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Influence of shallow infiltration on time-lapse ERT

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Monitoring of resistivity changes in the subsurface is an attractive method for studying environmental processes linked with ground water flows. Potential applications are mainly pollution plume monitoring, location of deep infiltration or recharge zones. In hydrology, the knowledge of the soil moisture variations is important in flooding forecast.

Time-lapse Electrical Resistivity Tomography (ERT) surveys are often considered as efficient for studying 2D or 3D resistivity changes in the subsurface. However some time lapse ERT surveys fail in recovering actual resistivity changes because inverted resistivity cross-section displays artefacts (increase or decrease of calculated resistivity) where no changes are expected or measured (Descloitres, 2007). These time-lapse ERT inversion problems are often neglected by users. This study demonstrates how a shallow infiltration (i.e. few tens of centimetres) affects the ERT reconstruction image. Indeed, most of time-lapse ERT surveys are not designed to sample shallow phenomena, and could produce unrealistic results. We study the effect of an increase of apparent resistivity at intermediate electrode spacing, well known by previous authors (Kunetz, 1966), on ERT reconstruction image.

Using 2 synthetic time-lapse scenarios and DC2DInvRes inversion software package (Guenther, 2007), we investigate how a better resistivity sampling of the shallow subsurface helps in recovering more realistic results. The first time-lapse scenario considers a 1D model with a small rainfall episode that lowers the shallow surface resistivity. The second time-lapse scenario considers 1D background and a Hydrus 2D-generated infiltration bulb geometry. We investigate the influence of various parameters (electrode spacing, reference model, decoupled regions) and determine how we can improve the resolution of the inversion.

In a first step, we show that a large inter-electrode spacing overestimate the depth of infiltration front and underestimate resistivity changes. Smaller spacing improve the resolution of shallow resistivity changes as expected, while the determination of depth of infiltration remains not satisfactory enough from a hydrological point of view. Moreover, false increases of calculated resistivity are noted at depth of 10 times the infiltration thickness. In a second step, considering that the depth of infiltration front could be known from external information, we tested a decoupling of shallow surface cells. We found better results: shallow resistivity changes are correctly calculated that will allow a confident determination of water content variation. Also at depth, artefacts of increasing calculated resistivity are notably reduced. Finally, this time-lapse procedure is tested on field data set with shallow infiltration.