Science and Technology Infusion Climate Bulletin
NOAA's National Weather Service
39th NOAA Annual Climate Diagnostics and Prediction Workshop
St.. Louis, MO, 20-23 October 2014

Evaluation of an Indicator for the Early Warning of Strong Summer Drought over the South Central United States*

D. Nelun Fernando[1], Rong Fu[2], Ruben S. Solis[1], Robert E. Mace[1],
Ying Sun[2], Binyan Yang[2], and Bing Pu[2]

[1]*Water Science & Conservation, Texas Water Development Board, Austin, TX*
[2]*Department of Geological Sciences, The University of Texas at Austin*

1. Introduction

Strong summer droughts over the Southern Great Plains region are often characterized by rapid intensification in the late-spring and early-summer. The decreased rainfall in these drought years are coupled with strong increases in summertime temperature extremes, as for example, was the case with the 2011 drought over Texas and the Great Plains drought in 2012. Dynamic climate models failed to predict these summer droughts. This is largely due to model weaknesses in predicting summer rainfall, underestimating summer rainfall variance, and weaknesses in capturing soil moisture feedbacks. By contrast, climate models are more reliable in capturing the variability in large-scale circulation features and temperature during winter and spring.

Observations show that severe-to-extreme summer drought events over Texas are preceded by dry springs. Over the period 1895-2014, there were 13 severe-to-exceptional droughts (defined as the 12-month Standardized Precipitation Index (SPI, a rainfall based drought index) for August $\leqslant$ -1.2) over Texas. Ninety two percent of these drought events were characterized by anomalously low rainfall in the spring (March through May). Dry springs cause anomalous high pressure systems and anticyclonic (clockwise) flow in the prevailing wind system, which lead to subsidence (sinking motion) in the atmosphere. Such subsidence persists through much of the summer and inhibits rainfall from convective (rising motion) processes. This work explored the potential predictability of strong summer droughts, and the feasibility of using a process-based empirical model to predict summer droughts, over the Southern Great Plains based on such persistent drought-inducing atmospheric circulation patterns and surface dryness in spring.

2. Process-based empirical model for drought early warning

We developed a process-based statistical model to provide an early warning indicator of summer (meteorological) drought based on the anomalous large-scale middle tropospheric (that is, 500 hectopascals level, or approximately 5,500 meters above sea level) circulation, convective inhibition energy (a numerical measure in meteorology indicating the negative energy available in the environment to prevent development of convective weather systems), and land surface moisture conditions in spring (March to May). We used the three aforementioned conditions in spring (March, April, and seasonal mean March through May conditions) as inputs to our statistical model to predict cumulative rainfall deficits or surplus (referred to as the cumulative rainfall anomalies hereinafter) during May-July and the six-month SPI for July.

Comparison of the hindcasts made using the statistical model with the observations shows that the model can predict summer droughts over Texas and the southern Great Plains region in spring with skill levels acceptable to decision makers (~60 percent or higher) — particularly those tasked with drought emergency

---

* The findings reported here have been published as the Texas Water Development Board Technical Note 15-02 titled 'Early warning of summer drought over Texas and the south central United States: spring conditions as a harbinger of summer drought'. (Full report available at:
http://www.twdb.texas.gov/publications/reports/technical_notes/doc/TechnicalNote15-02.pdf)

Correspondence to: D. Nelun Fernando, Water Science & Conservation, Texas Water Development Board, Austin, TX;
E-mail: Nelun.Fernando@twdb.texas.gov

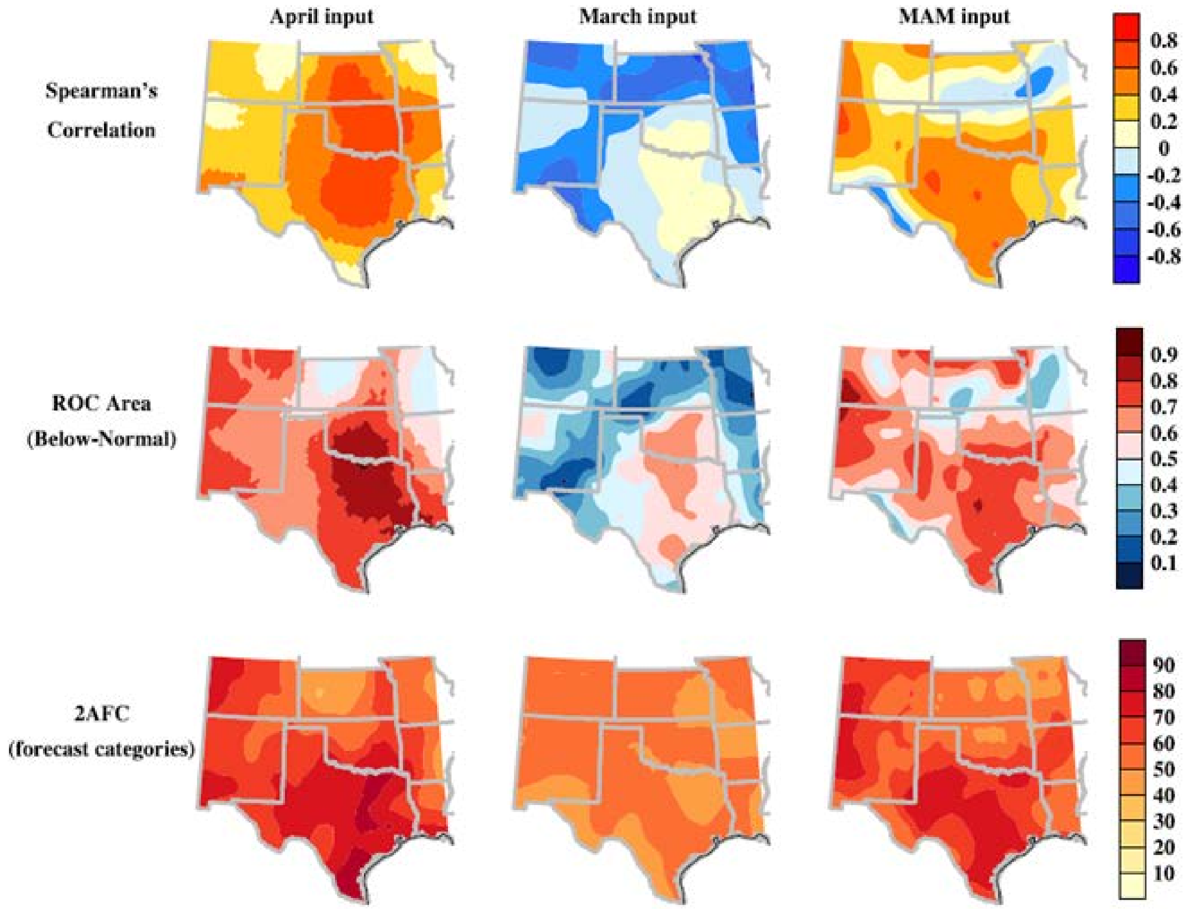

Fig. 1 Skill level as depicted by the Spearman's Correlation (top), Relative Operating Characteristics Area (below-normal) (middle), and two-alternative Forced Choice (forecast categories) (bottom), using April (left), March (center) and March through May seasonal average (right) initial conditions for the predictor fields.

management. The drought indicator shows higher success rates in correctly predicting the occurrence of dry or wet summers than the baseline drought predictability (that is, autocorrelation of rainfall anomalies) and forecasts from dynamical models over south central, central, northern and eastern Texas, western Louisiana, most of Oklahoma and southern Kansas at three to six months lead time. In all realizations of the model, we find that the grid points with the highest skill scores lie within Texas. The best skill is achieved when using April initial conditions (Fig. 1) of the three predictor variables. As a rule of thumb, if there is a high pressure system at 500 hectopascals over the Southern Great Plains, very high values of convective inhibition, and dry land-surface conditions in the region in April, there is a strong probability of an impending intense summer drought over this region.

3. Test prediction for summer 2014 and lead time skill assessment

We made a first forecast for the summer of 2014 using observed April fields. The forecast showed abnormally wet conditions, which better matched observed conditions than the official forecast from the National Oceanic and Atmospheric Administration's Climate Prediction Center for this region (Fig. 2).

We developed a combined dynamic-statistical prediction approach to assess the feasibility of providing an early warning of summer drought at the four- to six-month lead time. This approach uses the ensemble mean dynamic prediction for April conditions, initialized by observed conditions in January, February and March, respectively, as input to the statistical model to predict May through July rainfall anomalies, or the

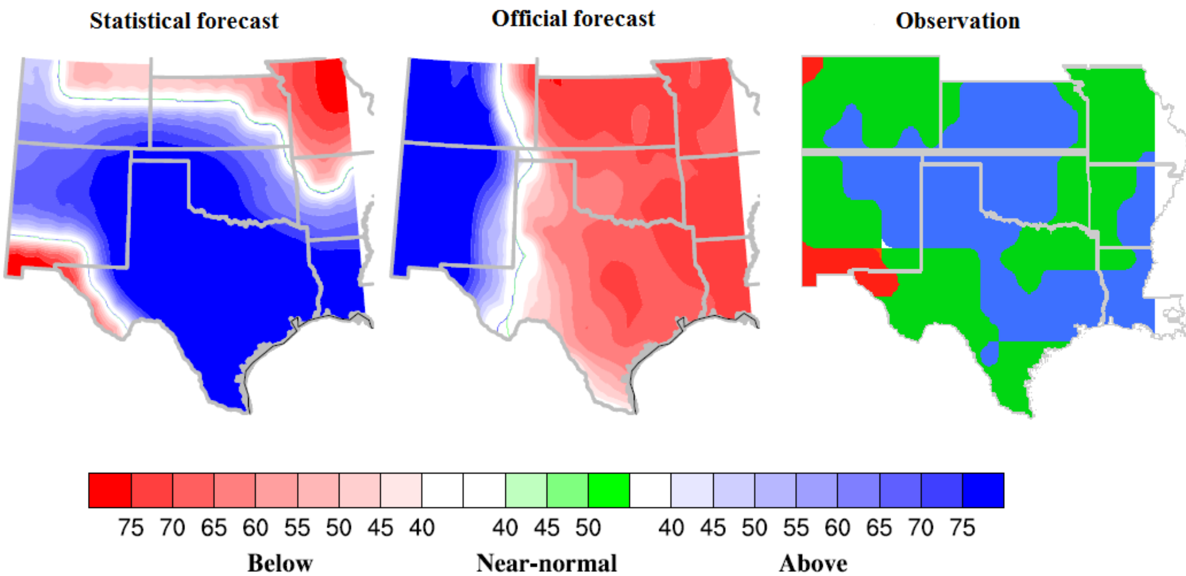

Fig. 2 Statistical prediction (left), official forecast using the National Multimodel Ensemble (middle), and observed (right) precipitation anomalies for the 2014 May through July season.

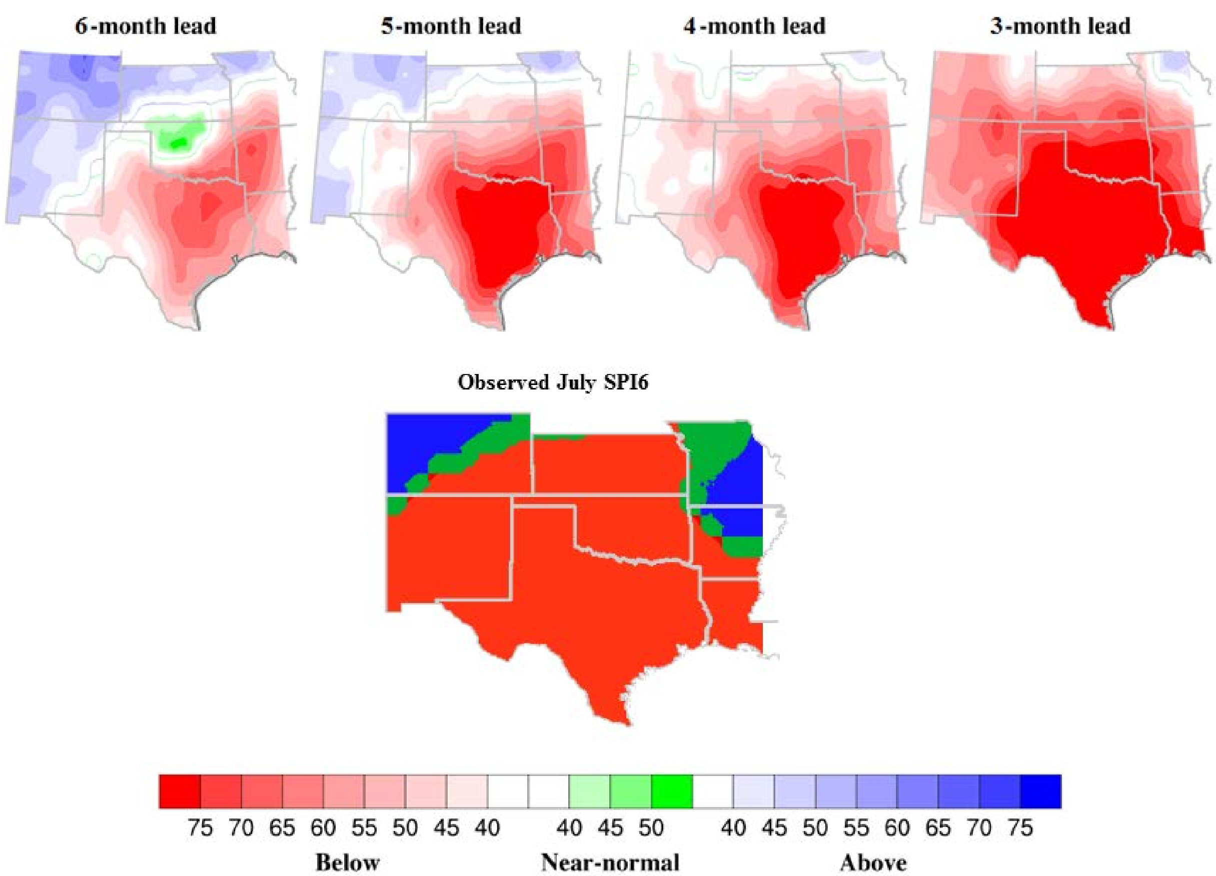

Fig. 3 Six- to three-month lead categorical forecasts of the 6-month Standardized Precipitation Index for July (SPI6) in 2011 (top, from left to right), and observed July SPI6 in 2011 (bottom).

six-month SPI for July, at the 6-month, 5-month and 4-month lead time. The categorical seasonal forecasts (that is, probabilistic estimates of whether a season will be below-, near- or above-normal) from the indicator provide added information on drought susceptibility for up to six-month lead time with the skill levels acceptable to decision makers. Of notable interest is the ability of this combined dynamic and statistical approach to hindcast the 2011 summer drought in January with up to six month lead time (Fig. 3). This implies that the 2011 summer drought over Texas could have been predicted in January 2011.

Given the performance of the drought early warning indicator over Texas, we will explore the possibility for providing summer drought forecasts from January onwards to the Texas Drought Preparedness Council, state emergency management initiatives, and water planners. Such forecasts would ideally be made available to the public through the Texas Water Development Board’s drought web page and the Water Data for Texas web site.