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Inversion of a small number of parameters in cross-well GPR tomography: comparison to GPR velocity obtained from surface acquisition

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Subsurface aquifers are the main water resources. But, they are used and polluted intensively.

The setting up of a reliable non invasive geophysical methodology able to monitor water transfers in quantity and in quality from the soil surface to the water table, would be a major progress. Because it could be a significant step in water conservation.

We have studied a zone situated in the alluvial plain of the Adour river in the northen Pyrénées piemont (France). It located at the border of a corn field where fertilizers and irrigation are applied. The alluvial deposits are composed of pebbles, sand, silt which overly an impermeable layer of clay with pebbles.

From february 2002 to january 2003, multi-offset GPR was conducted. These data made it possible to monitoring vertical transport of water from the soil surface to the water table each month. GPR data were processed by an original technique like Common Reflexion Surface Stack (CRS), for RMS velocities estimation. The classical Dix formula was used in order to convert RMS velocities in time into interval velocity in depth.

In january 2004 and in june 2005, cross-well transmission GPR data were recorded so as to compare with the results obtained from the multi-offset acquisition. For this acquisition, ten holes were drilled along the same profile used for the surface acquisition,

every five meters and with six meters depth.

The aim is to validate the non destructive surface acquisition from different comparisons between the two datasets.

Inversion of cross-well GPR first-arrival traveltimes was performed by a new algorithm. This cross-well tomographic inversion scheme uses only a minimal number of parameters and considers that the media can be decomposed into several homogeneous layers, with horizontal or dipping interfaces. The methodology has been developed for media with significant contrast of electrical permittivity, for example near surface sedimentary soil. The advantages of this method are that it is based on the geological structure of the media and position, dip and continuity of interface are well identified compared to classical methods which need regularizations and consider regularity of the media.

Comparisons are made between surface and cross-well GPR velocities for moist (december) and dry (june) periods. In moist period, the water table varies from 1 m to 1.5 m depth and in dry period, it varies from 2 m to 3.5 m depth. In each case, interval and RMS velocities from both experiments were calculated and compared to. In moist and dry periods, interval and RMS velocities for both acquisitons give the same variations. However, some differences exist between velocity obtained from surface and cross-well acquisitions, specially for the uppermost layer. These discrepancies could be due to the volumetric water content which was not exactly the same. They also could be due to the technique of processing in multi-offset GPR profiling. In fact, to be applied CRS method need a constant surface velocity. Or, these differences simply show the limits of the cross-well inversion methodology.