Reducing Ambiguity in Controlled-Source Electromatic (CSEM) Inversion

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Geophysical inverse modelling is very rarely a well-posed modelling problem, and the CSEM interpretation problem is no exception. The ambiguity is manifested by the equivalence between models having the same resistivity thickness product. For example, with the most basic survey configuration a 300m thick section of carbonate rich material can produce an identical CSEM anomaly to a 10m thick, hydrocarbon saturated reservoir. This non-uniqueness associated even with a simple 1D layered earth results in the need for regularisation to be incorporated in any inverse modelling algorithm. Although regularisation is necessary to obtain a unique solution to the interpretation problem, it is difficult to determine the probability that any returned ‘optimal’ model is correct. Regularisation artificially reduces the confidence intervals associated with each model parameter, leading to overconfidence in the inverse model. The effect on a drilling decision could be disastrous if the regularisation constraint favoured the more economically interesting model.

The ambiguity in the inverse CSEM problem has numerous sources, viz, the fact that there is noise in the data, the fields are not perfectly sampled, and the geometry of the survey apparatus varies during acquisition. The equivalence can be quantified (for simple problems) by measuring the volume of the region enclosing all the ‘acceptable’ models according to a data misfit criteria. The influence of the different sources of error can be quantified, and the improvement in resolution obtained through alternative acquisition methods assessed.