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Estimating the water balance and uncertainty bounds in a highly groundwater-dependent and data-scarce areas: An example for the upper Citarum basin

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In this study, we estimate the water balance components of a highly groundwater-dependent and hydrological data-scarce basin of the upper reaches of the Citarum river in West Java, Indonesia. Firstly, we estimate the groundwater abstraction volumes based on population size and a review of literature (0.57mm/day). Estimates of other components like rainfall, actual evaporation, discharge, and total water storage changes are derived from global datasets and are simulated using a distributed hydrological wflow_sbm model which yields additional estimates of discharge, actual evaporation, and total water storage change. We compare each basin water balance estimate as well as quantify the uncertainty of some of the components using the Extended Triple Collocation (ETC) method.

The ETC application on four different rainfall estimates suggests a preference of using the CHIRPS product as the input to the water balance components estimates as it delivers the highest r^2 and the lowest RMSE compared to three other sources. From the different data sources and results of the distributed hydrological modeling using CHIRPS as rainfall forcing, we estimate a positive groundwater storage change between 0.12 mm/day - 0.60 mm/day. These results are in agreement with groundwater storage change estimates based upon GRACE gravimetric satellite data, averaged at 0.25 mm/day. The positive groundwater storage change suggests sufficient groundwater recharge occurs compensating for groundwater abstraction. This conclusion seems in agreement with the observation since 2005, although measured in different magnitudes. To validate and narrow the estimated ranges of the basin water storage changes, a devoted groundwater model is necessary to be developed. The result shall also aid in assessing the current and future basin-scale groundwater level changes to support operational water management and policy in the Upper Citarum basin.