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Assessing recent water mass losses from the continents by integrating output data from a global glacier model into a global hydrological model

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Development of global hydrological models (GHMs) in the last decades has made it possible to assess water balance components at the continental scale. The global spatial coverage enables the investigation of large-scale relationships such as the contribution of continental water storage change to sea-level rise. In the frame of the Climate Change Initiative Sea Level Budget Closure project, this contribution is estimated for 1992-2016 (altimetry era) with WaterGAP2.2d, a state-of-the-art GHM. This model calculates all water storage compartments (canopy, soil, snow, groundwater and surface water bodies) except glaciers, and water fluxes as well as the impact of human water use and reservoirs at a 0.5° x 0.5° spatial resolution and daily time steps.

The contribution of continental glacier mass change to ocean mass change has initially been estimated separately with the global glacier model (GGM) from Marzeion et al. (2012). However, in this configuration, the interactions between glaciers and the other components of the GHM are neglected. In order to take into account the effect of glacier mass change on streamflow and total land water storage anomalies (TWSA), monthly time series of GGM output data (glacier area, precipitation on glacier area and glacier mass change) were integrated into WaterGAP. We first compare seasonal mass balances of individual glaciers simulated with GGM against observations, to show the value of using glacier mass change data of GGM in terms of seasonal variability. We then present the effect of the WaterGAP-GGM coupling on simulated streamflow in glacierized basins and on simulated TWSA over the global continental area for 1992-2016. Streamflow and TWSA as simulated with and without consideration of glaciers are compared to in-situ streamflow observations and to global continental mass change from GRACE satellite gravimetry, respectively, at seasonal, interannual and longer time scales. This study shows the value of using the output from a state-of-the-art GGM as input to a GHM, for an improved estimation of the contribution of global continental water (and ice) storage change to sea-level rise as well as of streamflow in glacierized basins.