Examples on the effect of different apriori informations to constrained inversion of AEM data

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SUMMARY

We present examples of integration of ancillary information to AEM data from different surveys around the world. The data enters the inversion as apriori extra parameter, either from a grid, or from a point source. We use the spatially constrained inversion to migrate the apriori information across the dataset. This approach allows also using the apriori information to re-calibrate the AEM dataset, solving for extra calibration parameters, along the lines of holistic inversion.

Key words: A-priori, AEM

INTRODUCTION

There are a number of concurring factors that promote the use of a-priori information in inversion of Geophysical data. The first one is probably the desire to cross check the geophysical derived model against ancillary information. The second is the inherent non uniqueness of the results of inversion of geophysical data, which is due to the fact that the problem is usually ill posed. The third is the ever higher level of accuracy of the output sought after by end users that, rightly so, demand results (either direct or derived) they can use directly for management. Last, but not least, is the drive to incorporate different physical parameters originating from different sources into one inversion problem, in order to derive directly, e.g., geological or hydrogeological models that fit all data sets at once.
In this paper we present some examples obtained with a simple yet rigorous way of adding a priori information to inversion of Airborne EM data.

METHOD AND RESULTS

In order to add a-priori information to the AEM data, and to have it migrate throughout the dataset, we use the framework of the Spatially Constrained Inversion (Viezzoli et al., 2008). In the SCI the resistivity models constrained spatially to make use of the inherent geological spatial coherency present, in different degrees, in every environment. These constraints represent, per se, a priori information, that are fitted, together with the AEM data, during the inversion. They can be regarded as "soft a-priori".
However we now want to add also "hard" a-priori, namely downhole resistivity logs, geological layers, hydrogeological units. We use respectively .las files, and grids (or point sources). In all cases the a-priori information is treated as nothing but an extra data set, carrying location, values, uncertainty, and expected lateral variability. The information it contains is spread to the location of the neighbouring AEM soundings. These fields enter the SCI formulations as showed below, with the Obs matrix containing the data (AEM and a priori), the Roughening matrix the constraints, the error matrix the uncertainties for all datasets. Constraints and uncertainties are usually different depending on data types and geology.

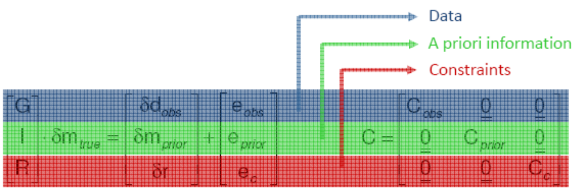

Figure1. Inversion matrixes. The a-priori information enters as extra dataset, with its uncertainty, the global objective function to be minimized.

At the conference we will present different examples of the effect of adding a-priori to the inversion of different AEM data.
In this extended abstract we use a Resolve (HEM) dataset from South Australia. The original dataset had been re-calibrated using borehole information. We inverted the whole dataset with a multilayers SCI with no extra a-priori information. Refer to Viezzoli et al. (this volume) for an

overlook of the results at large scale. Then we added the punctual information about the depth to the water table (defined as thin conductive layer below more resistive layer), derived from borehole readings carried out few weeks after the AEM survey (confirm). Figure 2 shows an example of a .las file that is used to input electrical logs data from a borehole.

Figure 3 shows a comparison of the cross sections, and of the 5D models closest obtained with and without a-priori. The data residual (data misfit) in presence of a-priori is very similar to that obtained without a-priori, well below the noise level, suggesting that the a-priori information does not clash with the data The water table at this location was around 4,2 m. In absence of a-priori, the minimum in resistivity resulted above the water table, which is unrealistic from a hydrogeological perspective. The a-priori bring the minimum in resistivity to coincide with the GW table depth. Similar results are obtained from other areas. The results obtained with a-priori, apart from recovering the water table depth better, as expected, could be used to derive meaningful information about the unsaturated zone. Even though the a-priori do not change the overall results significantly, they helped resolving better subtle model parameters

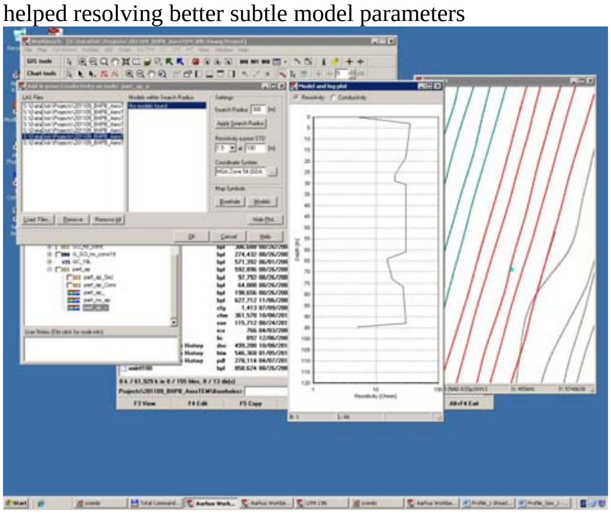

Figure 2: Example of .las file used to input borehole log data as a-priori information.

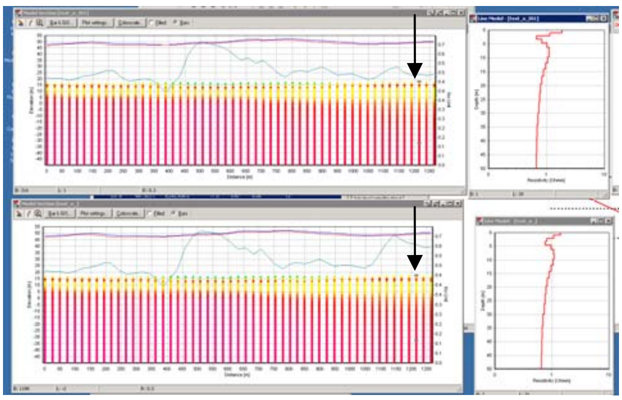

Figure 3. Inversion results with (bottom) and without (top) a-priori information in groundwater table depth (which was at 4.2 m). The 1D models to the right show the results from sounding closest to the borehole (marked by the black arrow).

We now present a SkyTEM example where seismic layers were added to the inversion as a-priori. One of the purposes of the survey was to identify the depth to the Paleogene clay, which, in some places, could not be resolved accurately using the AEM system data alone, because at those times there were little information left in the data. Figure 4 (top) shows the result obtained with SCI (few layers-blocky model) without a-priori. Then the depth to the clay layer as interpreted from seismic was added to the inversion as depth to the bottom of 3rd layer. Figure 4b shows the results obtained. The depth to the clay layer is now better resolved, thanks to the added information. Notice that the results do not follow the input exactly, because of the uncertainty that was added to the a-priori.

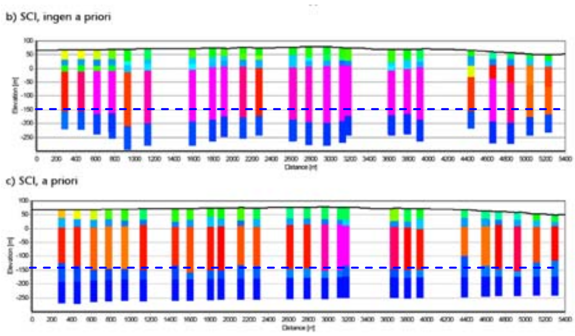

Figure 4. The effect of adding as a –priori seismic determined depth to clay layer (dashed line) to inversion of SkyTEM data. Top no a-priori, bottom a –priori.

Figure 5 shows another example of the same approach applied to multilayers inversion. Notice how adding a priori allowed resolving the depth to clay in areas where the AEM alone could not, as it was too deep. In both cases of figure 2 and 3 the data were fitted to the same degree.

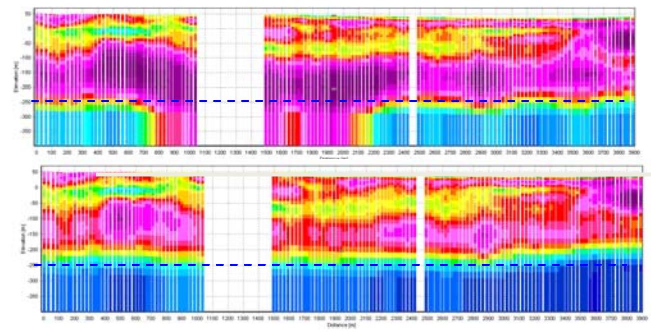

Figure 5. The effect of adding as a –priori seismic determined depth to clay layer (dashed line) to inversion of SkyTEM data. Top no a-priori, bottom a –priori (multilayers).

Obviously, when AEM data and a-priori information are in significant disagreement on a given model parameter to which the AEM is sensitive, adding a-priori information to the inversion produces more drastic effects. Depending on the relative uncertainties applied to geophysical and a-priori data, one of the two can be non-fitted. Or the AEM model can take unrealistic values of some model parameters to accommodate the conflicting data with a-priori. In these cases the a-priori information can be used as the reference to which the AEM data are forced to get back to, by adding a correction factor to the AEM data, as another inversion parameter, in a similar fashion to the holistic inversion approach by Brodie and Sambridge (2006).

CONCLUSIONS

Adding a-priori to the inversion of AEM data in form of depth to layers, or resistivity values, can help refining the resolution of otherwise poorly determined parameters. In presence of issues of instruments calibration it also provides a chance to flag the problem, and possibly correct it.

REFERENCES

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