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3D imaging of a contamination zone at Oslo airport from joint interpretation of surface GPR and electrical resistivity data

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In this study we show an application of geophysical measurements using surface GPR and electrical resistivity methods to image a contaminated area at the Oslo airport (Gardermoen), Norway. In order to secure the landing and takeoff a large amount of deicing fluids (Potassium Formate (KFo)) is spread over the runways every year during winter time. Moreover, propylene glycol (PG) used to melt the ice formed on the wings on airplanes, is also accumulated on the runways as a thin film. Although most of the PG (about 80%) is collected and taken to a local waste water treatment plant, part of it still infiltrates into the subsurface.

In the framework of the SoilCAM project funded by EU, GPR and electrical resistivity data were acquired in a 100×100 m2 area along lines parallel and perpendicular to the western runway at Gardermoen to study the contaminated zone in three dimensions. The GPR data were collected with a 200 MHz transmitter and a line spacing of 2.5 m (parallel lines) and 5 m (perpendicular lines). The OhmMapper instrument (Geometrics) was used to measure the electrical resistivity with a dipole-dipole configuration (5&10 m dipole length) along lines with 10 m separation.

The GPR data were routinely processed using a reflection seismic processing package. As a result, five dominant boundaries were selected and imaged in three dimensions. We used reciprocal measurements to check the quality of resistivity data and to reject bad data. The remaining resistivity data were then modelled in 2D where the GPR boundaries were used to remove smoothing across them in the regularization functional of the inverse problem. The inclusion of these boundaries provided sharper resistivity models and even helped to reduce the data misfits. The 2D resistivity models were then gridded in 3D and imaged.

In order to make a crude estimate of water conductivity, we used simultaneous measurements of water content performed in six boreholes (located in the study area) down to a depth of 3.5-5 m. We then estimated the median values of the measured water contents as a function of depth and used them as a model for the entire study area. As the last step the water conductivity was estimated in 3D using the gridded water content, gridded modelled resistivity and Archie's law (assuming equal cementation factor and saturation exponent). The spatial distribution of the estimated water conductivity shows that there is a highly conductive zone located 10-20 m to the west of the western runway that is most likely caused by the infiltration of saline/contaminated water in the unsaturated zone. The estimated water conductivity models show that the zone stretches below the runway at a depth of about 3 m even though a membrane is installed to direct the contaminated water away from the runways. The membrane reaches a maximum depth of 2.7 m at a distance of 7 m away from the runways. This may be caused by horizontal flow of contaminants, but needs to be confirmed in flow and transport models.

Our results show that inclusion of radar boundaries in the inversion of electrical resistivity data improves data fit and provides resistivity models with sharper contrasts. Use of measured water content and Archie's law together with 3D grid of resistivity models provided a more realistic estimate of water conductivity and rough estimate of geometry of contaminated zone in 3D.