Groundwater over-exploitation and terrestrial water storage change: A global analysis using hydrological models and GRACE

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In this study, we use different spherical harmonic products from the gravity recovery and climate experiment (GRACE) satellite mission and the results from two state-of-the-art hydrological models that explicitly simulate groundwater extractions to (1) examine the variations in terrestrial water storage (TWS) and its individual components, (2) attribute the changes in TWS to natural and human-induced factors, especially groundwater overexploitation, over a range of global river basins, and (3) assess the performance of different GW schemes incorporated in two models. Analysis of the spatial patterns of the long-term trend in TWS from the two models and GRACE suggests that both models capture the GRACE-measured direction of change, but differ from GRACE as well as among each other in terms of the magnitude over different global regions. A detailed analysis of the seasonal cycle of TWS variations shows notable differences not only between models and GRACE but also among different GRACE products and between the two models. The isolation of natural and human-induced changes in TWS in some of the managed basins reveals a consistently declining TWS trend during 2002-2010 caused primarily by groundwater overexploitation, however; significant differences are again obvious both between GRACE and models and among different GRACE products and models. Results from the decomposition of the TWS signal into the general trend and seasonality indicate that while one model doesn’t capture the long-term trend which dominates the original time series over the basins impacted by continuous drought and long-term GW storage depletion, the other model fails to estimate the seasonality in snow-dominated basins.

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