A Hybrid OCCAM-CG Inversion Algorithm

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SUMMARY

Egbert (2012) developed a hybrid multi-transmitter (mTX) OCCAM-Conjugate Gradient (CG) algorithm and illustrated basic ideas on a simple 2D MT inverse problem. Here we present results of application of these ideas to more computationally challenging problems, 3D marine controlled-source EM (mCSEM), and 3D MT. There are two main aspects to our approach. First, we save results of calculations required for an iterative solution of the data-space Gauss-Newton (GN) normal equations, based on the Golub-Kahan bidiagonalization of the Jacobian matrix, and use these to construct a low dimensional approximation of the full Jacobian. Once computed, this allows rapid computation of trial inverse solutions for a range of regularization parameters, so Occam-type schemes become practical even for very large problems. Second, every transmitter (Tx; i.e., different frequency and/or location) requires solution of a separate adjoint problem, associated with the gradient of the data misfit for that separate Tx dataset. By saving results of these distinct calculations (instead of summing them, to compute the gradient of the total data misfit) we can form a more complete approximation to the Jacobian. Furthermore, with suitable modifications to the iterative CG algorithm (Egbert, 2012), more rapid (fewer adjoint and forward solves) and more stable solution of the G-N equations can be achieved. We demonstrate the effectiveness of our methods using synthetic datasets based on a realistic 3D resistivity model constructed for the Campos Basin on the Brazilian margin. We also demonstrate how the mTX algorithm can be useful for joint inversion of multiple EM data types, specifically for combining MT and mCSEM data. The hybrid scheme allows for efficient exploration of relative weights for the different measured data types, using the approximate Jacobian. The approximated Jacobian can also be used for linearized uncertainty and resolution analysis of the solutions obtained.

Keywords: 3D Inversion, Gauss-Newton Methods