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Evaluating different-scale hydrological corrections against high-precision terrestrial gravity time series at the Geodetic Observatory Wettzell, Germany

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Hydrological monitoring methods usually observe water storage changes in specific depths or for a limited number of storage compartments and are often representative for a small volume only. In contrast, gravity measurements are sensitive to mass changes as a spatially integrated signal. This makes them a valuable complementary tool for monitoring total water storage changes. The hydrological contribution to the time-variable gravimetric signal often plays a major role for the overall signal dynamics. Nevertheless, there is still a lack of understanding the influence of the local hydrological dynamics at many terrestrial gravity stations. Thus, advancing the hydrological corrections of gravity signals is highly valuable for improving the interpretation of gravity measurements with respect to other processes of interest, e.g., geodynamic, atmospheric or ocean-loading effects. At the same time, high-precision gravity measurements provide a reliable validation to mass-variations as represented by hydrological models.

In this case study, we consider the Geodetic Observatory Wettzell (GOW), located in the river Regen catchment in a low mountain range in East Bavaria, Germany. Here, long-term stable records of superconducting gravimeters (SGs) are available at three different points at the observatory within a distance of about 200 meters. Moreover, an extensive hydrological sensor network has been operated at GOW for more than a decade, which allows for a precise consideration of local effects. Dividing the hydrological effects into local, regional and global contributions, the regional component is calculated based on the mesoscale Hydrologic Model (mHM, Helmholtz Centre for Environmental Research – UFZ), implemented for the river Regen catchment with a spatial resolution of one kilometer and forced with national and global meteorological data sets. Global contributions are considered from various models, including MERRA-2 and several GLDAS solutions.

To assess the efficiency of a small-scale versus a large-scale approach for hydrological corrections, we evaluate all hydrological contributions against gravity residuals, after precise removal of tides, atmospheric, non-tidal ocean loading and polar motion effects. We focus on the consistent combination of each contribution and the impact of local influences, e.g., finely resolved

topography in the vicinity of the gravimeters and the effect of buildings. First results show that changing the approach for, or neglecting the local contribution can easily double the total hydrological effect. This emphasizes the importance of carefully considering local effects in the hydrological gravity modelling, in particular at stations with a marked subsurface complexity and heterogeneity like GOW.