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Superconducting gravimeter as a hydrological tool at Metsähovi, Finland

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The superconducting or cryogenic gravimeter (SG) is a stationary instrument that produces a continuous record of gravity at a fixed laboratory-type installation site. The SG has high sensitivity: for a step-like event the detection threshold is about 0.1 microgal. This corresponds to the attraction a horizontal water sheet 2 mm thick that extends below the instrument as well. The drift rate of a SG is low but not zero, thus trend-type phenomena cannot be distinguished. We describe here the hydrology-related work with the gravimeter GWR T020 that has been operating continuously at Metsähovi since August 1994. In order of magnitude, Earth tides, the gravity influence of atmospheric mass redistribution, the pole tide, the non-tidal loading (deformation and attraction) by the nearby Baltic Sea, ocean tidal loading and trend are removed from the record. The remaining gravity residual is mostly due to variation in terrestrial water storage. To give an idea of its magnitude: the peak-to-peak variation 1994-2006 is 6 microgals and the mean annual term has double amplitude 4 microgals. These figures correspond to a water storage of 120 and 80 mm, respectively, using the horizontal sheet approximation. Assuming uniform variation in storage per unit area, it can be estimated that at least 85 percent of the Newtonian attraction of the local storage is generated within 0.1 km of the SG. However, not all observed hydrological gravity is due to local storage. We estimate that roughly 1/3 of it is caused by regional and global hydrology, through elastic crustal deformation (i.e., elevation change) and far-field attraction. In this estimation we have used a.o. the Watershed Simulation and

Forecasting System (WSFS) of the Finnish Environment Institute, the global models CPC and GLDAS, and monthly solutions of the regional gravity field from the GRACE gravity satellite.

As to the remaining 2/3, the local hydrogeology combines fractured crystalline bedrock and a thin overburden (typically 0-1 m, maximally 3 m) of moraine; the site was in fact originally chosen to minimize local hydrological effects on gravity. Currently we are working to separate the gravity effects of the groundwater (in the fractured bedrock) and of the soil moisture in the moraine. In addition to groundwater boreholes, we have installed soil-moisture and meteorological sensors. Modelling the local hydrology independently of SG would allow us to use the SG to check regional hydrology from GRACE. The work is supported by the Academy of Finland in the joint project HYDROGRAV of the Technical University of Helsinki, the Finnish Geodetic Institute, and the Finnish Environment Institute.