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Hydro-gravimetry as a tool to constrain water mass transfer in catchments. Example from the Strengbach Catchment in the Vosges mountains, France.

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Gravimetric measurements are sensitive to water storage changes in the critical zone: their spatial-integrative nature make them sensitive to the hydrological balance fluctuations of sub-catchments. Thus gravimetry may be a key method to access water storage changes in catchments with complex hydrology such as mountainous catchments, where local measurements of water level in boreholes may differ from the global water storage due to local heterogeneity.

Here we propose a joint analysis of hydrological balance and relative gravity measurements fluctuations in the well instrumented Strengbach catchment in the Vosges Mountains, France. This study provides new constraints on the water mass transfers within the Strengbach catchment. Data consist in two years of continuous meteorological monitoring and 19 gravimetric and hydrologic time-lapse repetitions of a co-localised network of boreholes and gravimetric stations.

We first found the base station which maximizes the coherence of the observed relative gravity variations, then we used the principal component analysis method to infer the coherent gravity variations on the whole network. We compared the coherent part of the measured gravimetric signal to the hydro-gravimetric signal of an homogeneous water sheet following the topography, the water sheet thickness being forced by global water storage variations. We used two kinds of forcing: the first is based on hydro-meteorological data (measured outflow, precipitation and evapotranspiration) while the second one is based on borehole water level data. Whatever the forcing, the hydro-gravimetric model predicts the phase of the coherent relative gravity variations, meaning that an hydro-gravimetric signal was actually captured, being partially controlled by the topography. However the predicted amplitude is too low, which shows that water storage changes are strongly heterogeneous spatially. In addition, two case studies allow to detect a fast water storage decrease under the base station (monthly temporal scale), and a longer scale (several years) water storage redistribution within the Strengbach catchment.