Oasis montaj How-To Guide

VOXI Earth Modelling - Running an Inversion

Manual release date: November-18-13.

Please send comments or questions to info@geosoft.com

The software described in this manual is furnished under license and may only be used or copied in accordance with the terms of the license. OM.h.2013.01

Data used in this document:
Ontario Geological Survey 2000. Reid-Mahaffy airborne geophysical test site survey; Ontario Geological Survey, Miscellaneous Release – Data 55. © Queen's Printer for Ontario, 2000. Reproduced with permission.

Geosoft Incorporated
Queen's Quay Terminal
207 Queen's Quay West
Suite 810, PO Box 131
Toronto, Ontario
M5J 1A7
Canada
Tel: (416) 369-0111
Fax: (416) 369-9599

Website: www.geosoft.com
E-mail: info@geosoft.com

Support

For obtaining technical support, email support@geosoft.com

If you wish to speak to a technical support representative in your region, please visit the Geosoft Support page at: www.geosoft.com/about-geosoft/contact-us/world-offices for contact information.

Running an Inversion

Overview

This document describes how to run a simple inversion in VOXI Earth Modelling. It focuses solely on the functionality in the VOXI Earth Modelling interface and assumes that you are familiar with the Oasis montaj environment.

We strongly recommend that you properly prepare your data prior to inversion. Please refer to the Best Practice Guide - Preparing Data for Inversion document, which describes the files required for an inversion and guidelines on how to create them.

In this example, you will:

- Create a new VOXI session from a polygon
- Add data to the model
- Run an inversion
- Export the VOXI model

The data used in this example is airborne magnetic data, sourced from the Ontario Geological Survey (OGS). It was acquired over the Reid-Mahaffy property at a nominal 200 m line spacing and 60 m terrain clearance.

The Reid-Mahaffy property in Ontario, Canada, has been designated by the OGS as a test site and was flown by a number of airborne companies. The airborne Reid-Mahaffy magnetic data was flown in 1999 by Dighem as part of an airborne EM survey, commissioned by the OGS, under the project number MRD-55. The coinciding SRTM elevation grid was downloaded from the Oasis montaj DAP server using Seeker.

The outcome of this document should not be interpreted as the actual sub-surface structure.

The data used in this guide can be downloaded here. Please refer to the *README.txt* file for a description of the files and where to save them to.

The folder includes the following:

- An outline of the area to be modelled.
- A database containing potential field measurements. The data has a projected coordinate system defined.
- A Digital Elevation Model grid covering the area of interest.

You will begin by creating a new project and loading the VOXI menu.

To load the VOXI menu:

1. Start Oasis montaj and create a new project in the **VOXI Run Inversion Data** folder named **VOXI.gpf**.
2. From the **GX** menu, select **Load Menu**.

   The Load Menu window opens.
3. Select **voxi.omn** and click **Open**.

   The VOXI menu is added to your menu bar.

New VOXI from Polygon

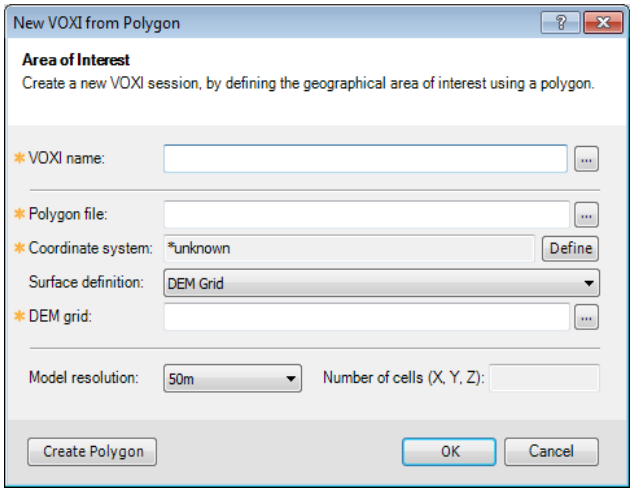
VOXI offers two approaches for defining the area of interest (AOI): you can either use a polygon file that defines the outline of your area, or you can supply a georeferenced voxel model compiled from other sources, the outline of which will be automatically calculated. In this example, you will use a supplied polygon file.

To create a new VOXI session from a polygon:

1. From the **VOXI** menu, select **New VOXI from Polygon**.

   The New VOXI from Polygon dialog box opens.

   Figure 1.1 New VOXI from Polygon dialog box



2. For **VOXI name**, enter **Mahaffy**.
3. For the **Polygon file**, click the **Browse** button ...
4. From the **VOXI Run Inversion Data** folder, select **Mahaffy.ply** and click **Open**.

   This is the polygon file that defines your area of interest (AOI). By default, the coordinate system information for this VOXI document is based on the defined coordinate system of the selected file. If the selected polygon file does not have a coordinate system defined, then the **Define** button becomes active and can be used to define the coordinate system for the VOXI document.

*You can click the **Create Polygon** button to interactively create a new polygon to define your area of interest from an existing map. If the existing map is not already in your project, you will be prompted to load it.*

If you are working with data located on a geographic (longitude, latitude) coordinate system, use Geosoft tools to create a projected coordinate system map from which to define a polygon.

5. For the **DEM grid**, click the **Browse** button ...
6. From the **VOXI Run Inversion Data** folder, select **DEM.grd** and click **Open**.

   This is the grid of the Earth's surface elevation (DEM) that covers the area defined by the supplied polygon. You can also choose to define the surface using a constant elevation value.

7. For **Model resolution**, use the default value of **50m**.

   By default, VOXI calculates the model resolution to generate the smallest appropriate model based upon the input data resolution. Generally, this will be less than 100 cells in the x and y directions.

   The Reid-Mahaffy data used in this example was flown at 200 metre nominal line spacing and 60 metre terrain clearance. The default model resolution of 50 metres is appropriate because it is roughly equivalent to the flying altitude and a quarter of the line spacing.

   It is good practice to use the default voxel resolution when running the first inversion for a project area. To begin with, you may even want to define a coarser mesh than the default. As your knowledge of the area increases, you can refine the voxel resolution as required.

8. Click **OK**.

   The VOXI Viewer opens and displays the voxel mesh to be inverted, the area-defining polygon, and the DEM; at this point, the Add Data to VOXI message window opens asking if you would like to run the Add Data wizard.

Figure 1.2 VOXI Viewer

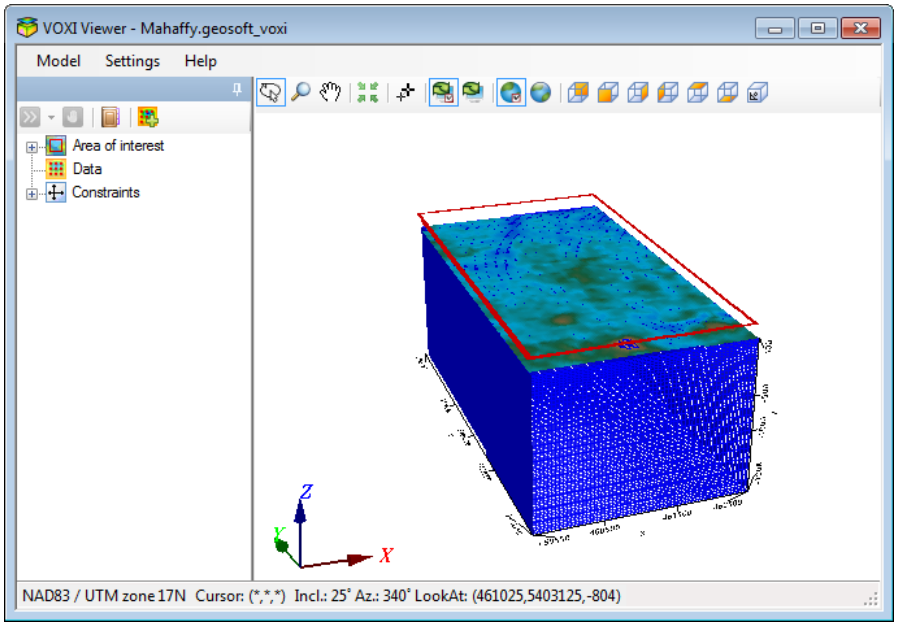
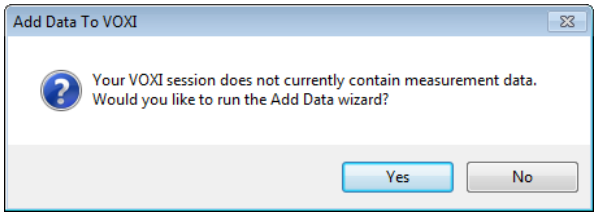


Figure 1.3 Add Data To VOXI window



9. For this example, click **No**.

   You will add data after you visually inspect your model.

   *If you are satisfied with the model you have defined, you can click **Yes** to directly run the Add Data wizard.*

The 3D view of the constructed model provides the opportunity to visually inspect the model. If it is not properly defined, for example if the mesh is too coarse or too fine, if the terrain does not register correctly or if the AOI polygon is not the correct one, you can modify the model prior to adding data and proceeding with inversion.

The standard Oasis montaj 3D visualisation tools are available in the VOXI Viewer.

Figure 1.4 3D visualisation tools

You may notice an "interference" between the mesh and the terrain colour image. This is an expected effect that will occur if your DEM is of a higher resolution than the voxel mesh. In such a case, the program will average the elevation measurements over the horizontal extent of each voxel element.

*To modify the Area of interest settings, right-click the Area of interest item in the tree list and select **Modify**.*

Adding Data

Now that you have created the voxel mesh defining your area of interest, you will add data by selecting a measurements database containing the data to be modelled.

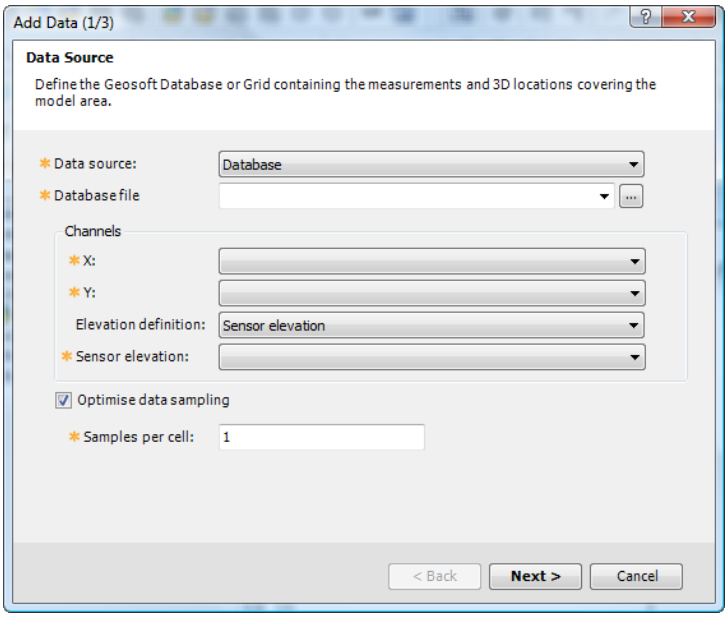
Note that you can also use gridded data (Geosoft Grid format) as an input for inversion.

To add data:

1. In the VOXI Viewer tree list, right-click **Data** and click **Add Data** or click the **Add Data** button on the VOXI toolbar.

   The Add Data (1/3) dialog box opens.

   Figure 1.5 Add Data (1/3) dialog box



2. From the **Data Source** list, select **Database**. For the **Database file**, click the **Browse** button.
3. From the **VOXI Run Inversion Data** folder, select **ReidMahaffy_DIG.gdb** and click **Open**.

   Because the coordinate channels in this database are already defined, the X and Y channels are automatically set. If you have an alternate pair of X and Y channels, you can select them as long as they have a defined projected coordinate system.
4. From the **Elevation definition** list, select **Sensor elevation**. From the **Sensor elevation** list, select **gps_z_final**.

   The sensor elevation should be in the same units as the coordinate system of the DEM.
5. Ensure the **Optimise data sampling** option is selected.

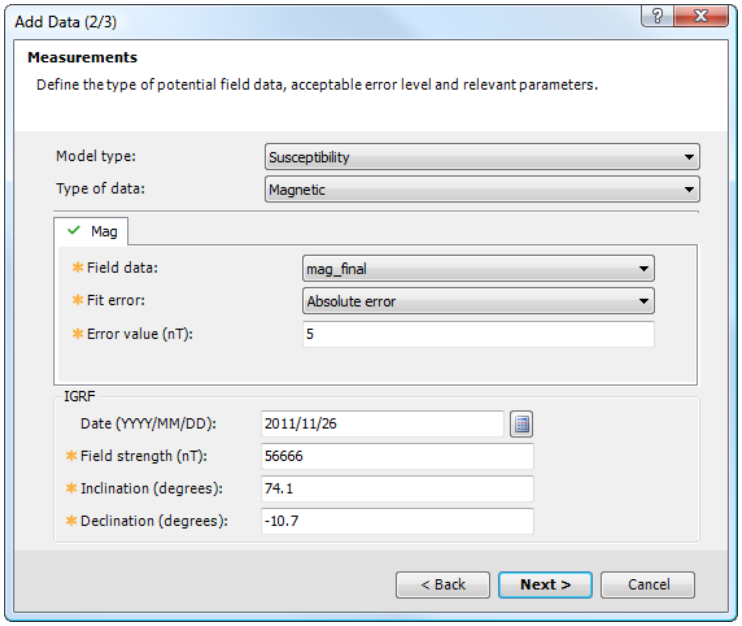
With this option, you can decimate the data if it is too highly sampled relative to the size of the voxel model element. By default, a decimation factor is chosen that will provide roughly one sample per surface voxel element.

It is highly recommended that you decimate the observed data to one sample per cell. All observed measurements that fall within the same element are appropriately averaged. Not decimating the data increases the computation time without any corresponding gain in the resolution of the output model.

6. Click **Next**.

   The Add Data (2/3) dialog box opens. Here you will select the type of model you want. You have the choice of Susceptibility, Density or Vector magnetization model. When you select the **Model type**, the **Type of data** field will update according to your choice.

Figure 1.6 Add Data (2/3) dialog box



7. From the **Model type** list, select **Susceptibility**.

   The Type of data automatically changes to **Magnetic** and additional options are now available in the dialog box.

8. From the **Field data** list, select **mag_final**.

9. For the Absolute **Error value (nT)**, enter **5**.

   By default, an Absolute error value is calculated to 5% of the standard deviation of the data, which in this example is a calculated Error value of approximately 6 nT. A VOXI Inversion will attempt to fit your data until the difference between the model prediction (the fit) and the measured data is on average less than the Fit error. In general, this default error calculation allows for a reasonable fit; however, you may opt to modify it to better suit your dataset. If you wish, you can specify an alternative means by which to calculate the fit error. The other

options are: Relative Error, Fraction of Standard Deviation or Data Error Channel

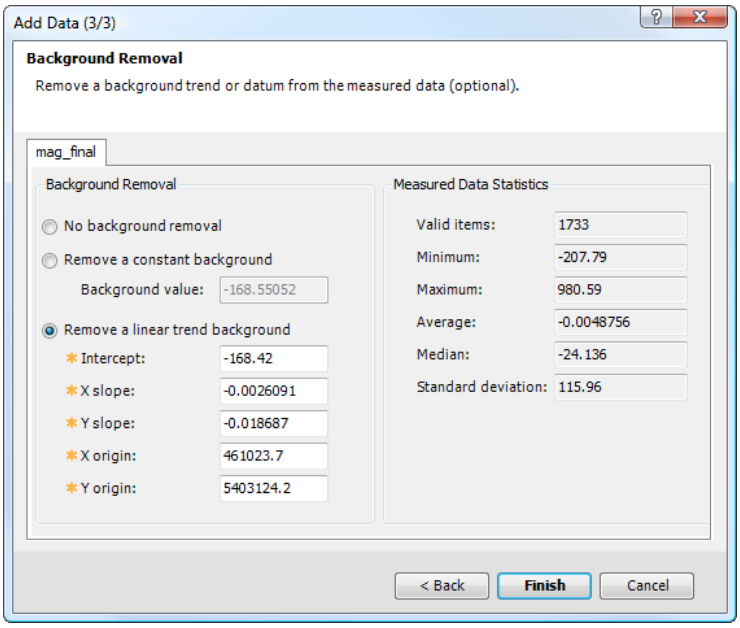
Click the Help button to learn more about alternate approaches to setting the error level.

In the case of a susceptibility model, you can specify or modify the IGRF parameters. If the survey date is stored as a property of the lines in the database, then the IGRF parameters are calculated automatically. Otherwise, you have to supply the survey date in order for the IGRF parameters to be calculated.

10. Click **Next**.

    The Add Data (3/3) dialog box opens.

Figure 1.7 Add Data (3/3) dialog box



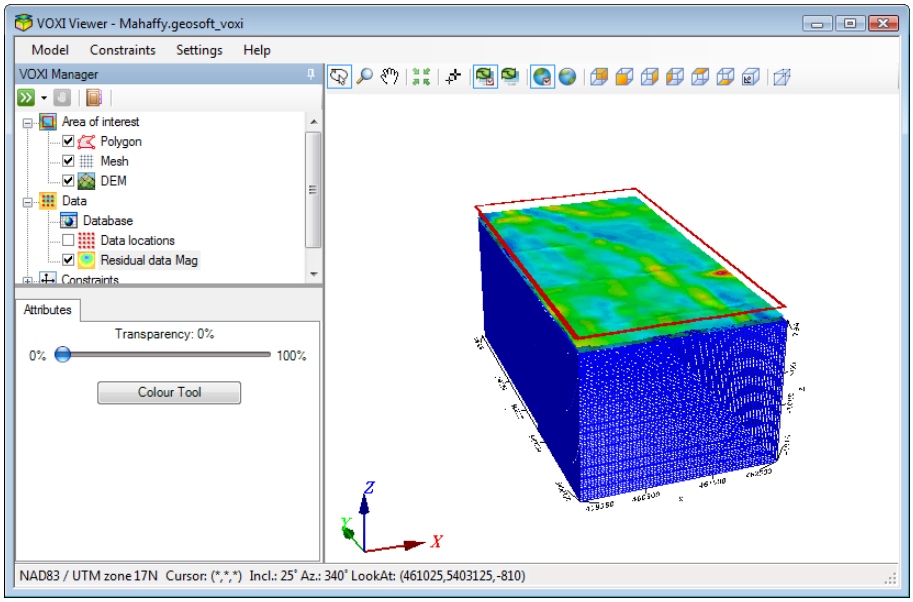
This dialog gives you options by which to remove the regional component of the potential field data, so that the inversion can focus on localised anomalies. The default option, **Remove a linear trend background**, will remove the linear trend plane from the observed data in an attempt to eliminate the long wavelength (regional) component of the field. The best-fit linear trend parameters of the observed data are automatically calculated.

The Measured Data Statistics are dynamically updated to reflect the statistics of the observed data after the removal of the suggested linear trend background. You would expect that the Average of the data would be around zero. If you have removed the background in the data preparation stage and are confident in the method applied, you are encouraged not to remove it again here.

11. For this example, select **Remove a linear trend background** and click **Finish**.

The selected data is added to the VOXI document and displayed in the VOXI Viewer. This data is placed at the observation elevation. Note that the Run Inversion button on the VOXI toolbar is now active.

Figure 1.8 VOXI Viewer with data added to model



The Database, Data locations and Residual data items are now listed under Data in the VOXI Manager. You can turn the Residual data item on and off to display the input field data. All data displays are coloured based on a linear colour scheme.

Running the Inversion

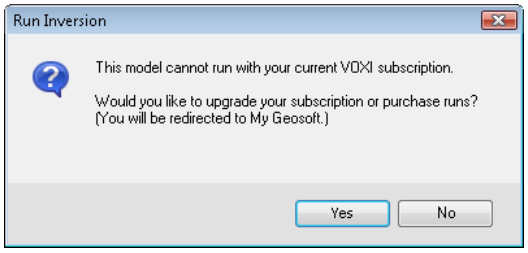
At this point, you have defined your area of interest, created a voxel mesh, and have added the data to be modelled. You will now run the inversion.

To run the inversion:

1. From the **Model** menu, select **Run Inversion** or click the **Run Inversion** button on the VOXI toolbar.

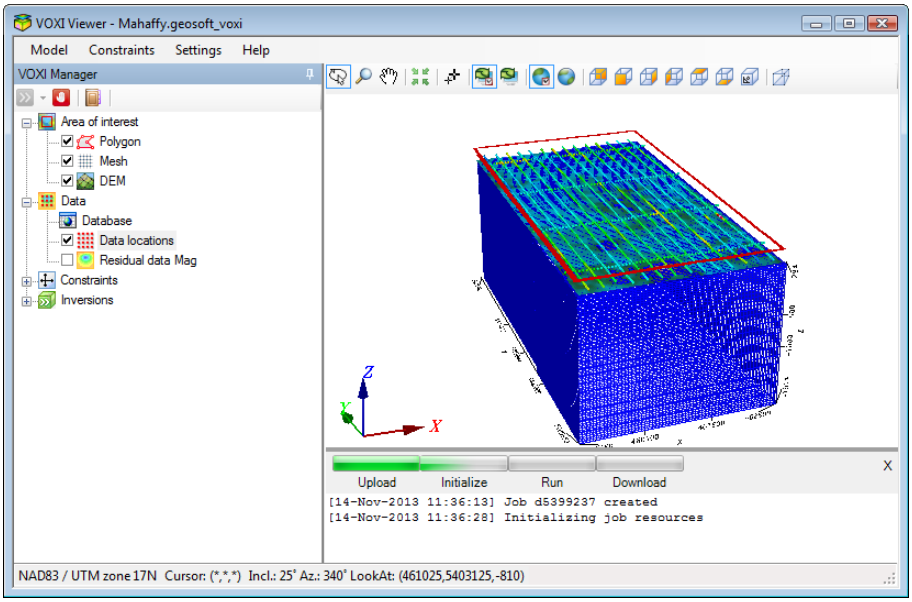
   If your subscription does not support running a forward model or your number of runs have expired, a warning dialog prompts you to upgrade or purchase new runs from My Geosoft.

   Figure 1.9 VOXI Subscription warning



After you start the inversion process, the Inversion item is added to the VOXI Manager and the progress of the inversion is reported in the Progress log pane in the lower-right of the VOXI Viewer.

Figure 1.10 VOXI Viewer with inversion in progress



After the data has been uploaded, you can safely close the window without stopping the inversion. You can revisit the session at a later time, check the progress and ultimately the results of the inversion.

If you decide to edit your input data further while the inversion is running, you can stop the process by clicking the Stop Process button . The inversion will terminate immediately.

2. In the VOXI Manager, expand **Inversions** to see the item representing the model you are inverting.

   The name of the item is composed of the type of model, and suffixed by the current date and time stamp. All subsequent trials will appear under Inversions with their unique date and time stamp.

   The Input data item contains a copy of the input data used for this inversion process. In subsequent trials you may modify some of the model parameters; the snapshot of the input parameters together with the output modelled voxel allows you to review your settings for each inversion.

   Using the VOXI Journal on the VOXI toolbar, you can enter comments to describe the specifics of individual inversion sessions and notes on the differences between different inversion results.

   At the successful completion of the inversion, a check box is added in front of the session name and the inversion results are displayed. This check box can be used to turn the display of the resulting voxel model off and on in the VOXI Viewer. The Process log is also saved in the tree list and can be viewed and saved at any time.

For more descriptive clarity in the 3D Viewer pane, you may want to turn off some elements. You can try the following:

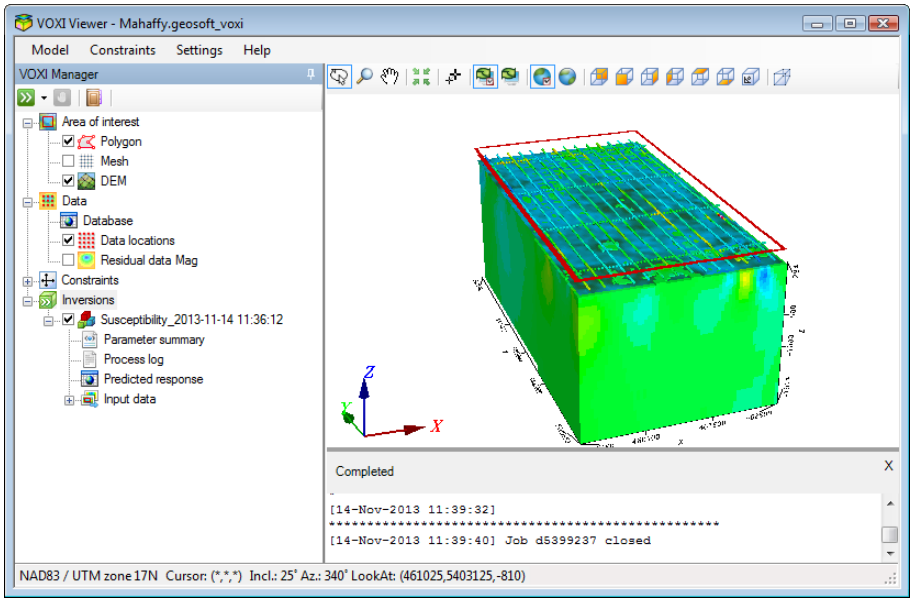
- You may wish to turn off the display of the model mesh.

  In the VOXI Manager, expand **Area of interest** and clear the check box beside **Mesh**.

- You may also wish to turn off the display of the data locations.

  Within the **Data** item list in the VOXI Manager, clear the check box beside **Data locations**.

Figure 1.11 VOXI Viewer with completed inversion model



As in the Oasis montaj 3D Viewer, you can select an item in the tree list and adjust its Attributes, Clipping and Colours. For example, you can clip the extents of the output voxel model by selecting it and adjusting the Clipping parameters.

Exporting a VOXI Model

Once you have created your VOXI model, you can export it as a Geosoft Voxel file to share with others or to integrate with other data in the 3D Viewer. Alternatively, you can also display the results in a 3D map.

To export a VOXI model:

1. Under Inversions in the VOXI Viewer tree list, right-click the **Susceptibility** modelling session item and select **Export**.

   The Save As window opens.

2. Use the default File name or enter a new name and click **Save**.

   The VOXI model is saved as a Geosoft Voxel file (*.geosoft_voxel) and can be further analysed using the 3D tools in Oasis montaj.

To see a comparison of inversion results with and without constraints, please refer to the Best Practice Guide - Comparing Upper Bound Constrained and Unconstrained Inversion Results document.

To display results in a 3D map

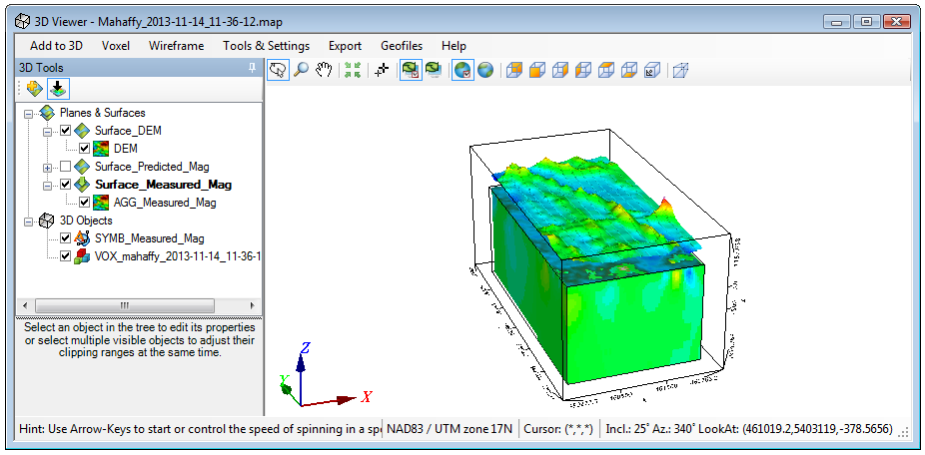
1. Under Inversions in the VOXI Viewer tree list, right-click the **Susceptibility** modelling session item and select **Display Results in 3D Map**.

   The Display Results in 3D Map window opens.

2. A unique default file name will be generated, however you can specify a more descriptive name. Click **OK**.

   The VOXI model is saved as a Geosoft Map file (*.map). The observed and modelled data are gridded displayed along with the DEM grid.

Figure 1.12 VOXI model displayed in 3D Viewer



Exporting the Predicted Response (Forward Calculation) Database

At the completion of the inversion calculation, the input as well as the predicted data are saved in the predicted database, under the current inversion model. You can export this content to a Geosoft Database file (*.gdb).

To export the predicted response (forward calculation) database:

1. Under Inversions in the VOXI Viewer tree list, expand the **Susceptibility** modelling session item.

2. Right-click **Predicted response** and select **Export**.

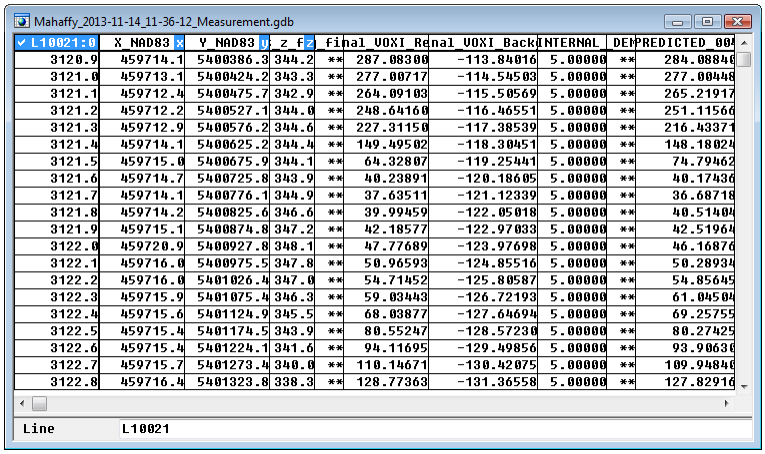
   The Save As window opens.

3. A unique default file name will be generated, however you can specify a more descriptive name. Click **Save**.

   The predicted response (forward calculation) database opens and is saved as a Geosoft Database file (*.gdb). This data can be further analysed in Oasis montaj or used to grid the predicted response. The predicted channel is named

PREDICTED_###, where ### indicates the number of iterations conducted to obtain the inversion result.

Figure 1.13 Predicted response (forward calculation) database



Mahaffy_2013-11-14_11-36-12_Measurement.gdb

L10021:0	X_NAD83 x	Y_NAD83 y	z_f z	Final_VOXI_R	enal_VOXI_Back	INTERNAL_	DEP	PREDICTED_00
3120.9	459714.1	5400386.3	344.2	**	287.08300	-113.84016	5.00000	**	284.08840
3121.0	459713.1	5400424.2	343.3	**	277.00717	-114.54503	5.00000	**	277.00448
3121.1	459712.4	5400475.7	342.9	**	264.09103	-115.50569	5.00000	**	265.21917
3121.2	459712.2	5400527.1	344.0	**	248.64160	-116.46551	5.00000	**	251.11566
3121.3	459712.9	5400576.2	344.6	**	227.31150	-117.38539	5.00000	**	216.43371
3121.4	459714.1	5400625.2	344.4	**	149.49502	-118.30451	5.00000	**	148.18024
3121.5	459715.0	5400675.9	344.1	**	64.32807	-119.25441	5.00000	**	74.79462
3121.6	459714.7	5400725.8	343.9	**	40.23891	-120.18605	5.00000	**	40.17436
3121.7	459714.1	5400776.1	344.9	**	37.63511	-121.12339	5.00000	**	36.68718
3121.8	459714.2	5400825.6	346.6	**	39.99459	-122.05018	5.00000	**	40.51404
3121.9	459715.1	5400874.8	347.2	**	42.18577	-122.97033	5.00000	**	42.51964
3122.0	459720.9	5400927.8	348.1	**	47.77689	-123.97698	5.00000	**	46.16876
3122.1	459716.0	5400975.5	347.8	**	50.96593	-124.85516	5.00000	**	50.28934
3122.2	459716.0	5401026.4	347.0	**	54.71452	-125.80587	5.00000	**	54.85645
3122.3	459715.9	5401075.4	346.3	**	59.03443	-126.72193	5.00000	**	61.04504
3122.4	459715.6	5401124.9	345.5	**	68.03877	-127.64694	5.00000	**	69.25755
3122.5	459715.4	5401174.5	343.9	**	80.55247	-128.57230	5.00000	**	80.27425
3122.6	459715.4	5401224.1	341.6	**	94.11695	-129.49856	5.00000	**	93.90636
3122.7	459715.7	5401273.4	340.0	**	110.14671	-130.42075	5.00000	**	109.94846
3122.8	459716.4	5401323.8	338.3	**	128.77363	-131.36558	5.00000	**	127.82916

Line L10021