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Overcoming low induction number approximations: apparent electrical conductivity estimation for frequency domain electromagnetics and its potential for simultaneous apparent magnetic susceptibility mapping

Daan Hanssens, Christin Bobe, Marc Van Meirvenne, and Philippe De Smedt

Research Group Soil Spatial Inventory Techniques (ORBit), Faculty of Bioscience Engineering, Ghent University, Coupure 653, 9000 Gent, Belgium

Recent strides in frequency domain electromagnetic (FDEM) instrumentation drive the rapid growth of (ground-based) applications. For investigating the very near surface, these instruments often used the premise of a low induction number (LIN), for instance by making use of LIN apparent electrical conductivity (ECa) for describing the out-of-phase response. As FDEM is deployed increasingly in conditions where such approximations are no longer valid, new methods are needed to relate the complex responses to comprehensible but robust measures for subsurface properties.

Here, we present a novel approach whereby the ECa is estimated robustly, overcoming LIN approximations. Instead, the method considers the relationship between a homogenous ECa volume and its associated forward response. An ECa value is then sought-after until its theoretical response matches the FDEM measurement sufficiently. The method builds on an integrated 1D forward model, which accounts for instrument elevation, coil pair geometry, operating frequency, subsurface electrical conductivity, and – unlike existing approaches – is fairly robust against variations in magnetic permeability. Furthermore, we determined the method its limitations and advantages, by using Monte-Carlo sampling of aforementioned parameters and by comparing it to established ECa methods. Ultimately, we assessed the potential of this method for simultaneous mapping of apparent magnetic susceptibility, further contributing to the robustness of the overall method and the multi-variate potential of FDEM prospection in general.