GEOSOFT

Oasis montaj Best Practice Guide

VOXI Earth Modelling - Exploring Inversion Solution Space

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Exploring Inversion Solution Space

Introduction

Voxel inversion of geophysical data is ill-posed: there are many models which satisfactorily fit the observed data. Producing one model which fits the data is certainly helpful, however, it would be far more informative to produce a suite of models; all of which also fit the data, and in this sense, to explore the space of viable inversion solutions. We demonstrate how this can be achieved in VOXI in this Best Practice guide.

Producing a Single Model

We begin by considering a simple prism in a half space model as shown in *Fig. 1*. For simplicity, in all that follows, we will view only the EW section through the center of the model. Simulating the TMI response at the magnetic pole over the prism yields the data shown in *Fig. 2*. Inverting the TMI data yields the result shown in *Fig. 3*. We will call this the "default" VOXI result and we can see that it is a reasonable approximation to the true model.

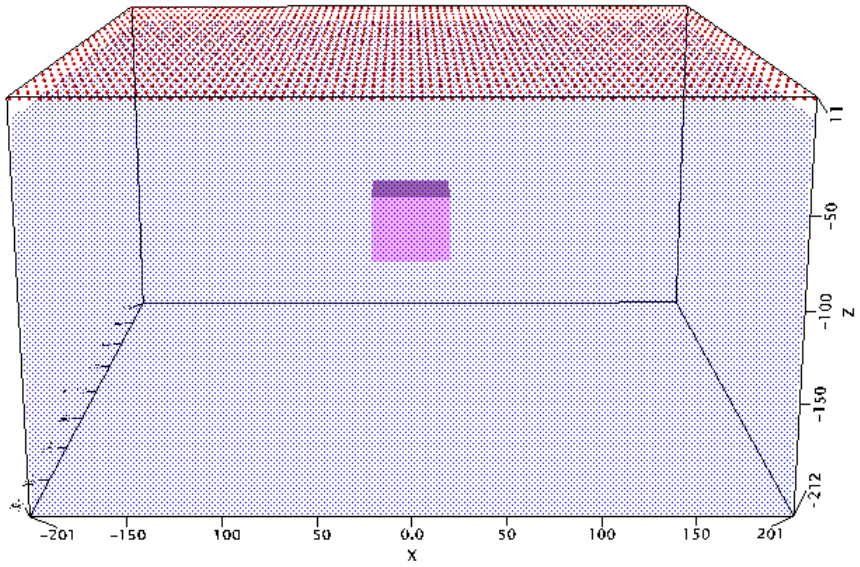


Fig. 1: The Prism Model

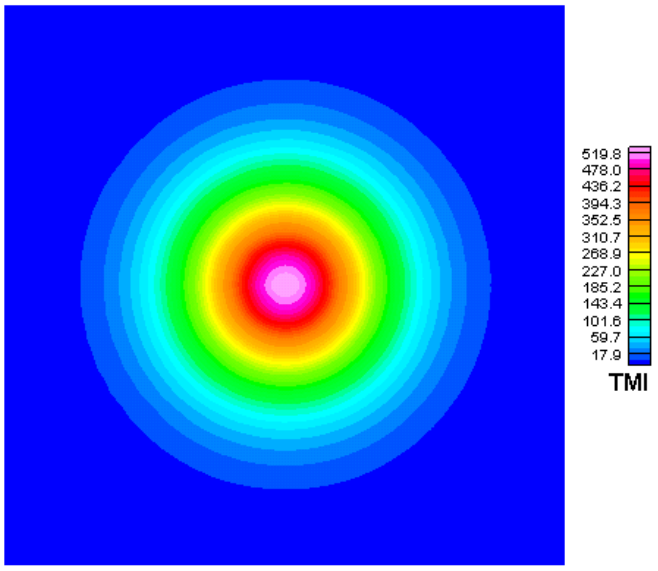


Fig. 2: The Prism model TMI response

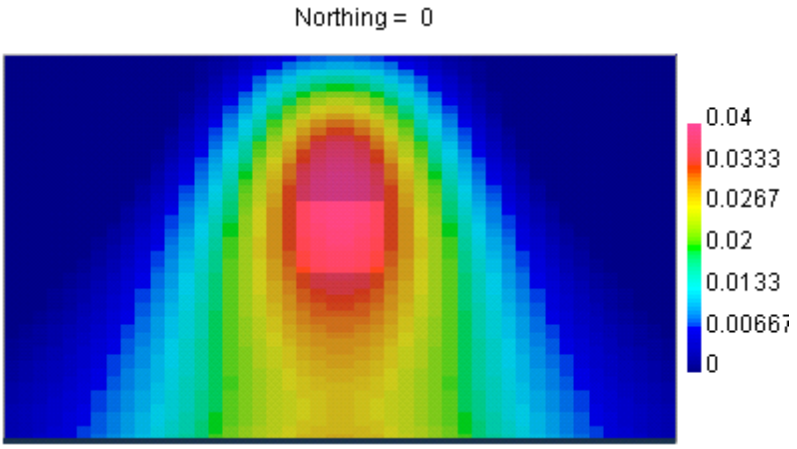


Fig. 3: The Default VOXI inversion result

Producing a Suite of Models

We can investigate a suite of models, all of which fit the same data, by varying the depth weighting. In VOXI, we do this by generating a vertically varying voxel model and using it as a reweighting function. In *Fig. 4*, we show a suite of models together with the corresponding depth reweighting function.

Proceeding from top to bottom in *Fig. 4*:

1. Depth weighting z^{-1} produces a very shallow model,
2. Depth weighting $z_{max} - z$ produces a somewhat shallow model,
3. Depth weighting 1 produces the default model,
4. Depth weighting z produces a deep model.

With the appropriate choice of depth weighting, the inversion output model transformed continuously between (and beyond) the cases shown in *Fig. 4*. In this manner, we are able to explore the space of viable solutions.

Discussion

We have produced a suite of models, all physically reasonable, and all of which fit the data shown in *Fig. 2*. In an exploration context, in the absence of any other information, the geoscientist performing the inversion must keep in mind the ambiguity inherent in the geophysical data, and would be advised to convey that ambiguity to rest of the exploration team. Doing so will allow the team to decide on an appropriate strategy to reduce the ambiguity in the interpretation, leading to a more effective and efficient exploration process.

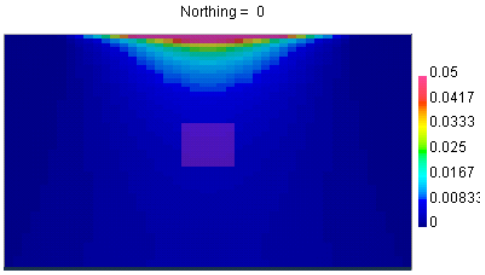
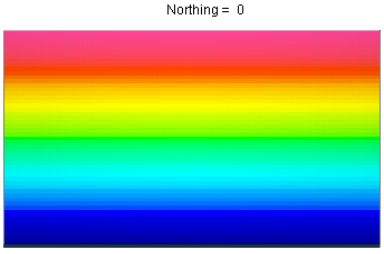
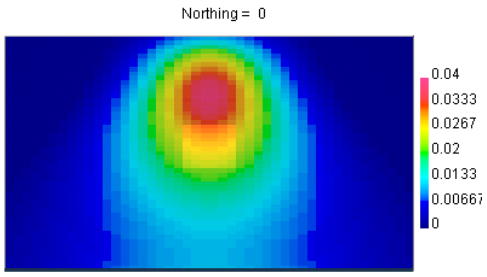
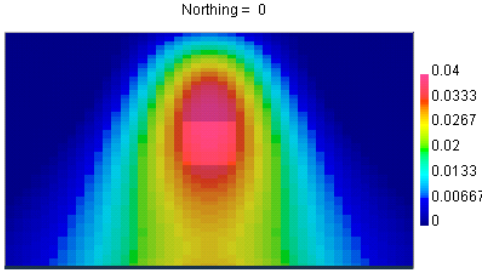
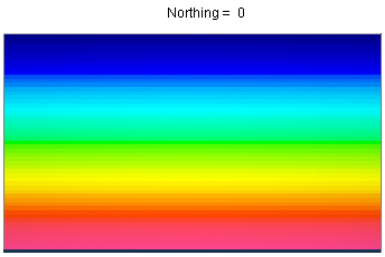
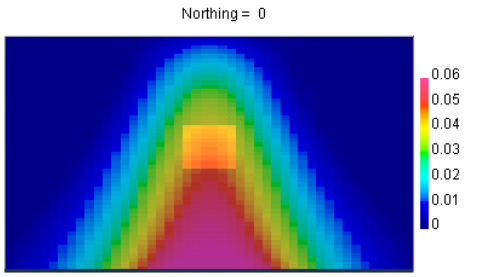
Depth Weighting	Inversion Result
z^{-1}	
$1 - z$ 	
1	
z 	

Fig. 4: On the left, the depth weighting function imported via the iterative reweighting constraint into VOXI. On the right, the corresponding inversion result.

Appendix

Here is a simple set of steps to produce a depth dependent reweighting model:

1. Set up a default VOXI inversion.
2. Export the padded mesh as voxel V_0
3. Use voxel math to generate the depth dependent voxel V_z, for example $V_z = V_0 * z$ to produce a deep model like that shown in *Fig. 4*, bottom panel.
4. Use V_z as the Iterative Reweighting voxel constraint in VOXI.
5. Run the inversion.

To change the depth of the recovered target in the inversion, modify the voxel math expression in (3).