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Geological controls on groundwater discharge to a kettle lake: integrating data from waterborne geophysics in a groundwater flow model

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Groundwater discharge to surface water bodies has an enormous ecological importance. However, it is difficult to quantify these exchange fluxes between groundwater and surface water due to their large spatial and temporal variability. The spatial variability in groundwater fluxes can also be related to the heterogeneity in sediment properties below the surface water bodies. In this study waterborne geophysical measurements, Electrical Resistivity Tomography (ERT) and Ground Penetrating Radar (GPR) surveys were used to characterize sediment properties under a lake. Subsequently, the survey results were used as input in a groundwater flow model to assess if sediment properties could explain the observed discharge patterns.

The study site is located at Tissø, the fourth largest lake in Denmark with a surface area of 12.3 km^2. The lake has a maximum depth of 14 meters and water depth is quickly increasing at the lakeshore making traditional quantification of groundwater fluxes difficult. Thus, Distributed Temperature Sensing (DTS) was used at the lake bottom to infer interactions between groundwater and surface water up to 250 m offshore up to a water depth of 4.5 m in three surveys in December 2016, May and June 2017. As it was not possible to obtain independent estimates of groundwater fluxes, numerical modelling with a conceptual understanding of the local geology was used to validate the findings of the DTS surveys.

The study shows that a flow model with homogeneous geology is not capable of reproducing the observed discharge patterns. However, assigning sediment distribution based on the waterborne geophysical surveys, the model predicts two offshore discharge peaks agreeing with DTS measurements showing potential groundwater discharge at approximately 60 and 130 m offshore. Thus, the combination of offshore geophysics and DTS proved to be an efficient way of characterizing groundwater-surface water interaction over larger areas with greater water depth.