Geophysical Research Abstracts
Vol. 20, EGU2018-938, 2018
EGU General Assembly 2018

Classifying long and severe droughts from centuries of monthly reconstructed flows

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Here we present a new advance in reconstructing streamflow from tree-rings that permits reconstruction of flows at a monthly, rather than annual time scale. Monthly reconstructions are critical for characterizing hydrologic droughts at temporal scales that are relevant to water resources planning. We demonstrate the potential for this approach by reconstructing monthly flow since 1430 CE in the Weber Basin of northern Utah (western United States) as part of an ongoing drought contingency study for the region. Incorporating reconstructed monthly flows lengthened the available flow record from approximately 100 to 600 years, producing 144 unique drought events that could be used directly as inputs in an existing water systems model for the region. Because of this expanded catalog of historical drought events, we sought to identify recurrent drought types using hierarchical clustering to be used as potential scenarios. Clustering produced nine distinct drought types, of which four were of sufficient length and severity to require drought mitigation actions. The four relevant clusters were defined as short (< 2 years), moderate (2-4 years), and two unique long drought types (> 4 years). The long drought clusters differed in shape, either accumulating shortages gradually or producing rapid shortages that continued for the duration of the event. Analysis of the reconstructed drought events also confirmed that, while the observed drought of record (1930, 7 years) remains the most severe drought in terms of minimum flow percentile during the past 600 years, drought events lasting longer than 13 years exist during this period (1658, 1705). Duration and drought type (i.e. gradual or rapid) are potentially a greater drought mitigation challenge than minimum flow in the Weber basin, as most reservoirs are designed with a 2-year capacity. This study demonstrates the value of new monthly flow reconstructions derived from tree-rings for drought vulnerability studies, particularly when combined with clustering techniques that can narrow and classify potential drought scenarios. The classification scheme can also be used to merge reconstructions with the observed record and climate change projections to quantify shifts in drought types and severity over time. All reconstructed flows are publicly available in an online visualization tool (www.paleoflow.org).