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Prediction of hydraulic parameters from block joint inversion of magnetic resonance and vertical electric soundings

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For assessing the impact of climate changes on salinity of coastal aquifers, numerical modelling needs to be done. As input, the spatial distribution of the parameters porosity, hydraulic conductivity and salt concentrations is needed. Airborne resistivity data are available that gives hints to fluid conductivity. Magnetic resonance soundings (MRS) can provide free water content directly yielding porosity, which in turn is needed for fluid conductivities and thus TDS concentrations. Furthermore, hydraulic conductivities can be retrieved by empirical relations using porosity and decay times.
For having a unique model with all three primary parameters, vertical electrical and magnetic resonance soundings are inverted jointly using a block discretization. The MRS data were preprocessed using noise cancellation, despiking and a new gate integration scheme. Data errors were derived from fitting and include the effect of gating. Since the resistivity model affects the MRS inversion but demands an extensive kernel calculation, resistivity is updated only once. After inversion, a systematic model variation is done in order to retrieve confidence intervals of the primary and secondary parameters.
We apply the methodology to several soundings at the North Sea Island Borkum, where the dynamics of the fresh/salt water interface is currently investigated. All soundings exhibit a very good data quality. One sounding close to a research borehole verifies the approach qualitatively. Another sounding was done to calibrate the petrophysical parameters using a pumping test. Finally, it is applied to a sounding in the flooding area. Whereas single MRS and VES data can be explained by a 3-layer and 4-layer model, respectively, a 5-layer model is needed to find a comprehensive model. Even though porosities are fairly constant, we can distinguish lithology and salinity due to the combination of resistivity and decay time. This case shows two fresh/salt water interfaces separated by a silt layer. The computed uncertainties of all three parameters are significantly larger for the silt and the lowest salt-water layer. Finally, we can further derive uncertainties for all derived hydraulic parameters using error propagation.