Analysis of Teleconnections and Drought for the Arbuckle-Simpson Aquifer

Virginia Silvis[1], Renee McPherson[1,2], Heather Lazrus[3], Michael Richman[4], and Michael Hunter[5]

[1]University of Oklahoma Dept. of Geography & Environmental Sustainability, [2]South Central Climate Science Center, [3]National Center for Atmospheric Research, [4]University of Oklahoma School of Meteorology, [5]University of Oklahoma Dept. of Psychology

INTRODUCTION:

The Arbuckle-Simpson Aquifer in south-central Oklahoma, situated in the heart of the Chickasaw Nation, is the state's only sole-source groundwater basin and sustains the Blue River, the state's only free-flowing river. Recent comprehensive hydrological studies of the aquifer indicate the need for sustainable management of the amount of water extracted. The Southern Great Plains, within which the aquifer is located, are well documented to be susceptible to drought due to climate variability, making sustainable water management a priority for water managers in the area as periods of drought have become more frequent.

A survey of the current literature shows the El Niño/Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), the Arctic Oscillation (AO), and the Atlantic Multidecadal Oscillation (AMO) all have an affect on rainfall amounts and/or drought occurrence in the region. To determine if these teleconnections can be downscaled to the climate division level the climate oscillations were combined into six different scenarios (e.g., positive AO, positive Oceanic Niño Index) based on existing literature and then compared to the Palmer Drought Sensitivity Index (PDSI) for the Oklahoma Climate Division 8, where the Arbuckle-Simpson Aquifer is located.

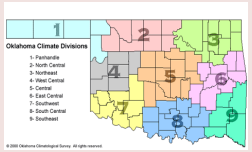

Figure 1. The 9 climate divisions for Oklahoma. The Arbuckle-Simpson Aquifer is located within Climate Division 8.

METHODOLOGY:

- The Southern Great Plains has a long history of drought, and Climate Division 8 is no exception
  - Severe drought occurring in late 1910s, 1930s, late 1950s, & early 2010s
- From the literature 4 climate oscillations were identified based on teleconnections identified as affecting drought frequency in the Southern Great Plains
  - El Niño/Southern Oscillation (ENSO)
  - Pacific Decadal Oscillation (PDO)
  - Artic Oscillation (AO)
  - Atlantic Multidecadal Oscillation (AMO)

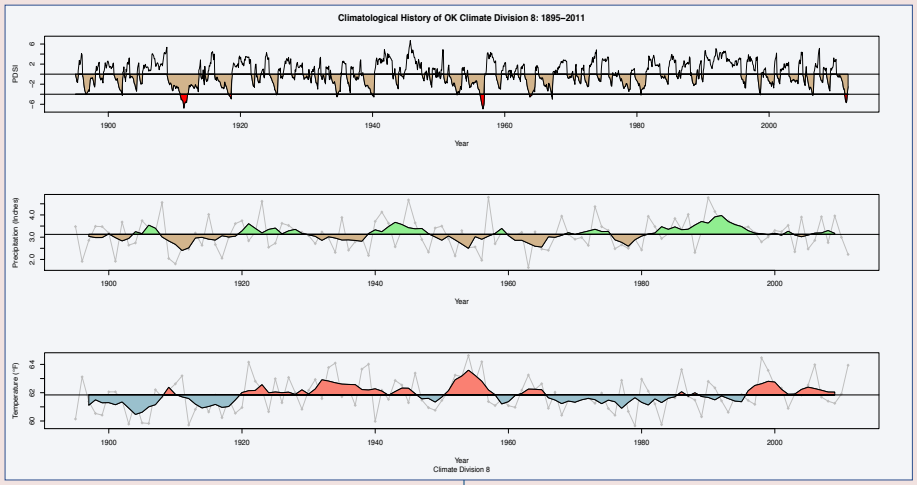

Figure 2. Time series of the Palmer Drought Severity Index (PDSI), precipitation, and temperature for Climate Division 8 in Oklahoma. The 5-yr running mean is shown by the shading in the precipitation and temperature plots.

- These oscillations were then grouped into 6 likely drought scenarios developed out of the literature for testing how well drought teleconnections downscale to the climate division level
- A proportional odds logistic regression model was fit to determine if the expected teleconnections from each scenario would verify in only Climate Division 8
  - Forward & backward stepwise model selection based on AIC was used for model training

Scenario	Description
Scenario #1	Negative ENSO
Scenario #2	Positive AMO
Scenario #3	Negative ENSO & Negative PDO
Scenario #4	Negative ENSO & Positive AO
Scenario #5	Positive AMO & Negative PDO
Scenario #6	Negative ENSO, Negative PDO, & Positive AMO

Figure 3. Table providing a description of each of the 6 scenarios tested. For example, for a period of time to be classified as scenario #3, indices for both ENSO and PDO must be negative.

Results/Conclusions:

	AO	AMO	PDO	ENSO	AO*AMO	AMO*PDO
Proportional Odds Ratios	1.01	0.17	1.36	1.78	0.50	0.39

	AO*ENSO	AMO*ENSO	PDO*ENSO	AO*AMO*ENSO
Proportional Odds Ratios	1.17	3.21	1.32	0.39

Figure 4. Table of estimated proportional odds ratios for the logistic regression model used. A coefficient of 1.0 indicates no impact; a coefficient of 2.0 indicates that for every one unit increase in the oscillation, the next higher tercile of PDSI is twice as likely; a coefficient of 0.5 indicates that for every one unit increase in oscillation, the next higher tercile of PDSI only half as likely. Coefficients of 2.0 and 0.5 indicate effects equal in magnitude and opposite in direction.

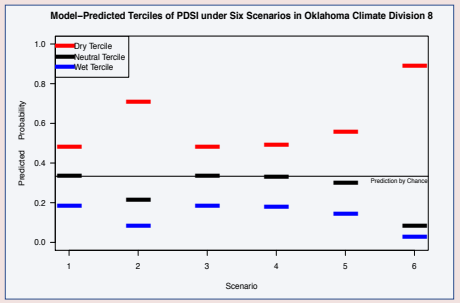

Figure 5. The predicted probabilities of a PDSI value occurring in one of three terciles under a given scenario. Values in the dry tercile represent the lowest third of measured PDSI values for OK Climate Division 8; values in the neutral tercile represent the middle third of measured values; the wet tercile represents values in the highest third of measure values. Any predicted probability above the line indicates more skill than chance in the prediction.

- All 6 scenarios were shown to predict drought at better than chance
- Scenarios 2, 5, & 6 make the strongest predictions for drought in the climate division
- The positive AMO phase is common in all 3 above scenarios and appears to be a good predictor for drought for the Arbuckle-Simpson Aquifer

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