Closing the gap between galvanic and inductive induced polarization: EEMverter, a new modelling tool for Electric and Electromagnetic data

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Workshop session: "From field data acquisition and processing to inversion"

Is the first and presenting author a student? No

The phenomenon of Induced Polarization (IP) is commonly studied with galvanic methods, both in the field and in the laboratory. IP effects on inductive electromagnetic (EM) data have been reported since the early '80s, but the attention of the EM community in IP focuses mainly on exploration purposes, because strong chargeable anomalies trigger negative EM responses. However, Fiandaca et al. (2022) showed that the IP effect strongly affects EM data also in sand/clay environments, with a variety of acquisition systems, ranging from airborne EM to systems for continuous ground acquisitions. In this study we present a novel inversion software, EEMverter, specifically developed to model electric and electromagnetic data taking into account the IP phenomenon. Four distinctive features have been implemented in EEMverter: i) selectable IP parameterisations are allowed, ranging from Constant Phase Angle to Debye-Warburg decomposition, also making use of petrophysical relation for defining IP parameters in terms of hydraulic properties; ii) 1D, 2D and 3D forward modelling can be mixed sequentially or simultaneously in the iterative process within multiple inversion cycles, for diminishing the computational burden; iii) the joint inversion of Airborne IP (AIP), ground EM-IP and ground galvanic IP data is fully supported with a common IP parameterization; iv) time-lapse inversions of AIP, EM and galvanic IP data is possible with both sequential and simultaneous approaches.

Figure 1 presents the resistivity section of a synthetic model that mimics the electrical properties (both conduction and polarization) of sand, clay and consolidated formations, based on the petrophysical relations described in Weller et al. (2015), together with the inversion model of inductive and galvanic data. In particular, four different inversion results are presented: direct current and full-decay induced polarization (DCIP) galvanic data, with 10 m electrode spacing and 2D gradient sequence; AEM + ground EM data, with sounding distance of 40 m; AEM+ground EM + tTEM data (Auken et al., 2019), with tTEM soundings every 10 m; all data together in a joint inversion scheme.

The joint inversion presents much better resolution capability, with the inductive and galvanic data complementing each other in resolving both conductive and resistive layers. Examples of joint inversion of AEM, ground EM and galvanic IP data through EEMverter are presented in Dauti et al. (2024) in applications related to mineral exploration and in Signora et al. (2024) for the characterization of the HydroGeosITe, the Italian reference and calibration site for hydrogeophysical methods under development in Brescia, Italy.

We believe that EEMverter, with its common inversion environment for the IP inversion of inductive and galvanic data will help in closing the gap between galvanic and inductive IP.

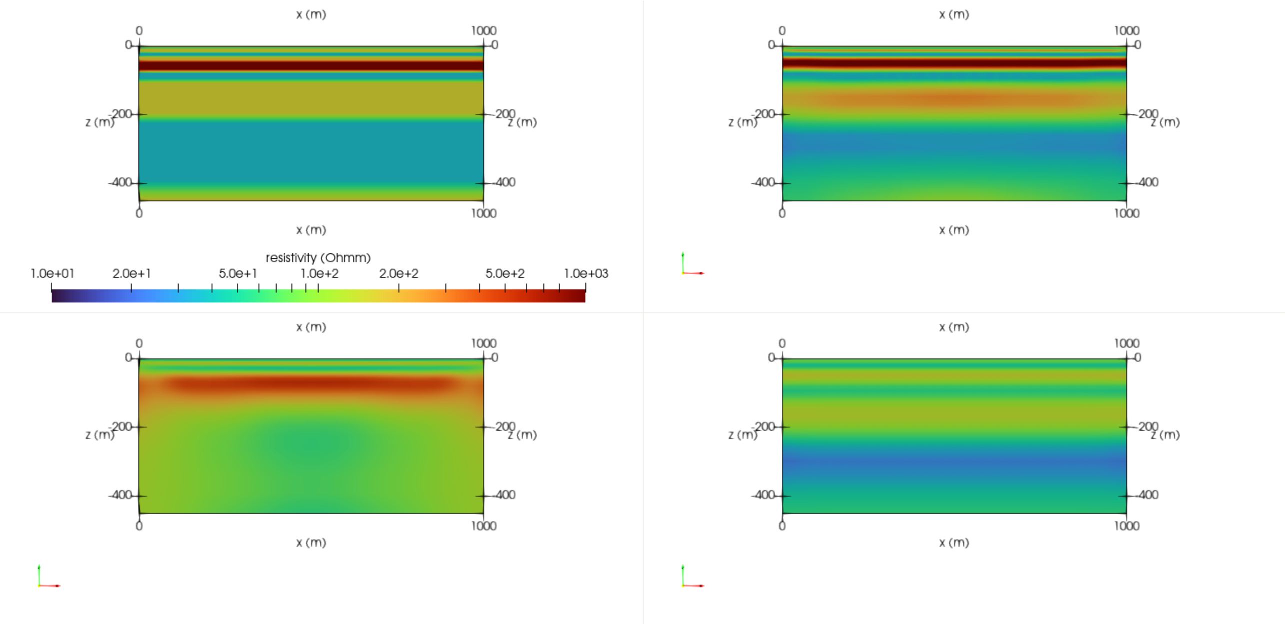

Figure 1. Synthetic model and inversion results. Top left) resistivity section of a MPA IP simulation of electrical properties; Bottom left) inversion model of DCIP data; Bottom right) inversion model of AEM+ground EM data; Top right) joint inversion of all inductive and galvanic data.

References

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