Closing the water budget at the global scale using observations, remote sensing, and reanalyses

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Despite the accuracy of GRACE terrestrial water storage estimates and the variety of global hydrological datasets providing precipitations, evapotranspiration, and runoff data, it remains challenging to find datasets satisfying the water budget equation at the global scale.

We select commonly used and widely-assessed datasets. We use several precipitations (CPC, CRU, GPCC, GPCP, GPM, MSWEP, TRMM, ERA5 Land, MERRA2), evapotranspiration (land surface models CLSM, Noah, VIC from GLDAS 2.0, 2.1, and 2.2; GLEAM, MOD16, SSEBop, ERA5 Land, MERRA2), and runoff (land surface models CLSM, Noah, VIC from GLDAS 2.0, 2.1, and 2.2; GRUN, ERA5 Land, MERRA2) datasets to assess the water storage change over more than 150 hydrological basins. Both mascons and spherical harmonics coefficients are used as the reference terrestrial water storage from different centres processing GRACE data. The analysis covers a wide range of climate zones over the globe and is conducted over 2003-2014.

The water budget closure is evaluated with Root Mean Square Deviation (RMSD), Nash-Sutcliffe Efficiency (NSE), and seasonal decomposition. Each dataset is assessed individually across all basins and dataset combinations are also ranked according to their performances. We obtain a total of 1080 combinations, among which several are suitable to close the water budget. Although none of the combinations performs consistently well over all basins, GPCP precipitations provide generally good results, together with GPCC and GPM. A better water budget closure is generally obtained when using evapotranspiration from Catchment Land Surface Models (GLDAS CLSM), while reanalyses ERA5 Land and MERRA2 are especially suitable in cold regions. Concerning runoff, the machine learning GRUN dataset performs remarkably well across climate zones, followed by ERA5 Land and MERRA2 in cold regions. We also highlight highly unrealistic values in evapotranspiration computed with version 2.2 of GLDAS (using data assimilation from GRACE) in most of the cold basins. Our results are robust as changing the GRACE product from one centre to the other does not affect our conclusions.