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Local hydrological information in gravity time series: reduction and application

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Hydrological variations of up to some 10 $\mathrm{nm/s^2}$ represent significant, broadband, and integral information in temporal gravity observations. Thus, they can be considered as a valuable supplement to traditional hydrological point measurements. Of particular interest is to what extent such information can be used to improve the understanding of hydrological process dynamics and to evaluate distributed hydrological models. In this context, a new application of temporal gravity observations has been emerging: the study of natural hydrological mass changes and their underlying processes.

Gravity data derived from GRACE satellite observations are affected by global and regional hydrological variations. Continuous recordings from superconducting gravimeters additionally contain information on local changes. Complementary to these data, repeated gravity observations on a local network contribute to gaining additional local information on spatial changes in hydrology and enabling a separation of the local hydrological influence from regional and global changes.

To catch the local temporal hydrological influence on gravity of the hilly and geologically inhomogeneous surroundings of the superconducting gravimeter at the Geodynamic Observatory Moxa, Germany, interdisciplinary research has been carried out. For an area of approximately $1.5\times1.5\ \mathrm{km}^2$ a hydrological catchment model was combined with a well-constrained gravimetric 3D modell, which is made up of nearly 29.000 triangles and achieves a resolution of 5 metres in the close vicinity of the gravimeter. These combined modelling was used jointly with repeated gravity observations on a local network to develop a high accuracy reduction for the local hydrological signal in the continuous recordings of the superconducting gravimeter with uncertainties of $\pm1.5\ \mathrm{nm/s^2}$ for rain events and $\pm2.5\ \mathrm{nm/s^2}$ for seasonal variations.

Applying this reduction, the data of the superconducting gravimeter become suitable to be interpreted with regard to changes in continental water storage. Clear continental seasonal variations with a peak-to-peak amplitude of about 30 $\mathrm{nm/s^2}$ are detected which were previously masked by the local hydrology. This seasonal signal is also found in variations based on the global hydrological model WGHM and in GRACE satellite observations.

The evaluation of the local hydrological model based on the gravity modelling results and the superconducting gravimeter data provided ideas for further enhancement of the internal process representation in particular concerning the modelled effect of extreme hydrological events such as heavy rain or snow melt.