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Gravimetric observations of water storage change - lysimeters and superconducting gravimeters

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The measurement of water storage changes (WSC) in the subsurface is still a challenging task. Despite many advances of WSC measurement techniques, gravimetric measurements are the most precise method. Advances in lysimeter techniques enable the direct measurement of the soil water balance, but exclude WSC in greater depths below the lysimeter. Superconducting gravimeter (SG) measurements are influenced by local water mass changes and, thus, allow for observing WSC in the vadose and saturated zone in an integrative way. Vice versa, lysimeters can contribute to the reduction of signal components by hydrological surface processes in SG observations.
The Geodetic Observatory Wettzell (Germany) is the only place where both systems – a state-of-the-art lysimeter (as described in the session outline) and a dual sphere SG – measure in parallel at a distance of around 40m. This gives the unique opportunity to observe in-situ gravimetric WSC at the field scale by two independent techniques. In this study we focus on assessing the WSC estimated by the lysimeter and its local effect (Newtonian attraction) on the SG. First, we evaluate the lysimeter measurements by comparing them to TDR soil profile data in and around the lysimeter. Then, using directly the lysimeter data, the effect of local soil moisture variations on the SG residuals is identified. Finally, we use a hydrological 1D model to estimate WSC in the vadose zone below the lysimeter, defining the upper boundary in the model by the lysimeter drainage and the lower boundary by groundwater level data. The different gravimetric measurements in combination with modeling are used to explain the sources of the SG signals and, thus, to quantify local WSC and contributions of different storage compartments. The results show the importance of WSC in the vadose zone below the lysimeter and the potential of SG in combination with lysimeter observations to improve the parameterization of groundwater and vadose zone models.