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A groundwater drought index for Germany

Jude Lubega Musuuza (1,2), Rohini Kumar (2), Luis Samaniego (2), Roland Barthel (3), Sabine Attinger (1,2)
(1) University of Jena, Institute of Geociences, Jena, Germany (jude.musuuza@uni-jena.de), (2) UFZ Leipzig, Germany, (3) University of Gothenburg, Sweden

Droughts occur when storage in the surface-water bodies, soil and the ground falls below long-term climatological mean values. Surface-water storage reacts immediately to precipitation events and can result in meteorological droughts. Soil moisture however needs longer reaction times than surface water and is only influenced by longer-term precipitation deficits, causing agricultural droughts. Groundwater storage responds very slowly in comparison to surface-water and soil moisture and is usually only affected by very persistent deficits in precipitation and soil moisture, resulting in hydrological droughts. The groundwater response lags behind those in surface water and soil moisture. A systematic investigation of the lag times could give valuable insights into the temporal relationships between the meteorological, agricultural and hydrological droughts. The specific questions are whether a system can recover from meteorological and agricultural droughts before the onset of a hydrological drought; if it is possible for a system to to be under hydrological drought conditions after surface and soil moisture storages have been replenished and the severity of meteorological and agricultural droughts required to trigger a hydrological drought. Such knowledge would be useful in the agricultural regions of Germany and for planning sustainable use of groundwater. Measured water-table positions are direct representations of groundwater storage with increased draw-downs indicating depletion. Due to lack of reliable long-term water-table measurements over the entire country, we first correlate the modelled groundwater storage anomaly derived from a hydrological model mHM (Samaniego et al. 2010), with the limited groundwater measurements at locations in the Southern region of Germany. After this model verification process, we extend our analysis to develop a groundwater drought index GWI similar to the soil moisture index SMI (see e.g., Samaniego et al. 2012). The latter index is used to characterise soil moisture deficit in agricultural drought monitoring and forecasting systems while the proposed GWI characterises the groundwater deficit. Based on GWI, we investigate different statistics (severity, area and duration) of individual groundwater drought events. Furthermore, the regional relationships between different drought indices will be investigated in this study.

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