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Toward a rapid 3D spectral deconvolution of EMI conductivities measured with portable multi-configuration sensors

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Portable loop-loop electromagnetic induction (EMI) sensors using multiple coil configurations are of growing interest in hydrological, archaeological and agricultural studies for mapping the subsurface electrical conductivity. In contrast with EMI methods employing larger scale geometries (e.g., magnetotellurics, marine EM, airborne EM, transient EM, large offset loop-loop harmonic source EM), the portable EMI multi-configuration sensors operate in the low induction number (LIN) domain as they employ a rather low frequency harmonic source (< 20 kHz) and rather small coil separations ($\leq$ 2 m). In the LIN domain, electrical conductivity has a minor effect on the forward modelling kernel. Accordingly, we have developed an algorithm to model this kind of data, which is based on a homogeneous half-space kernel. By formulating the problem in the hybrid spectral-spatial domain (k_x, k_y, z), we show that it is possible to generate large data maps containing more than 100,000 stations within a minute on a standard modern laptop computer. We compared this forward modelling approach to a robust approach based on the integral equation (IE) method. Our results show that, as long as the LIN approximation is fulfilled (i.e., for the system of interest, if the electrical conductivity is smaller than 0.5 S/m), the linear theory allows to accurately and robustly handle the structural characteristics of the subsurface conductivity distribution. We therefore expect that our forward modelling procedure can be implemented in rapid multi-channel deconvolution procedures in order to rapidly extract the structural properties of the subsurface conductivity distribution from data sets acquired across rather large (hectare scale) areas.