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Merging tTEM data and borehole lithological information to generate hydrogeologic structural models and redox conditions through Direct Sampling

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Detailed 3D structural information of the subsurface is fundamental for the development of both hydrological and geochemical models. This structural information is often derived from geophysical mapping results. Some parts of a catchments areas are however inaccessible for the geophysical mapping or might suffer from low data quality, which results in information gaps. Multipoint statistics can be used to remediate these data gaps and incorporate uncertainty in the construction of the hydrogeological models. This results in an ensemble of plausible 3D hydrogeological models.

This project focusses on nitrate retention mapping. The approach taken is to start from the resistivity models that are obtained from the tTEM measurement campaign. These resistivity datasets are combined with borehole lithological data from the Danish national well-database in an automated procedure that estimates resistivity-to sand/clay translator functions. This results in a clay fraction – resistivity data pair for every point in the subsurface where resistivity data is collected. These clay fraction – resistivity data pairs are converted to discrete hydrogeological units through clustering. This procedure is performed because the groundwater model that uses the end-product of this workflow, uses hydrogeological units rather than resistivity values or clay fractions to define zones of similar hydrogeological behavior.

Direct sampling is used to go from the cluster information obtained at the resistivity model location to fill out the full model volume and generate multiple plausible model realizations. This method allows, at the same time, for incorporating uncertainty through separation of data into a hard data set for the cluster information with higher probability, and a soft data set for the cluster information with lower probability. Since the redox conditions in the subsurface are related to the hydrogeological conditions, we are using this method to co-simulate hydrogeological units and redox conditions by merging the cluster training dataset with a redox condition training dataset that is constructed based on the cluster dataset and hydrogeochemical samples that are collected across the catchment. We combine the three training images: resistivity, cluster and redox condition, to simultaneous simulate the three variables in each grid point as a vector, instead of simulating them as separate variables. The resulting set of 3D hydrogeologic structural models

and redox condition models retains the complex geostatistical spatial relationships that can exists between the different type of datasets within the training image, making them suitable for nitrate retention modeling at catchment scale.