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Bias of hydrological indicators derived by GRACE

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Hydrological droughts affect the environment in multiple ways with often disastrous consequences for economy and human life. Observational monitoring of hydrological droughts has often focused on surface water availability, while observing subsurface water storages is challenging. Since 2003, however, the Gravity Recovery and Climate Experiment (GRACE) satellite mission allowed the total water storage changes including both surface and subsurface waters to be observed, albeit at large scales. A range of GRACE-based drought indicators has been developed to detect the hydrological droughts, where most of them seek to mimic meteorological indicators.

However, at “GRACE-scales”, i.e. averaged spatially over few hundred kilometers and temporally over one month with about 15 years coverage, droughts appear very different. As of today, we still have little understanding of how “true” drought signals propagate through GRACE analysis, postprocessing and formulation of GRACE-drought indicators. For example it is unclear whether other typical signals observed at GRACE- spatial scales, e.g. linear trends or seasonal signals, influence or bias the detection of droughts. The GRACE-Follow On (GRACE-FO) mission launched in May 2018 will enable a more precise monitoring of total water storage changes, emphasizing the need to better understand and assess GRACE-based drought indicators.

To achieve this goal, we develop a synthetic framework. For this, total water storage changes from 2003 to 2016 are simulated and a synthetic drought signal is added. Based on these time series, existing indicator functions are computed (Houborg et al., 2012, Thomas et al., 2014 and Zhao et al., 2017). We also modify existing indicators to account for various accumulation periods. The performance of various indicator functions relative to the varying strength of GRACE-based signals and drought signals is analysed. Additionally, the influence of the spatially correlated GRACE noise on the drought detection is investigated. Our main results show that most indicators are strongly biased by linear trends, accelerations and spatially correlated GRACE noise. We identify that using accumulation periods makes the indicators more robust against those biases.