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Pareto-optimal Joint Inversion Modelling and Data Set Compatibility Analysis

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In the process of modelling geophysical properties, jointly inverting different data sets can greatly improve the results. In order to conduct a joint inversion modelling, a relationship between the different data sets has to be established, which can be either be of analytical or structural nature. Classically, the joint inversion problem is then expressed as a scalar objective function, which combines the misfit functions of all involved data sets combined with a joint term accounting for the assumed connection between the data sets. This method bears two major disadvantages. Firstly, a weighting of the data sets is enforced by aggregating all misfit terms. Secondly, the data sets cannot be assessed with respect to their compatibility. Data sets are compatible if they are sensitive to similar physical features, and the joint interpretation of incompatible data sets can lead to incorrect resulting models.

In order to generate unbiased joint inversion models, it is important to mitigate the influence of weighting and to analyse the compatibility of data sets. Therefore, we have developed a new approach to the joint inversion modelling of geophysical data. We present *MOJO*, a Pareto-optimal multi-objective joint inversion algorithm. It is based on an advanced genetic algorithm, hence it does not only calculate a single optimised model, but a distribution of possible models as final result. In contrast to common approaches, *MOJO* treats data sets as a separate objectives, which avoids spurious weighting. Additionally, we use the output of *MOJO* to calculate and evaluate curves of the trade-off between the different objectives. The shapes and evolutions of these curves yield a measure for the compatibility of the used data sets. Furthermore, the evaluation of the resulting model distribution provides valuable uncertainty estimates.

Keywords: Multi-objective optimisation, Joint-inversion, Data set compatibility, Model uncertainty, Magnetotellurics