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Voxel inversion of airborne electromagnetic data for improved model integration

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Inversion of electromagnetic data has migrated from single site interpretations to inversions including entire surveys using spatial constraints to obtain geologically reasonable results. Though, the model space is usually linked to the actual observation points. For airborne electromagnetic (AEM) surveys the spatial discretization of the model space reflects the flight lines. On the contrary, geological and groundwater models most often refer to a regular voxel grid, not correlated to the geophysical model space, and the geophysical information has to be relocated for integration in (hydro)geological models.
We have developed a new geophysical inversion algorithm working directly in a voxel grid disconnected from the actual measuring points, which then allows for informing directly geological/hydrogeological models.

The new voxel model space defines the soil properties (like resistivity) on a set of nodes, and the distribution of the soil properties is computed everywhere by means of an interpolation function (e.g. inverse distance or kriging). Given this definition of the voxel model space, the 1D forward responses of the AEM data are computed as follows: 1) a 1D model subdivision, in terms of model thicknesses, is defined for each 1D data set, creating “virtual” layers. 2) the "virtual" 1D models at the sounding positions are finalized by interpolating the soil properties (the resistivity) in the center of the "virtual" layers. 3) the forward response is computed in 1D for each “virtual” model.

We tested the new inversion scheme on an AEM survey carried out with the SkyTEM system close to Odder, in Denmark. The survey comprises 106054 dual mode AEM soundings, and covers an area of approximately 13 km X 16 km. The voxel inversion was carried out on a structured grid of 260 X 325 X 29 xyz nodes (50 m xy spacing), for a total of 2450500 inversion parameters. A classical spatially constrained inversion (SCI) was carried out on the same data set, using 106054 spatially constrained 1D models with 29 layers. For comparison, the SCI inversion models have been gridded on the same grid of the voxel inversion. The new voxel inversion and the classic SCI give similar data fit and inversion models.

The voxel inversion decouples the geophysical model from the position of acquired data, and at the same time fits the data as well as the classic SCI inversion. Compared to the classic approach, the voxel inversion is better suited for informing directly (hydro)geological models and for sequential/Joint/Coupled (hydro)geological inversion. We believe that this new approach will facilitate the integration of geophysics, geology and hydrology for improved groundwater and environmental management.