3D modeling of CSEM data in the radio frequency band with different sources

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ABSTRACT

Radio-magnetotellurics (RMT) is a passive electromagnetic (EM) technique in geophysics often used for shallow environmental and geotechnical applications. The method uses remote radio antennas broadcasting in a range of around 10-1000 kHz as transmitters. Due to the natural limitations of RMT in its depth of investigation and its dependency on remote radio transmitters, the technique has been extended to use control source in wide frequency range in the past decade. Here, we term it as CS/RMT measurements, as they combine the plane wave RMT range and the source intermediate zone (CSEM). Therefore, the approach can be thought, especially in terms of 3D inversion, as a combined CSEM and RMT method. The CS/RMT measurement frequency range extends from 1-1000 kHz.

Considering the source intermediate zone has several advantages over the previous approach of considering only the far-field: (i) easier logistics, as we do not need to place the source far enough to maintain far-field conditions; (ii) better signal-to-noise ratio; (iii) combined resolution of CSEM and RMT, among others. Such implementation requires modelling of the EM field considering the source. Here, we study the resolution capabilities of different source types in the radio-frequency band over the 3D sub-surface. For this we develop our modelling software – an object-oriented code in Python – MR3DMod.py.

To calculate the background 1D solution for different source types, general 1D field formulations were implemented, following the computational recipes of the well established 3Dinv. Moreover, we combine the fast Hankel transform (different filters) with direct quadrature via optimised Python routines to derive the field components.

We will show the advantages and disadvantages of the various sources at high frequencies for the selected synthetic models and give recommendations for the CS/RMT survey planning.

Keywords: forward modelling, CSEM, RMT, CS/RMT