A DATA DRIVEN APPROACH FOR ROBUST INVERSION OF INDUCED POLARIZATION EFFECTS IN TRANSIENT ELECTROMAGNETIC DATA

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As the TEM method is being increasingly used in high-resistive areas and arctic regions, Induced polarization (IP) effects are often adversely affecting the data. IP effects in TEM data can manifest in the traditional monotonic decays as fast-decaying, sign-changing or as fully-negative, depending on the origin and magnitude of the IP signal. IP signals are usually associated with polarizable bodies, such as permafrost, clay-rich materials, mineral deposits, etc.

IP effected TEM (TEM-IP) data should be modelled appropriately to avoid erroneous resistivity models. The Cole-Cole model, which consist of four parameters (ρ, DC resistivity; m_0, chargeability; τ, relaxation time; and c, frequency parameter), is a popular model for modeling the TEM-IP data. However, the inversion problem for the Cole-Cole parameters is ill-posed and a strong correlation between some of the parameters increases the non-uniqueness between data and model parameters. As a direct consequence of this, the TEM-IP inversion is quite unstable and highly sensitive to the starting model. Therefore, selecting appropriate starting model parameters in the TEM-IP case becomes an important factor to achieve convergence and/or produce appropriate output models.

In the context of a ground-based towed TEM system (tTEM), we observe that the forward data response of the starting model parameters should have similar pattern to the observed TEM-IP data to achieve convergence in most cases. Therefore, inverting the TEM-IP data without the consideration of the forward data pattern of the starting model requires a trial and error approach with random starting model combinations to achieve convergence, which makes the computationally expensive inversion process even more costly.

To propose an appropriate starting model for a given TEM-IP decay, we propose a data-driven approach where we generate a database of forward data of 100,000 unique combinations of homogenous half-space Cole-Cole parameters consistent with the expected range of the parameters. The patterns of the forward data in the database are compared against the observed TEM-IP decay through a pattern matching approach. Our pattern matching approach uses the relative percentage difference between the data points of the observed TEM-IP decay and the forward data curves in the database. A maximum of 20 models are selected by iteratively updating the acceptable percentage difference between the data points, which ensures that the pattern between the data points is matched and a representative number of models are obtained. We observe that the proposed model parameters generally result in a unimodal or a uniform distribution for each Cole-Cole parameter, and thus, the mean values of the distributions for the parameters are selected as the starting model.

We test our approach on data with prominent IP effects from different survey areas, and we observe that inverting the TEM-IP data with the proposed starting model generally achieves convergence with a good data fit. We also compare tTEM inversion results with the inversion results of direct current/ induced polarization (DC/IP) data for the coinciding lines. In the presentation, we will discuss the proposed concept of obtaining appropriate starting models in detail for the robust inversion of TEM-IP data. We will also show several inversion results and comparisons to demonstrate the effectiveness of our approach.