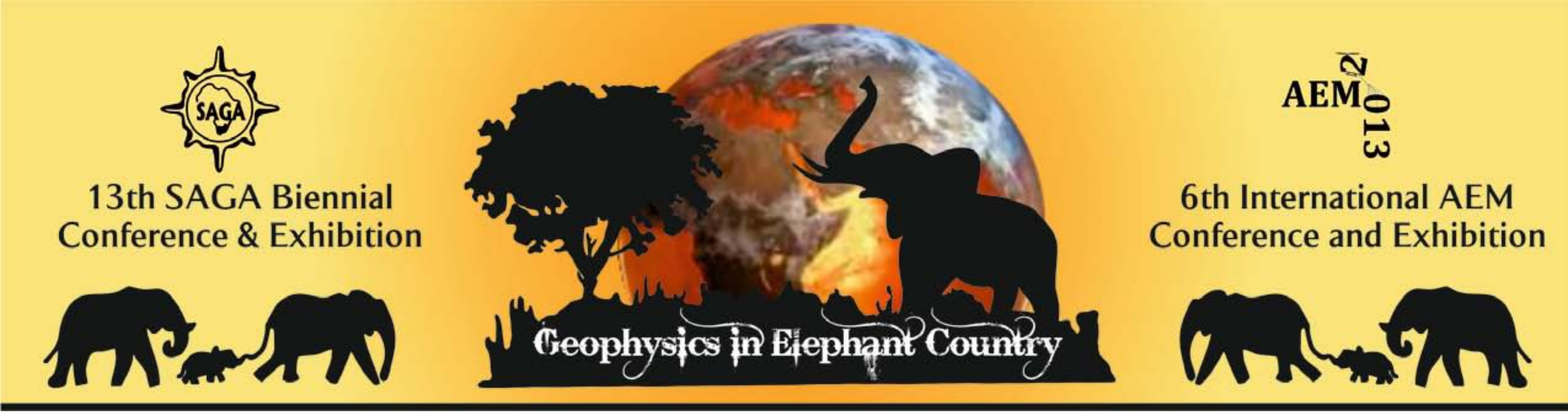

PROCESSING AND INVERSION OF COMMERCIAL HELICOPTER TIME-DOMAIN ELECTROMAGNETIC DATA FOR ENVIRONMENTAL ASSESSMENTS AND GEOLOGIC AND HYDROLOGIC MAPPING

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Helicopter time-domain electromagnetic (HTEM) surveying has historically been used for mineral exploration, but over the past decade it has started to be used in environmental assessments and geologic and hydrologic mapping. Such surveying is a cost-effective means of rapidly acquiring densely spaced data over large regions. At the same time, the quality of HTEM data can suffer from various inaccuracies. We developed an effective strategy for processing and inverting a commercial HTEM data set affected by uncertainties and systematic errors. The delivered data included early time gates contaminated by transmitter currents, noise in late time gates, and amplitude shifts between adjacent flights that appeared as artificial lineations in maps of the data and horizontal slices extracted from inversion models. Multiple processing steps were required to address these issues. Contaminated early time gates and noisy late time gates were semi-automatically identified and eliminated on a record-by-record basis (Figure 1). Timing errors between the transmitter and receiver electronics and inaccuracies in absolute amplitudes were corrected after calibrating selected HTEM data against data simulated from accurate ground-based TEM measurements (Figure 2). After editing and calibration, application of a quasi- 3D spatially constrained inversion scheme significantly reduced the artificial lineations. Residual lineations were effectively eliminated after incorporating the transmitter and receiver altitudes and line-to-line amplitude factors in the inversion process (Figure 3). The final inverted model was very different from that generated from the original data provided by the contractor (Figure 4). For example, the average resistivity of the thick surface layer decreased from ~1800 to ~30 Om, the depths to the layer boundaries were reduced by 15%–23%, and the artificial lineations were practically eliminated. Our processing and inversion strategy is entirely general, such that with minor system-specific modifications it could be applied to any HTEM data set, including those recorded many years ago.

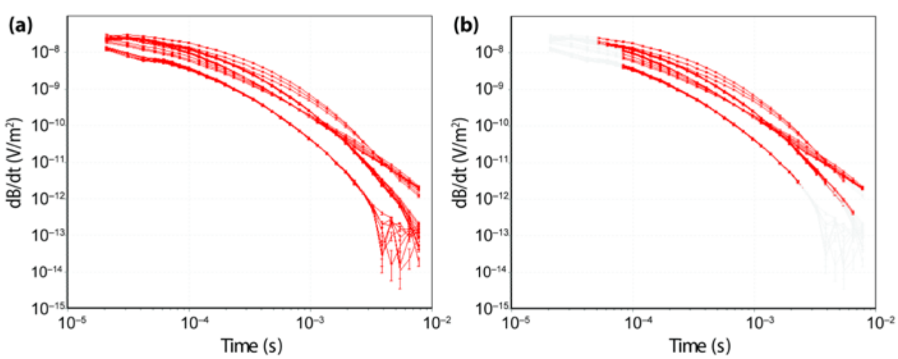

Figure 1. Editing of time gates for 25 example recordings. (a) No editing showing all 33 time gates from 21 - 7828 µs for all recordings. (b) The same recordings after gate editing. Early and late time gates were automatically evaluated for anomalous changes in dB/dt that resulted from the effects of residual transmitter current and the onset of significant noise, respectively. Once identified, the affected time gates were eliminated from the processing flow.

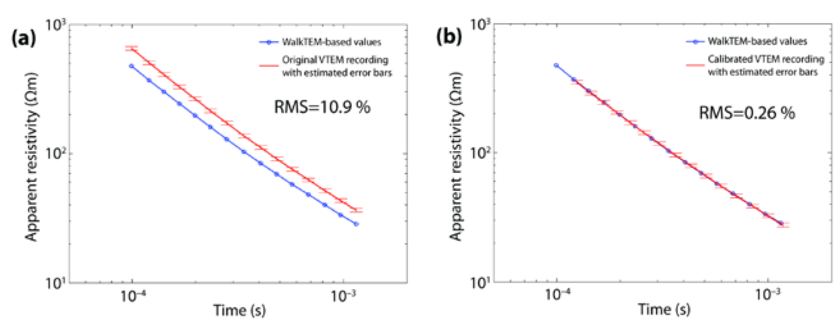

Figure 2. One of 13 examples used to calibrate the VTEM recordings. Early and late gates were omitted to improve accuracy (see Figure 1) (a) WalkTEM-based values and original VTEM recording. (b) WalkTEM-based values and calibrated VTEM recording. To force the VTEM values to coincide with the simulated WalkTEM-based values required adding 30 µs to the times and multiplying the amplitudes by 1.44 The 30 µs time shift was added to all gate times and all dB/dt values were multiplied by the 1.44 amplitude factor prior to conversion to apparent resistivities.

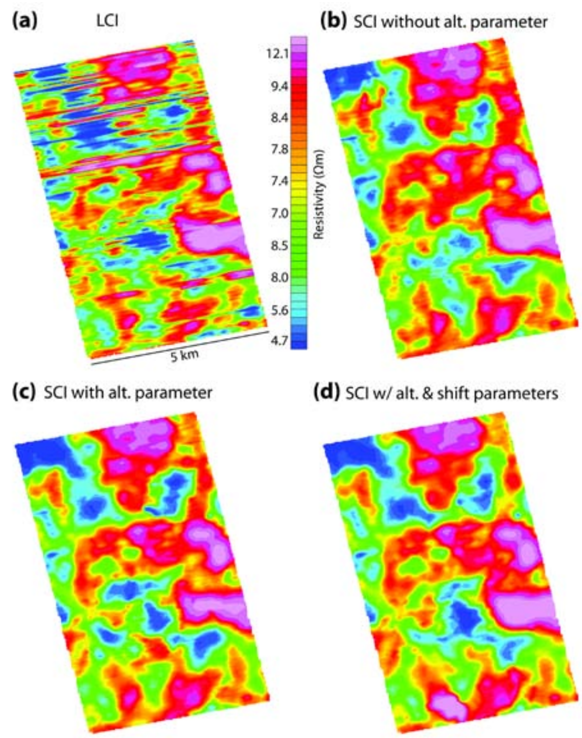

Figure 3. Comparison of layer 2 resistivities resulting from 4-layer inversions of the example data set that has been subjected to gate editing and timing and amplitude calibrations using (a) a pseudo 2-D LCI scheme (Auken and Christiansen, 2004), (b) a pseudo 3-D SCI scheme (Viezzoli et al., 2008), (c) as for (b) but with transmitter and receiver altitudes included as inversion parameters, and (d) as for (c), but with a data shift inversion parameter.

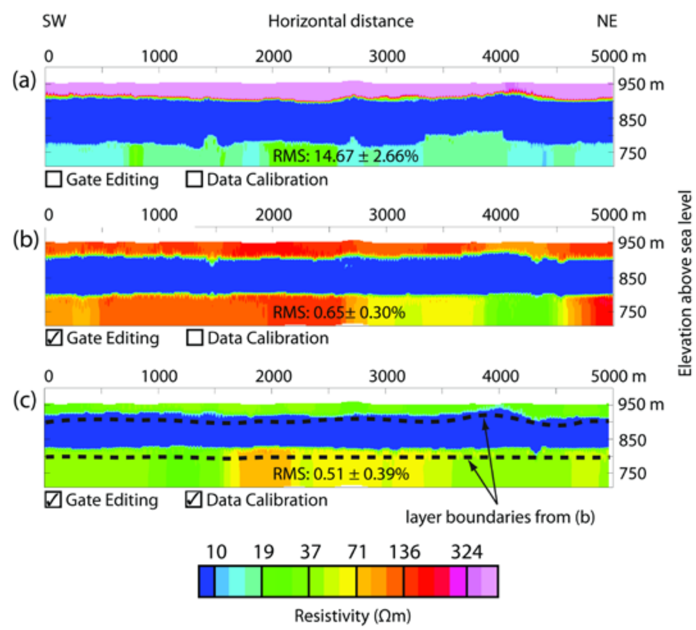

Figure 4. Inverted vertical resistivity models for a line of data after application of various processing steps. ‘Gate Editing’ refers to the removal of early gates affected by residual transmitter current and the elimination of noisy late gates. ‘Data Calibration’ refers to the incorporation of a 30 µs time shift and a 1.44 multiplicative amplitude factor (see Figure 2). The most significant changes are in the lower RMS values after gate editing (14.67 ± 2.66 % versus 0.65 ± 0.3 %) and changes in resistivity and layer boundary depth after data calibration.

Cited Literature

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