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Informing regional groundwater models with airborne electromagnetic and borehole hydrostratigraphy

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Introduction

Good spatial coverage along with high resolution make airborne time-domain electromagnetic (AEM) data valuable for the structural input to regional groundwater models. Geological structures and heterogeneity, which spatially scarce borehole lithology data may overlook, are well resolved in AEM data [1]. 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.

Due to the discrepancy between hydrological and geophysical parameter spaces the challenge is to translate the electrical resistivity distribution into hydrogeological units. The relationship between hydrological and geophysical parameter space varies spatially and between sites, making a fixed translation insufficient.

Groundwater model prediction uncertainty is primarily driven by structural (geological) uncertainty [2]. Sampling of the structural model space is necessary to estimate prediction uncertainties. This is not possible with the standard practice of one geological model.

This study presents a semi-automatic sequential hydrogeophysical inversion method for the integration of AEM and borehole data into regional groundwater models in sedimentary areas, where sand/clay distribution govern groundwater flow.

Method

The coupling between hydrological and geophysical parameters is managed using a translator function with spatially variable parameters followed by a non-parametric hydrogeological zonation. Observed borehole lithologies are represented as clay/sand fractions. The translator function translates the electrical resistivities obtained in geophysical inversion into clay fractions using the observed clay/sand from boreholes. 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 translated clay content, geophysical resistivities and uncertainty estimates. Zonation is carried out by k-means clustering on the principal components. The estimation of hydraulic parameters of the zones is constrained using head and discharge observations in a groundwater model calibration. 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 classical geological model is available for comparison.

Results

Our results suggest that a competitive groundwater model can be constructed from the AEM dataset using the automatic procedure outlined above, see Figure 1. Alternative zonations using various classification settings, comprising the number of clusters, clustering variables and weights were evaluated with respect to the performance of the associated groundwater model and by comparison with the classical geological model.

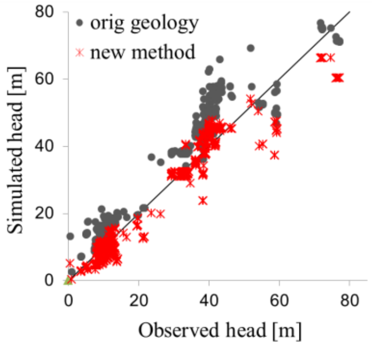

Figure 1 Groundwater model performance with respect to head.

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