The importance of the AEM data processing in Hydrogeological application

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In the past decade, the application of AEM data in hydrogeological investigations has steadily increased both in terms of areal coverage and also in complexity. This in turn has led to an increased demand for the accurate resolution of the shape and the absolute value of the conductivity–depth structure of the ground. The intent has been to extract important hydrogeological parameters in the subsurface, such as aquifer bounds, composition, and groundwater quality. To address these demands, four main issues needed to be met, including the acquisition of data by better calibrated systems, the monitoring of the system at all times during acquisition, the appropriate processing of the derived raw data, and accurate inversion to model space that follows.

If we look at the raw data, either gridded or in profiles, provides only information of signal levels and little information about electrical resistivities (conductivities) and depth. We need to invert the raw data to extract a conductivity depth structure. The first column of Figure 1 shows the results of an inversion of raw data, without applying any processing or filtering (Case 1). The results are shown as resistivity slices at four selected depths: 20, 50, 110, and 180 m b.g.l. The main features of the inversion result of Case 1 are the northsouth trending feature corresponding to a power line (notice that in the near surface, it is seen as a relatively broad conductive feature, whereas at depth as a resistive narrow lineament sided by two more conductive areas), a correlation between roads and low-resistivity structures, especially in intermediate depth intervals and a spotted appearance in the deeper maps due to the lack of proper noise processing.

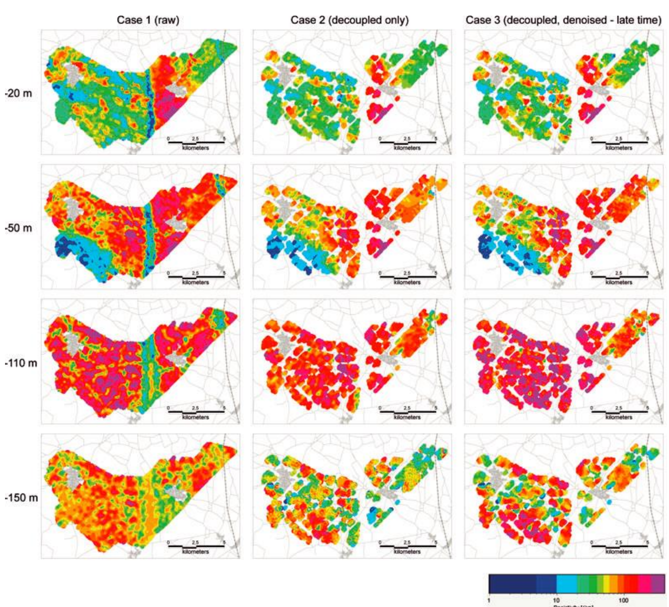

Figure 1

Case 2 shows the results of a careful automatic and manual decoupling of the EM data. By comparison with the results of Case 1 (raw data), it is clear that the northsouth trending feature along the power line has been totally removed and therefore will not be misinterpreted. Moreover, there is no correlation between conductors and roads or other infrastructures is present, whereas the spotting at depth is still seen in the decoupled inversion results. This is expected, as these features are caused by ambient noise rather than coherent noise due to coupling with infrastructure. Finally, Case 3 takes into acount the late time noise assessment. Inverting the data set with the late time noise present can cause artifacts in the deeper parts of the inverted models to be interpreted as conductors. The third column of Figure 1 shows a more uniform appearance at depth, the occurrence of more resistive units, both at depth and at intermediate levels, while the near-surface results are similar.

Figure 2 shows a comparison among the 3 cases on a resistivity cross section. The borehole on the left shows a superficial cover of sands and gravel (orange), overlying a clay layer (cyan). Borehole lithology: ks and gs = sands; gl = Gram clay.

It is clear the artifacts crossing all over the section in Case 1, due to couplings. The imaging of Case 3 has a more "geological" meaning that those of Case 2, and matches better the borehole stratigraphy.

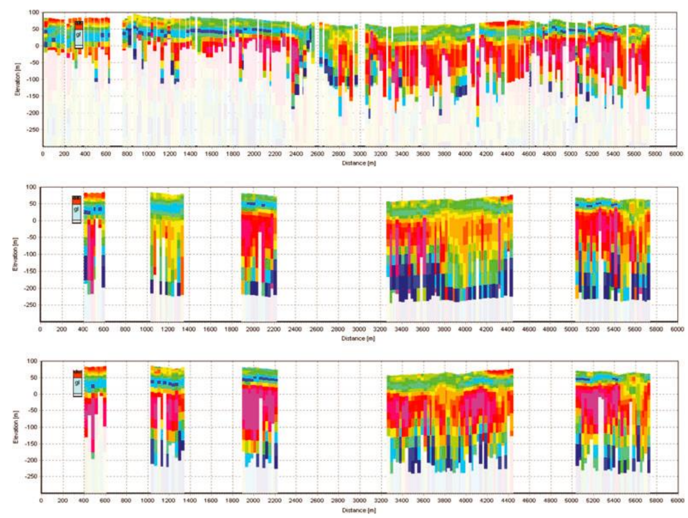

Figure 2

Hence, AEM methods, can be applied to quantitative hydrogeological investigations. However, accurate processing and editing of AEM data is one of the crucial steps involved in obtaining information appropriate to their effective and full use. Having the best source data, the best inversion procedures and most skilled hydrogeologists do not prevent a potential disappointing result.

Failing to remove data affected by infrastructure, poor noise assessment and removal, and excessive filtering are all issues that map directly to the model space, to the geological and hydrogeological parameters, and to the interpretation or modeling. The consequences can be many: low confidence in the derived models in general, overestimation of the depth to bedrock (or bottom of aquifer) by several tens of meters, excluding abstraction from good aquifers due to fake flow barriers, and posing the shallow aquifers at risk due to overestimation of the protecting impermeable layers. The impact, both environmentally and financially, can be severe.

We contend that, from a groundwater and environmental management perspective, the efforts and resources spent on proper processing of the AEM data are necessary to achieve the most out of a very effective methodology and to reduce the risk of possible misinterpretation of the final results.

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