Supplementary→ Prism Anomaly Simulations - 2) Software

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GaMField Manual

Contents

0.1 Introduction

GaMField is a suite of interacting WINDOWS modules that include ***A) GaMField*** with a graphical user interface (GUI) for gravity and magnetic anomaly modeling of prisms, ***B) ModelBuilder*** for constructing $3D$ anomalous sources of prisms, and ***C) FieldViewer*** for visualizing the $3D$ models, as well as the related anomaly effects in map and profile formats (Pignatelli et al., 2011).

0.2 Installation

The 32-bit or 64-bit versions of ***GaMField*** maintained by the *Istituto Nazionale di Geofisica e Vulcanologia* (INGV) in Rome, Italy can be downloaded from⇒ **geosoftware.sci.ingv.it** upon registration.

Once downloaded from the INGV website, the user then must extract the appropriate archive [i.e., ***GaMField32Bit.zip*** or ***GaMField64Bit.zip***] into a single folder with a path name containing no spaces [e.g., ***GamField32Bit_15Apr13*** or ***GaMField64Bit_15Apr13***].

When unzipped or extracted, the user clicks → ***GaMFieldInstaller.exe*** to continue installing ***GaMField*** onto the user's machine. This operation brings up a DOS command window that installs the MATLAB runtime routines which allow the user's machine to run the MATLAB codes in ***GaMField***. The DOS window may take a few minutes to come up and complete the one-time installation of the MATLAB runtime routines. The user must stroke the **y**-key followed by the **Enter**-key on the keyboard to the few questions that appear as the installation of the runtime routines proceeds.

Thereafter, the user returns to the folder and clicks→ ***GaMField.exe*** to start the program for any anomaly modeling application. This operation generates the main program window shown in **Figure 0.1**, which may take up to a few minutes to appear depending on the computer's operating system and speed.

0.3 Operations

A flowchart outlining the general functions of ***GaMField*** is given in **Figure 0.2**.

0.3.1 DEFINE/SAVE SURVEY AND SOURCE GRIDS

GaMField requires the user to specify first the horizontal boundaries, altitude, and other parameters for the $2D$ ***Observation Grid***, and next the

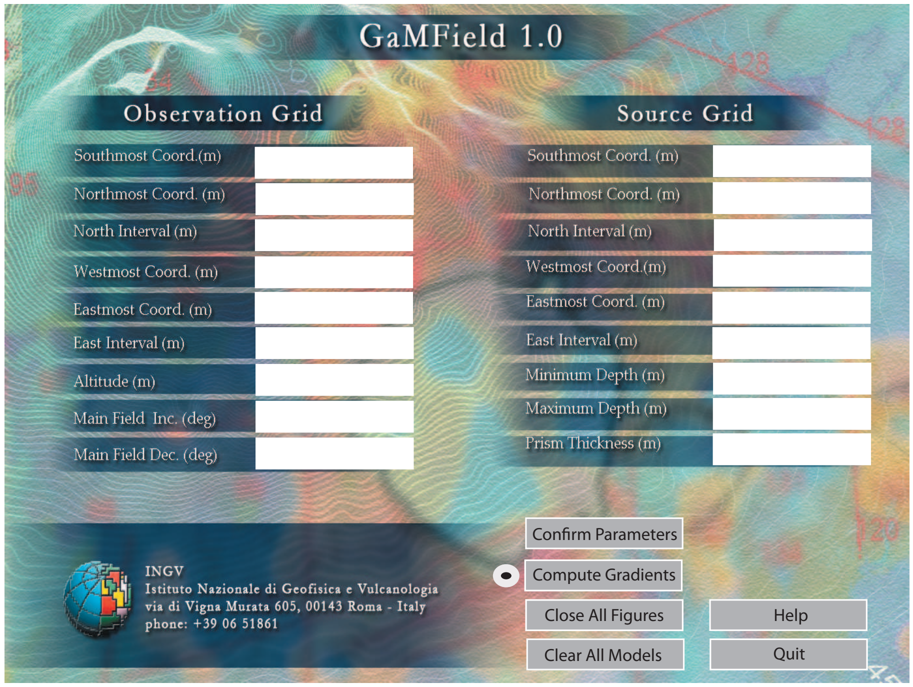

Figure 0.1 Main program window for the ***G***ravity ***a***nd ***M***agnetic anomaly ***Field*** modeling program ***GaMField***.

horizontal and vertical boundaries and other parameters of the $3D$ ***Source Grid*** [see **Figure 0.1**]. The additional parameters to be specified include the intervals along the two horizontal axes of the ***Observation Grid*** and the three axes of the ***Source Grid***. All linear parameters are defined in meters, with altitudes above and below sea level input as negative and positive values, respectively.

For total magnetic field calculations, the uniform geomagnetic field inclination and declination in degrees assumed for the observation grid is also included.

Whenever the parameters of either an observation grid or source grid are selected, the user must click→ ***Confirm Parameters*** to check the integrity and completeness of the data inputs, and continue with the ***GaMField*** operations.

At this point, the user may save the data inputs for later recall according to the following options:

- Clicking→ ***File***→ ***Survey Parameters***→ ***Save*** saves the observation and source grid parameters as a .txt file.

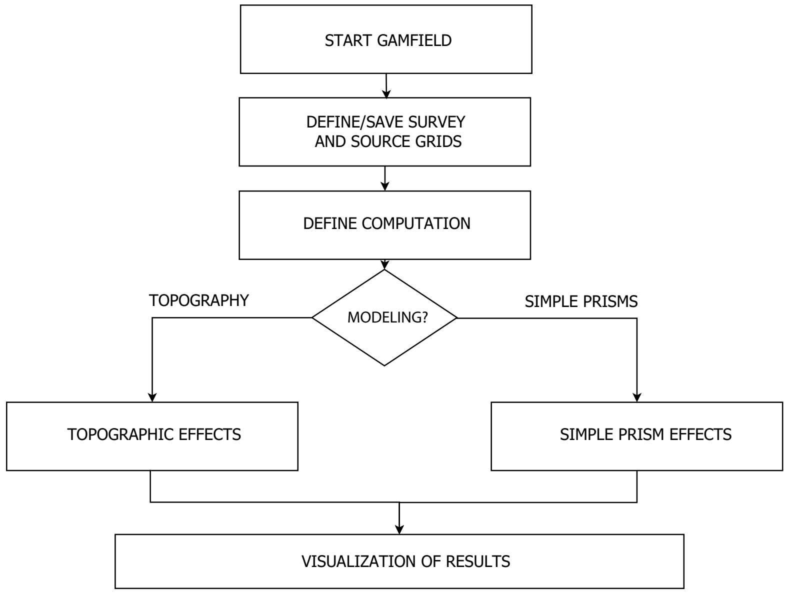

Figure 0.2 Flowchart generalizing the basic operations of ***GaMField***.

- Clicking→ ***File***→ ***Model Parameters***→ ***Save*** saves the model parameters as a .txt file.
- Clicking→ ***File***→ ***Total Parameters***→ ***Save*** saves the observation and source grid parameters and the model parameters as a .txt file.

A flowchart outlining the setting and saving of observation and source grid parameters for ***GaMField*** is given in **Figure 0.3**.

0.3.2 DEFINE ANOMALY COMPUTATIONS

At this point, the user may specify the anomaly modeling computions desired from ***GaMField*** as outlined by the flowchart in **Figure 0.4**. For example, the ***Compute Gradients*** button must be toggled ***on*** if the anomaly gradients are desired in addition to the anomaly field; otherwise, the botton must be toggled ***off*** to minimize the CPU time and effort in computing the anomaly field.

The gradients are computed numerically, and thus when the ***Compute Gradients*** button is toggled ***on***, a spatial interval or step for the derivative computations must be specified in a pop-up window that appears with the selection of any of the five options in the ***Compute*** menu or any of the three

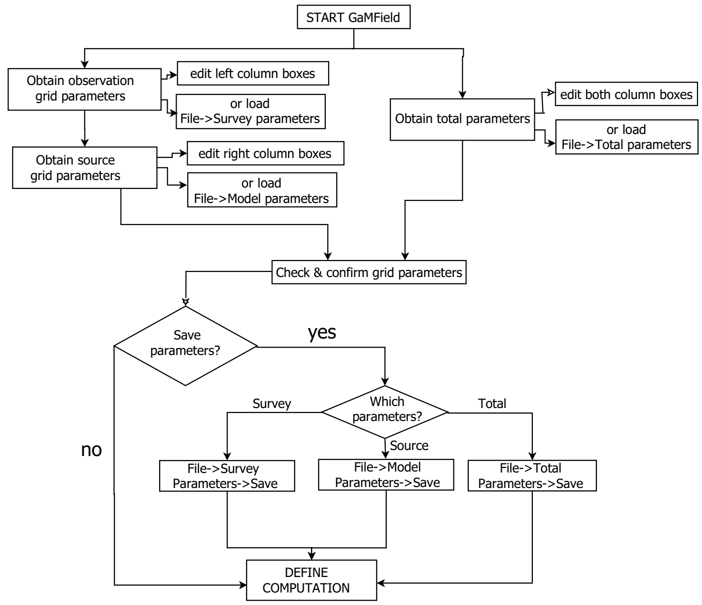

Figure 0.3 Flowchart for setting and saving the observation and source grid parameters in ***GaMField***.

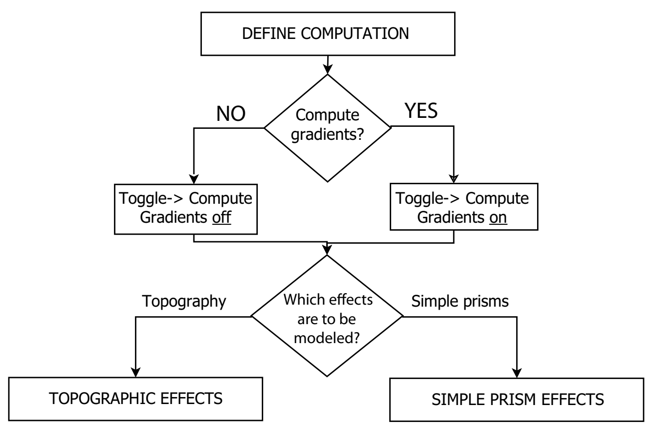

Figure 0.4 Flowchart for defining the anomaly modeling computation in ***GaMField***.

compute-options in the ***Topography*** menu. The rule-of-thumb for effective gradient estimates is to set this step at 10% or smaller of the depth to the top of the source.

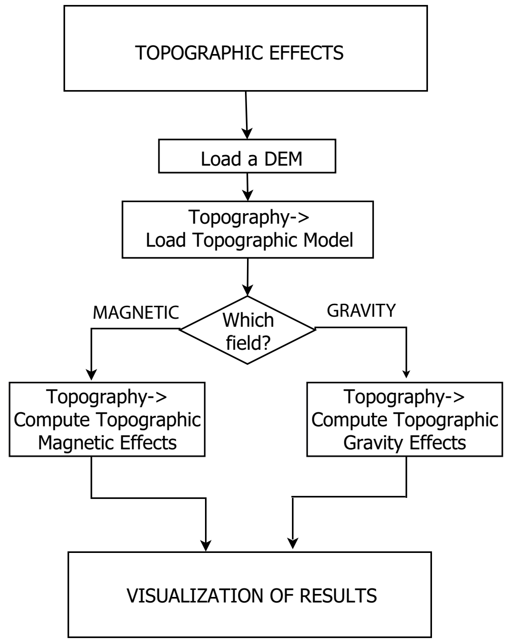

Figure 0.5 Flowchart to load a DEM for modeling the magnetic and gravity effects of topography.

Two anomaly field modeling options are available to the user from ***GaMField*** at this point. The user may model the topographic effects from a user-supplied digital elevation model (DEM) or model the effects of a $3D$ distribution of simple prisms, either user-supplied or interactively constructed from the ***ModelBuilder*** module.

0.3.3 MODEL TOPOGRAPHIC EFFECTS

Figure 0.5 gives a flowchart for modeling the magnetic and gravity effects of topography. In the ***GaMField*** window,

- clicking → ***Topography***→ ***Load Topographic Model***

allows the user to submit a digital elevation model (DEM) as a plain .txt file in the following comma-separated format of up to 7 columns⇒ [*Easting-coordinate, Northing-coordinate, Top-elevation, Bottom-elevation, Density (in g/cm*^{3}*)/Magnetization Intensity (in A/m), Magnetization Inclination (in degrees), Magnetization Declination (in degrees)*].

Anomaly modeling options are selected as follows:

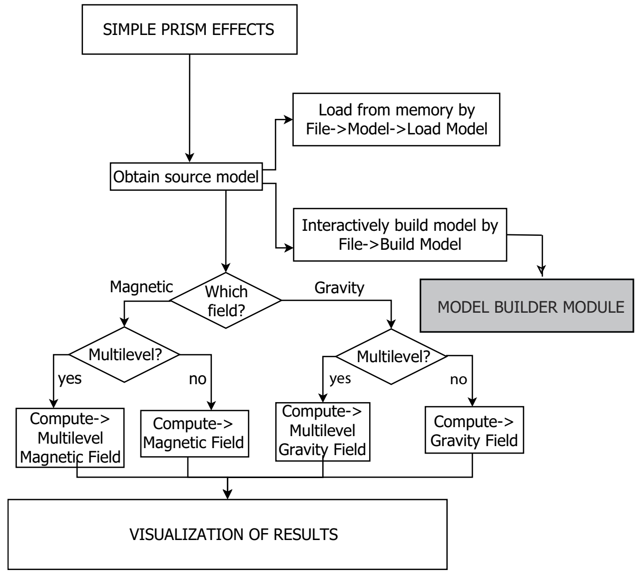

Figure 0.6 Flowchart for modeling the effects of a $3D$ source made up of simple prisms.

- To model the magnetic effects of the DEM, click→ ***Topography***→ ***Compute Topographic Magnetic Effects***. If the anomaly gradients are also desired, the user must have toggled the ***Compute Gradients*** button ***on*** prior to selecting this field option.
- To model the gravity effects of the DEM, click→ ***Topography***→ ***Compute Topographic Gravity Effects***. If the anomaly gradients are also desired, the user must have toggled the ***Compute Gradients*** button ***on*** prior to selecting this field option.
- To compute the selected effects along a profile taken interactively from the anomaly map with mouse clicks indicating the starting and ending points, click → ***Topography***→ ***Compute a profile on topographic field***. The user also must specify the uniform interval of the desired observation points along the profile.

0.3.4 MODEL SIMPLE PRISM EFFECTS

Figure 0.6 outlines the procedures for modeling the gravity and magnetic effects for a $3D$ source of simple prisms. The $3D$ source can be loaded from memory by

- clicking→ ***File***→ ***Model***→ ***Load Model***

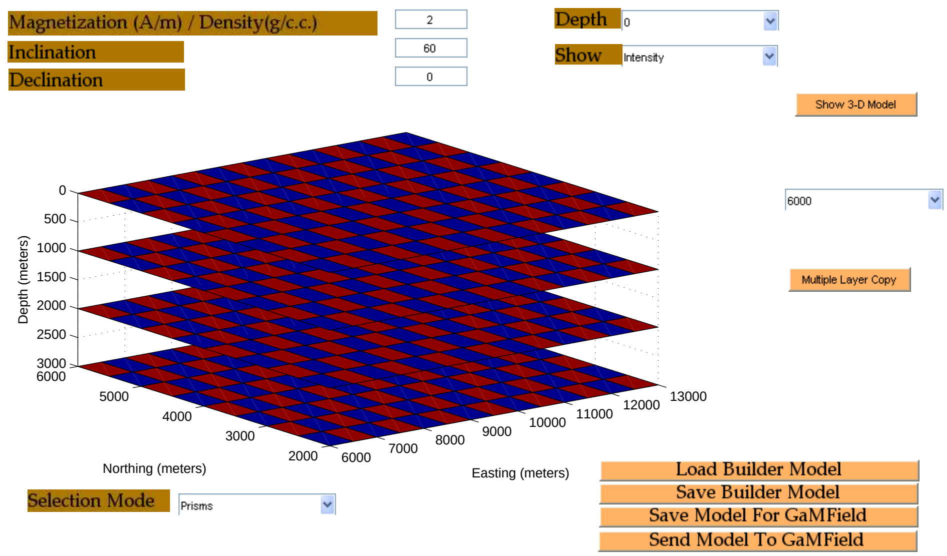

Figure 0.7 Screen plot of the ***ModelBuilder*** GUI for constructing 3D gravity and magnetic anomaly sources in ***GaMField***.

or interactively constructed from simple prisms by

- clicking→ ***File***→ ***Model***→ ***Build Model***,

which opens the window with the stylized 3D perspective view of the source region shown in **Figure 0.7**. The parameters of the simple prism model can be saved to a .txt file at any stage of development for further development and recall to subsequent applications by

- clicking→ ***File***→ ***Model Parameters***→ ***Save***.

Each prism specified by the user has its top on a plane with its horizontal boundaries defined by the *North Interval* and *East Interval* values of the ***Source Grid*** menu of the main program window [**Figure 0.1**].

- For magnetic modeling, input the magnetization intensity in Amperes/meter into the *Magnetization (A/m)/Density (g/c.c.)* field and the appropriate degree values into the underlying *Inclination* and *Declination* fields.
- For gravity modeling, input the density in grams/cubic centimeter into the *Magnetization (A/m)/Density (g/c.c.)* field.
- Select the layer to edit by selecting its depth from the *Depth* field. This procedure brings up the window shown in **Figure 0.8**.

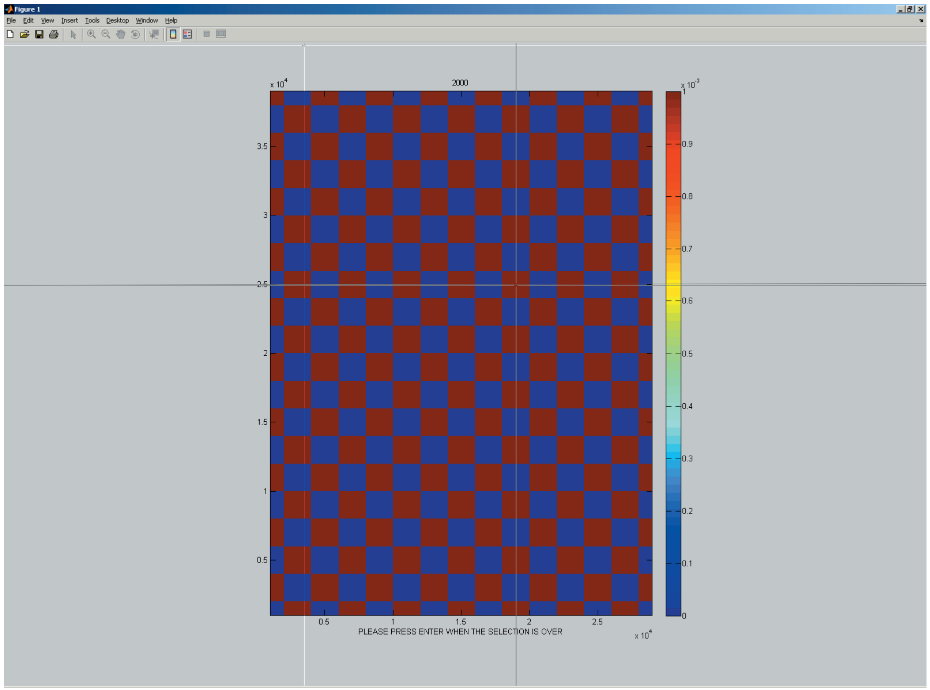

Figure 0.8 Clicking activates the prism beneath the cross-hairs with the selected physical properties. Clicking on an activated prism de-activates it.

- Placing the cross-hairs on a cell and clicking activates the underlying prism with the previously selected physical properties. Clicking on an activated cell de-activates it.
- When all the desired cells for the layer have been activated, the user must press the **Enter**-key on the keyboard to store the selected prisms and their physical properties for further processing.
- The user is then returned to the ***Build Model*** window [**Figure 0.7**] to construct additional prisms at other depths and/or with other physical properties.

The ***Build Model*** window [**Figure 0.7**] contains additional tools to speed up the model building, which include:

- Clicking→ ***Polygon*** in the *Selection Mode* field allows the user to draw a general polygon with mouse clicks onto the layer window [**Figure 0.8**] to activate all prisms within the polygon when the **Enter**-key is pressed.
- Clicking→ ***Multiple Layer Copy*** allows the user to copy the prisms from one layer to one or more other layers. It is done by clicking on the

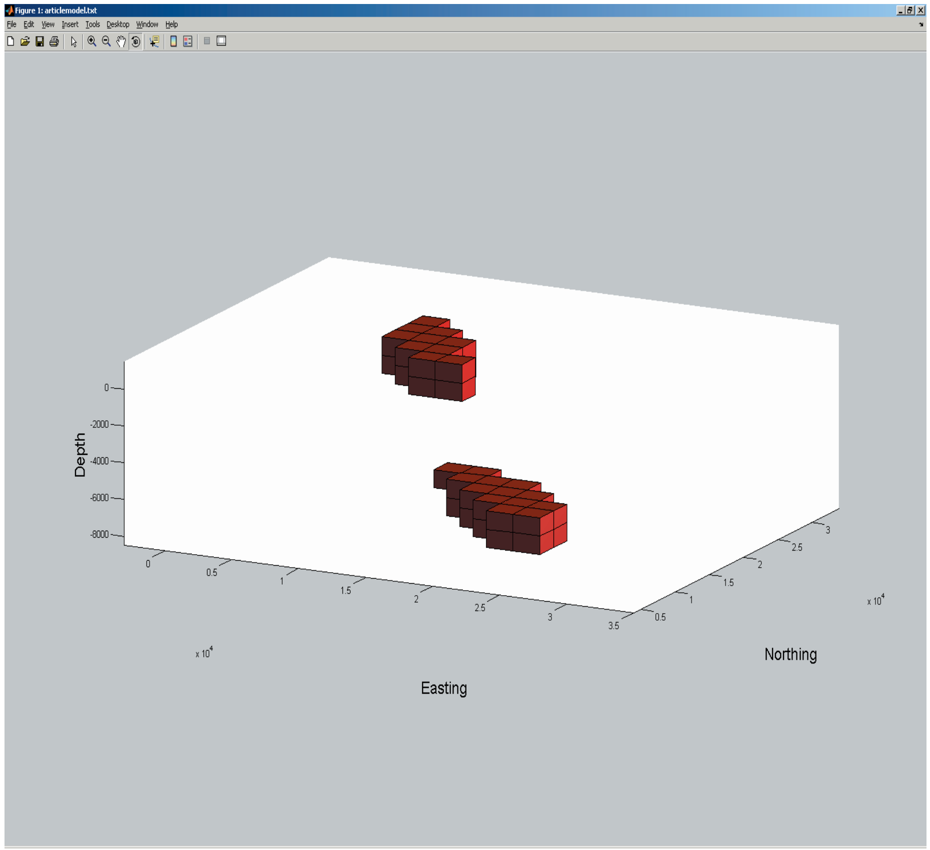

Figure 0.9 Screen plot of the perspective view of the prisms defining the three-dimensional sources in the ascii file *Ex1_model.txt* in the ***ExampleFiles*** sub-folder of the extracted ***GaMField*** folder [e.g., the ***GaMField32Bit_15Apr13*** folder] . Placing the mouse's pointer on the image and moving it about while holding the left button down changes the 3*D* perspective view of the prisms.

button and following the program requests. Note that this button is absent if the source grid has no activated cells.

- Clicking→ ***Show 3-D Model*** allows the user to visualize the model from various perspectives in three-dimensions as illustrated by the example in **Figure 0.9**.

When a satisfactory volumetric distribution of prisms is established, the source model can be saved or recovered in one or more of the following ways:

- Clicking→ ***Save Builder Model*** allows the user to save the model in MATLAB's .mat binary file format that can be loaded directly into the ***ModelBuilder*** module. This option is useful for saving intermittent model files during the construction of complex models.

- Clicking→ ***Load Builder Model*** allows the user to load the saved .mat model file directly into the ***ModelBuilder*** module.
- Clicking→ ***Save Model For GaMField*** allows the user to save the model parameters in the plain text .txt format that can be read by the main ***GaMField*** module [**Figure 0.1**] for further processing.
- Clicking→ ***Send Model To GaMField*** submits the model directly to the main ***GaMField*** module [***Figure 0.1***] for immediate anomaly computations.

The anomaly computations may be selected according to the following options:

- Clicking→ ***Compute→ Gravimetric Field*** or → ***Compute→ Magnetic Field*** computes the respective gravity and magnetic effects of the subsurface model. If the anomaly gradients are also desired, the user must have toggled the ***Compute Gradients*** button ***on*** prior to selecting either of these two field options.
- Clicking→ ***Compute→ Multilevel Gravimetric Field*** or → ***Compute→ Multilevel Gravimetric Field*** allows the user to generate the related effects over a range of altitudes at a user-specified altitude-interval. If the anomaly gradients are also desired, the user must have toggled the ***Compute Gradients*** button ***on*** prior to selecting this option.
- Clicking→ ***Compute→ Profile On Map*** allows the user to compute the effects along a profile taken interactively from the anomaly map with mouse clicks indicating the starting and ending points. The user also must specify the observation point interval along the profile.

In addition, before the anomaly computation starts, ***GaMField*** displays the $3D$ image of the source and asks if the user wishes to specify the observation points rather than use the default input *Observation Grid* points. In this case, the user can load the observation points as an ascii file of three columns separated by commas giving the spatial coordinates in the following format⇒ (*Easting, Northing, Altitude*)-coordinates.

0.3.5 VISUALIZATION OF RESULTS

The ***View*** menu in the main ***GaMField*** window [***Figure 0.1***] displays the DEM and simple prism model, as well as their gravity and magnetic effects according to the following options:

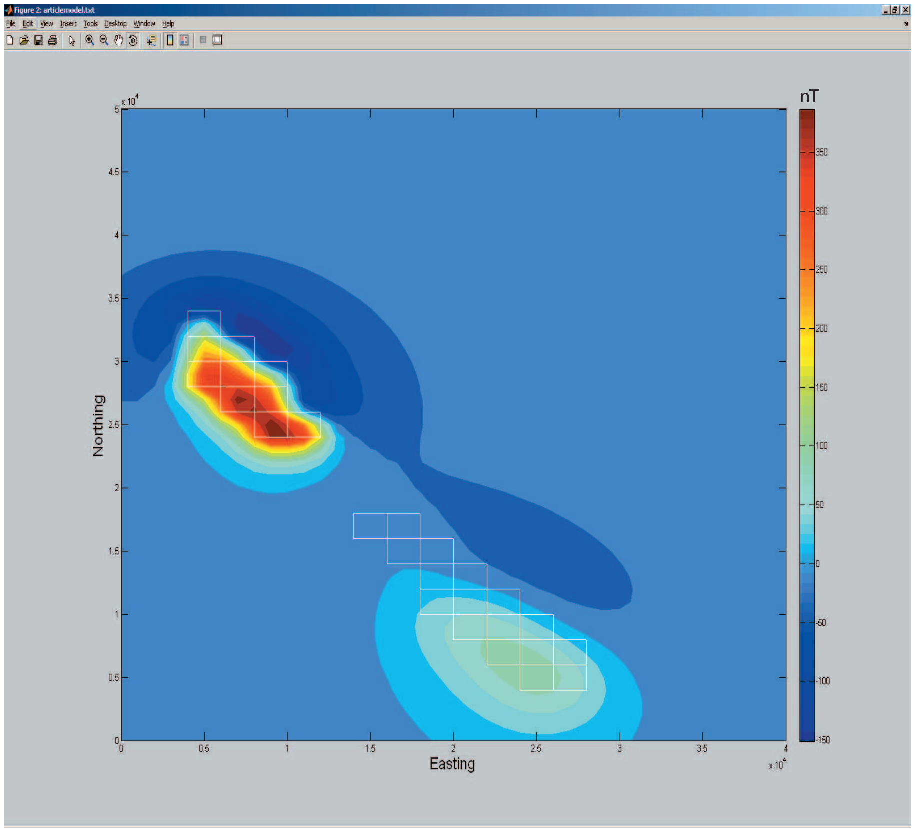

Figure 0.10 Screen plot of the total magnetic field effects of the 3*D* prisms in **Figure 0.9** computed from the associated source model in ascii file *Ex1_model.txt* as listed in the anomaly field values of the ascii file *Ex1_fields.txt*, which are both located in the ***ExampleFiles*** sub-folder of the extracted ***GaMField*** folder [e.g., the ***GaMField32Bit_15Apr13*** folder] .

- Clicking→ ***View***→ ***Built Model*** in the ***GaMField*** window provides a 3*D* image of the model that can be interactively viewed from different perspectives as shown by the example in **Figure 0.9**.
- Clicking→ ***View***→ ***DEM*** provides an interactive 3*D* image of the topographic DEM.
- Clicking→ ***View***→ ***Complete Model Effects*** provides color-filled maps and related statistics of the gravity or magnetic effects of the built model including any specified gradient components. For the souce model of **Figure 0.9**, the related magnetic and gravity anomaly fields are shown in **Figures 0.10** and **0.11**, respectively.

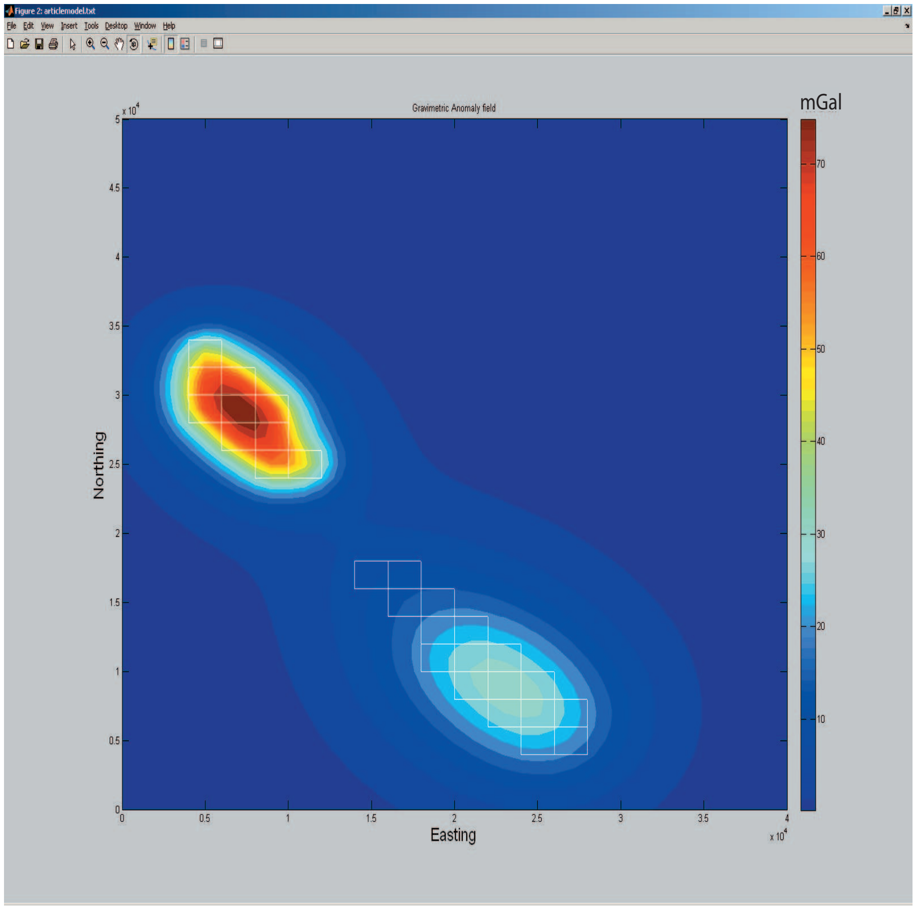

Figure 0.11 Screen plot of the gravity field effects of the $3D$ prisms in **Figure 0.9** computed from the associated source model in ascii file *Ex1_model.txt* as listed in the anomaly field values of the ascii file *Ex1_fields.txt*, which are both located in the ***ExampleFiles*** sub-folder of the extracted ***GaMField*** folder [e.g., the ***GaMField32Bit_15Apr13*** folder] .

- Clicking→ ***View***→ ***Complete DEM Effects*** provides color-filled maps and related statistics of the gravity or magnetic effects of the DEM including any specified gradient components.
- Clicking→ ***Close All Figures*** in the ***GaMField*** window closes all the figures.
- Clicking→ ***Clear All Models*** in the ***GaMField*** window cleans the memory of all the built and loaded models

0.4 Conclusions

GaMField is a MATLAB-based geopotential field generator that constructs and visualizes topographic and subsurface sources in $3D$ space and computes their gravity and magnetic effects. ***GaMField*** also computes anomaly gradients and remanent magnetization effects. The user inputs Cartesian prisms along with their physical properties to fabricate the topographic or subsurface sources in an interactive WINDOWS environment. The ***ExampleFiles*** sub-folder of the extracted ***GaMField*** folder [e.g., the ***GaMField32Bit_15Apr13*** folder] contains file examples for loading and modeling the magnetic and gravity effects of a subsurface distribution of simple prisms, and a DEM of the Tenerife volcano in the Canary Islands off the Atlantic coast of Spain.

GaMField and its periodic updates can be freely downloaded from the website given in **Section 0.2**-above that the INGV operates as a public service. The website also entertains questions and recommendations from users for implementing and improving ***GaMField***.

References

Pignatelli, A., Nicolosi, I., Carluccio, R., Chiappini, M., and von Frese, R. 2011. Graphical interactive generation of gravity and magnetic fields. *Computers & Geosciences*, **37**, 567–572.