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LARGE-SCALE AUTOMATIC GENERATION OF HYDROLOGICAL INPUT FROM RESISTIVITIES AND BOREHOLES

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KEYWORDS:

Inversion, integrated modeling, boreholes, hydrological models

INTRODUCTION

This study presents a semi-automatic sequential hydrogeophysical inversion method for the integration of resistivity data and lithological borehole information into groundwater models in sedimentary areas.

Large scale airborne geophysical EM-surveys play an increasingly important part in the geological mapping of the subsurface especially in a hydrogeological context. Airborne EM surveys provide valuable information of the geological structures and the lateral heterogeneity than boreholes cannot reveal due to the spatial scarcity (Jørgensen et al., 2003). However, boreholes play a key role in linking the resistivity to the different lithological and hydrological classes. Today, geologists and hydrogeologists in most cases 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 classes.

Our results suggest that a competitive groundwater model can be constructed from densely sampled resistivity models from AEM surveys together with borehole information, using the procedure outlined below.

METHODOLOGY

The petrophysical connection between hydrological parameters and geophysical parameters varies spatially within survey areas and to an even larger degree between survey areas. This means that a global, fixed petrophysical connection is non-exisisting. In this paper, the connection between hydrological and geophysical parameters is managed by a translator function with spatially variable parameters.

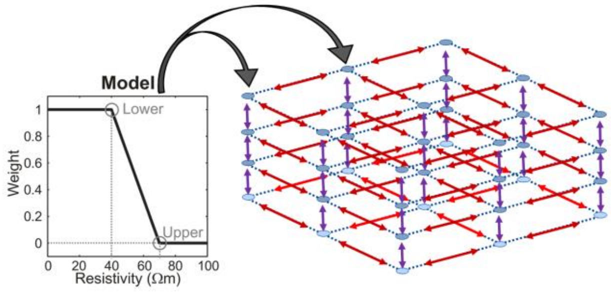

Figure 1. Simple translator model converting resistivity into clay content by defining resistivity-dependent weights. Each node of a regular model grid holds a set of two model parameters to allow for spatial variation in the translation. Lateral and vertical constrainst between the model parameters act as regularisation in the inversion problem.

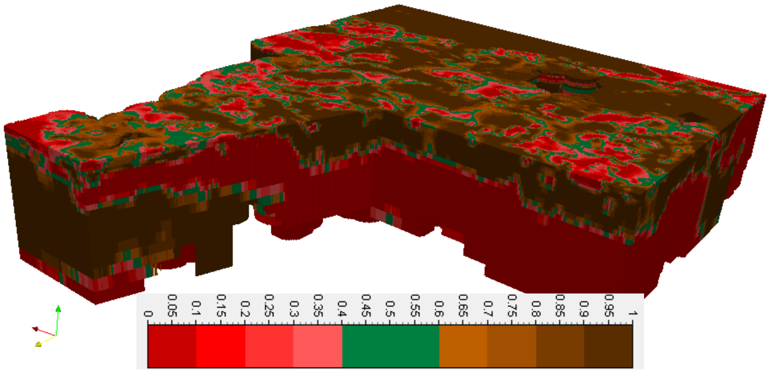

Figure 2. Result from the Tønder survey area, Denmark showing a cut in a 3D clay fraction model cube (20 km x 18 km x 250 m). The area holds approximately 1400 boreholes of which only 65 reached a depth of 50 meters. The area is covered with AEM data from the SkyTEM system (Sørensen and Auken, 2004) with a line spacing of 200 m, in total more than 50,000 soundings.

In sedimentary areas, the distribution of mainly clay and sand will be the governing factors for the groundwater flow. Hence, a model describing the clay content can be used for forming hydrological zones. In boreholes we describe the cumulated thickness, or clay-fraction, in intervals (this is our *observed data*). On the other hand we have geophysical resistivity models, which through a translator *model* (figure 1), will translate the resistivities into clay fraction through a weight on the resistivities (this is the *forward problem*). The translator model is a very simple function defined in a regular grid with two parameters per node, a lower and an upper parameter. The *inverse problem* seeks the translator model that results in the best fit between the clay fractions described in the boreholes and the clay fractions computed from the resistivity models. The best translator model from the inversion process is lastly applied to the resistivity models, thereby forming a 3D-clay fraction model. This output thus holds the integrated information about the amount of clay layers from both the boreholes and the geophysical resistivity models.

The clay fraction model can be used directly in setting up hydrological units simply by grouping the clay fraction values in into a number of intervals, as done in e.g. figure 2. More advanced classification and zonation schemes are being investigated currently, which includes e.g. soil maps and other ancillary information, if the information is present. The output from the presented approach is evaluated in a full scale groundwater model calibration, and the result is compared with a calibration result from a traditional hydrostratigraphic model.

EXAMPLES

Figure 2 shows a cut in the resulting 3D-clay fraction model (The Tønder SkyTEM survey, Jørgensen et al., 2012), in this case with three primary classes: clay (brown), sand/gravel (red), and mixed (green). A horizontal slice in the 3D resistivity and clay fraction model is shown in Figure 3.

The resulting image of the clay-sand distribution includes both the resistivity data and the borehole data, which means that a global, non-varying translator model would not have produced the same image. Needless to say, neither would the borehole information alone. In the simplest form the three classes can form three hydraulic zones in the groundwater model with no further zonation.

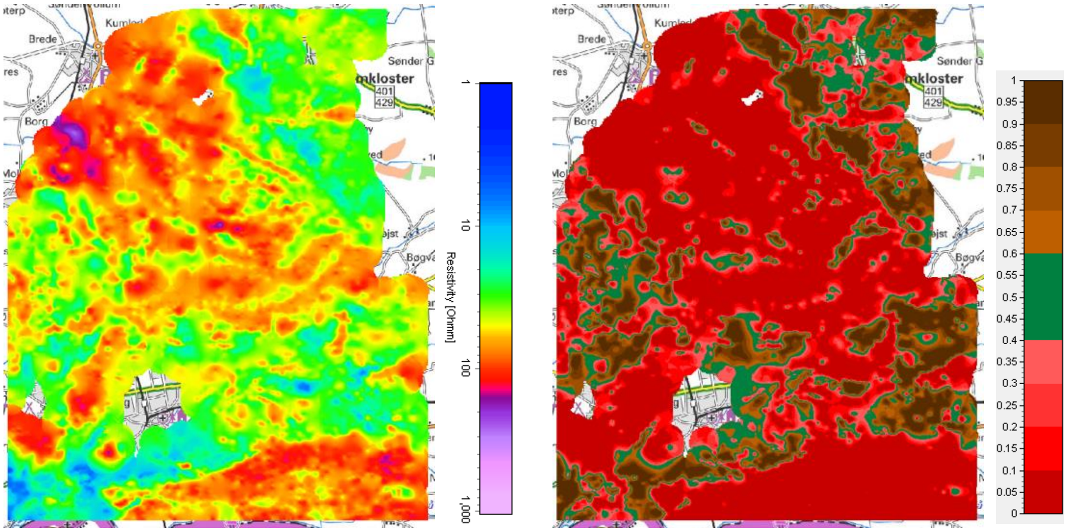

Figure 3. Left: Horizontal slice at 15 m.b.s.l in the 3D-resistivity model. Right: corresponding slice in the 3D-clay fraction model.

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