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Monitoring water storage variations with a superconducting gravimeter in a field enclosure

Andreas Güntner (1), Michal Mikolaj (1), Marvin Reich (1), Stephan Schröder (1), and Hartmut Wziontek (2)

(1) GFZ German Research Centre for Geosciences, Section 5.4 Hydrology, Potsdam, Germany (guentner@gfz-potsdam.de), (2) Federal Agency for Cartography and Geodesy (BKG), Frankfurt, Germany

Water storage dynamics are notoriously difficult to monitor in a comprehensive way beyond the point scale. Superconducting gravimeters (SG) measure temporal variations of the Earth's acceleration of gravity with very high precision and temporal resolution. They have been shown to be sensitive to mass variations induced by hydrological processes in their surroundings, typically within a radius of few 100 meters around the instrument. Thus, in turn, SGs are unique instruments for monitoring water storage variations in the landscape in an integrative way, accounting for soil moisture, vadose zone and groundwater storage, snow, and surface water bodies if existent. Nevertheless, hydrological applications of SGs so far have usually been hindered by the instruments being located in observatory buildings. This infrastructure disturbs the local hydrology and causes many uncertainties due to the often poorly known geometry of the construction, non-natural flow paths of water, and unknown water storage variations below and/or on top of the infrastructure.

By deploying the SG in a small enclosure, these disturbances and unknowns are minimized. We report on the first experiences with exposing a SG of the latest generation (iGrav) in a small housing of less than 1 m2 footprint to temperate hydro-meteorological conditions. The system has been set up on a grassland site at the Geodetic Observatory in Wettzell, Bavarian Forest, Germany, in early 2015. We present the technical layout and challenges in running the gravimeter system. Additionally, we report on the quality of data acquired so far and present comparisons to in-situ soil moisture monitoring with TDR and TOMST sensors, a lysimeter, and groundwater observations, and two SGs located in nearby observatory buildings. We discuss the value of SG observations for estimating water storage variations, evapotranspiration and groundwater recharge beyond the point scale.