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# Novel quantitative calibration approach for multi-configuration electromagnetic induction (EMI) systems using data acquired at multiple elevations

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Electromagnetic induction (EMI) systems offer a great potential to obtain highly resolved layered electrical conductivity models of the shallow subsurface. State-of-the-art inversion procedures require quantitative calibration of EMI data, especially for short-offset EMI systems where significant data shifts are often observed. These shifts are caused by external influences such as the presence of the operator, zero-leveling procedures, the field setup used to move the EMI system and/or cables close by. Calibrations can be performed by using collocated electrical resistivity measurements or taking soil samples, however, these two methods take a lot of time in the field. To improve the calibration in a fast and concise way, we introduce a novel on-site calibration method using a series of apparent electrical conductivity (ECa) values acquired at multiple elevations for a multi-configuration EMI system. No additional instrument or pre-knowledge of the subsurface is needed to acquire quantitative ECa data. By using this calibration method, we correct each coil configuration, i.e. transmitter and receiver coil separation and the horizontal or vertical coplanar (HCP or VCP) coil orientation with a unique set of calibration parameters. A multi-layer soil structure at the corresponding measurement location is inverted together with the calibration parameters using full-solution Maxwell equations for the forward modelling within the shuffled complex evolution (SCE) algorithm to find the optimum solution under a user-defined parameter space. Synthetic data verified the feasibility for calibrating HCP and VCP measurements of a custom made six-coil EMI system with coil offsets between 0.35 m and 1.8 m for quantitative data inversions. As a next step, we applied the calibration approach on acquired experimental data from a bare soil test field (Selhausen, Germany) for the considered EMI system. The obtained calibration parameters were applied to measurements over a 30 m transect line that covers a range of conductivities between 5 and 40 mS/m. Inverted calibrated EMI data of the transect line showed very similar electrical conductivity distributions and layer interfaces of the subsurface compared to reference data obtained from vertical electrical sounding (VES) measurements. These results show that a combined calibration and inversion of multi-configuration EMI data is possible when including measurements at different elevations, which will speed up the measurement process to obtain quantitative EMI data since the labor intensive electrical resistivity measurement or soil coring is not necessary anymore.