Magnetotelluric 3D inversion solution using Huber loss function

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SUMMARY

Solving the MT inverse problem remains a challenge, especially in 3D. One of the problems that needs to be addressed is dealing with noisy and therefore inconsistent data. Here we refer to bias error, which is not reflected in random error estimation. Routine approach to mitigate the influence of "bad" data is to deal with it during the processing and estimation of transfer functions. However, bias errors often remain in the final transfer functions due to, for example, near field effects from cultural noise. The first and simplest approach is to exclude sites from the inversion which look suspicious or not fitted after the first inversion trial. More advanced editing include removing certain frequencies from particular sites, which either looks like outliers or cannot be fit due to e.g limitations with respect to model discretization. All of this is to some extent subjective and depends on expert decision.

Since the first works of Huber(1964), who introduced the M-estimators in robust statistics, attempts has been made to use robust norms of data term (residuals) when solving inverse problems (Scales, 1988). Although this looked promising, computational limitations were an obstacle to implement robust statistics in a practical way. Robust M-estimators can be implemented using iteratively reweighted least squares (IRLS) scheme. The implementation is straight forward but requires special attention to evaluate weights at every IRLS iteration. In our implementation weight *W* are period dependent and estimated after the solution of inverse problem is obtained (gauss-newton type iterations converged). Typically, 2-3 IRLS iterations are sufficient to significantly reduce the influence of “bad” data. The final RMS of 1 is often reached after final IRLS iteration (with starting error floor of 1-3%). We show that phase out of quadrant data can also be well fitted and not missed using the approach. It is especially important in Precambrian environments, where such strongly 3D data often occur and carry valuable information (sometimes the most valuable information when applied to mineral exploration targets).

Keywords: Magnetotellurics, 3D inversion, robust statistics