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Using airborne time-domain electromagnetics to inform regional groundwater models: A semi-automatic 3D hydrogeological zonation approach

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Good spatial coverage along with high resolution make airborne time-domain electromagnetic (AEM) data valuable for the structural input to regional groundwater models. Geometry and configuration of hydrogeological units are often poorly determined from hydrogeological data alone, emphasizing the need for an AEM data interpretation procedure that can be integrated in groundwater model calibration. Considering costs and data coverage traditional geological data such as borehole observations are alone not ideal for regional scale modelling. Today geologists and hydrogeologists interpret AEM-derived electrical resistivity distributions manually along with borehole observations within the context of a given geological setting. Due to the discrepancy between hydrological and geophysical parameter spaces the challenge is to translate the electrical resistivity distribution into hydrogeological units. The translation between hydrological and geophysical parameter space varies spatially and between sites, making a fixed translation insufficient.

This study presents a semi-automatic sequential hydrogeophysical inversion method for the integration of AEM data into groundwater models. The coupling between hydrological and geophysical parameters is managed using a translator function with spatially variable parameters followed by a non-parametric hydrogeological zonation. The translator function translates the electrical resistivities obtained in geophysical inversion into clay content using clay observations from borehole logs. The translator function is allowed to vary spatially thus accounting for lithological variability not captured by AEM. After kriging onto a common 3D grid principal components are computed for the translator function variables, translated clay content, geophysical results and uncertainty estimates. The zonation is carried out as a k-means classification on the principal components. The method was applied to field data collected at a Danish field site. The dataset includes interpreted borehole observations and AEM flight path coverage. A classically developed geological model is available for comparison.

Our results suggest that a competitive groundwater model can be constructed from the AEM dataset using the automatic procedure outlined above. Alternative zonations using various classification settings, comprising the number of classes and classification variables were evaluated with respect to the performance of the associated groundwater model and by comparison with the classical geological model.