Geophysical Research Abstracts
Vol. 20, EGU2018-292-1, 2018
EGU General Assembly 2018

A critical reevaluation of streamflow drought under semiarid conditions: a novel seasonal approach for monitoring streamflow drought

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Proper estimation of streamflow drought frequency provides the basis for both short and long-term planning of water resources management. Hydrological drought is commonly used to describe accumulated shortfalls of both surface and subsurface water supplies, which define the overall state of streamflow drought. Numerous drought indices have been proposed to provide descriptions of hydrological drought severity, duration and impact. Some of the widely used hydrological drought indices are Streamflow Drought Index (SDI), requiring streamflow as input; Surface Water Supply index (SWSI) requiring snowpack, streamflow, precipitation and reservoir storage; Standardized Runoff Index (SRI); Standardized Hydrological Index (SHI); etc. Recent advances in multivariate analysis have offered the opportunity to combine different drought categories through the use of copulas, introducing indices such as Multivariate Standardized Drought Index (MSDI), incorporating meteorological and agricultural droughts; Standardized Precipitation Streamflow Index (SPSI), incorporating meteorological and hydrological droughts; Non-parametric Multivariate Standardized Drought Index (NMSDI); Multivariate Standardized Reliability and Resilience Index (MSRRI) and Joint Deficit Index (JDI). However, when semiarid regions are being assessed, the advantages gained by choosing an appropriate index considering the presented water crisis are offset by the failure of the selected index to represent a proper state of drought due to overlooking seasonal characteristics of streamflow. Under semiarid conditions, it is common to have several months with little or no rain, whereby, streamflow is characterized by base-flow, generally fed by groundwater and snowmelt or zero-flow. A key objective of this study is to propose a methodology to overcome an apparent flaw in the estimation of streamflow drought in semiarid regions.
In this study, time series of streamflow was disaggregated into two distinct wet and dry seasons on the basis of differences in statistical properties, found by utilizing a boxplot approach for monthly averaged streamflow amounts. An adjustment was proposed for SDI, allowing the index to account for seasonal characteristics of streamflow drought. Results revealed some major differences in behaviors of drought time series with time scales of 3, 6, 9 and 12 months during dry and wet seasons. Differences include, longer mean and maximum drought duration in the dry season, longer recovery time from drought in the dry season SDI and a higher number of droughts during the wet season. These results emphasize the need for seasonal treatment of drought indices such as SDI, when utilizing streamflow data of semi-arid regions. This calls for a critical reevaluation of streamflow related drought indices used under semiarid conditions. We aim to highlight the most foundational issue of drought analysis and yet amenable to repair. Failure to recognize the discrepancy between drought properties of the dry and wet season may result in catastrophic failures in water resources management planning.