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Surface-to-borehole Controlled-source Electromagnetics for monitoring temperature changes in a geothermal aquifer

Suzanne van Noordt¹, Guy Drijkoningen³, Alexandros Daniilidis⁴, and Paula Rulff²

¹TU Delft, Civil Engineering and Geoscience, Geoscience & Engineering, Netherlands (s.vannoordt@tudelft.nl)

²TU Delft, Civil Engineering and Geoscience, Geoscience & Engineering, Netherlands (p.rulff@tudelft.nl)

³TU Delft, Civil Engineering and Geoscience, Geoscience & Engineering, Netherlands (g.g.drijkoningen@tudelft.nl)

⁴TU Delft, Civil Engineering and Geoscience, Geoscience & Engineering, Netherlands (a.daniilidis@tudelft.nl)

A High Temperature Aquifer Thermal Energy Storage system will be installed on the TU Delft campus, The Netherlands, utilising an aquifer at 120-180 m depth to store hot water (>60 °C). For optimal recovery efficiency, it is essential that the injected water stays near the injector well until it can be extracted, and that there is no mixing with cold water. By monitoring the spread of injected water using Controlled-Source Electromagnetics, the heat transport in this subsurface storage system could be better understood. For this, a surface-to-borehole survey design was proposed, sensitive to the resistivity at the depth of the aquifer through the vertical component of the electric field. 3D time-lapse data will be acquired using receivers inside a monitoring borehole and horizontal electric dipole sources surrounding the site. Optimal source positions will be determined through a feasibility study, using forward-modelling and inversion of synthetic data. By relating the resistivity of the water to its temperature, this data can be used to image hot plume propagation over time. However, the relationship between conductivity and temperature is expected to vary between sites and for large temperature ranges. Laboratory measurements will therefore be performed, uncovering site-specific resistivity-temperature relationships to improve the interpretation of Controlled-Source Electromagnetic data. Lastly, a future research interest lies in the combination of monitoring data with thermodynamic modelling. Through workflows of data-assimilation or process-based inversion, these methods could complement each other, leading to an enhanced understanding of heat flow in the aquifer.