Understanding the Impact of Drought on Crop Yield in South and North Carolina

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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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UNIVERSITY OF SOUTH CAROLINA

Introduction

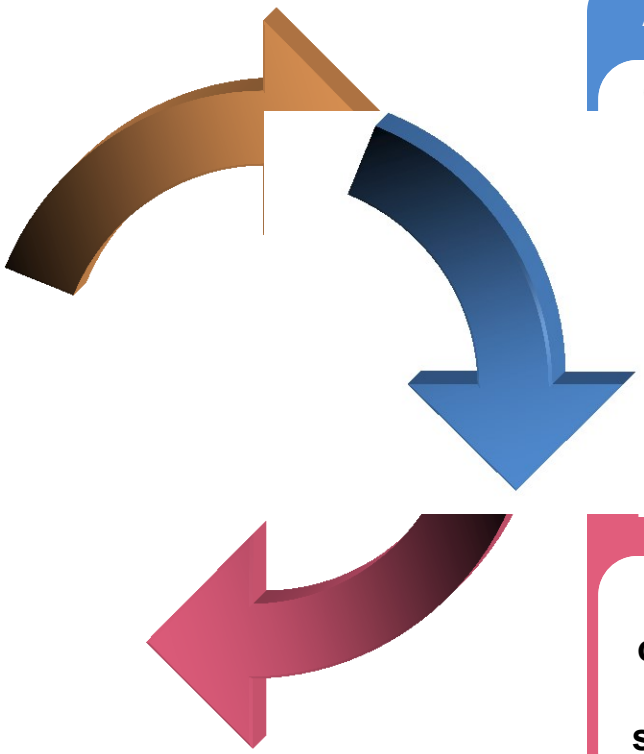
Drought Classification

Meteorological Drought

Absence or reduction of precipitation over a region, precipitation are used commonly as primary indicator

Agricultural drought

Occurs at a critical time during the growing season resulting in declining soil moisture and crop failure



Socio-economic drought

Associated deficits of water resources systems leading to failure to meet the demand of some economic goods and social needs

Hydrological drought

Precipitation deficits over a prolonged period that affect surface or subsurface water supply

Heim 2002, Mishra and Singh 2010

Data Source

- Long-term county-level agriculture statistics were obtained from USDA's National Agricultural Statistics Service (NASS) (http://www.nass.usda.gov/).

- County-level drought indices (Monthly PDSI, Palmer Z-index, 3-Month SPI, 6-Month SPI, 9-Month SPI) are obtained from Dynamic Drought Index Tool (DDIT) For Basins In North and South Carolina (https://www.dnr.sc.gov/drought/).

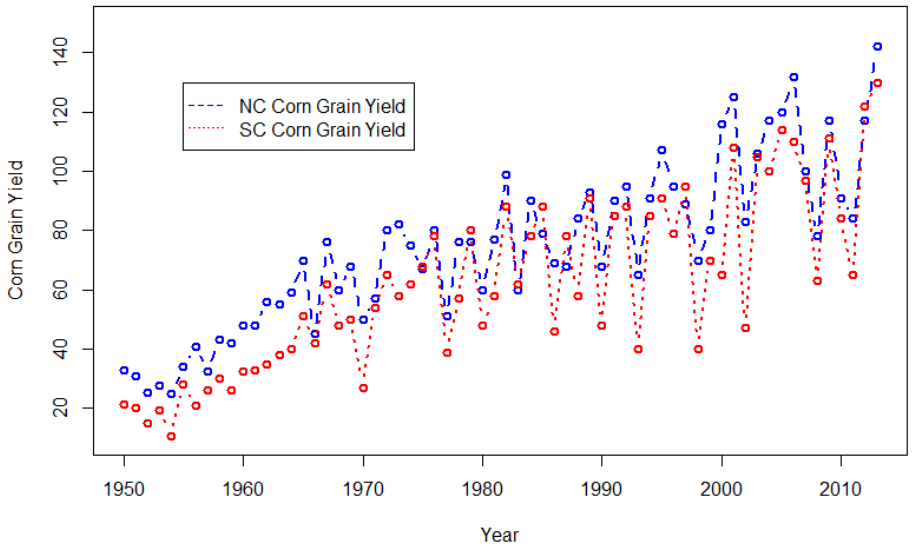
Drought Indices

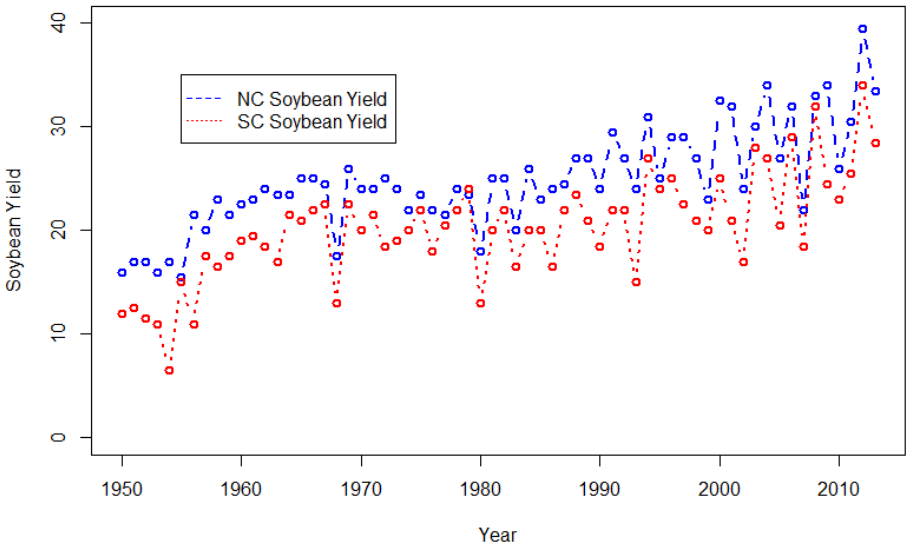
- Monthly PDSI (Palmer Drought Severity Index)
- Based on the supply-and-demand concept of the water balance equation by using long term historical precipitation, temperature data and also Available Water Content (AWC) of the soil.

- Palmer Z-index
- Palmer Z-index can be expressed as the "Moisture Anomaly Index." Each monthly Z value is a measure of the departure from normal of the moisture climate for that month.

- SPI (Standardized Precipitation Index)
- SPI is based only on precipitation data. It is standardized into different time scale and can be comparable over space and time.

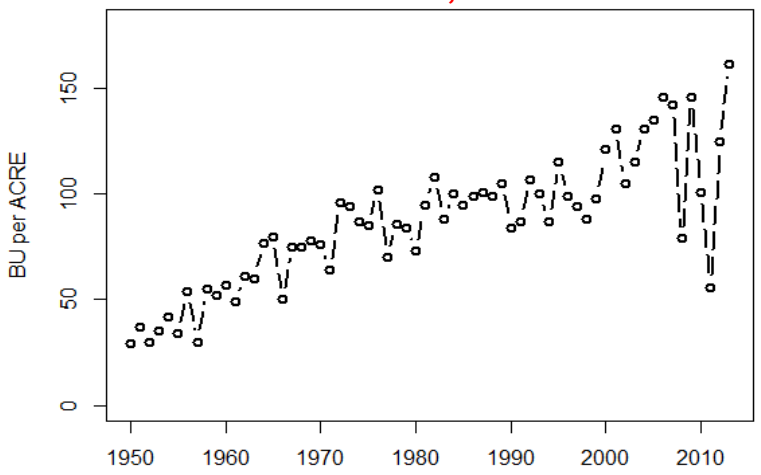
State Crop Yield Trend



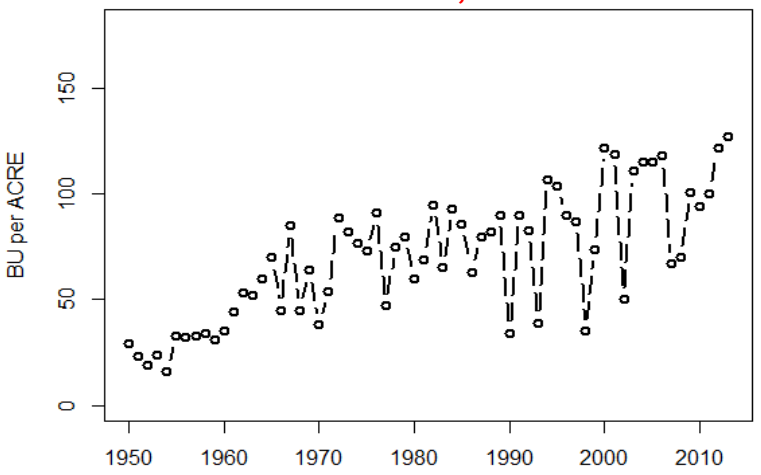


County Corn Yield Trend

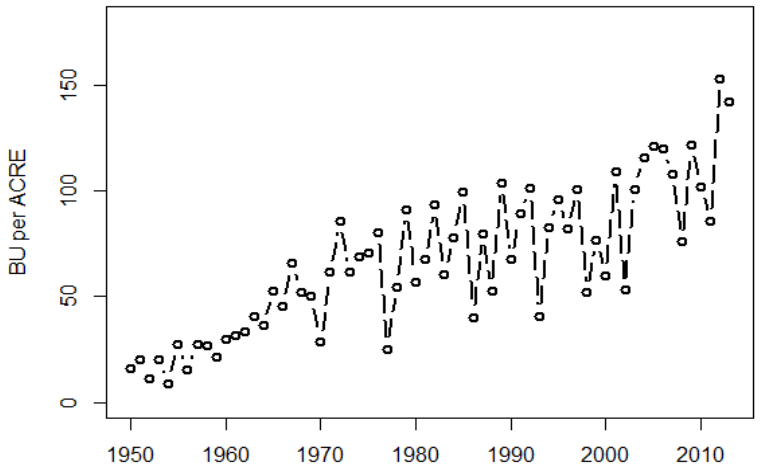
Beaufort, NC



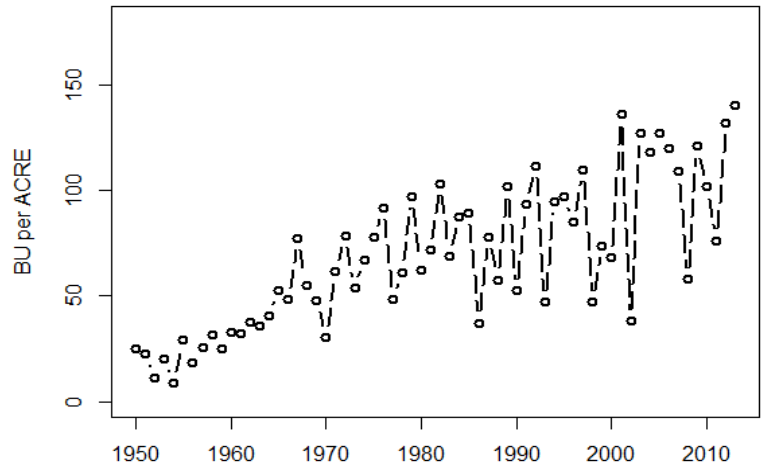
Robeson, NC



Orangeburg, SC



Clarendon, SC



Research Question?

- How can we separate irregular roughness caused by weather related factor from long-term trend caused by science advancement and technology development?

- What are the drought impacts on crop yield?

Trend Simulation Method: Simple Linear Regression Model

- Simple Linear Regression Model
- $y = \beta_0 + \beta_1 x + \varepsilon$

- Where
- β_0, β_1 are unknown constants
- x represents time (year)
- y represents crop yield
- ε represents random effects

Trend Simulation Method: Moving Average Model

- Moving average smoothing can be used to smooth out the irregular roughness and high-frequency variation.
- Centered Moving Average: use values both before and after the current time

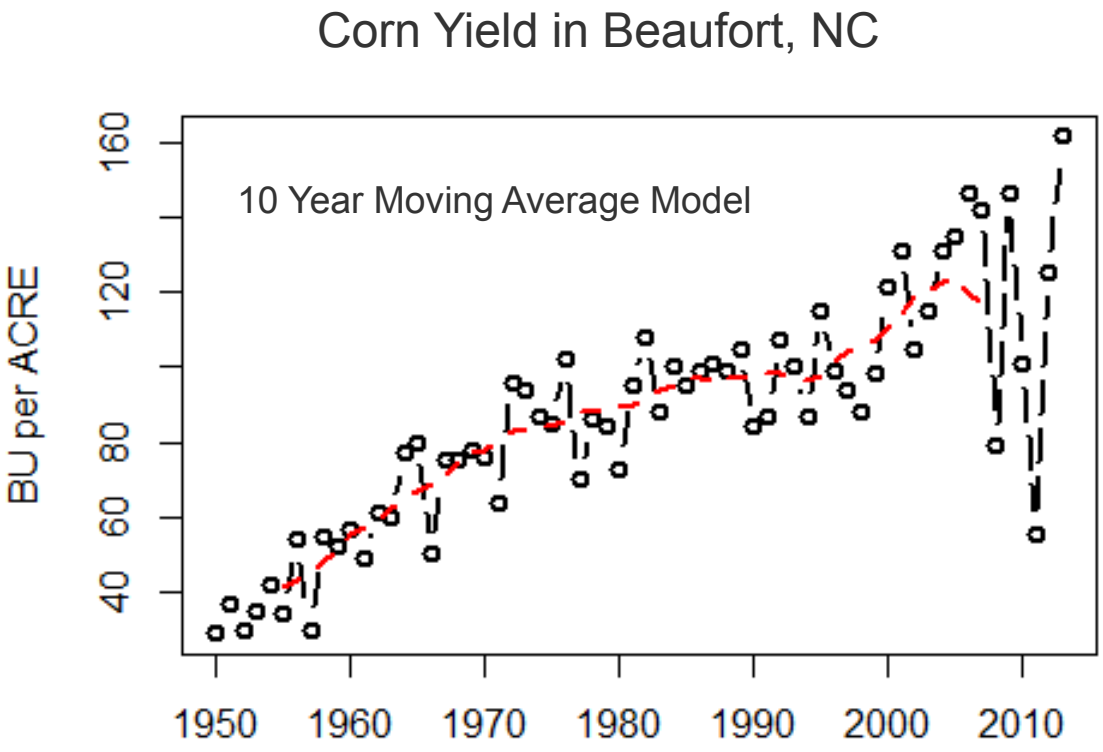
- Half a decade (5 years) and One decade (10 years)
- 5 Years Centered Moving Average Model

$$mx_t = \frac{1}{5}x_{t-2} + \frac{1}{5}x_{t-1} + \frac{1}{5}x_t + \frac{1}{5}x_{t+1} + \frac{1}{5}x_{t+2}$$

- 10 Years Centered Moving Average Model

$$mx_t = \frac{1}{20}x_{t-5} + \sum_{j=-4}^{4} \frac{1}{10}x_{t+j} + \frac{1}{20}x_{t+5}$$

Simple linear regression model VS Centered moving average model



Decomposition Model

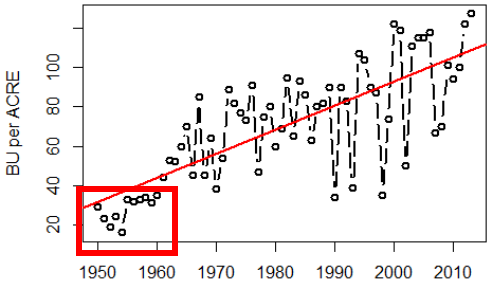
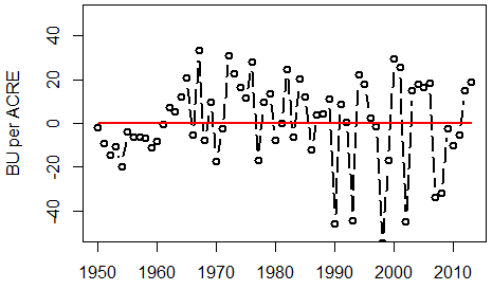
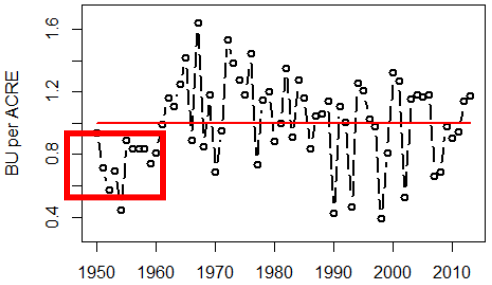
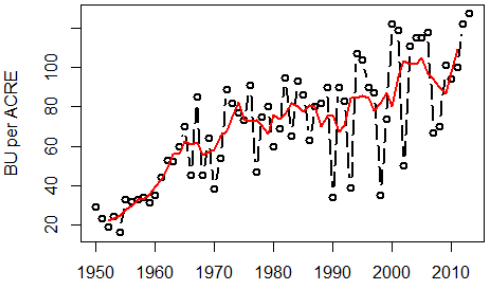
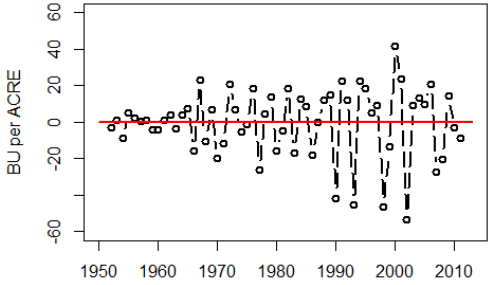
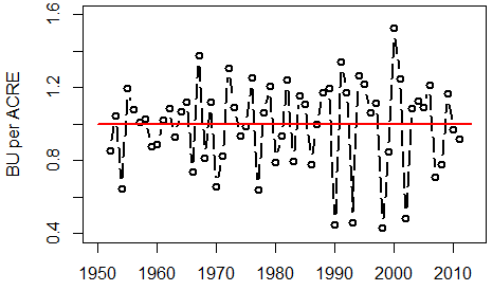
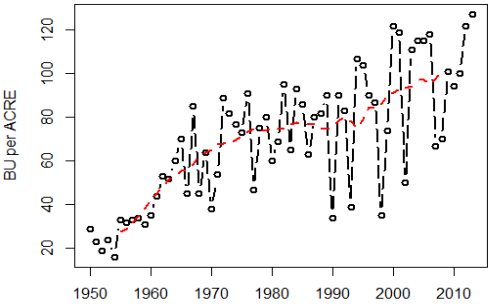
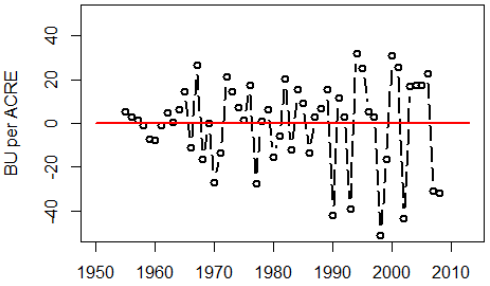
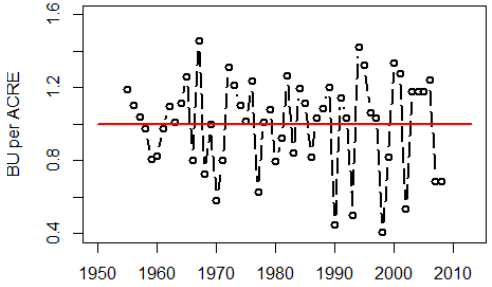
- Additive Decomposition Model:

$$x_t = Trend + Weather\ related\ \ factor + Random$$

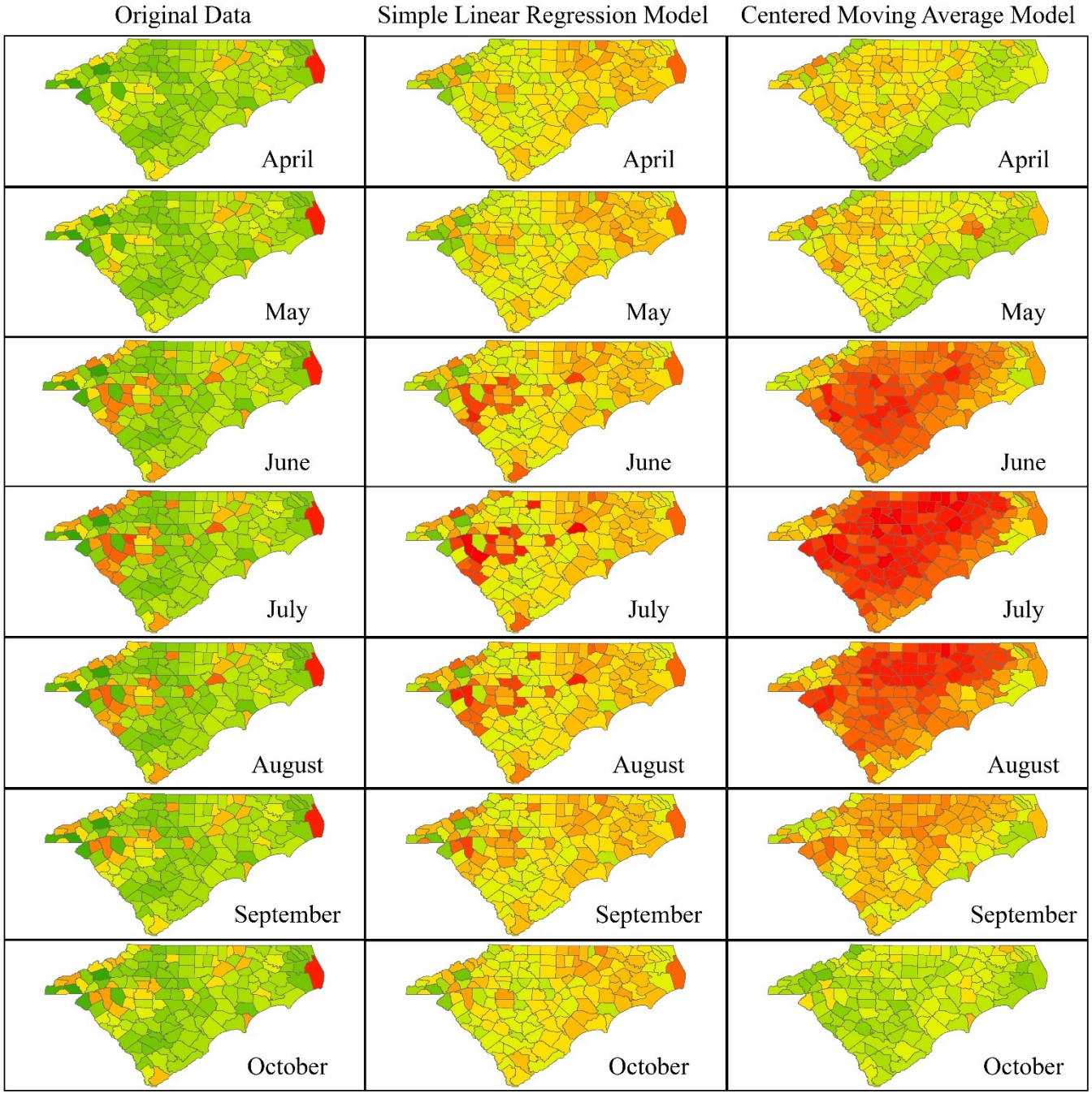
- Multiplicative Decomposition Model:

$$x_t = Trend * Weather\ related\ \ factor * Random$$

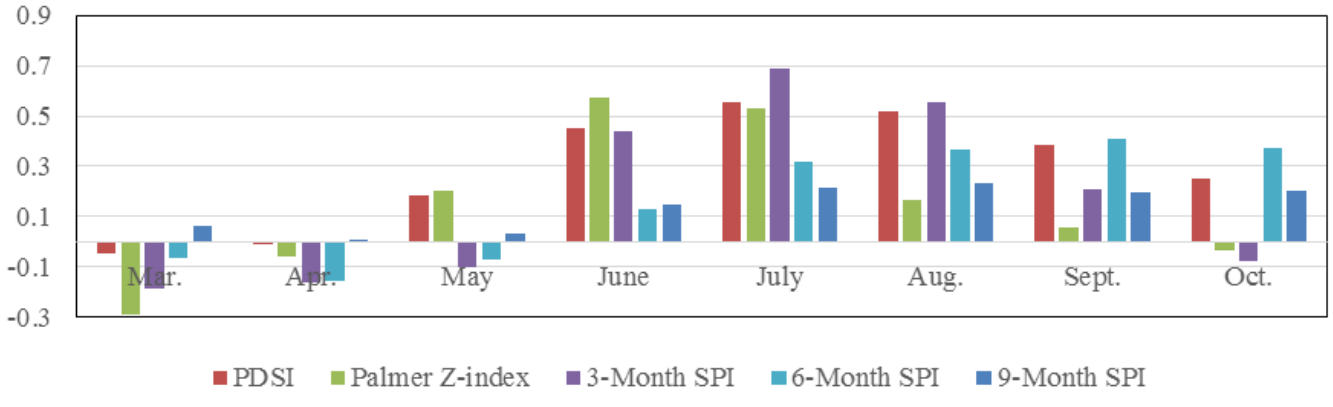
Robeson, NC

	Original Data	Additive decomposition	Multiplicative decomposition
Linear Regression Model			
5 Year centered Moving Average Model			
10 Year Centered Moving Average Model			

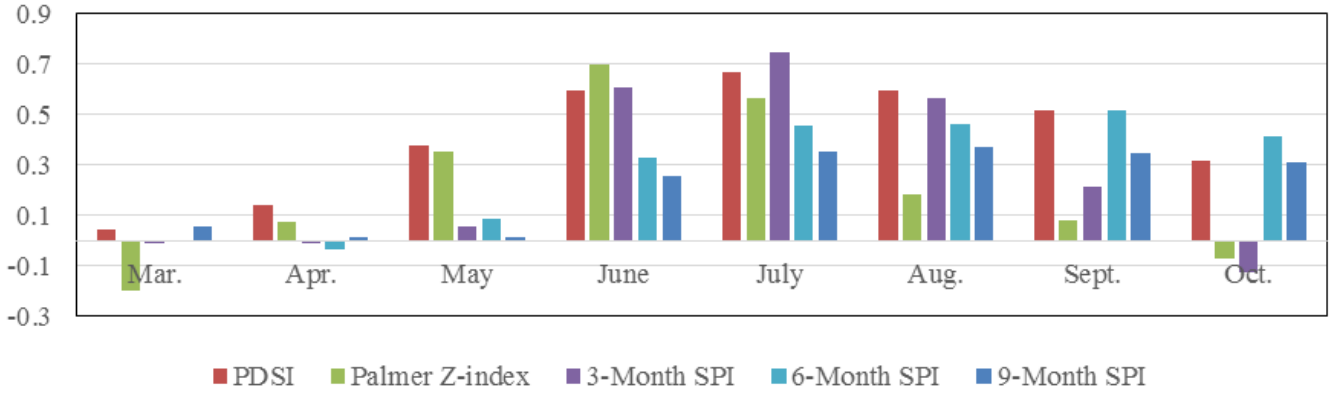
Moving Model



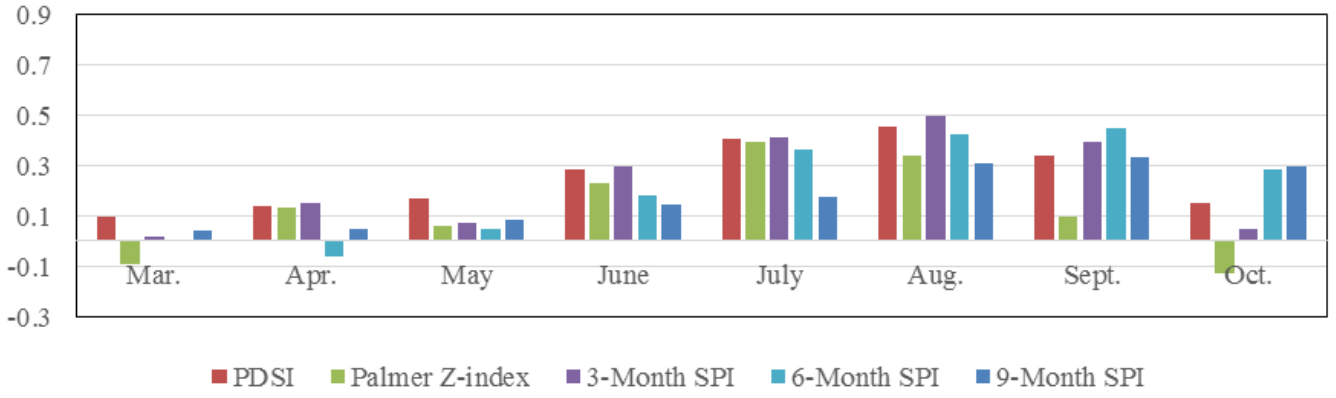
Correlation between CMA Detrended Corn Yield and Drought Indicies in North Carolina



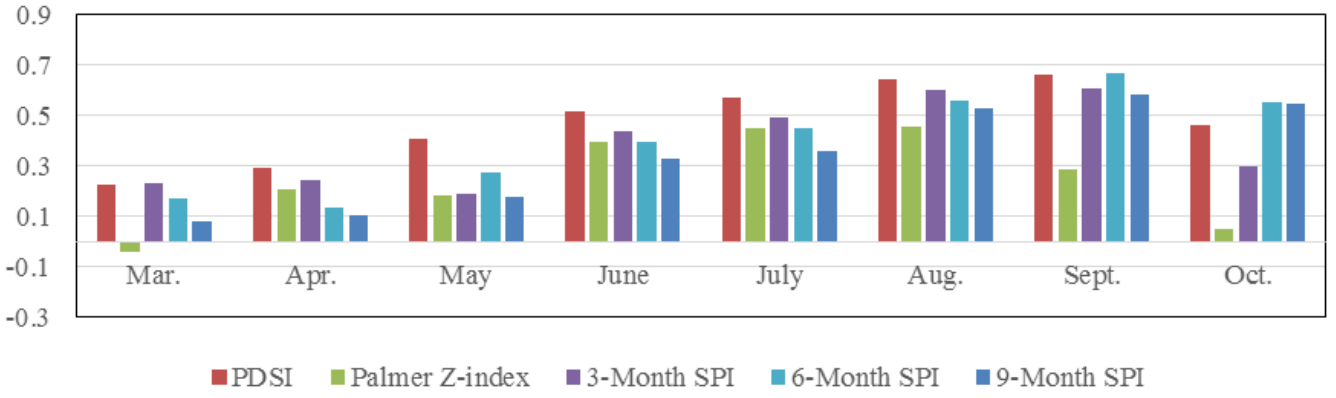
Correlation between CMA Detrended Corn Yield and Drought Indicies in South Carolina



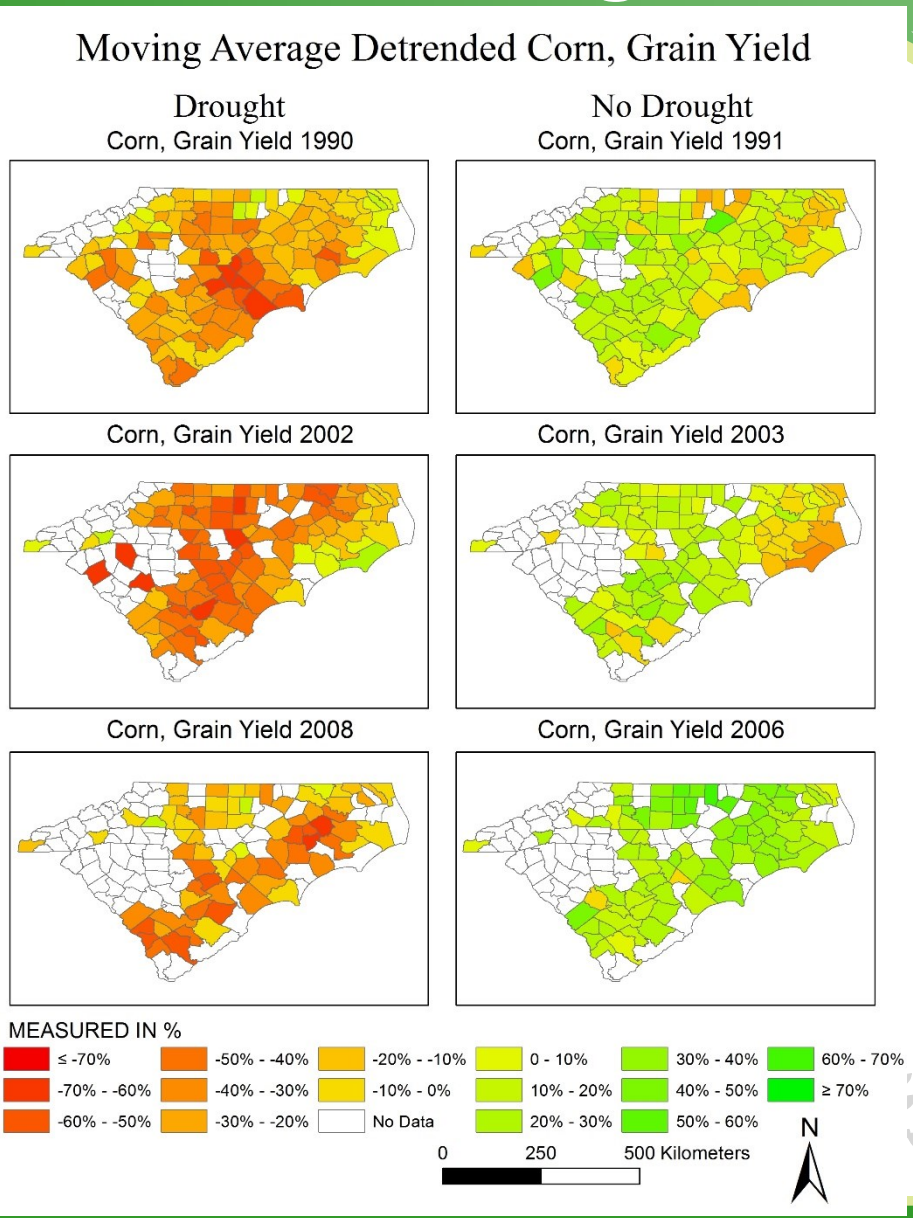
Correlation between CMA Detrended Soybean Yield and Drought Indicies in Nouth Carolina



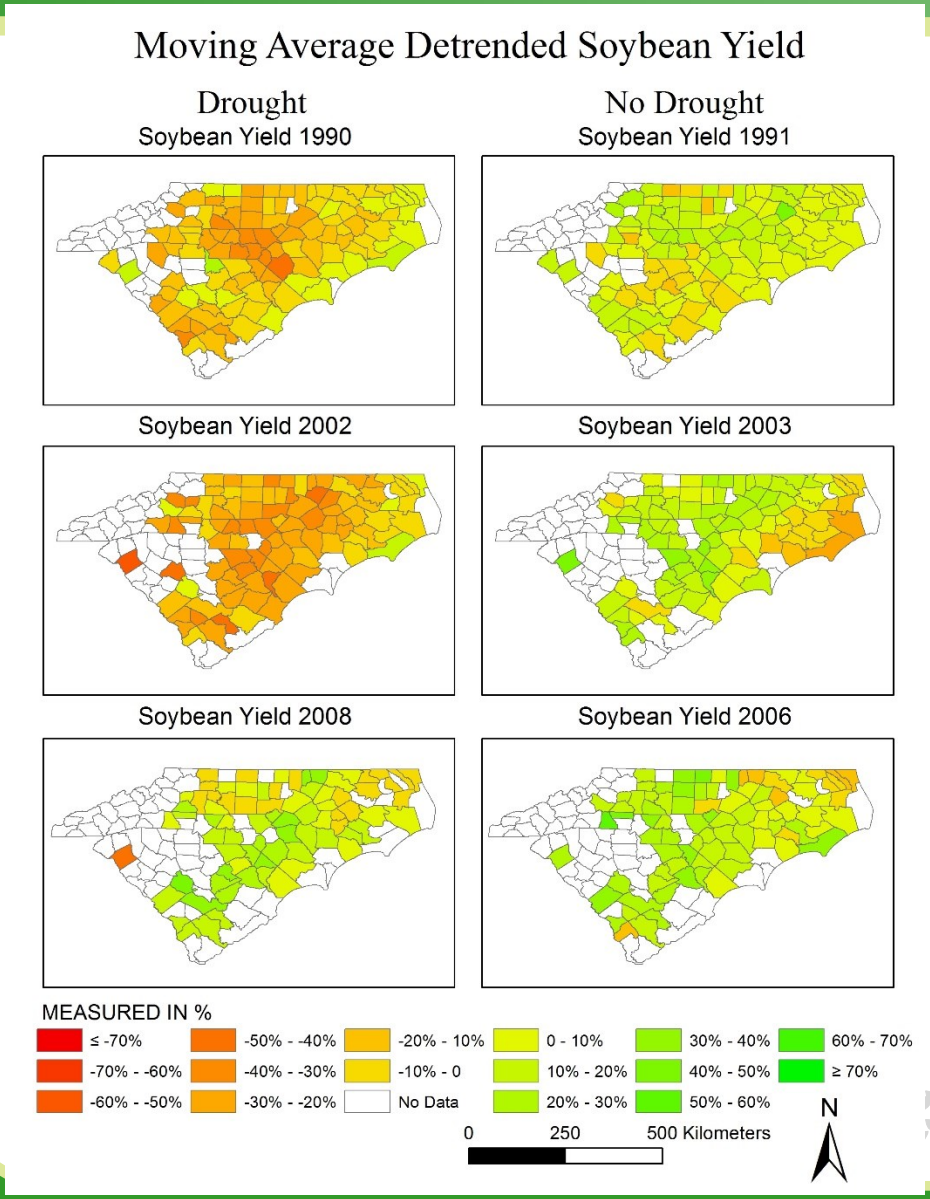
Correlation between CMA Detrended Soybean Yield and Drought Indicies in South Carolina



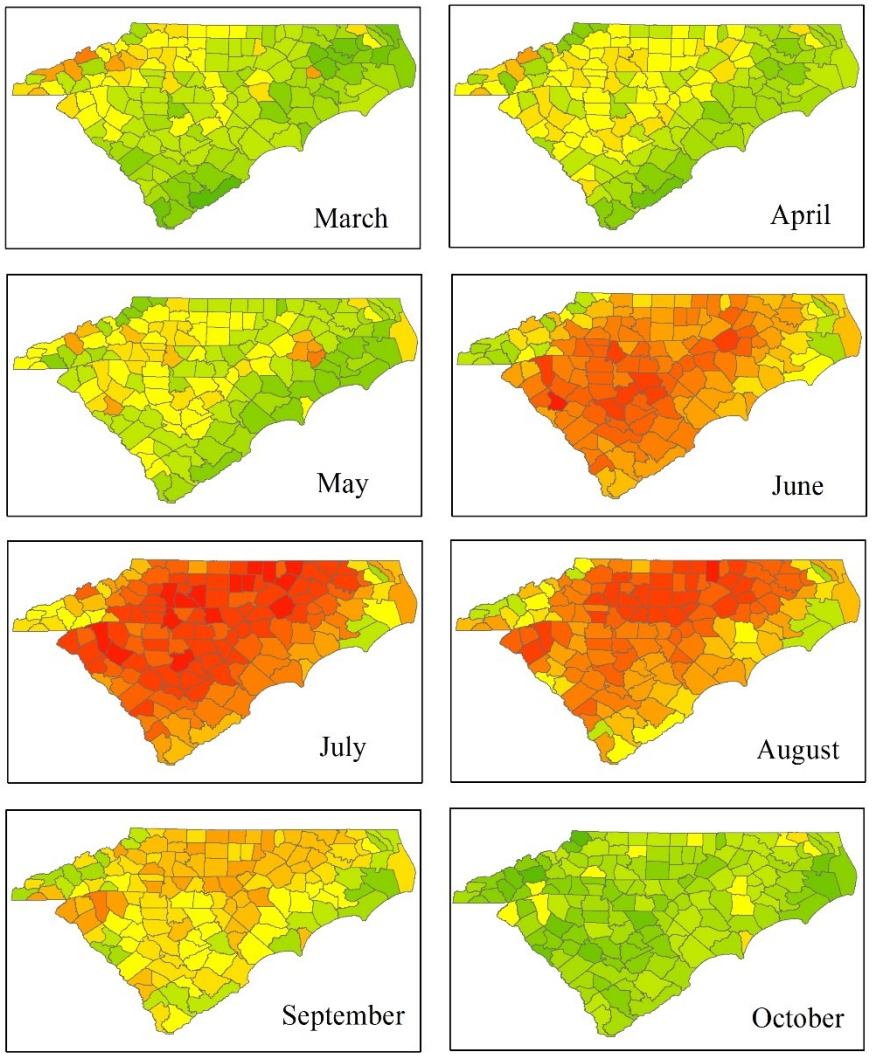
Drought Year vs No Drought Year



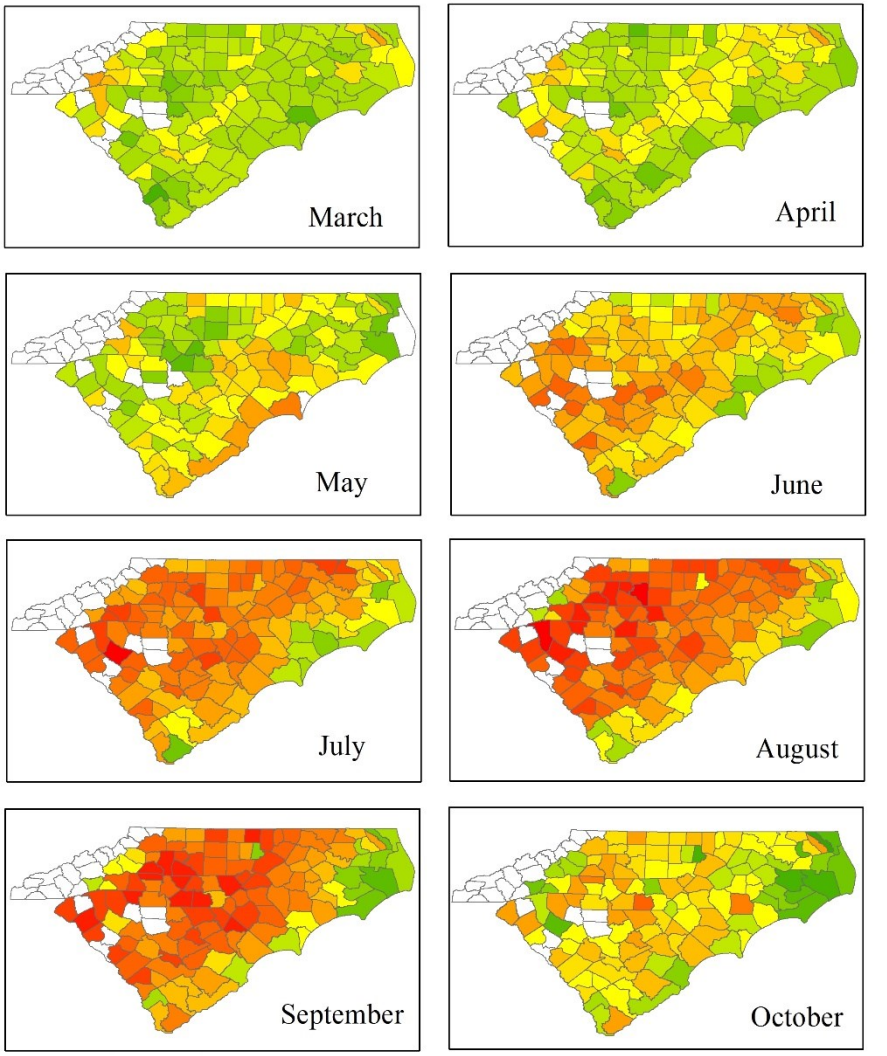
Drought Year vs No Drought Year



Correlation between MA Detrended Corn Yield and 3-Month SPI



Correlation between MA Detrended Soybean Yield and 3-Month SPI



Results

- Centered moving average (CMA) model performed better than linear regression model to simulate the long-term trends of the crop yield.
- The multiplicative decomposition model did better at separating out high frequency variation than the additive decomposition model.
- Detrended corn yield showed a higher level of correlation with 3-Month SPI in June, July and August than the other months and detrended soybean yield showed a higher level of correlation with 3-Month SPI in July, August and September.

Discussion

- In this research, we are focused on drought impact on crop yield.

- In the future, we need to incorporate other extreme weather impacts, such as flood, heat wave and tropical storm.

Thank you!

Questions or comments?

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