Geophysical Research Abstracts
Vol. 12, EGU2010-4855, 2010
EGU General Assembly 2010

Reservoir properties inversion in a karst aquifer using absolute gravity measurements

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Direct estimate of water storage and transfer in karst aquifers are difficult to obtain due to the extreme permeability variation of the medium. In this study, we aim to quantify water transfer properties in a karst aquifer of the Larzac plateau (South Massif Central, France) using absolute gravity monitoring. Our measurements are cutting edge as they directly measure the integrated water content below the gravimeter. We analyze monthly repeated FG5 absolute gravity measurements (1-2 microGal precision) over a three-year period at three sites on the karst aquifer.
Important precipitation events lead to significant gravity increases which peak up to several weeks after the events depending on the site. Also, gravity decreases in a different manner at each site during drier periods. We consider the different gravity responses at each site to relate to water transfer properties between the surface and the unsaturated zone beneath. Within this scope, the gravity signal is used to invert for those water transfer properties.
A simple two-tank reservoir model including a 'soil' reservoir that feeds into a 'subsurface' reservoir is used as the forward model in a Monte Carlo simulation. Reservoir discharge proceeds according to Maillet's law. Water levels within the reservoirs are converted into a gravity signal considering an infinite slab scaled by a factor that accounts for both the surrounding topographic effects and the water interception by the building where the measurements are made. Inverted parameters are the discharge constants and the scaling factors. Model input is rainfall measured with rain gauges at each site minus estimated evapotranspiration.
The inversion leads to scaling factors much smaller than 1 for the attraction of the surface reservoir. The effects of the surrounding topography and those of the building on gravity are compared to the inversion result of the 'surface reservoir' scaling factors. We discuss if the forward model and underlying assumptions may be well-suited to account for the observed signal.
We finally attempt to link the gravity-based discharge properties of the 'subsurface' reservoir with the local karstification at each site and with the whole aquifer dynamics.