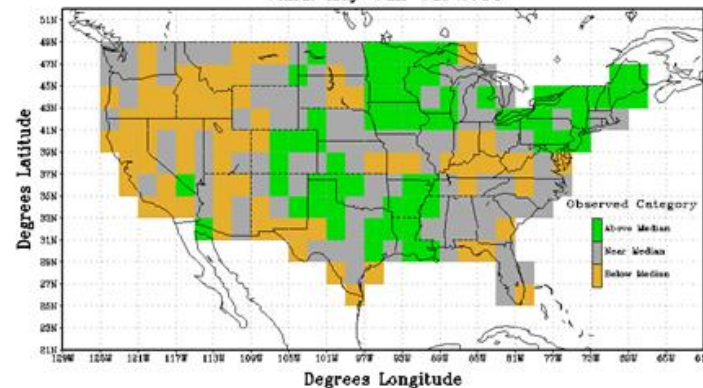
Near-normal

Above

Categorical Precipitation Official Forecast  
Issued: Apr 2014 Valid: May-Jun-Jul 2014



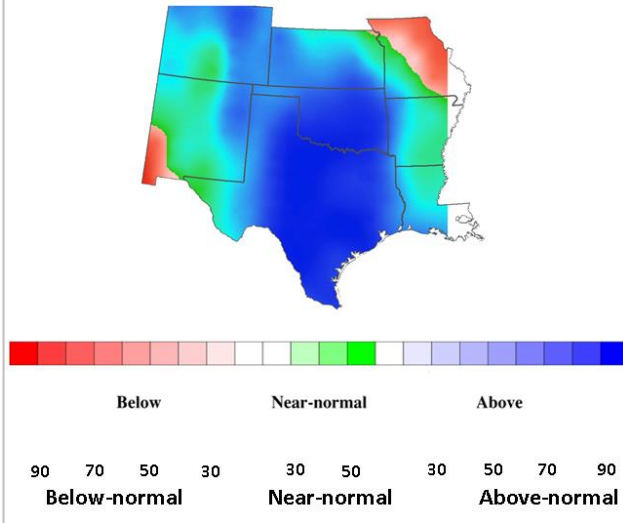
Categorical Precipitation Observations  
Valid: May-Jun-Jul 2014



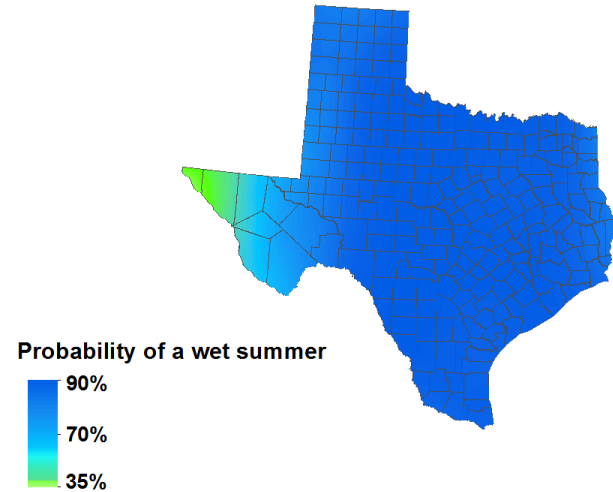


# Forecast for MJJ 2015 and 2016

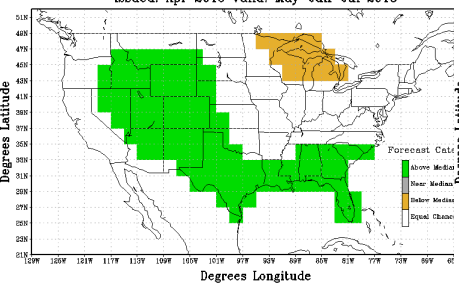
TWDB/U. Texas forecast 2015 MJJ rainfall  
With April observations



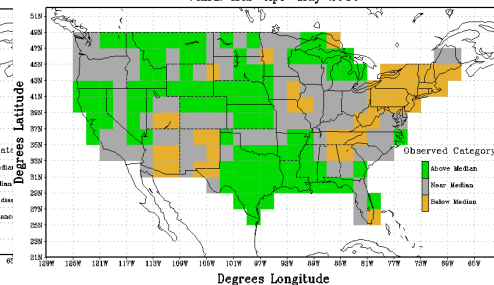
2016: May to July Rainfall Probability  
(Based on April Observations)



Categorical Precipitation Official Forecast  
Issued: Apr 2015 Valid: May-Jun-Jul 2015



Categorical Precipitation Observations  
Valid: Mar-Apr-May 2016



***Forecast reported in the Texas Water Conditions Report for May 2016, issued in the first week of May 2016.***

# What role does TWDB play in drought preparedness planning?

# TWDB, drought, and the state water plan

- The Texas Water Development Board (TWDB) is the state agency tasked with developing and securing water for Texas
- TWDB prepares a state water plan (SWP) based on 16 regional water plans
- Plan addresses needs of all water user groups during a repeat of the 1950s drought of record
- **Post 2011 drought (rule modification):**
  - Plans must provide for the preparation for, and response to, drought conditions.
  - Water user groups must:
    - *Identify sources of water*
    - *Have drought response triggers*
    - *Have a drought water management strategy*

*Regional Water Planning Areas*



# Seasonal forecast tool: *link to drought planning for surface water reservoirs*

**Regional water planning regions  
need better information to  
implement drought action triggers**

**Such information can be fed into water  
availability models (WAMS) used to allocate  
water from surface water reservoirs**

**Seasonal rainfall forecast tool provides  
county-level information on impending  
drier-than-normal conditions**

# U.S. Bureau of Reclamation project

- TWDB received a WaterSMART grant to further develop the forecast tool through the Drought Resiliency funding solicitation of the U.S. Bureau of Reclamation's Drought Response Program
- Work started on October 1, 2015 and is scheduled to be completed on September 30, 2017.



<http://www.usbr.gov/drought/applications.html>

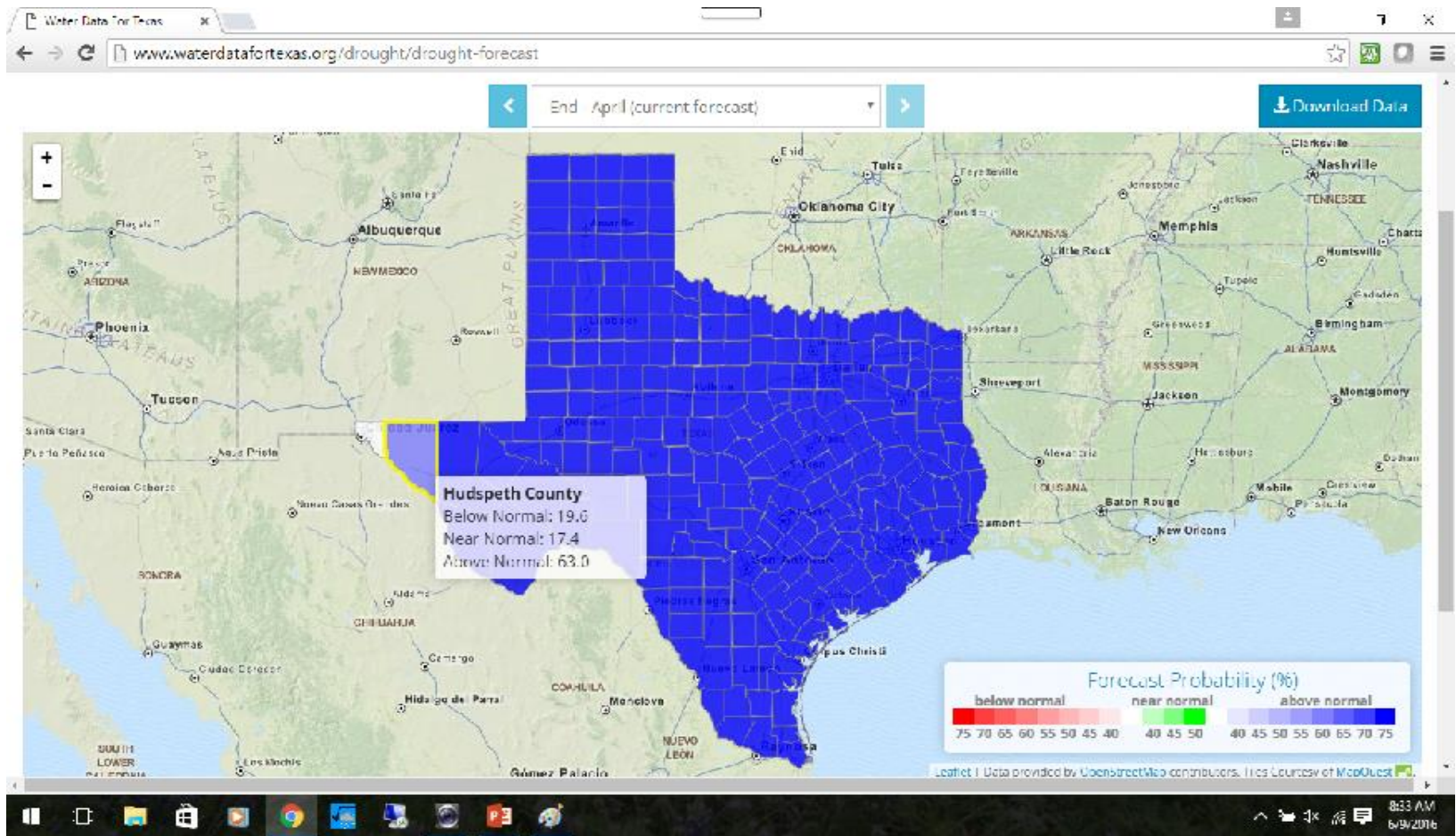
# USBR project activities

## 1. Automation of the drought forecast tool

- Provide probabilistic forecasts of average May–July rainfall for each county in Texas; updated on a bi-weekly basis
- Make forecasts from January 15 through May 1
- Forecast lead times:
  - 6-month lead (January initial conditions – forecast fields)
  - 5-month lead (February initial conditions)
  - 4-month lead (March initial conditions)
  - 3-month lead (April initial conditions - observations)
- Make forecasts available on the Water Data for Texas Website.



# “Drought” forecasts



<http://www.waterdatafortexas.org/drought/drought-forecast>

<http://www.waterdatafortexas.org/drought/drought-forecast-info>

**Went online on  
May 6, 2016**

# USBR project activities (cont.)

## 2. Experimental probabilistic reservoir storage forecasts

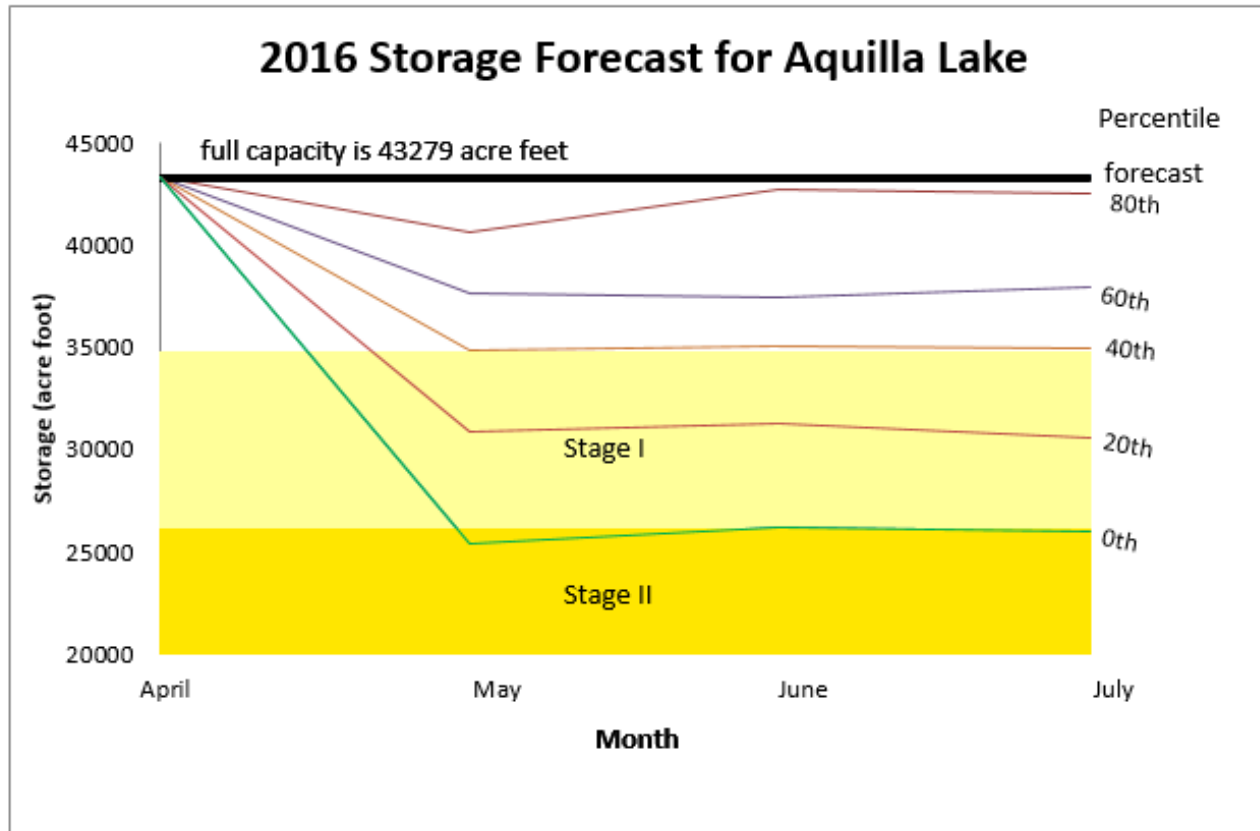
- Reservoir storage forecasts can be tailored as probabilistic forecasts of whether storage will drop below drought trigger thresholds defined in drought contingency plans
- For a particular reservoir, we would be able to provide 3-month lead time forecasts of the likelihood of storage dropping below drought trigger thresholds
  - *Advanced warning could be provided at the beginning of May (based on observed April conditions)*
  - *Advanced warning would cover the coming May–July cumulative storage period*

# Project activities: *experimental probabilistic reservoir storage forecasts*

- May–July storage forecasts for three select reservoirs in:
  - *The Brazos River Basin (Planning Regions O, G, H)*
  - *Conditional Reliability Modeling run for WAM (Wurbs and Salazar, 2004)*



# Experimental reservoir storage forecasts



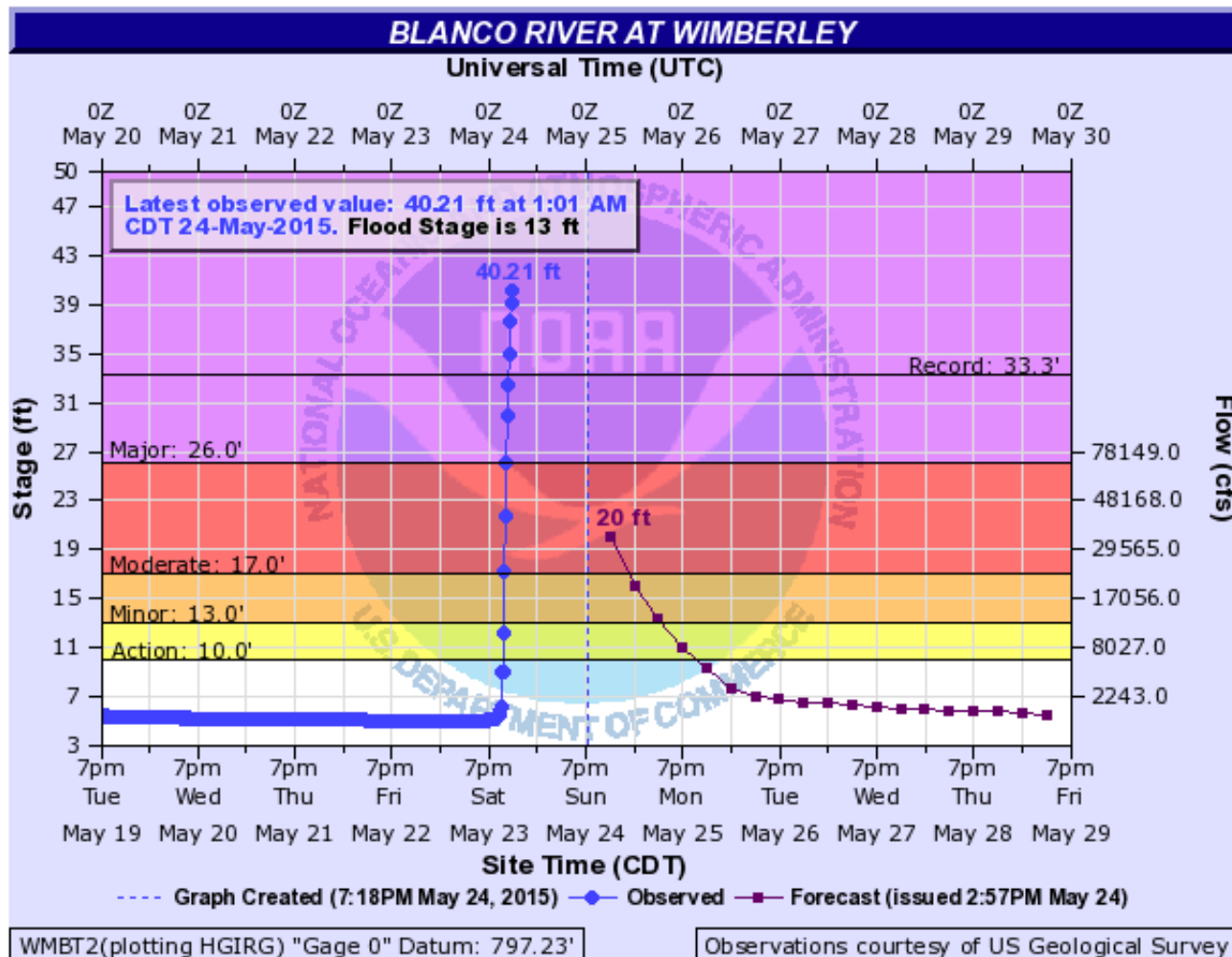
**Work done by  
Dr. John Zhu (Water  
Availability Modelling,  
TWDB) with input  
from Water Services  
Division staff at the  
Brazos River Authority**

**Climate information needed:** exceedance probability or rainfall percentile

**Hydrological information needed:** reservoir initial storage, reservoir diversion, WAM/CRM inputs (historical hydrology, storage-flow-frequency relationship, etc.)

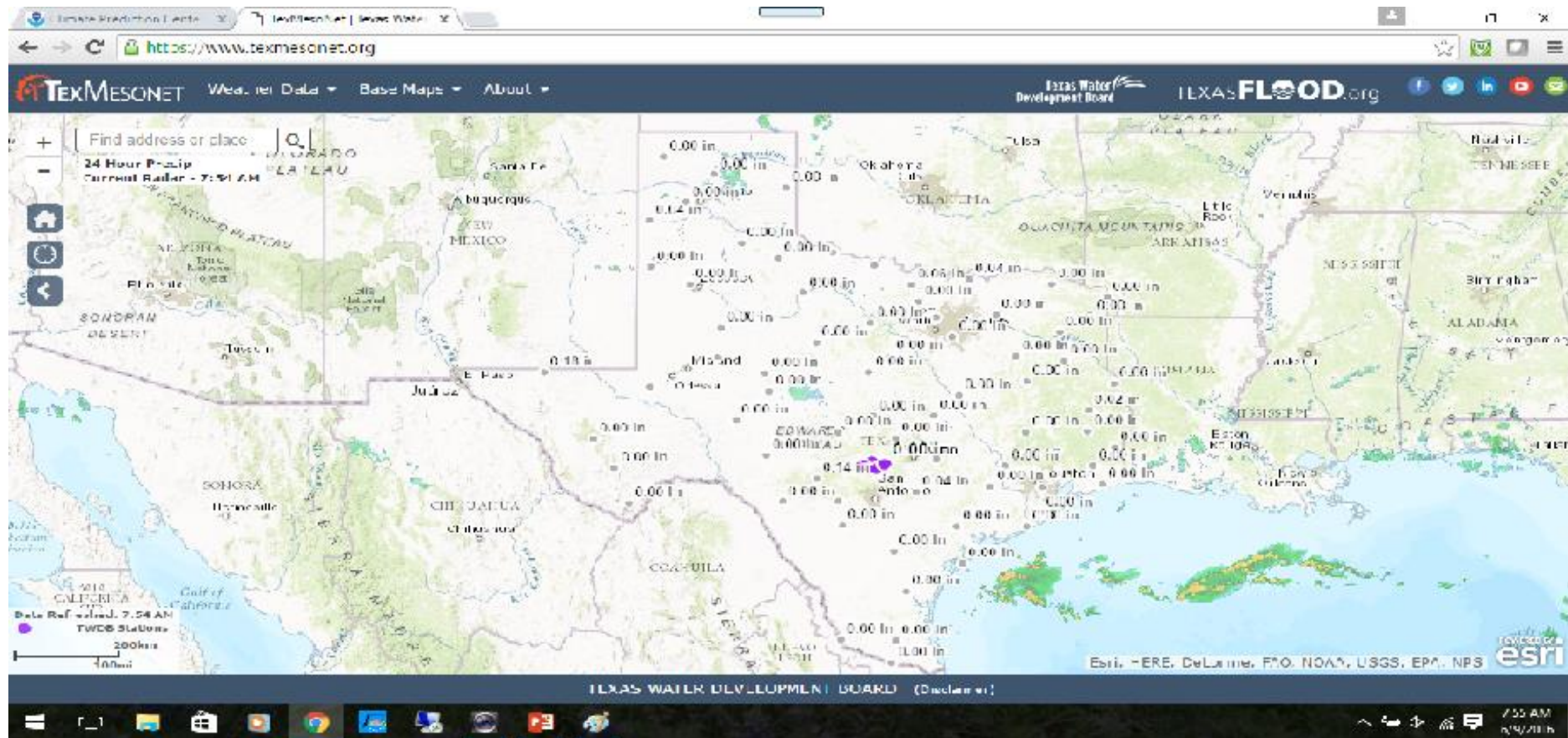
# TWDB information needs at the S2S timescale

# Forecasts for flash-flood inducing rainfall

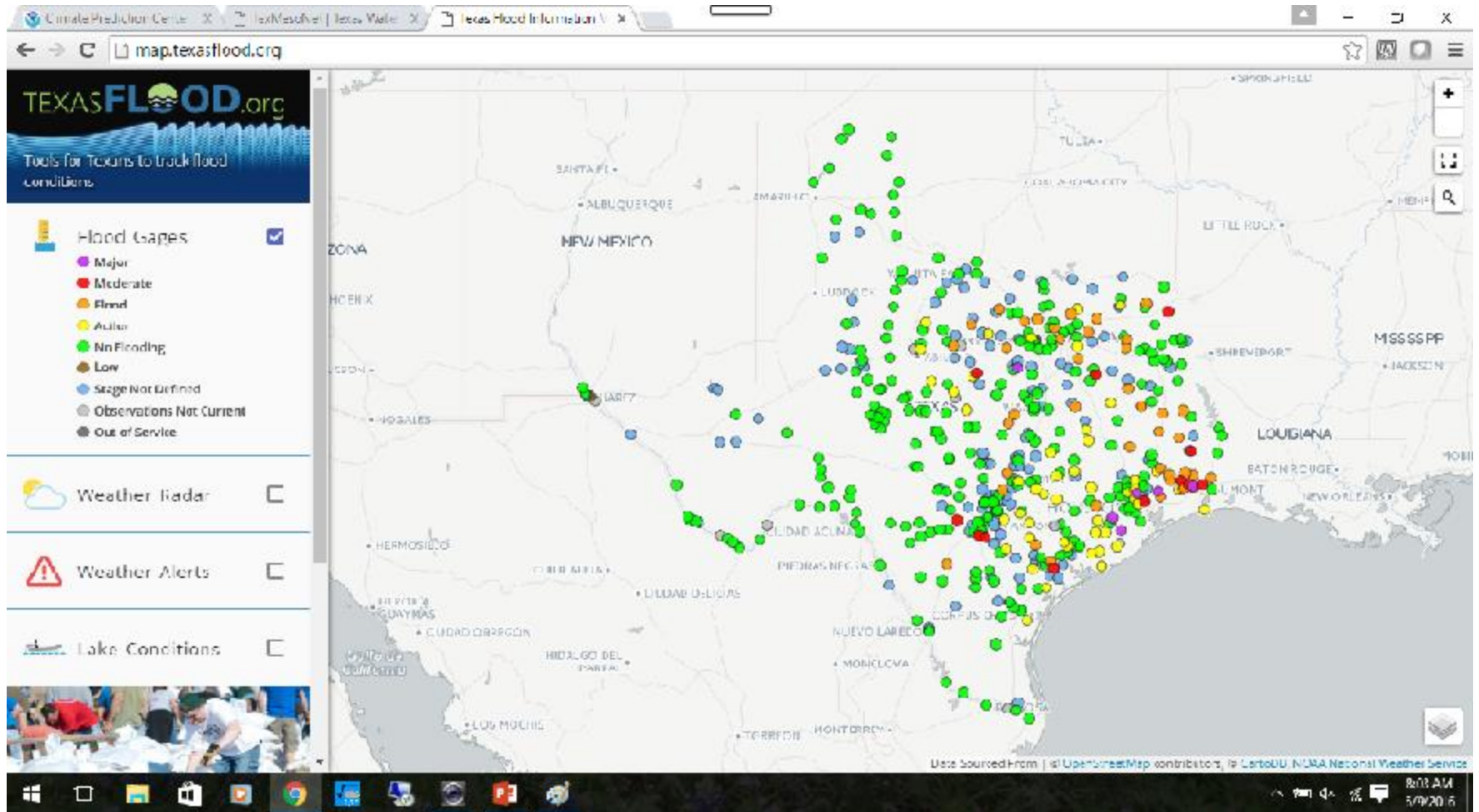




# Flood TexMesonet



# Texas Flood Viewer



# Robert Mace to Nelun (June 2, 2016)

## R to N:

*“Any chatter out there on how this May relates to last May?*

*Also, when are the rains gonna stop?*

*-r.”*

## My response:

*“So far, May 2015 still rules. I’m attaching images showing departures from normal (courtesy of NOAA’s Advanced Hydrologic Prediction Service <http://water.weather.gov/precip/>).*

*On when the rains are gonna stop ☺:*

- Looks like we should be dry from next Thursday (June 10) going forward. You can blame NOAA’s dynamical models, slogging away on the sub-seasonal timescale, if this doesn’t come to pass!”*

# Unknowns for Texas drought/floods

- Sources of predictability in other seasons
- How much rainfall is needed to overcome a soil moisture deficit so that runoff occurs?
  - *Reservoir inflow*
  - *Soil saturation and flooding (“when is the pump primed?”)*
- Can the “rain bombs” be predicted with lead time of ~ 2 weeks?
- What causes the strong westerly winds at the 850 hPa level in April in years of drought (not La Niña)?
- Soil moisture leads 500 hPa geopotential height anomalies by 2–3 weeks in the MJJ season
  - *How can this finding be exploited to improve S2S forecasts?*



# TWDB interactions with NASA and NOAA/RISA/SCIPP

- Co-hosted the 4<sup>th</sup> NASA SMAP Applications Science Workshop and Tutorial held in Austin in April 2016.  
(<https://www.regonline.com/builder/site/tab2.aspx?EventID=1823913>)
- Decision making user of SMAP products through Rong Fu (SMAP early adopter)
- Collaborator on Rong Fu's proposal for the SMAP funding solicitation
- SCIPP stakeholder
  - *Texas Oklahoma Climate Extremes Workshop (October 2015)*  
(<https://www.drought.gov/drought/calendar/events/texas-and-oklahoma-climate-extremes-workshop-learning-recent-four-year-drought-and>)
  - *Hosting a SCIPP intern for the 2016 summer (study on soil moisture and runoff during drought years)*

# Concluding thoughts/wish list

- Statistical methods, based on process understanding, have worked over Texas for the May–July main rainfall season.
- Results can be used to guide dynamical model error correction
  - Land surface feedback processes
  - Cloud cover and radiation processes (particularly in spring)
- Would like to use model output from other NMME models (so far not all the fields, mainly soil moisture, are not provided on the data archive).
- Sub-monthly rainfall forecasts would help flood preparedness.



# Contact info

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Texas Water Development Board

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Phone: 512-475-0454

Thank you 😊!!