Oasis montaj How-To Guide

VOXI Earth Modelling - Running a Forward Model

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 a Forward Model

Overview

This document describes how to generate the calculated potential field magnetic or gravity response of a given geophysical voxel model. It focuses solely on the functionality in the VOXI Earth Modelling interface and assumes you are familiar with the Oasis montaj environment.

In this example, you will:

- Create a new VOXI session from a voxel
- Add data to the model
- Add a DEM
- Modify the mesh parameters
- Run a forward model
- Export the predicted response

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 required input files for calculating the potential field response of a given geophysical model are:

- The voxel model for which to calculate the potential field.
- A database containing potential field measurements and their associated 3D coordinates. The database must have a projected coordinate system defined. The potential field channel need not contain meaningful data; however, this channel must exist in order to perform a forward potential field calculation.
- A Digital Elevation Model (DEM) grid covering the extent of the input voxel model, or a constant value representing the average elevation above the standard datum.

To calculate the field generated by an earth volume, you need to provide the voxel model that represents this volume. The voxel model can be generated in a number of different ways. It can be compiled from extensive drill hole information, it can be a model resulting from the inversion of a different dataset, or simply it can be a synthetic or "theoretical" model. This document uses a synthetic half-graben model built using voxel math. The half-graben model consists of basement rock overlain by three horizontal sedimentary layers, the second of which contains two high-density lenses of approximate dimension 1000 x 500 m. The model is cut by a normal fault with a displacement of around 500m.

💡 *For more information on how this input density voxel model was created, please see the Best Practice Guide - Building a Model document.*

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 Forward Model 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 Voxel

VOXI offers two approaches for defining the area of interest (AOI); you can either use a polygon that outlines the 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 voxel model to define the area of interest.

To create a new VOXI session from a voxel:

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

   The New VOXI from Voxel dialog box opens.

   Figure 1.1 New VOXI from Voxel dialog box
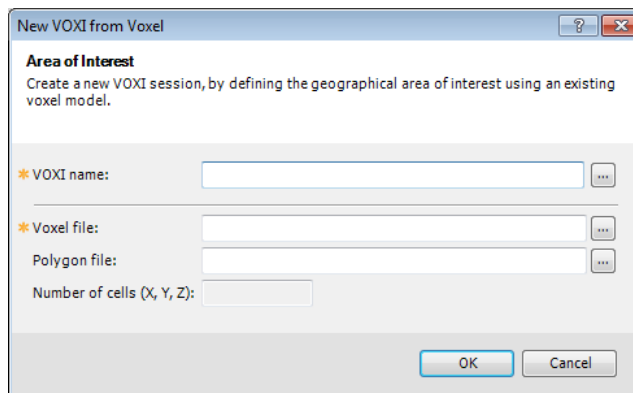
2. For **VOXI name**, enter **Forward Model**.

3. For the **Voxel file**, click the **Browse** button ⊡.

4. From the **VOXI Forward Model Data** folder, select **Half Graben.geosoft_ voxel** and click **Open**.

   The Number of cells (X, Y, Z) updates based on the size of the input voxel.

⚠️ *Optionally, a polygon file can be used to define the extents of the area to be modelled; if one is not selected, the footprint of the voxel will be modelled.*
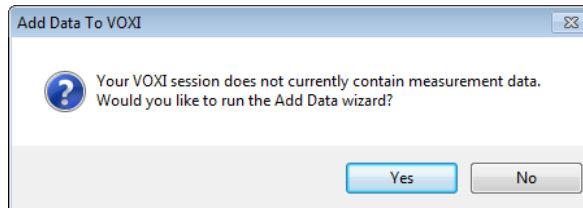
5. Click **OK**.

The VOXI Viewer opens and displays the voxel mesh to be modelled and a polygon defining the area of interest; the Add Data to VOXI message window opens asking if you would like to run the Add Data wizard.
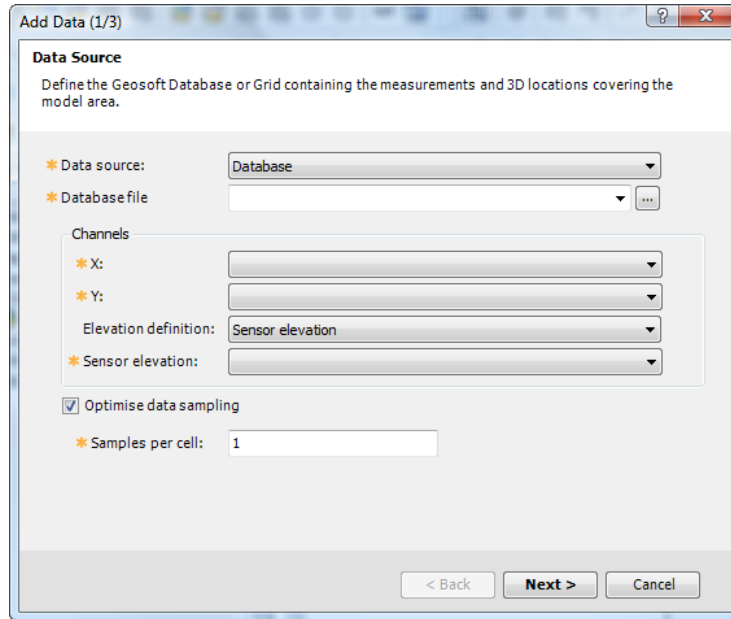
Figure 1.2 VOXI Viewer
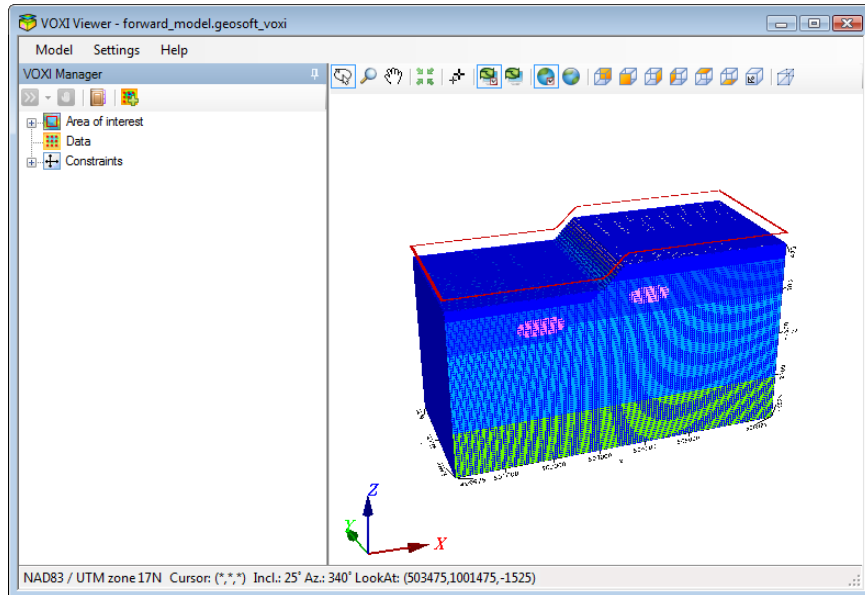
Figure 1.3 Add Data To VOXI window

6. For this example, click **Yes**.

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

Figure 1.4 Add Data (1/3) dialog box

Adding Data

Now that you have supplied the voxel model, you will add data by selecting the measurement database.

⚠️ *The input database file must have a potential field channel even though the values in this channel are not used. VOXI is used primarily for performing inversions; thus, the forward model option conforms to the inversion input requirements.*

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
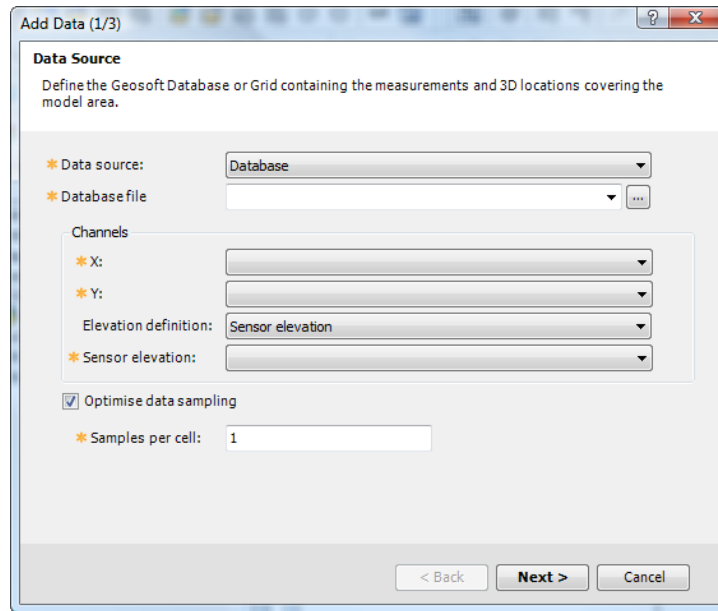
2. From the **Data Source** list, select **Database**. For the **Database file**, click the **Browse** button.

3. From the **VOXI Forward Model Data** folder, select **HalfGraben.gdb** and click **Open**.

   This database contains the data points for which to calculate the response field. It is populated with lines 500 m apart along the X axis at 100 m increments. The observation datum is placed at 500 m.

   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.

   ⚠️   *The input database must have a defined coordinate projection, otherwise you will not be able to proceed to the next dialog box.*

4. From the **Elevation definition** list, select **Sensor elevation**. From the **Sensor elevation** list, select **Z**.

5. Clear the **Optimise data sampling** option.

   With this option, you can decimate the data if it is too highly sampled relative to the size of the voxel model element. In this example, the synthetic database contains data points at the locations where the field is to be calculated; therefore, this option is not needed.

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 **Density**.

    The type of data automatically changes to **Gravity**. This is the type of database we are using in our example.

8. From the **Field Data** list, select **Bouguer**.

9. For the **Error value (mGal)**, enter a value **greater than 0** (e.g., **0.5**).

    The forward model calculation consists of a single iteration; thus, an error value is not necessary. However, you need to enter a value greater than 0 in order to proceed to the next dialog box.

10. Click **Next**.

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

Figure 1.7 Add Data (3/3) dialog box

The option of performing Background Removal only applies when using observed field data; since the forward model does not need or use observed field data, this option is not necessary.

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. The provided voxel model has a depression on the left side, representing the normal fault displacement. However, VOXI extrapolates the elements in this volume to a constant datum. Once you add the DEM, the extrapolated elements located above the DEM will be removed. Note that the Run Inversion button 	on the VOXI toolbar is now active.

💡 *You may wish to turn off the display of the Mesh layer by expanding the Area of interest item in the VOXI Manager and clearing the check box beside Mesh.*

Figure 1.8 VOXI Viewer with data added to model
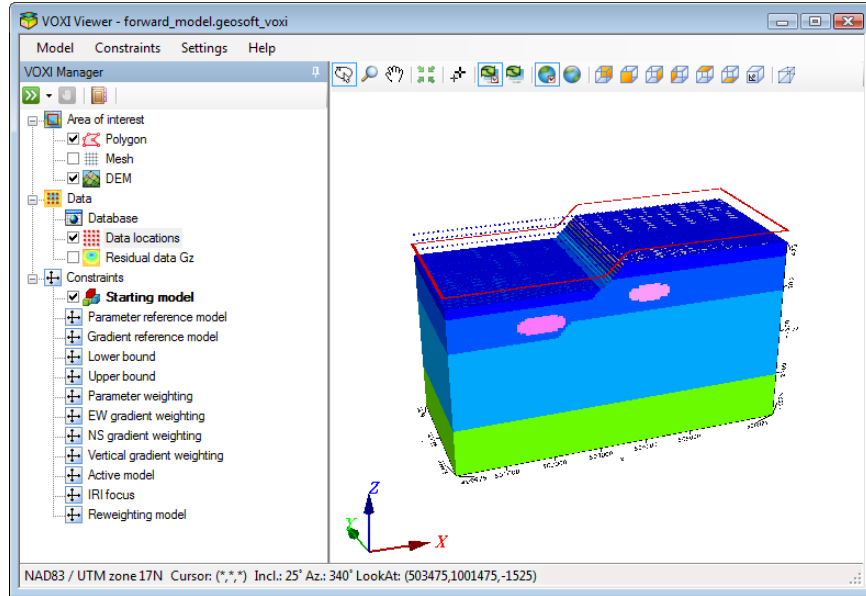
The Database, Data locations and Residual data items are now listed under Data in the VOXI Manager. By default, the field data is gridded and displayed in the VOXI Viewer. You can turn off the display of the Residual data layer by clearing the check box, since it is not applicable in this example.

The input voxel model is set as the Starting model in the Constraints branch in the VOXI Manager.

Modifying the DEM

By default, a constant DEM is calculated and displayed. The default DEM is placed at the highest vertical datum of the voxel model, which in this example is 475 m. You also have the option of selecting an existing DEM.

To modify the DEM:

1. In the VOXI Manager, expand the Area of interest tree.

2. Right-click **DEM** and select **Modify**.

   The Modify DEM Grid dialog box opens. By default, elevation is set to a constant value of 475 m.

   Figure 1.9 Modify DEM Grid dialog box
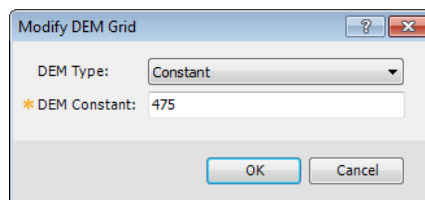
3. For **DEM Type**, select **Grid**.

4. For **DEM Grid**, click the **Browse** button ⬚.

5. From the **VOXI Forward Model Data** folder, select **elevation.grd** and click **Open**.

6. Click **OK**.

   This grid defines the true topography in the area of interest and therefore masks out the extrapolated voxel model cell values on the left side of the voxel.

Figure 1.10 VOXI Viewer with forward model and DEM added
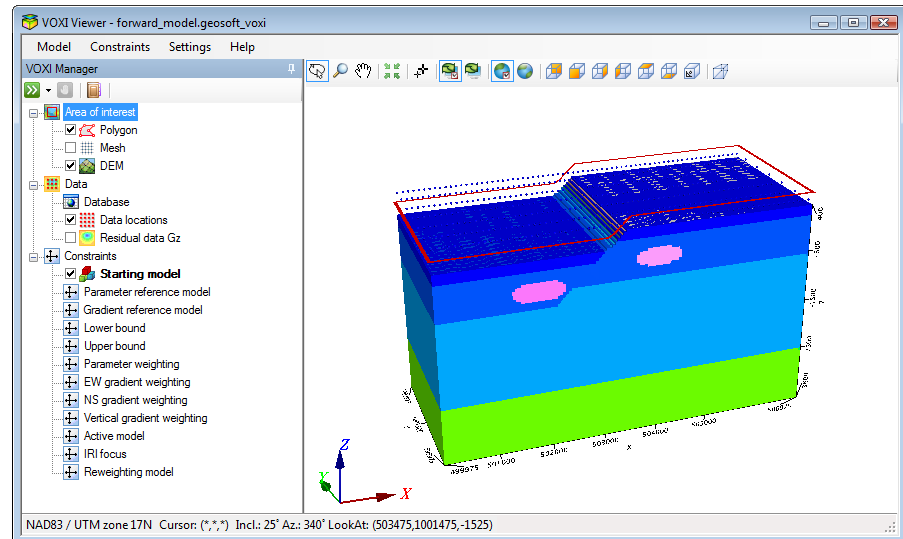
Padding the Active Volume

The mesh representing the Earth volume of interest is referred to as the Active Volume, which in this forward model example is defined by the supplied input voxel. Generally, you would add padding cells beyond the Active Volume laterally and at depth. These padding cells serve to maintain mathematically stability along the edges of your model (hence minimizing edge effects) during modelling/inversion, by mimicking a peripheral field contribution. The default padding extent is 5 cells.

The expansion ratio of the horizontal and vertical axis can be set to differing values. For example, you can set the expansion ratio to be larger along the direction of the predominant geologic strike than across it.

⚠ *If you omit this step, the resulting calculated forward field will taper off along the edges and exhibit edge effects.*

⚠ *Changing mesh parameters will create a new mesh.*

⚠ *Any results from a previous mesh will be overwritten.*

To pad the active volume:

1. In the VOXI Manager, expand the Area of interest tree.

2. Right-click **Mesh** and select **Modify**.

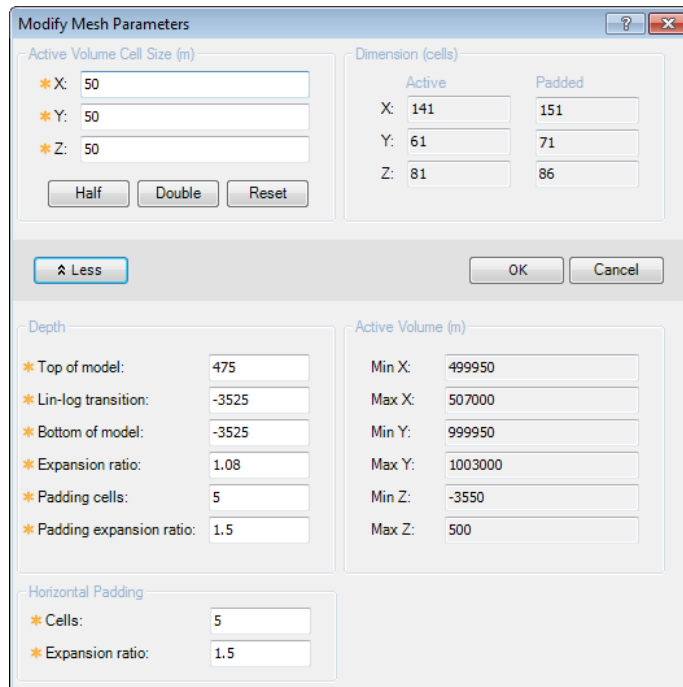   The Modify Mesh Parameters dialog box opens.

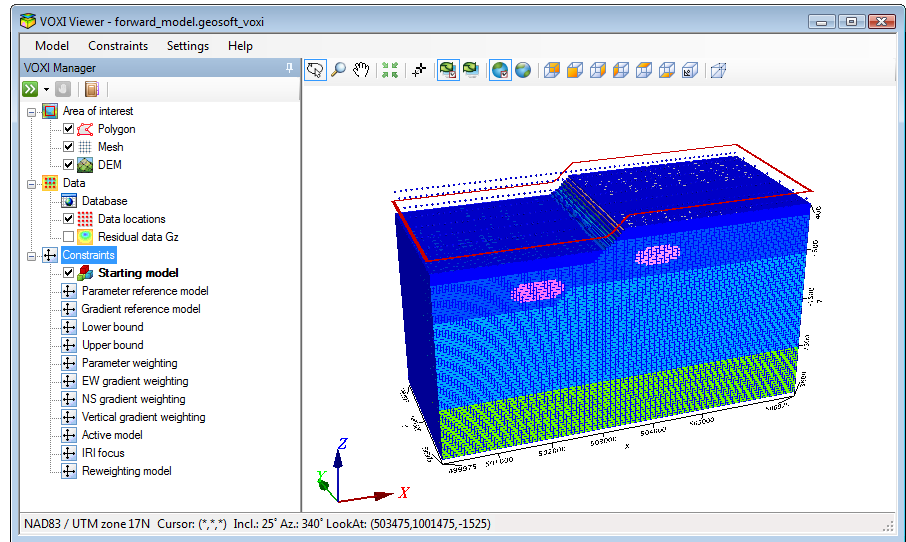**Figure 1.11** Modify Mesh Parameters dialog box
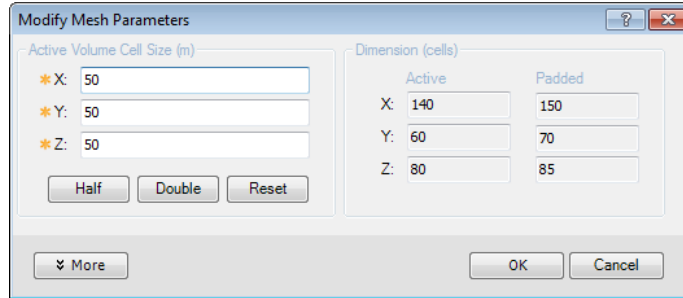
3. Click **More**.

   The Modify Mesh Parameters dialog box expands.

Figure 1.12 Expanded Modify Mesh Parameters dialog box

4. In the Horizontal Padding section, enter a value of **10** for **Cells**.

5. For the **Expansion ratio**, enter **2**.

6. Click **OK**.

Figure 1.13 VOXI Viewer with forward model and padding added

⚠ *You may notice a rim surrounding some of the contacts between different rock types in the model. This is due to the model interpolation that occurs when the padding cells are added.*
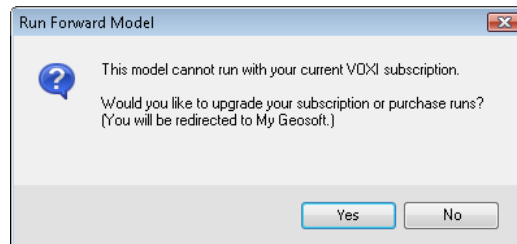
Running the Forward Model

Now that you have supplied the voxel model defining your area of interest, added the database containing the data channel to be populated, selected a DEM and modified the model mesh, you will run the forward model.
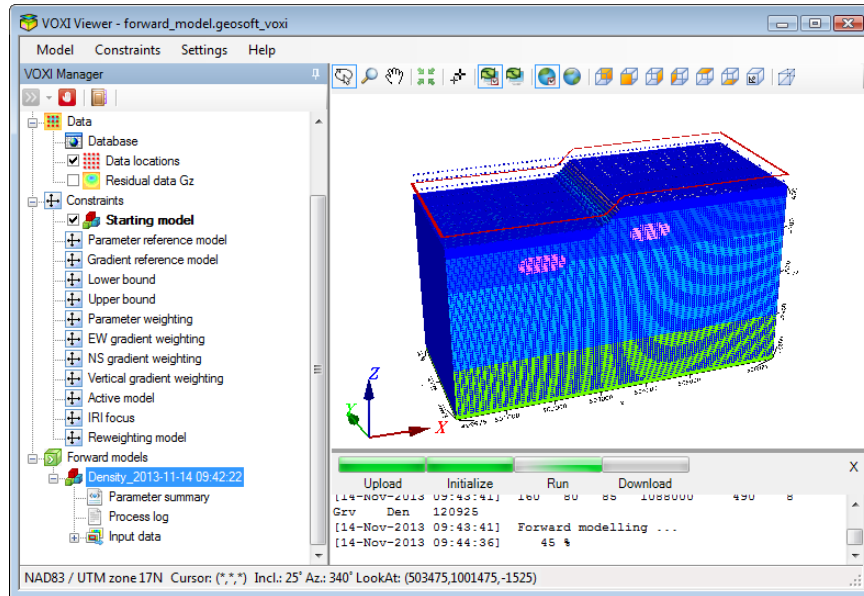
To run the forward model:

1. From the **Model** menu, select **Run Forward Model**, or click the arrow beside the **Run Inversion** button 〉〉 on the VOXI toolbar and select **Run Forward Model**.

   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 1.14 VOXI Subscription warning

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

Figure 1.15 VOXI Viewer with forward model in progress

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

⚠️ *If during the running of the forward model you realise you would like to edit your input data, you can stop the process by clicking the Stop Process button 🔴. The forward model will terminate immediately and the tokens will return to your account.*

2. In the VOXI Manager, expand **Forward models** to see the item representing the forward model you are calculating.

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

The Input data item contains a copy of the input data used for this forward model. 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 forward model.

💡 *Using the VOXI Journal 📓 on the VOXI toolbar, you can enter comments to describe the specifics of individual forward model sessions and notes on the differences between your inversion results.*

At the successful completion of the forward model, a check box is added in front of the session name. The Process log is also saved in the tree list and can be viewed and saved at any time.

3. Within the Forward models tree, clear the check box beside the **Density** item.

This represents the starting model and does not need to be displayed.
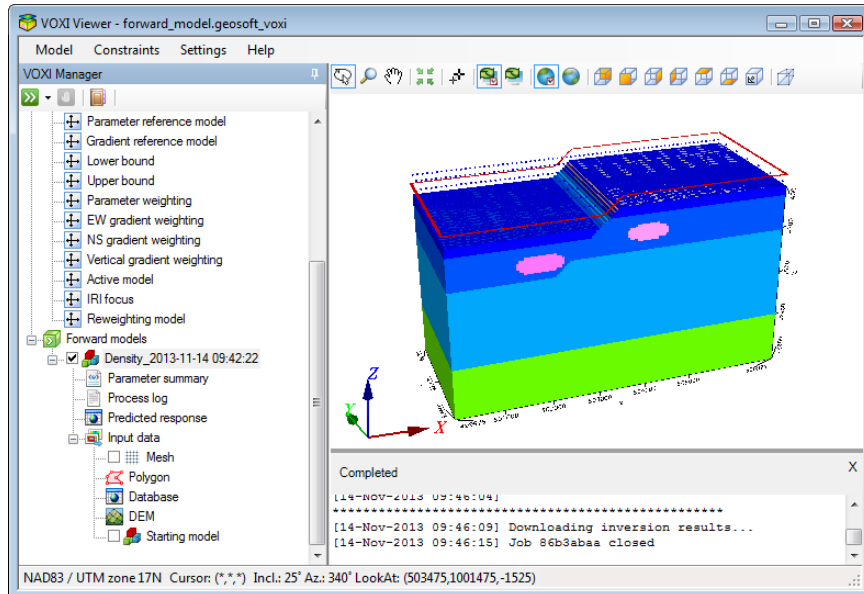
As in the Oasis montaj 3D Viewer, based on your selection of an item in the tree list, you can adjust Attributes, Clipping and Colours. For example, you can clip the output voxel model by selecting it and adjusting the Clipping parameters.

Exporting the Predicted Response (Forward Calculation) Database

At the completion of the forward model calculation, the input as well as the calculated forward gravity response at each provided data point 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 Forward models in the VOXI Viewer tree list, expand the **Density** 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

Figure 1.17 Predicted response (forward calculation) database

The GRV_FWD channel contains the calculated forward gravity response at each data point provided in the input database.

To grid and view the forward calculated data:

1. In **Oasis montaj**, create a grid using your preferred gridding method with the following parameters:

   › Channel to grid: **GRV_FWD**

   › Output grid: **fwd_grav_response**

   › Grid cell size: **50**

2. In the 3D Viewer, display **Half Graben.geosoft_voxel**.

3. Using the **Relief Surface** option in the Add to 3D menu, add the **fwd_grav_response** grid file to the 3D Viewer.

Figure 1.18 Voxel model and calculated gravity field displayed in the 3D Viewer