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On the use of distributed microgravity observations to inform hydrological models

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Inverse modeling of complex systems, such as a catchment, is an inherently ill-posed problem, in which the information carried by observational data is often very limited, leading to large uncertainties. When streamflow data are used in the inversion procedures, flow paths can be hardly identified because these aggregated data does not contain such information. These conditions often lead to a scarce identifiability of model parameters and large uncertainties in streamflow projections. The situation gets worst when the flow model is combined with a transport model to simulate the fate of contaminants released within the catchment. Since typically the flow model does not identify the relevant flow pathways and the correct distribution of travel times, transport modeling performance are in most cases not reliable. This is a well know problem in the hydrological literature, which can be alleviated by including in the inversion procedure measurements of the main state variable of the system, i.e. the distribution of soil water content.

In this work, we investigate the value of spatially distributed microgravimetric data to improve the conceptual model of the hydrological system. In particular, we explore the value of these data to better identify subsurface flows as a first step to better partition water losses between evapotranspiration and groundwater recharge (deep percolation). To this end, extensive microgravimetric measurements have been conducted in 6 field campaign between 2009 and 2011 in the Vermigliana catchment, Northeastern Italy. Highly resolved (in time) streamflow data are available for the same period at the Vermiglio stream gauging station, with a contributing area of 80 km2. During each microgravity campaign, point gravity measurements have been performed on a network of 13 points distributed in such a way to provide a good coverage of all the sub-catchments, including both slope and bottom valley areas. Successively, we used these microgravimetric data, corrected to remove the effect of ocean tides and instrumental drift, as a proxy of changes in the total water storage, namely soil water content, groundwater and snowpack. These data have been used in an inversion procedure coupling a semi-distributed hydrological model (GEOTRANSF) with a simple gravity model. With this exercise we observed that spatially distributed microgravity measurements allow to better define the conceptual model and the seasonal variations of storage within the catchment, with a clear improvement in the reliability of the hydrological model.