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Sub-monthly hydrological variability: In-orbit validation by GRACE level 1B observations

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Here, K-band range rate (KBRR) residuals are computed from GRACE level 1B observations and hydrological model output. The validation of hydrological models is usually performed by employing monthly gravity field solutions which have a very limited spatial and temporal resolution. The presented approach avoids the downward continuation and filtering process required for computing monthly solutions and, thus, enables to assess model-derived water storage variations with a high temporal resolution and at small spatial scales.

In a first step, modeled water mass variations are converted into simulated KBRR observations. Secondly, those simulated observations and a number of geophysical corrections are reduced from the original GRACE K-band observations to obtain the residuals. Smaller residuals imply that the model is able to better explain the observations. Time series of daily and monthly RMS of KBRR residuals are computed globally and for selected regions. Additionally, the residuals are investigated in space domain by computing spatial RMS values for one year on a regular grid.

In this study, three global hydrological models, the Land Surface Discharge Model (LSDM), the WaterGAP Global Hydrology Model (WGHM), and the GLDAS-Noah land surface model are evaluated exemplarily. Residuals from monthly model outputs are contrasted against daily model fields in order to quantify the information content on time scales shorter than one month. Furthermore, the high-frequent signal content is studied by comparing monthly solutions and the daily Kalman filter solutions from ITG-Grace2010 and ITSG-Grace2014.

Globally, the residuals are reduced by 2.54% if the daily instead of the monthly ITSG solutions are used. As a reference: the application of AOD-RL05 leads to a reduction of 1.12% with respect to AOD-RL04. Daily information from LSDM reduce the residuals from the monthly model output further by 0.67% considering only the continents. WGHM is found to produce smaller residuals than LSDM, but over Europe LSDM better explains the GRACE observations.
In summary, the evaluation of KBRR residuals provides detailed information about the model quality at different time scales.