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Towards understanding of the spatio-temporal composition of Terrestrial Water Storage variations in Northern Latitudes using a model-data fusion approach

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Understanding variations in the terrestrial water storage (TWS) and its components is essential to gain insights into the dynamics of the hydrological cycle, and to assess temporal and spatial variations of water availability under global changes.
We investigated spatio-temporal patterns of TWS variations and their composition in the humid regions of northern mid-to-high latitudes during 2001-2014 by using a simple hydrological model with few effective parameters. Compared to traditional modelling studies, our simple model was informed and constrained by multiple state-of-the-art earth observation products including TWS from Gravity Recovery and Climate Experiment (GRACE) satellites (Wiese 2015), Snow Water Equivalent (SWE) from GlobSnow project (Loujous et al. 2014), evapotranspiration fluxes from eddy covariance measurements (Tramontana et al. 2016), and gridded runoff estimates for Europe (Gudmundsson & Seneviratne 2016).
Thorough evaluation of model demonstrates that the model reproduces the observed patterns of hydrological fluxes and states well. The validated model results are then used to assess the contributions of snow pack, soil moisture and groundwater on the integrated TWS across spatial (local grid scale, spatially integrated) and temporal (seasonal, inter-annual) scales. Interestingly, our results show that TWS variations on different scales are dominated by different components. On both, seasonal and inter-annual time scales, the spatially integrated TWS signal mainly originates from dynamics of snow pack. On the local grid scale, mean seasonal TWS variations are driven by snow dynamics as well, whereas inter-annual variations are found to originate from soil moisture availability.
Thus, we show that the determinants of TWS variations are scale-dependent, while coincidently underline the potential of model-data fusion techniques to gain insights into the complex hydrological system.

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