Streamflow Responses to Climate Variability across a Gradient of Precipitation in Oklahoma

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Introduction

Precipitation in Oklahoma is dominated by decadal-scale cycles of relatively wet and dry periods primarily controlled by large-scale climatic phenomena such as the Pacific Decadal Oscillation (PDO). However, it is not well known how streamflow responded to these decadal-scale cycles of wet and dry periods and how did the response vary along the precipitation gradient.

Objectives

The objective of this study is to contrast the streamflow and precipitation relationship for watersheds along the precipitation gradient in Oklahoma and understand how this relationship is affected by the positive and negative phases of PDO.

Methods

We calculated annual total streamflow depth (inches) and streamflow coefficient (ratio between annual streamflow and annual precipitation) from 1932 to 2014 for 13 meso-scale watersheds across the State of Oklahoma. We analyzed the correlation between PDO indices and annual precipitation along the gradient. We also calculated the coefficient of determination between streamflow and precipitation for all years, negative, and positive phases of PDO, respectively, and plotted them on map. Streamflow data were from the USGS water watch database and precipitation data were from the United States Historical Climatology Network.

Results and discussions

Annual streamflow depth ranged from less than 1 inch in the Panhandle to over 20 inches in the southeast (figure 1).

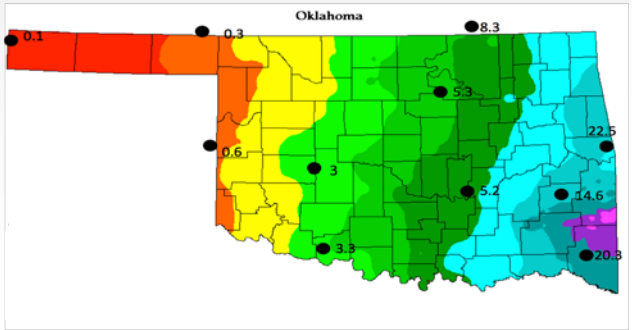

Figure 1. Annual streamflow depth (inches) averaged over the period between 1932 and 2014

The streamflow coefficient rapidly decreased from the southeast (up to 50%) towards the panhandle (less than 1%) (figure 2). Streamflow coefficient for a given watershed remained relatively constant for both negative and positive PDO phases (not present).

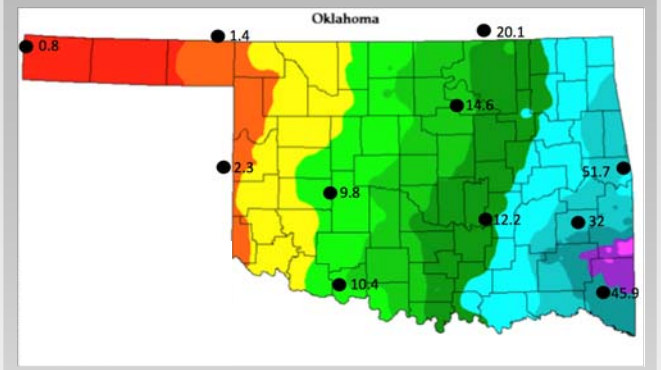

Figure 2. Streamflow coefficient percentage (ratio between annual streamflow and annual precipitation*100)

The correlation between PDO indices and annual precipitation increased from central Oklahoma to the west part of the state as elevation increases, with weak correlation for the east and south east part of the state (figure 3).

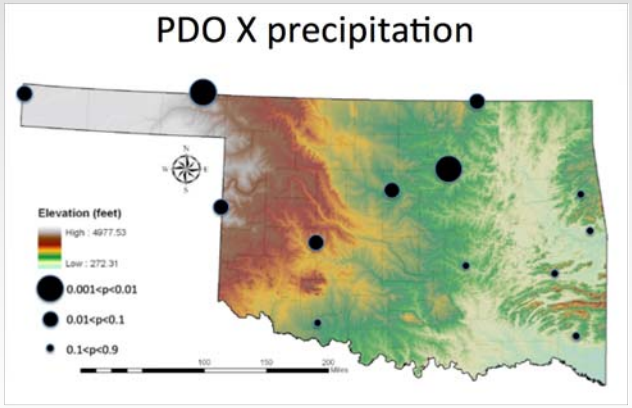

Figure 3. Elevation map showing correlation between PDO indices and annual precipitation between 1932 and 2014.

At the arid and semiarid panhandle regions, precipitation is a poor indicator for streamflow in general. In other regions of the state, precipitation accounts for 10-50% variability of the long term streamflow (figure 4).

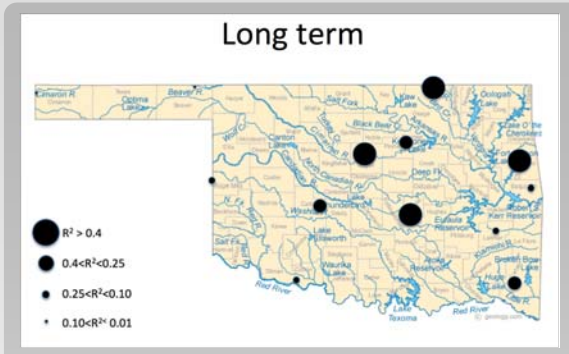

Figure 4. Relationship between precipitation and streamflow over the period between 1932 and 2014

The coefficient of determination between precipitation and streamflow were higher for negative phase (figure 5) than for positive phase of PDO (figure 6).

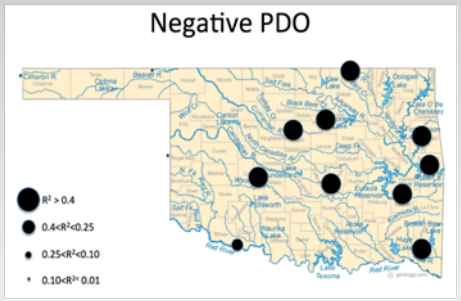

Figure 5. Negative PDO years are: 1932-1933, 1943-1956, 1961-1976, 1989-1991, 1999-2002, 2007-2013.

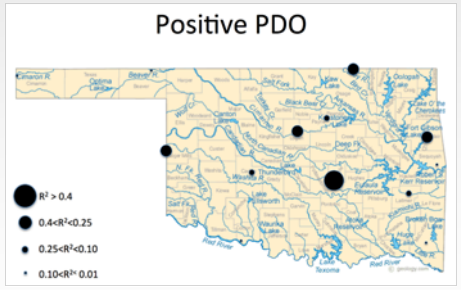

Figure 6. Positive PDO years are:1930-1931, 1934-1942, 1957-1969, 1977-1988, 1992-1998, 2003-2006, 2014.

Acknowledgement

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