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Local gravity variation at Metsähovi, Finland: first results from new hydrological sensors and modelling

Heikki Virtanen (1), Jaakko Mäkinen (1), Arttu Raja-Halli (1), Tero Hokkanen (2), and Risto P. Mäkinen (3)

(1) Finnish Geodetic Institute, Geodesy and Geodynamics, Masala, Finland (heikki.virtanen@fgi.fi, 358 9 29555211), (2) Aalto University School of Science and Technology, Espoo, Finland, (3) Finnish Environment Institute, Helsinki, Finland

Metsähovi is a fundamental geodetic station with multiple observation techniques, including a superconducting gravimeter (SG). The 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 are made, the remaining gravity residual is mostly due to variation in terrestrial water storage. The detection threshold of the SG corresponds to the attraction a hypothetical Bouguer slab of water 1-2 mm thick that extends below the instrument as well. From the beginning, the station was equipped with two borehole wells in the crystalline bedrock. The gravity residual shows strong correlation with the water level in these wells. The peak-to-peak variation 1994–2009 is 8 microgals. The boreholes serve as indicators for (1) the local groundwater in bedrock. But the observed gravity is generated also by (2) the attraction of local water storage in sediments, and by (3) loading and attraction by regional and global storage. Using large-scale hydrological models it can be estimated that about 2/3 of the observed hydrological variation in gravity in Metsähovi is due to attraction by local water. Accounting for it is then a pre-requisite for using the SG for validating GRACE observations, or for discriminating between regional hydrological models. It can further be shown that (given the topography and assuming constant variation in storage per unit area) some 85 percent of the attraction of the local storage is generated within 0.1 km of the SG.

Thus, detailed monitoring of the close-field hydrology is required. 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 lowered 11 tubes down to the bedrock surface. For radiometric measurements of soil moisture content and soil density we established 5 dry access tubes. From all sites and in a grid between them soil samples were taken for later analyses.

We present first results of studies of observed local water mass changes together with gravity observations with SG.