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Ground deformation above a granitic aquifer (French Brittany): GPS measurements and hydromechanical modeling

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Variations of the water table level due to natural seasonal effects and to human exploitation can produce pressure variations in a confined aquifer and consequently displacement of ground surface. Since 1991, the fractured granitic aquifer of Ploemeur (French Brittany), that is located on a contact between granite and micaschiste, has been exploited for water supply of the 20,000 inhabitants. Ground movements are supposed to be very low in such a context of granitic aquifer. We have recorded the ground deformation affecting the pumping site of Ploemeur during the 2005-2007 period by GPS and piezometric data.

We use a GPS receiver network with short baselines for a differential configuration. Receivers that surveyed the ground deformation were set up inside the pumping site, close to wells. The reference receiver was placed in a stable site on an undeformed granite massive disconnected from the hydrological influence of the aquifer. This setup allows reaching a precision of 3-5 mm on the vertical component. First studies based on GPS measurements and hydrological data analyses were done for the 2003 and 2004-2005 time periods (Moreau et al., 2006).

We present a new data set of continuous GPS measurements during 2005-2007 period corresponding to different seasonal variations. The first results show a seasonal signal on the three components, with the largest variations on the vertical one. The time series of the elevation display a large decrease of 1.5-2 cm from the end of winter to the end of summer.

We compare GPS measurements to hydrological variations and these data seem to be correlated on several time periods. The piezometric level of the aquifer show a classical pattern with a low stage at the end of the summer and a high stage at the end of the winter after the climatic recharge: this corresponds to a seasonal change of 5-7 m. However, the relation between the variation of aquifer height and the variation of vertical ground deformation is not simply linear: a study of short-term effects, based on a GPS survey of the deformation during a pumping test, shows a small deformation of 4-5 mm while we observe an important hydrological signal reaching 12 to 14 m on several wells.

The aim of this study is to understand this non-linear relationship between vertical ground deformation and piezometric level. A hydromechanical numerical modeling is processed to 1) determine the hydrological properties of the aquifer, 2) study the fluid pressure field and the deformation field and 3) understand the behaviour of a fractured granitic aquifer.