Gravity Variations Induced by Changing Snowpack at Conrad Observatory

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Water mass transport involved in hydrological processes causes gravity variations masking the pure geodynamical signals. In snow rich winters a snowpack of one meter in depth or even more can be observed at Conrad observatory. Here we focus specifically on gravity variations sensed by the superconducting gravimeter (SG) GWR C025 due to snow accumulation and melting. Gravitational signals are rather different for the accumulation and ablation phase, not only due to the different time scales of these processes but also due to the complex way path of melting water entering the ground beneath the SG.

Snow depth is monitored at three locations for assessing its spatial variability. At one place in front of the observatory, additionally the weight of the snow pack is determined which allows for calculating the snow water equivalent.

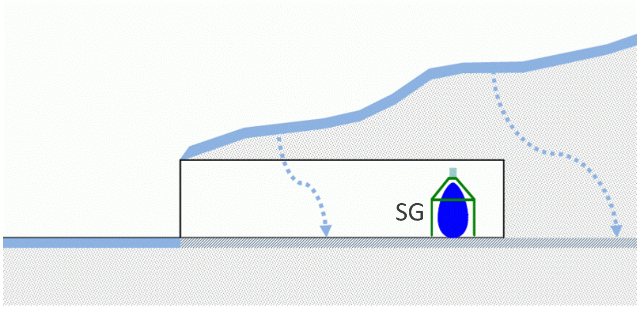

Figure 1: Snow melt phase: rapid water transport from top of topography beneath the SG sensor.

Two methods are used to account for the effect of the snow pack: the rainfall admittance concept (Meurers et al. 2007) based on high resolution terrain models and the Bouguer slab approach.

The gravity effect of snow accumulation is best described by the rain admittance approach using the observed snow water equivalent as input. Rapid water transport downwards from top of topography into the ground beneath the SG sensor characterizes the snow melt phase (Fig. 1). The associated gravity effect is well described by the Bouguer slab concept using the loss of snow water equivalent as input (Fig. 2).

Both concepts have their strengths and weaknesses. They work better for short-term mass transports than for long lasting accumulation or ablation processes because in the latter case interference with signals of other environmental processes gets more prominent.

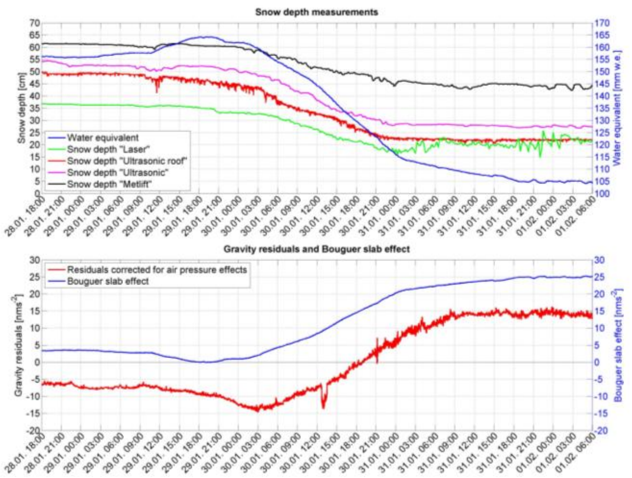

Figure 2: Snow melt due to a warm front passage between 2013 01 28 and 2013 02 01. Top panel: Snow height observations (black, red, green and magenta) and snow water equivalent (blue). Bottom panel: Gravity residuals (red) and Bouguer slab effect (blue). Note the time delay between water equivalent and gravity residuals

In other cases (not shown here) stepwise reduction of snowpack is connected to pronounced day-night time variations of the surface energy budget during clear-sky weather situations.

Reference:
Meurers, B., Van Camp, M., Petermans, T., 2007: Correcting superconducting gravity time-series using rainfall modelling at the Vienna and Membach stations and application to Earth tide analysis, Journal of Geodesy, 81, 11, 703–712, DOI - 10.1007/s00190-007-0137-1.

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