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Contribution of local hydrology to gravity variation observed with the superconducting gravimeter at Metsähovi, Finland: more sensors and modelling

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The superconducting gravimeter (SG) no. T020 has been operating continuously at Metsähovi since August 1994. After corrections for known time-variable gravity effects, such as tides, atmosphere and the Baltic Sea, the remaining gravity residual (8 microgals peak-to-peak 1994–2010) is mostly due to (seasonal) variation in terrestrial water storage. The hydrological effects in gravity are generated (i) by the attraction of local water storage in the fractures of the crystalline bedrock, (ii) by the attraction of local water storage in sediments, and (iii) by the loading and attraction by regional and global water storage. The three phenomena are nearly in phase, which makes it difficult to distinguish between them in the gravity record with statistical methods. To take an example: just regressing the gravity residual on the record of the local borehole well in the bedrock provides nearly as good a fit to gravity as first correcting for regional hydrology using models and then regressing. This means that if we want to use the record of the SG for discriminating between different regional/continental hydrological models, or for validating GRACE observations, physical modelling of the attraction of local storage is needed.

From the beginning (1994) the station was equipped with two borehole wells in the crystalline bedrock. The station stands on bedrock and sediment layers were removed from its closest surroundings as well. The remaining sediments are thin (0.2 to 4 meters) but geologically quite complex. In 2006 two arrays of Time Domain Reflectometer (TDR) sensors of soil moisture were installed by the Finnish Environment Institute at 30 m from the SG. In 2008–2009 several new instruments were installed within 100–150 m distance from the SG: Ten new capacitive arrays consist of 5 sensors each at different depths. Soil resistivity is measured in a 20 x 20 meter grid of 21 x 21=441 probes. For observing groundwater level in the sediments, we in 2009 lowered 11 tubes down to the bedrock surface. For radiometric measurements of soil moisture content and soil density we established 5 dry access tubes: they provide in-depth profiling, and a calibration control for the TDR sensors. From all sites and in a grid between them soil samples were taken.

We present an analysis of the local water mass changes in comparison with the gravity observations of the SG.