Joining multiple data sets

Extract from "Joining multiple AEM datasets to improve accuracy, cross calibration and derived products: The Spiritwood VTEM and AeroTEM case study", Near Surface Geophysics, 2015

Joining multiple AEM datasets

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Airborne time-domain electromagnetic methods (AEM) are fast and effective. However, AEM data, pre-processing and modelling procedures can suffer from inaccuracies that may dramatically affect the final interpretation. We demonstrate the importance and the benefits of advanced data processing, showing example of two AEM datasets (AeroTEM III and VTEM) collected over the Spiritwood buried valley aquifer in southern Manitoba, Canada. The AeroTEM and VTEM data are combined in a joint inversion. The distances between AeroTEM and VTEM coincident soundings range from approximately 10 m to 20 m. We designed the constraints so that any soundings falling within 20 m were tightly constrained. Beyond this reference distance, the effect of the constraints decreases with a partially dependent covariance that is scaled according to distance. As separate inversions, the different data sets produce two different smooth models that are correlated, in general, but at different levels of detail, especially at the very near surface. Results confirm consistency between the two different AEM datasets and the recovered models (Figure 1). The black line at the bottom shows the data residual: it is possible to assess a good fitting of the data.

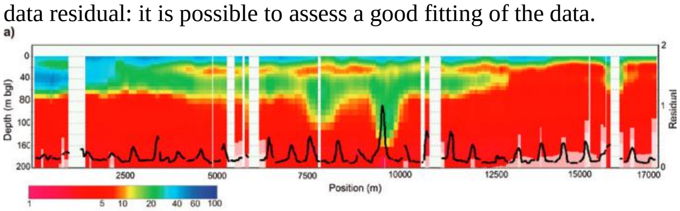

Figure 1. Example of joint inversion (after calibration).

On the contrary, joint inversion of unprocessed or uncalibrated AEM datasets (Figure 2) results in erroneous resistivity models which, in turn, can result in an inappropriate interpretation of the study area. For example, the shallow conductive layer, which would be not resolved by the full-processed data, does not have any geological explanation. Moreover, the data misfit is significantly worse. Thus, we suggest a protocol where a calibrated AEM data set can be used to calibrate others. Cross-calibration of the AEM data sets.

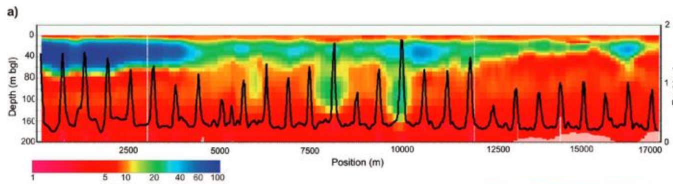

Figure 2. Figure 1. Example of joint inversion (before calibration calibration).

Examples of resistivity maps are show in in Figure 3. The maps were extracted from the uncalibrated (left) and the processed/calibrated (right) joint inversions. In general, we observe that the model changes drastically where the two datasets overlap. This is evident for the unprocessed data at all depths, while it is significantly mitigated for the re-calibrated joint inversion results except for the near surface. In particular, systematic striping along flight lines makes it difficult to carry out any hydrogeological interpretations of the unprocessed joint inversion result at depth (Fig. 11e vs. Fig. 11f). Furthermore, the unprocessed joint inversion result has a conductive near surface (Fig. 11a) and lacks resolution of the main resistive structures that are well resolved as inset channels in the processed/calibrated joint inversion at intermediate depths (Fig. 11c vs. Fig.11d). In addition to the main channels, other secondary valley-like-features in the western portion of the overlap areas are unclear in unprocessed joint inversion results.

Joint inversion demonstrates the degree of consistency between the different AEM systems and confirms the feasibility of the cross-calibration approach, which can be useful for reconciling large volumes of existing AEM data.

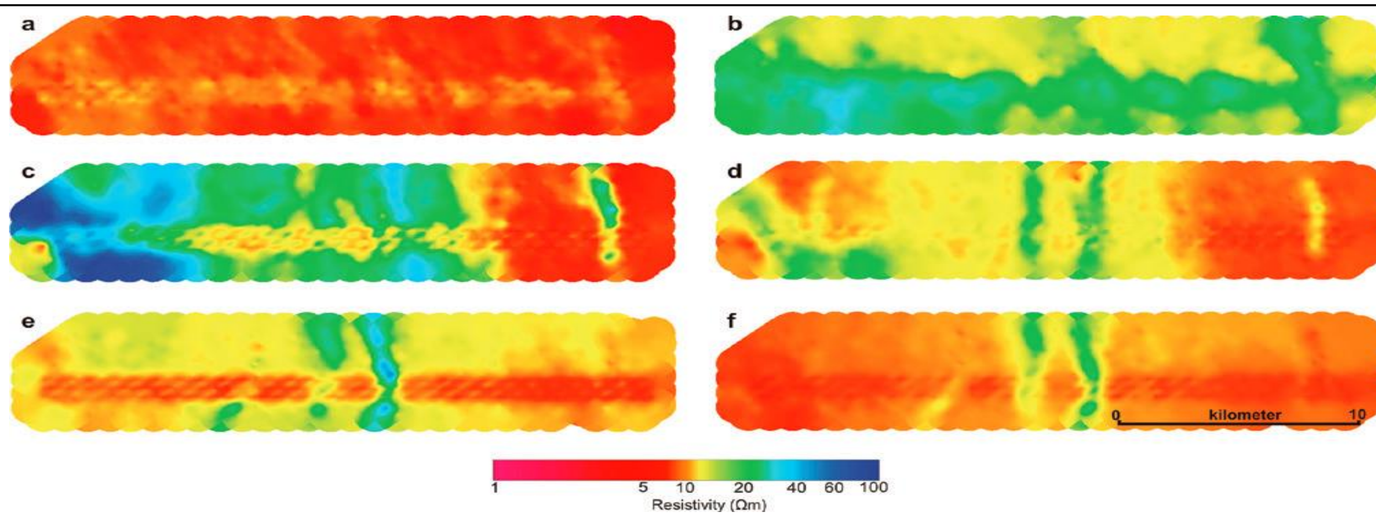

Figure3. Comparison of results of unlibrated (left) vs calibrated (right) data inversions.

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