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Spatial extent of hydrological drought in the United States: changes and hydro-meteorological drivers

Manuela Irene Brunner[1], Daniel L. Swain[2], Eric Gilleland[1], and Andrew W. Wood[1]
[1]National Center for Atmospheric Research, Research Applications Laboratory, Boulder, CO, USA
(manuela.i.brunner@gmail.com)
[2]Institute of the Environment and Sustainability, University of California, Los Angeles, CA, USA

Droughts can seriously challenge water management if they have large spatial extents. These extents may change in a warming climate along with changes in underlying hydro-meteorological drivers. Therefore, we ask (1) how streamflow drought spatial extent has changed over the period 1981-2018 in the United States, (2) which physical drivers govern drought spatial extent, and (3) whether/how the importance of these drivers has changed over time. We analyze temporal changes in streamflow drought extents and their drivers using drought events extracted for 671 catchments in the conterminous United States using a variable threshold-level approach. Drought spatial extents are determined as the percentage of catchments affected by drought during a certain month. Then, important drivers are identified by determining the spatial percentage overlap of the area under streamflow drought with precipitation droughts, temperature anomalies, snow-water-equivalent deficits, and soil moisture deficits. Finally, the spatial extent and overlap time series are used in a trend analysis to determine changes in drought spatial extent and to identify changes in the importance of different variables as drivers of drought spatial extent. Our analyses show that (1) drought spatial extents have increased, mainly because of increases in the extent of small droughts; (2) drought extents overall substantially overlap with soil moisture deficits and the relationship of drought to precipitation and temperature varies seasonally; (3) the importance of temperature as a driver of drought extent has increased over time. We therefore conclude that continued global warming may further increase the probability of spatially compounding drought events, which requires adaptation of regional drought management strategies.