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A weighted least-squares inversion algorithm : application to geophysical frenquency-domain electromagnetic data

IGeophysical inverse theory can be used to process data collected from the surface in order to build an image of the subsurface structures. This procesing is the only way to get a quantitative insight into the subsurface features. Inverse problems in geophysics, like the one-dimensional inversion of frequency domain electromagnetic data presented in this paper, frequently suffer from the lack of available information. Interpreting such inverse results can therefore be misleading or dangerous. This prompts us to propose an inverse formulation that contains a maximum of a priori information.
To introduce a priori information into the inverse problem, the least-squares formulation (Marquardt-Levenberg) is completed with weighting matrices. Various parameters (e.g. the damping factor) or the quality of the starting model allow the inverse process to converge towards a plausible solution. Nevertheless, the uniqueness of the solution cannot be guaranteed. Solving inverse problems seems complex at first sight but the background theory can be easily understood. The inverse problem solution, the characteristics of under- or over-determined systems, the principle of norm minimisation as well as the task of a weighting matrix can be presented in a straightforward way. The numerical resolution ot the inverse problem is intentionally kept as much general as possible in this work. Therefore, the numerical tools proposed in this paper can be used to solve other inverse problems. To invert a matrix, a Gauss reduction with partial pivoting is first used. The upper triangular linear system is then solved using a back-solving procedure. This method proved to be stable and the computational effort as well as the memory required can be optimised throughout the whole procedure.
This algorithm is used to invert synthetic data calculated on a horizontal-layer model. These examples enhance the influence of the lack of information on the quality of the model reconstruction. The role of the weighting matrices is also emphasized. These matrices, that can contain measurement errors or constraints on the model, introduce a priori information into the inverseproblem. This information proved to have a significantly positive influence on the quality of the model reconstruction. Nevertheless, poor quality results can sometimes be obtained when using starting models too different from the solution. The efficiency of the inversion algorithm is also demonstrated with field data.

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