Multivariate statistical analysis of geophysical data and models by neural network approaches

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SUMMARY

Combination of geophysical data including magnetotelluric and potential field data provide useful information for mapping and interpreting geological units. Application of neural network approaches has proven to have potential to analyze and classify complex multivariate and high-dimensional data. Results from application of quantitative classification based on the unsupervised Self Organizing Map (SOM) neural network (Kohonen, 1982) to regional-scale potential field data combined with newly acquired broadband magnetotelluric data (Vadoodi et al., 2021) were presented by Vadoodi and Rasmussen (2022). The data covered a 200 km by 250 km area located in the Paleoproterozoic Norrbotten ore province (northern Sweden). The quantitative analysis integrated the petrophysical parameters associated with three data types (obtained from 3D individual inversions of gravimetric and magnetic fields and magnetotelluric data). The input parameters to the SOM algorithm were defined such that the information on depth variation of each petrophysical property enters the classification jointly with actual values. The input data contained 3D resistivity, magnetic susceptibility, and density model parameter values for six selected depth levels covering the entire crust. The SOM analysis provided an easy way to map and characterize three petrophysical models jointly to find the locations in the crust that are similar with respect to all three petrophysical parameters as well as similar depth-wise distribution. The domain classification is discussed with respect to the geological boundaries and composition of the crust. In general, consistency was observed regarding the visual comparison between the SOM domains and the mapped geological units. However, some discrepancies were noted in specific areas where more work is needed to analyze the reasons for the discrepancies.

Deep learning algorithms have been profoundly used in the earth science during the last few years for a variety of scientific problems such as image processing and classification. It uses multiple layers to progressively extract higher-level features from the input data. In the current study, we present results from the application of an unsupervised deep learning algorithm (stacked auto-encoder) for the above-mentioned data including resistivity, magnetic susceptibility and density values obtained from 3D inversion models for the same depth sections presented by Vadoodi and Rasmussen (2022). The domain classification is further discussed and compared with the results from the SOM analysis.

Keywords: Magnetotelluric, Potential field, 3D inversion, Neural network, Deep learning

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