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Time-lapse relative gravity measurements in an underground structure provide a model of local hydrology

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This work has been performed at the absolute-gravity (AG) station at Riga, and its purpose is among other things to provide a model to correct the time series of AG measurements for local hydrological effects. The AG station is situated about 10 m underground, at the bottom of a silo-like concrete structure on the limestone basement. During the first AG measurement in 1995 by the FGI two excentre stations were established on the surface and tied to the AG station by relative measurements. It was realized that repeating the relative ties at every AG measurement would give an opportunity to isolate the gravity effect of the variable water storage in the sediment layers and to correct the AG results for it. At the AG station at bottom the attraction is upwards, at the surface stations downwards, and in the gravity difference it appears approximately double.

The relative measurements were repeated at subsequent AG station occupations (by the BKG, by the National Geospatial Intelligence Agency, St. Louis, USA, and again by the FGI), in 1996, 1996, and 2007. However, it turned out that they were too few for validating the results. Therefore, after the fifth AG measurement performed by the FGI in 2013 a monthly series of relative campaigns was started by the LGIA, using two Scintrex CG-5 gravimeters. The network comprises two underground stations at different depths, two stations at ground level, and one station in the silo structure 5 m above ground level. The variation in the gravity difference top-to-bottom is 16 microgal (peak-to-peak). The terrain is flat and the assumption of laterally homogeneous 1-D local hydrology (only perforated by the silo and the piers of the surface stations) is a reasonable first approximation. Using this approximation, we can invert the relative-gravity series for both variation in subsurface water mass and for the mean depth of the layers with variable water content, without using any hydrological observations at all. But in fact, there is a hydrological time series at the site, too: observations of groundwater level in an access tube. The time series has a high correlation with the time series of water mass from gravity inversion. Relative gravity then provides a scaling coefficient for the variation in water mass (groundwater+soil moisture) associated with the water table fluctuation, and then the groundwater time series together with the 1-D model can provide hydrological corrections to gravity measurements made at the site long before the establishment of the time-series of relative gravity.