Evaluation of an indicator for the early warning of strong summer drought over the South Central US

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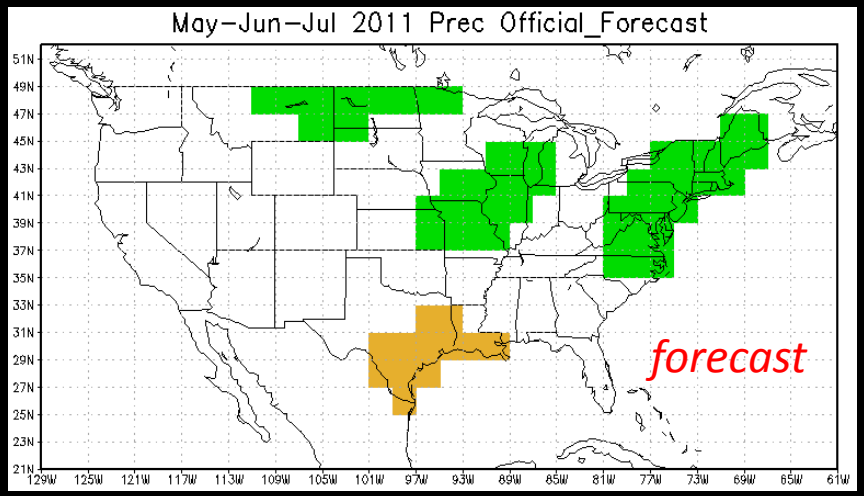
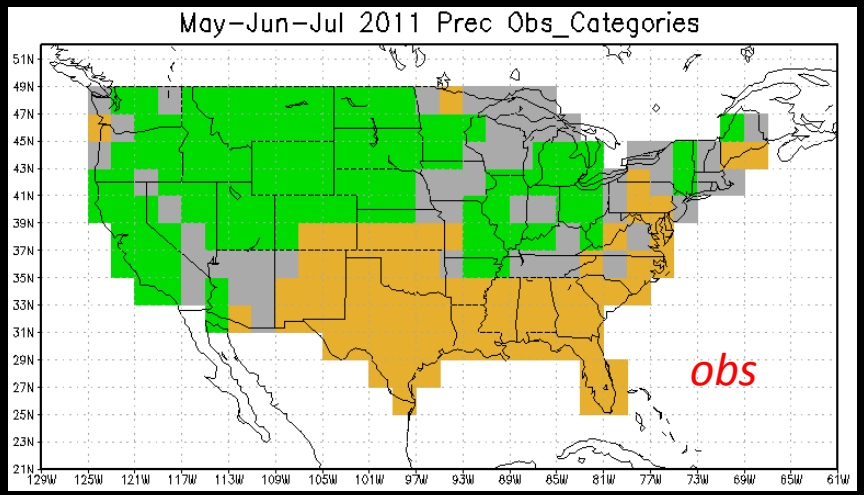
Dynamical model forecasts vs. observed conditions: May-July (MJJ) 2011 and 2012

2011:





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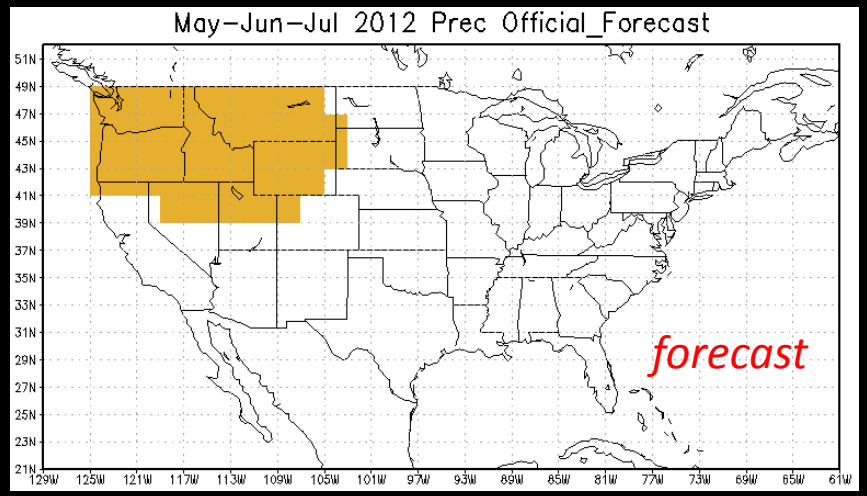
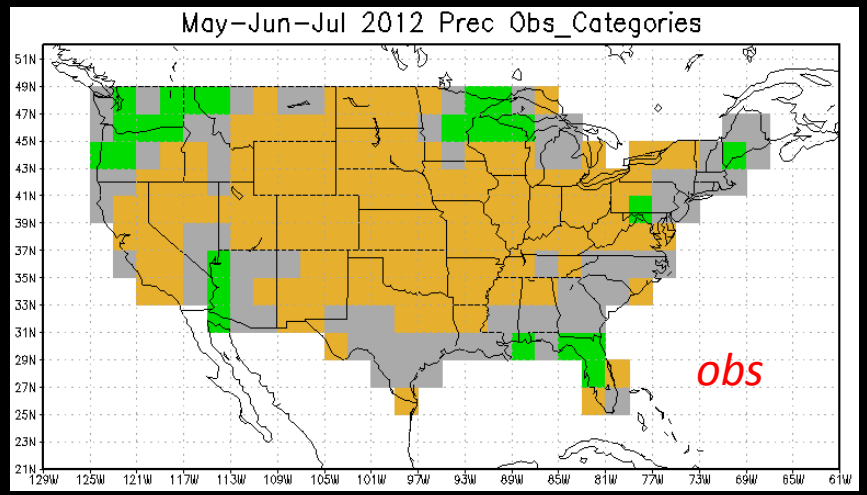




Basis for an early-warning indicator

Known

1. Large uncertainty in predict extreme summer droughts, as shown in 2011 over Texas and in 2012 over the US Great Plains.

2. GCMs have large uncertainty in predicting summer rainfall and capturing soil moisture feedback.

3. Models are more reliable in capturing variability in large-scale circulation features and temperature during winter and spring.

Goal of this work

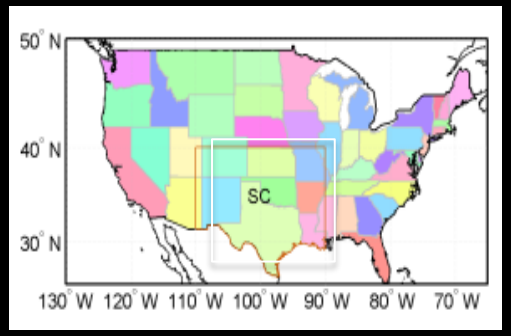
- Evaluate a process-based physical climate indicator of the risk of extreme summer drought over the US southern Great Plains (110W-92W; 24N-40N)

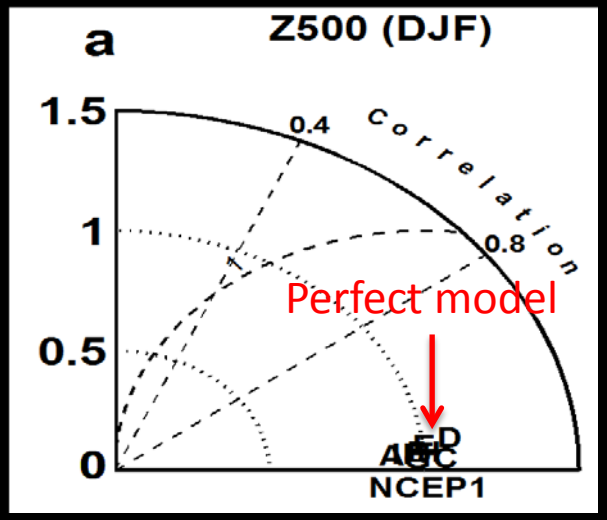
- Understand at what lead times skillful predictions (i.e. early warning) of intense summer drought are feasible

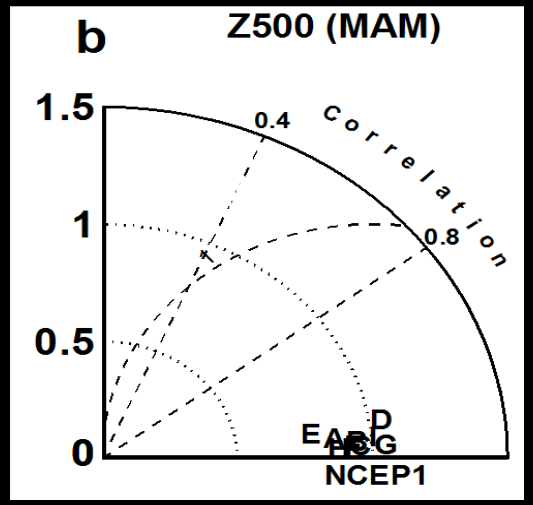
CMIP5 models

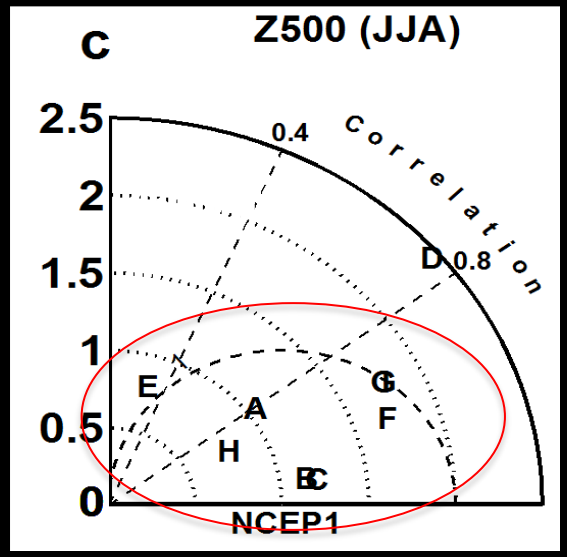
- *Realistically capture large-scale circulation in winter and spring,*
- *But have large uncertainty in representing summer large-scale circulation climatology in CMIP5 models*

Fu et al. 2014









Testing an empirical model: *variables*

Basis:

The indicator uses atmospheric circulation and land surface anomalies in the spring (April, March, May and MAM mean) to build a statistical forecast model to predict cumulative summer rainfall (e.g. May-to-July seasonal rainfall or July SPI6).

Predictors

Predictor term 1: 500 hPa geopotential height anomalies in spring

Predictor term 2: Anomalies in the difference in temperature at 700 hPa and surface dewpoint in spring

Predictor term 3: Soil moisture anomalies spring

Testing an empirical model: *method*

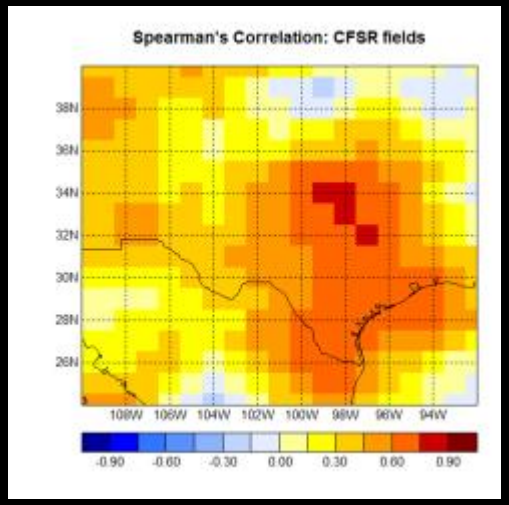
1. Use multivariate empirical orthogonal function (EOF) analysis on the three predictor fields
   - Input has three arrays of 33 (1982-2014) x 323 data points (19 longitude and 17 latitude points)
2. Retain ~2 modes that account for at least 70% of the variance in the predictor fields. Rotate these fields using varimax rotation.
3. Use the spatial loadings of the rotated fields as predictors to a Canonical Correlation Analysis (CCA) model
4. Use the IRI's Climate Predictability Tool (CPT) to run the CCA
   - Use a 24-year training period (1982-2005), leaving 1/3 of the data for validation and a 3-year cross validation window
   - 1982-2005 set as climatological period

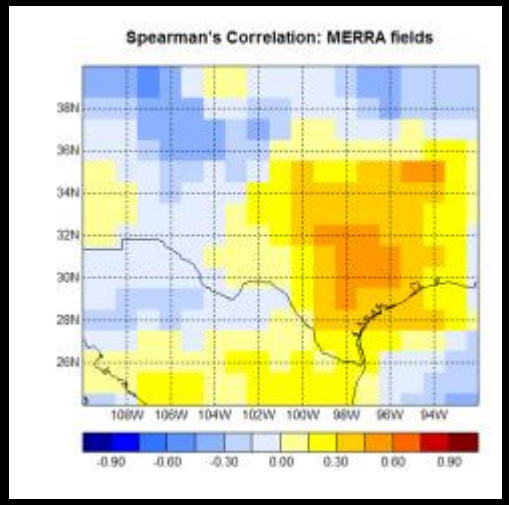
Data sets used

1. 500 hPa geopotential height, T700, dewpoint and soil moisture from CFSR(1982-2010)/CFSv2 realtime (post-2010)
2. 500 hPa geopotential height, T700, dewpoint derived from RH and temperature, and soil moisture from MERRA
3. Hindcasts of the three predictors from CFS Reforecasts at 3-, 2- and 1- lead times (i.e. Jan, Feb and Mar)
4. SPI-CAMSOPI_6-Month from the IRI SPI Analyses (http://iridl.ldeo.columbia.edu/SOURCES/.IRI/.Analyses/.SPI/)
5. Monthly hindcasts of rainfall from an ensemble mean of 7 NMME models (Kirtman et al., 2014) obtained from the NMME archive (http://iridl.ldeo.columbia.edu/expert/SOURCES/.Models/.NMME/)
6. Observed monthly rainfall from CPC PRECL v1p0 deg1p0 dataset (Chen et al., 2002)

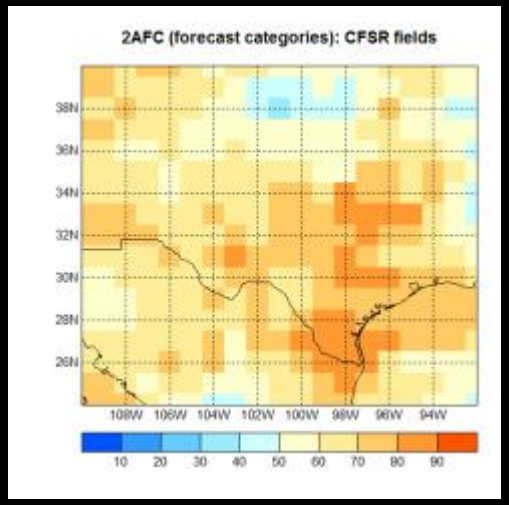
Sensitivity to input data:
Skill comparison: CFSR and MERRA

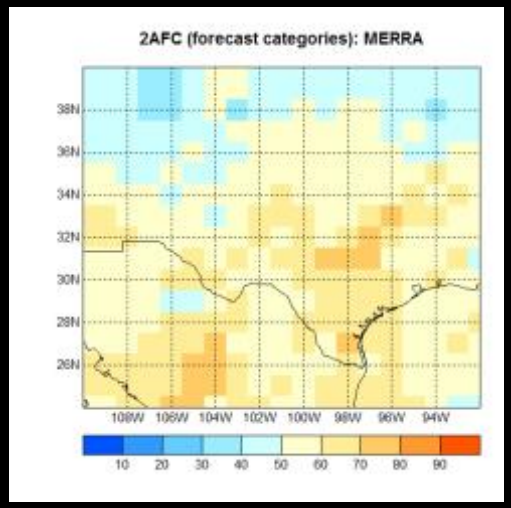
CFSR *MERRA*





Spearman's correlation

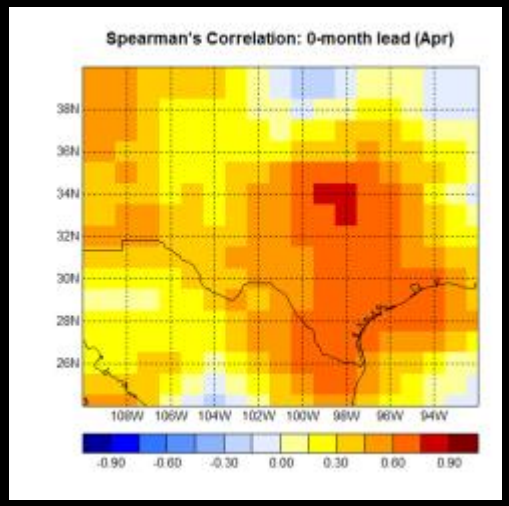


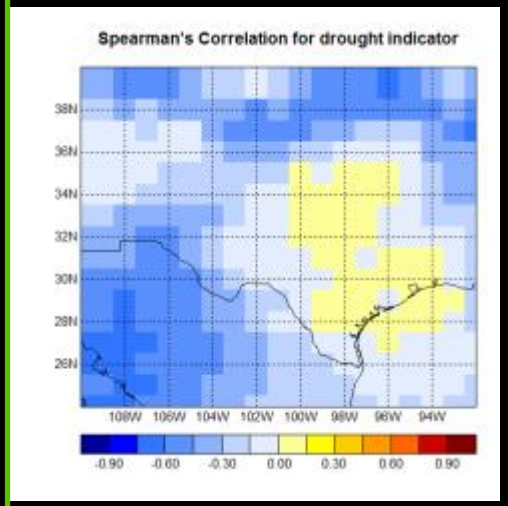


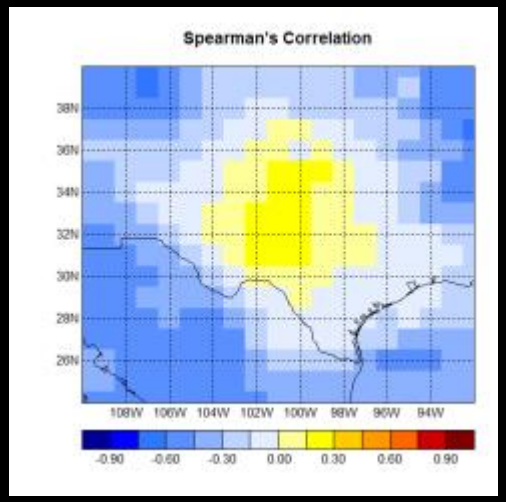
2AFC

Optimum skill: *seasonal input*

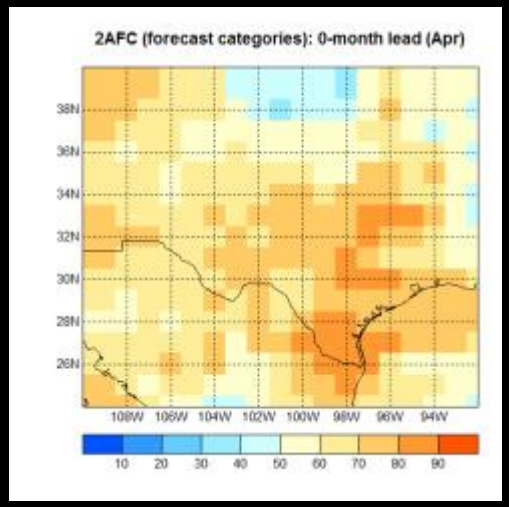
April IC ***Mar IC*** ***MAM IC***

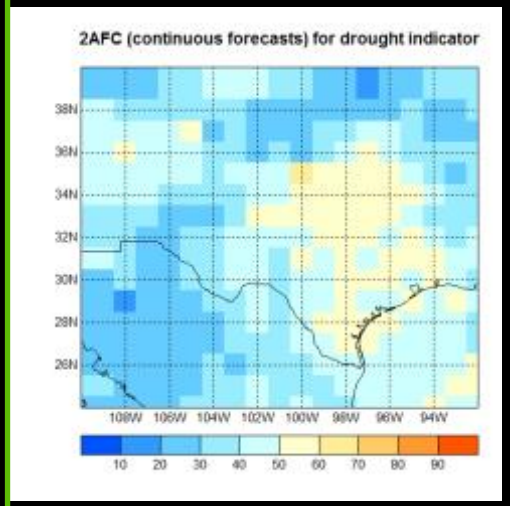


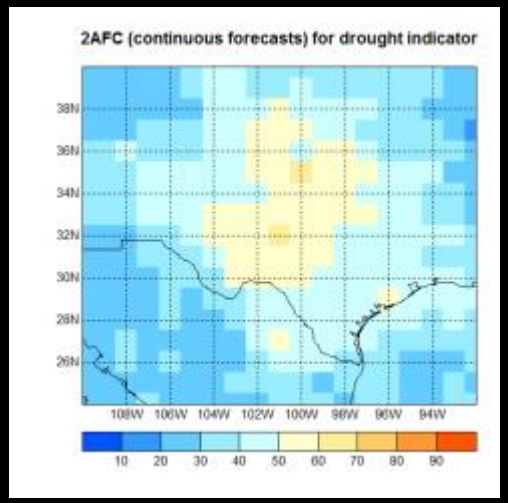




Spearman's correlation







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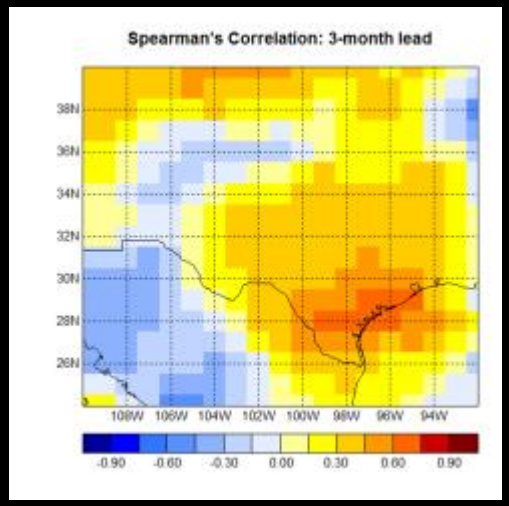
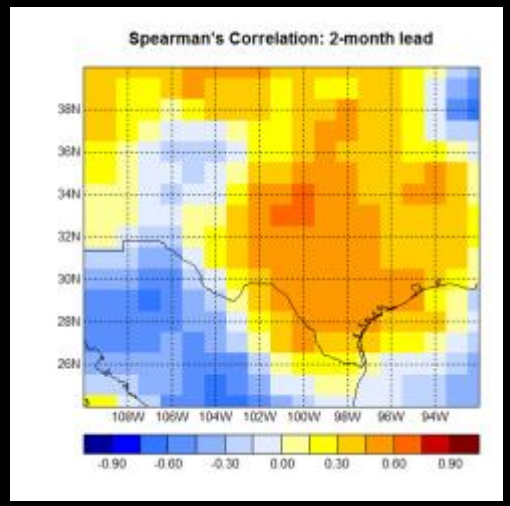
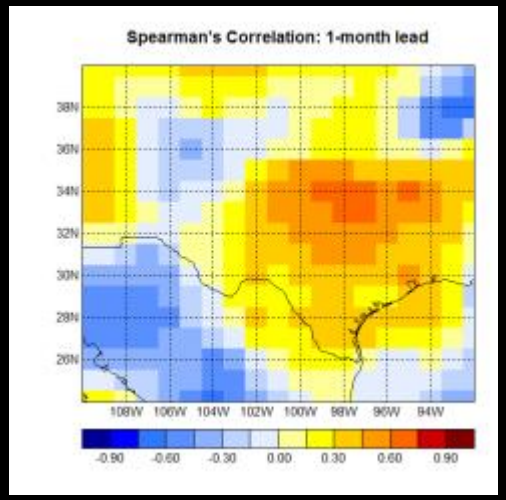
Optimum skill: *lead time for forecast Apr fields*

Jan (3-month) **Spearman's correlation** ***Feb (2-month)*** ***Mar (1-month)***







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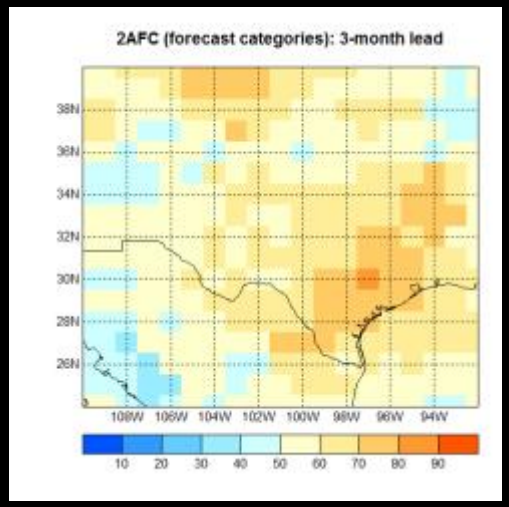
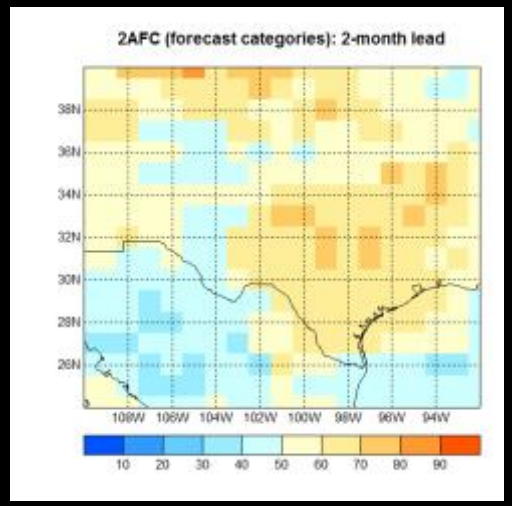
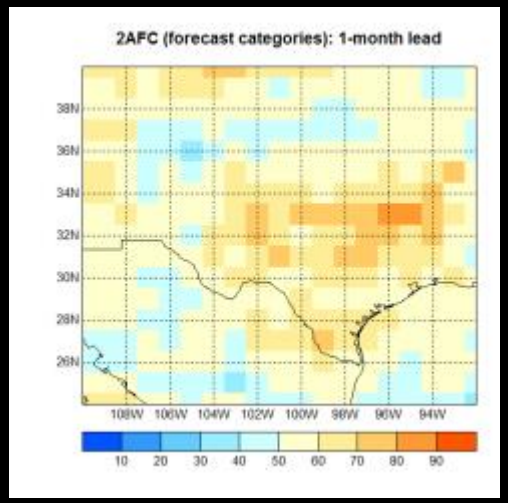
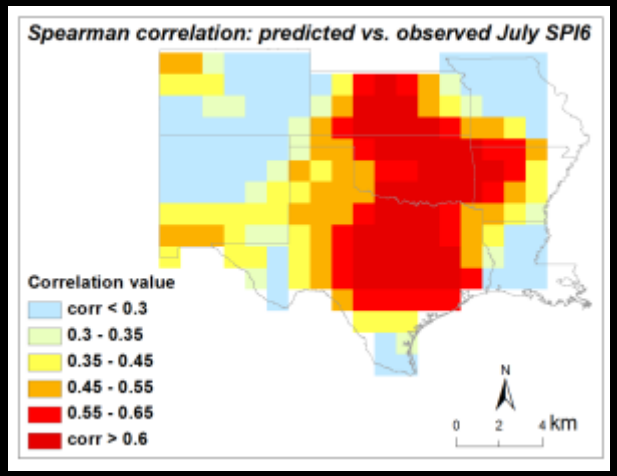
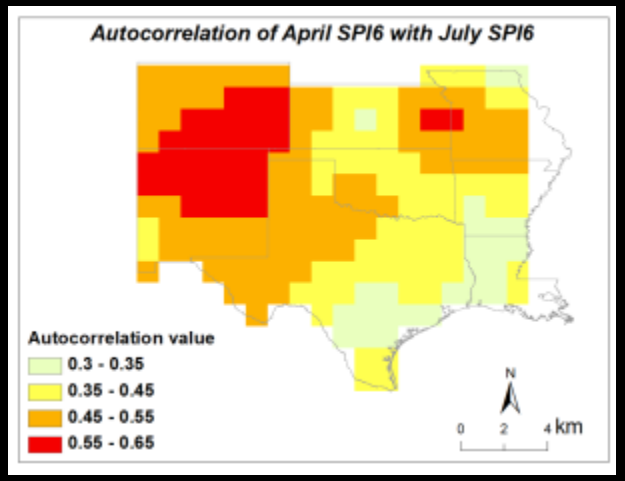


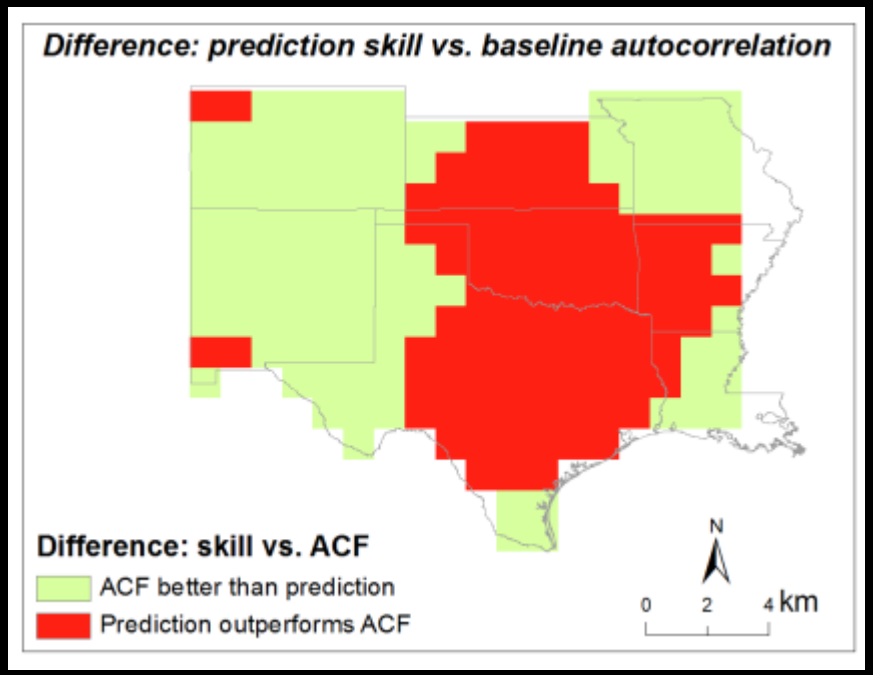




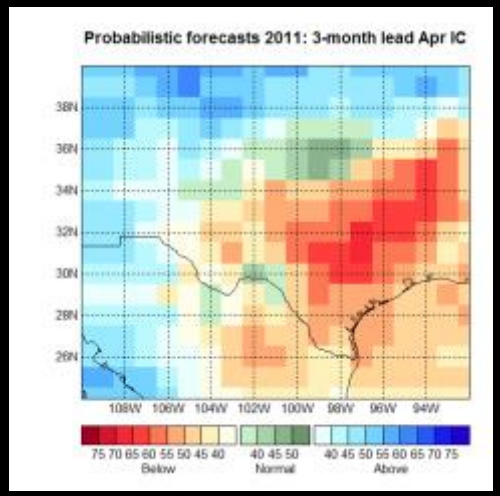
Does the indicator beat persistence?

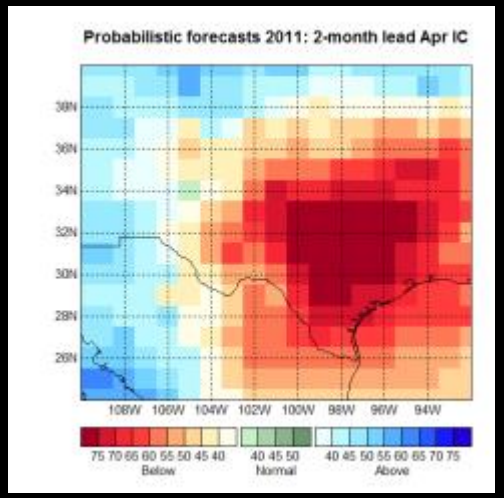


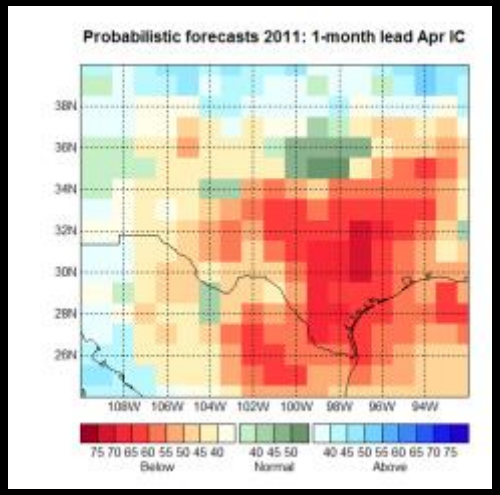


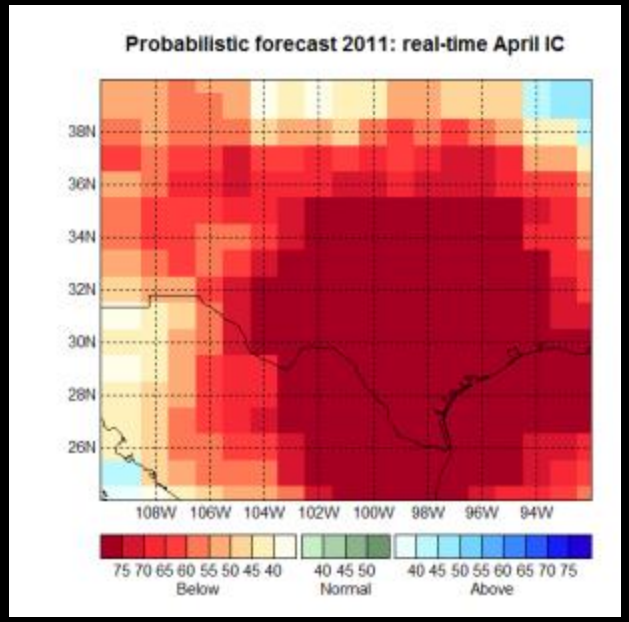


2011 hindcast: 3-,2-,1- and realtime Apr IC



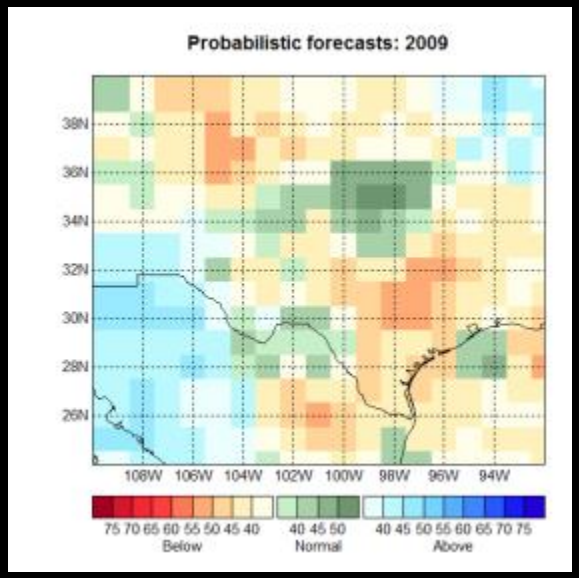


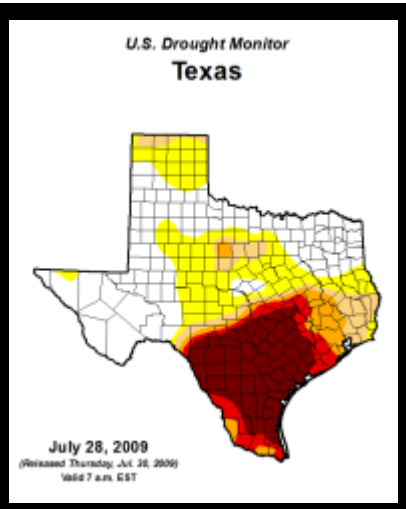




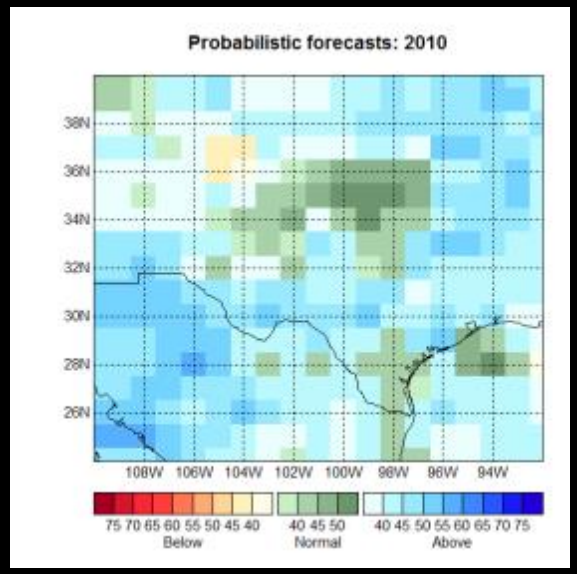
Hindcast: select years

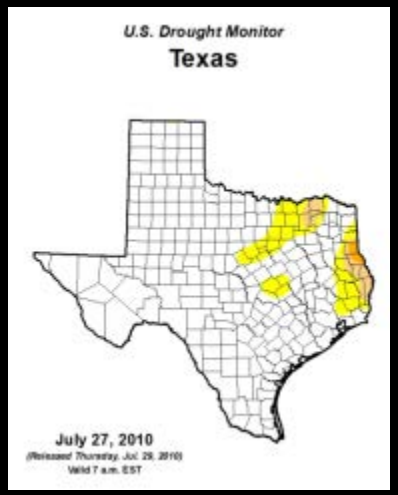
2009



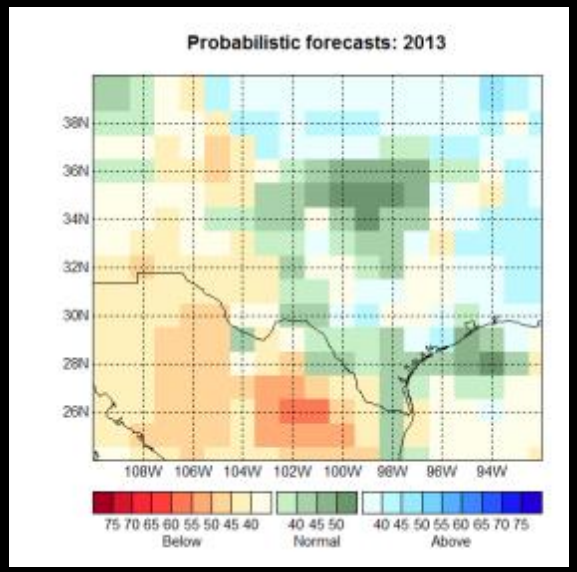


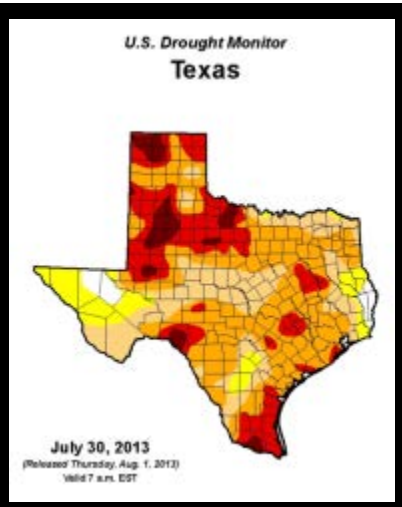
2010





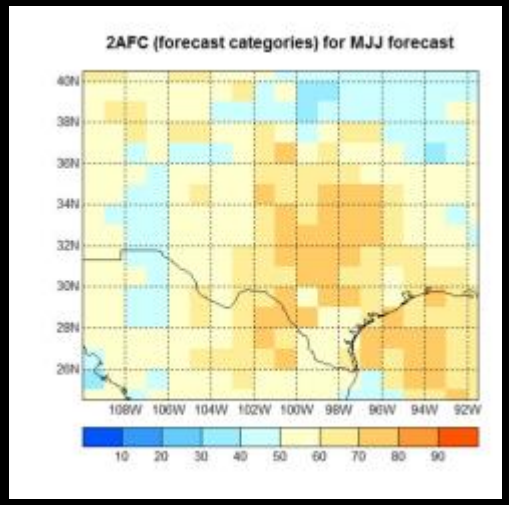
2013

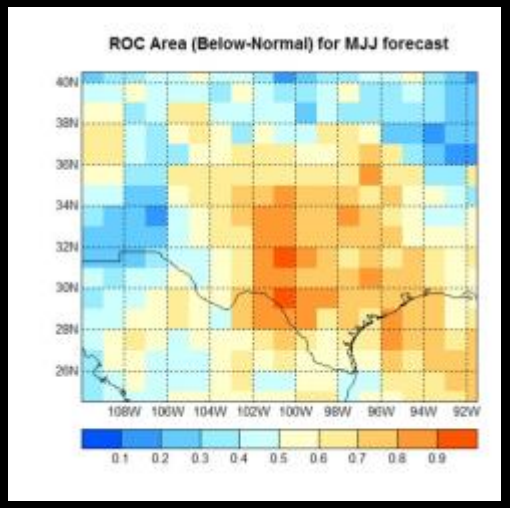


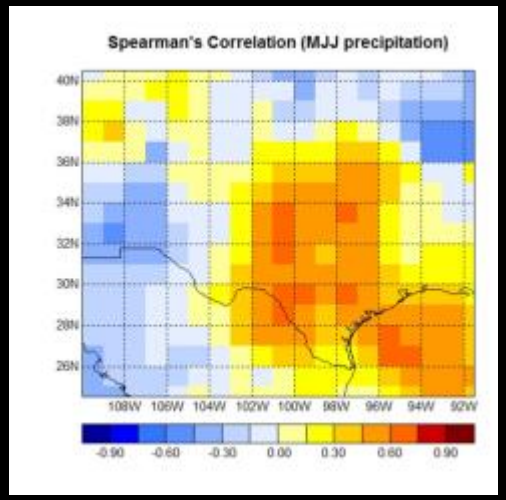


Skill comparison: indicator vs. NMME forecast MJJ rainfall (24-40N; 110-92W)

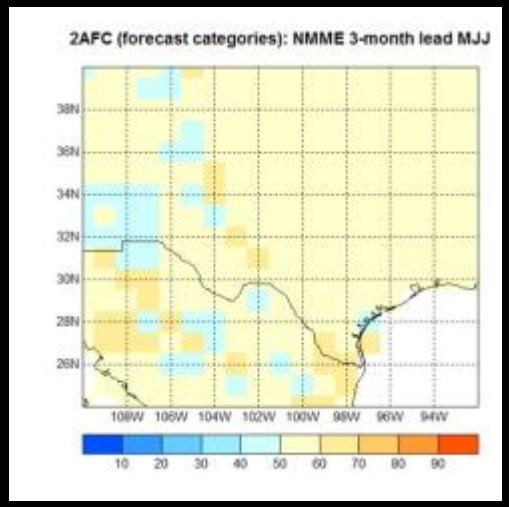
Indicator forecast with April IC

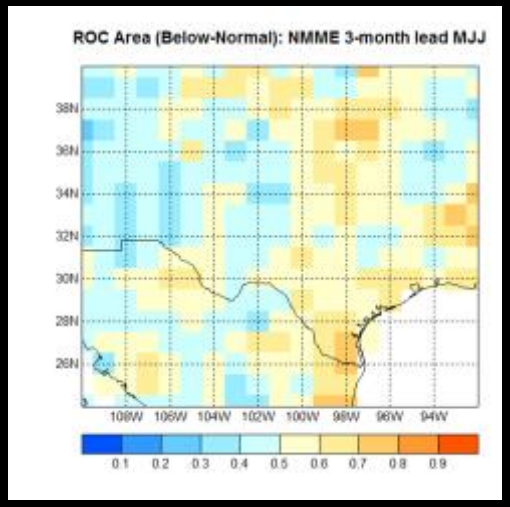


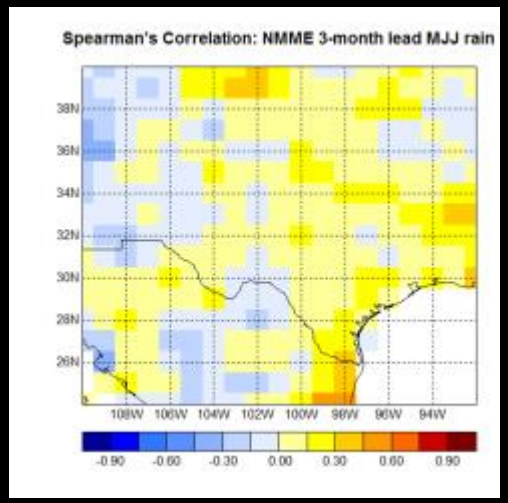




NMME ensemble mean 3-month lead prediction

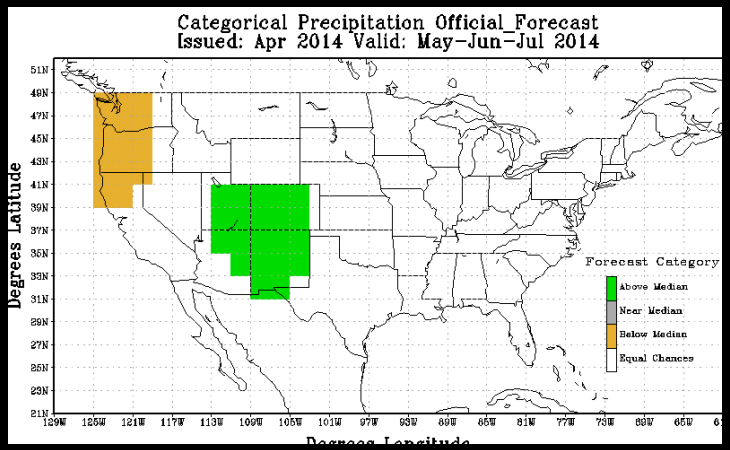




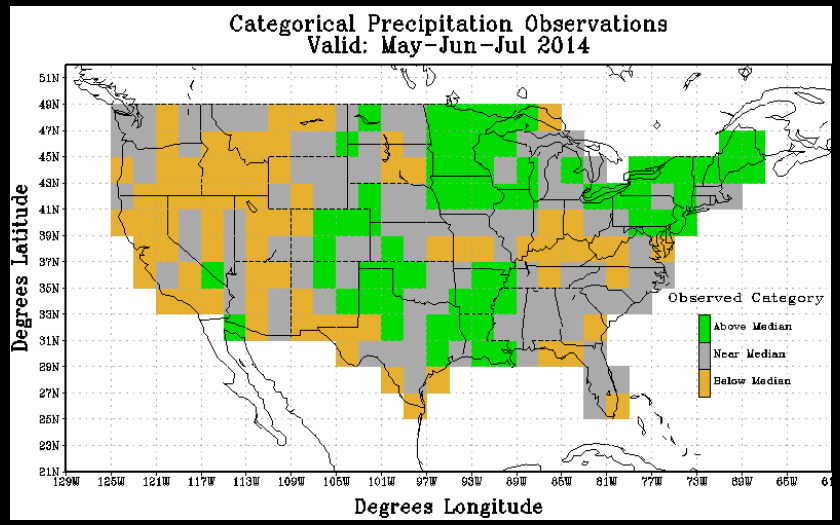


2014 MJJ: CPC forecast, indicator forecast and observations

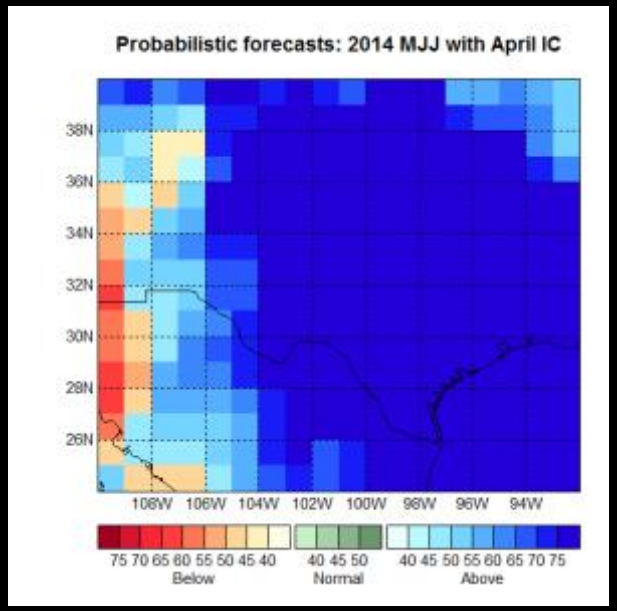
CPC forecast



Observed



Indicator forecast



NCDC Statistics for the South for <u>201405 – 201407:</u>
Rainfall total = 12.51” (1.35” anomaly), rank 94 wettest

(Link to time series):
http://www.ncdc.noaa.gov/cag/time-series/us/106/00/pcp/3/07/1895-2014?base_prd=true&firstbaseyear=1980&lastbaseyear=2010)

Indicator evaluation recap

- Summer droughts (depicted using July SPI6 or MJJ rainfall) over the southern Great Plains can be predicted with skill levels acceptable to decision makers (~0.60 or higher) using April large-scale circulation and land-surface moisture fields.
- The early warning indicator is able to capture the spatial pattern and magnitude of past drought events and non-drought events well.
- It exceeds baseline predictability over most of Texas and Oklahoma
- Forecast for 2014 showed abnormally wet conditions and matches observed conditions better than CPC forecast ☺!

Outreach and next steps

- The indicator will be made available to decision-makers in Texas through a link on the Drought web page of the Texas Water Development Board (including a Technical Note with details on methodology and datasets used)

- Efforts will be made to promote its utility and adoption by state emergency management initiatives such as the Texas Drought Preparedness Council and river authorities.

- Explore feasibility of apply this drought early warning indicator to the other north American and global Regions (already applied to the full Great Plains region)

Acknowledgements

- NASA National Climate Assessment
- TWDB
- NMME data