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An empirical spatial downscaling of GRACE by statistical assimilation of multiple hydrological variables

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GRACE has been used widely for various hydrological applications. However, the GRACE product provides the observations of the global total water storage change with coarse spatial resolution. The insufficient spatial resolution limits its application to global and large-scale studies only. Improving the spatial resolution is vital for closing the terrestrial water cycle at small scales, monitoring droughts and floods, and assessing the regional water resources. In this study, a statistical assimilation algorithm is developed for spatial downscaling of GRACE, based on a combination of moving average and partial least-squares regression. By assimilating GRACE with WGHM and multiple hydrological variables (i.e. precipitation, evapotranspiration and runoff) from highly-resolved hydrological models, a finer spatial resolution of terrestrial water storage in the Amazon basin is achieved. For a validation, the downscaled water storage is compared with GRACE and WGHM as well as GLDAS by aggregation of grids over catchment, and through the misclosure of the water balance. In addition, the spatial and temporal patterns of separated modes of the assimilation results are analyzed as well as the patterns of linear trends and annual amplitudes. As a result, the downscaled terrestrial water storage retains the dominant signals from GRACE and benefits from WGHM in local details. Our assimilation results maintain the same accuracy level of GRACE and meanwhile enhance the variation along the main river stem in the basin.