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Detecting drought-induced changes in catchment hydrological behaviors by combining data assimilation technique with process-based model

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Abstract: Persistent below-normal precipitation over a period of months to years, typically classified as meteorological drought, not only can result in severe low water availability in surface water and groundwater, which is typically classified as hydrological drought and has devastating effects on ecosystems and society in many ways, but also can induce changes in catchment hydrological behaviors (i.e. nonstationarity). However, at present, our understandings about drought-induced changes in catchment hydrological behaviors and development and recovery of hydrological drought are still very uncertain, especially for big drought events. It has limited our capability to predict and mitigate the impacts of prolonged drought events. In this study, drought-induced changes in catchment hydrological behaviors of two catchments in Southeast Australia (SEA) are examined by combining data assimilation approach (i.e. Ensemble Kalman Filter method) with a process-based hydrological model (i.e. two-parameter monthly water balance model). Both of these two catchments have about 100-year observations available and have experienced many small (< 5 years) and two big drought events, i.e. the World War II (WWII) drought (∼1937-1945) and the Millennium drought (1997-2009). Modelling experiments demonstrate that protracted drought events (> 5 years) have caused significant changes in catchment hydrological behaviors, indicating by significant temporal changes in state parameters of the hydrological model. Thresholds of the length of persistent meteorological drought (<-15% rainfall anomaly) for triggering, development and recovery of hydrological drought and changes in catchment hydrological behaviors are further investigated. Results of this study are consistent with previous findings on the impacts of the Millennium drought on regional water availability in the SEA. Importantly, based on long-term drought observations, here we have revealed the drought-induced changes in hydrological behaviors and have characterized the coevolution of meteorological and hydrological droughts quantitatively by combining of data assimilation techniques with hydrological models and. The proposed method in this study provides an effective way to assess the impacts of drought on local hydrological cycles and the findings can help us mitigate prolonged drought and develop preparedness and adaptation strategies for projected increasing in the frequency of big drought in future.
Key words: drought, hydrological changes, nonstationary, data assimilation, Ensemble Kalman Filter