Long Term Perspectives of Drought in the American West:

Lessons from 1918 to 2015

Abstract:

We investigated the spread of multiyear droughts of a specific severity during the 20th century by using a metric that integrated multiple climate indicators in order to analyze drought trends and examine drought effects on multiple vegetation types. A simple algorithm was used that summed estimated drought cover in the Western United States during 1918 to 2014 moisture deficit based on hydrological variables from the Variable Infiltration Capacity model over a threshold severity. Results indicate that 35% of the Western United States experienced a three-year drought during that time, with few areas of California affected by three-year droughts before the 2011 to 2014 drought. Drought severity in the 1930s was primarily driven by decreased precipitation, moderate temperature anomalies, and high evapotranspiration in regions accustomed to low moisture deficit. High temperatures and moderate evapotranspiration exacerbated severity in the 2000s in regions with low to high regional moisture deficit. Water managers should consider the impacts of multi-year droughts in different regions when assessing drought risk.

Introduction

Water has long been considered the most important resource of the Western United States. As regional populations grew over the last century at double the rate of the rest of the country, so has the importance of taming the arid expanses of desert with irrigated farmland and smoothing the peaky nature of the precipitation in Mediterranean coastal valleys (Hobbs and Stoop 2002, Cadillac desert). Winter precipitation accounts for the majority of rainfall with interannual variability explained the El Niño Southern Oscillation, a two to seven year cycle of cooling and warming of eastern equatorial sea surface temperatures.

Recent history of water management of the West has been one of public works projects that sought to control some of the earth’s wildest watersheds. Despite the hopes of the engineers that their works would provide continuous water for the burgeoning populations, the water history of the West is also one of periodic, extreme droughts (Dettinger et al. 2015, Colorado River Management). Archeological evidence and climate reconstruction from tree-ring chronologies point to “megadroughts” destabilizing agricultural societies. Current droughts covering the West have been some of the most severe for the last 700 years, but pale compared to records of elevated aridity from 900 to 1200 AD (Cook 2004). Modern droughts have been linked to increased fire severity and burned area, bark beetle infestations of conifers, crop losses, and tree mortality (Negron, Park, Guarín, Asner). Reliance on groundwater for irrigated agriculture has led to subsidence and permanent aquifer loss in California’s Central Valley and Southern Arizona during extended droughts as low precipitation and streamflow reduce recharge (Conway, Flaunt). Anthropogenic climate changes is thought to increase drought risk in the American Southwest (Cook),

Labeling current droughts with epithets like “historic”, “unprecedented”, or “epic” has little meaning without accounting for temporal and spatial differences of ecology, climate, and anthropogenic ecosystem pressures. But what is a drought? The onsets of most ecological disruptions can be recognized, but droughts are hydrological disturbances with a slow onset, differing severities and varying lengths. Many drought indices have been proposed, and generally fall into four categories based upon the method of measurement and affected populations: Hydrological, meteorological, agricultural, and socioeconomic (Heim). A widely used index is the Palmer Drought Severity Index (PDSI), though it has been criticized for how it treats spatially diverse regions and factors such as soil moisture, runoff, and precipitation. In addition, the index does not have minimum or maximum limits, leading to a somewhat arbitrary interpretation of severe, moderate, or extreme drought.

Several questions will be investigated in this work: When and where were multiyear severe droughts in the last century? Was temperature a driver of drought severity? How was vegetation influenced by different drought events? Are there hot spots of drought? Is drought frequency increasing? We will address these questions with a simple metric based upon moisture deficit that controls for drought length and severity and inspect patterns of regional drought throughout the 20th century.

As annual variation of precipitation is a normal occurrence in the West, a simple multi-year metric would be best suited to access drought over the last century. Due to recognized issues with using PDSI to compare spatially and temporally diverse regions, we decided that accessing moisture deficit could provide simple yet meaningful comparisons.