

# **GraviMag ModelingInversion**

**Gravity and Magnetic modeling and inversion  
technology in wavenumber domain for layer  
property and horizon position correction**

**User Manual**

**IPLAB**

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## 1. Introduction

The **GraviMag ModelingInversion** IP\_Seis plug-in (version: 2016.1.0.0, release date: November 2016) can be used to gravity or/and magnetic fields modeling and inversion. The earth model can be built via set of layers with top and bottom horizons and property varied laterally according surface. The gravity and magnetic data inversion theory (Priezzhev I, 1989) is based on the forward modeling equations in the frequency wave number domain, derived by Parker R.L. (1973), and optimization technique derived by A.I. Kobrunov (1981).

Plug-in allow to define 3D structural layers model based on surfaces and density definition.

The plug-in has the following main options for calculation:

1. Forward modeling.
2. Density correction in a layer.
3. Horizon position correction.
4. Combination correction for some layers density correction and for some layers horizon position correction.

The plug-in working with gravity and magnetic fields. For magnetic field we use assumption only induction magnetization exist and in this case need to define normal magnetic field vector **Azimuth** (0-360) and **Dip** (-90 degrees to 90 degrees).

Option for Join Inversion use both gravity and magnetic field simultaneously (only for horizon correction).

Data requirement.

1. Surface data must be defined for all grid nodes, because gravity and magnetic forward and inversion modules use 2D Fourier transfer.
2. Axe Z has up direction inside earth Z is negative. If Z positive it is upper the sea level.

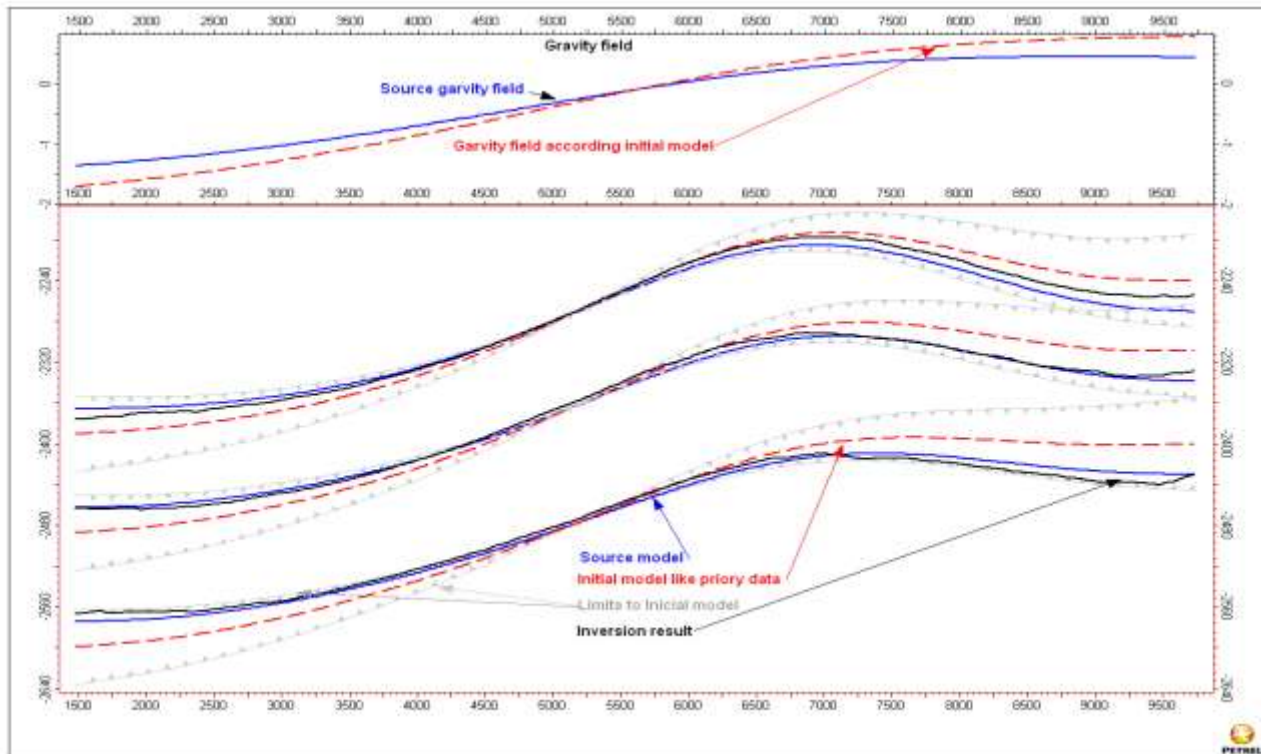


Figure 1: Synthetic example for horizons position correction. Blue curves are source (given) model. Red curves are initial model and gray curves are define limitations for initial model. Black curves show inversion result. Density contract was 0.1, 0.2, 0.3 for first, second and third surfaces correspondently.

## 2. Start

**Start:** Gravity Magnetic->

### **GraviMag ModelingInversion**

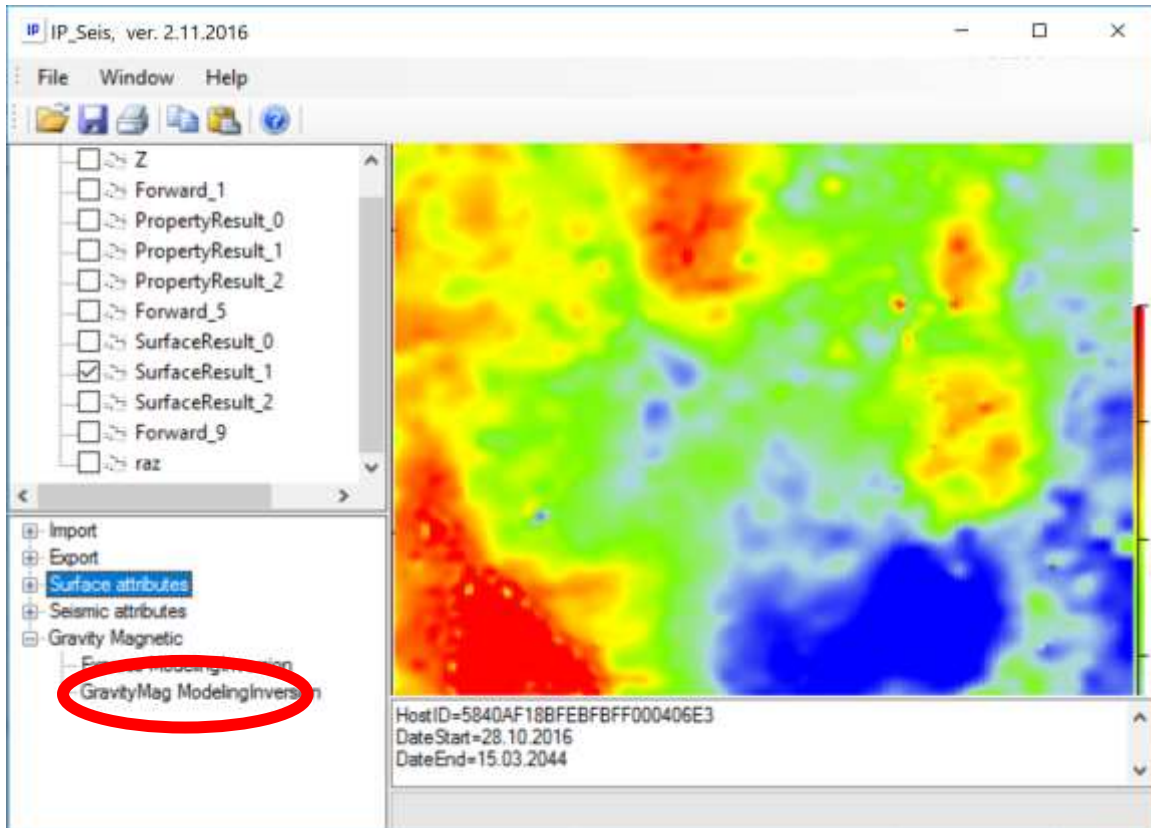


Figure 2: Project tree and programs tree to start **GraviMag ModelingInversion**

### 3. Forward Input parameters

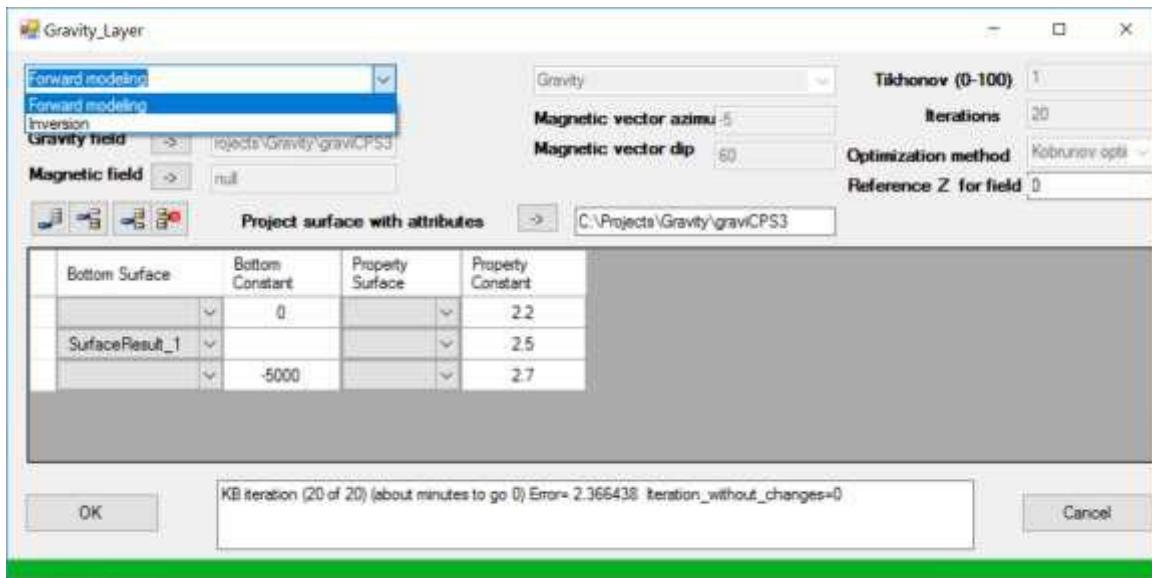


Figure 3: Input surface attributes data tab dialog view **GraviMag ModelingInversion**.

Parameters should be defined before calculation:

1. Select **Forward modeling** in the Calculation method list. All parameters needed to input will be *Enabled*.
2. Select the type of input potential field in the **Gravity** or **Magnetic** field.
3. Define **Gravity** or **Magnetic** surface (surface property) via using Project Tree node selection and push corresponded button.
4. If type pf field is **Magnetic**, define normal magnetic field vector **Azimuth** (0-360) and **Dip** (-90 degrees to 90 degrees).
5. Define **Reference Z** for potential field (default Z =0)
6. Define **Surface project set** by clicking surface with properties that can be used to create layers model.
7. Add new layer rows to layers table clicking corresponded icon.
  - a. Select **Bottom Surface** using pulldown menu that define bottom of the layer. As alternative, define **Bottom Constant** that will used like flat surface for bottom of the layer. Top for the layer will be define from bottom of previous layer or **Z reference** flat surface (constant surface) for first layer.

- b. Select **Property Surface** using pulldown menu that define density function (or magnetic property) of the layer. As alternative, define **Property Constant** that will used like constant property of the layer.
  - c. Select **Surface Up limit for Bottom Surface** using pulldown menu that define upper limit of the layer bottom. As alternative, define **Constant Up limit for Bottom Surface** that will used like flat surface for upper limit for bottom of the layer. Upper limit for bottom surface will not allow changing surface position according this limitation.
8. Click **OK** to start calculation.
- Result surface will be created in defined folder under name: "Forward n", where n is current property index.



## 4. Inversion for property corrections in layers

The screenshot shows the 'Gravity\_Layer' window. At the top, there are dropdown menus for 'Inversion' (set to 'Property correction (density/mag)') and 'Gravity' (set to 'Gravity'). Below these are fields for 'Gravity field' (set to 'projects\Gravity\graviCPS3') and 'Magnetic field' (set to 'null'). To the right, there are fields for 'Tikhonov (0-100)' (set to '1'), 'Iterations' (set to '20'), 'Optimization method' (set to 'Kobrunov opti'), and 'Reference Z for field' (set to '0'). Below these are buttons for 'Project surface with attributes' and a file path 'C:\Projects\Gravity\graviCPS3'. The main part of the window is a table with 8 columns: 'Bottom Surface', 'Bottom Constant', 'Property Surface', 'Property Constant', 'Surface with Property Min', 'Constant Property Min', 'Surface with Property Max', and 'Constant Property Max'. The table has three rows of data. At the bottom, there is a status bar showing 'KB iteration (20 of 20) (about minutes to go 0) Error= 2.366438 Iteration\_without\_changes=0' and 'OK' and 'Cancel' buttons.

Bottom Surface	Bottom Constant	Property Surface	Property Constant	Surface with Property Min	Constant Property Min	Surface with Property Max	Constant Property Max
	0		2.2		2.2		2.2
SurfaceResult_1			2.5		2.2		3
	-5000		2.7		2.7		2.7

Figure 4. Interface for layer density inversion.

1. Select **Inversion** in the Calculation method list.
2. Select **Property correction (density/mag)** in the Surface properties
3. Define number of **Iterations** (from 1 till 100)
4. Define **Gravity** or **Magnetic** or **Join Gravity Magnetic** option for input.
5. Define **Gravity** or/and **Magnetic** surface (surface property) via using Project Tree node selection and push corresponded button.
6. If field is **Magnetic**, define normal magnetic field vector **Azimuth** (0-360) and **Dip** (-90 degrees to 90 degrees).
7. Define **Reference Z** for potential field (default Z = 0)
8. Define **Surface project set** by clicking surface with properties that can be used to create layers model.
9. Add new layer rows to layers table clicking corresponded icon.
  - a. Select **Bottom Surface** using pulldown menu that define bottom of the layer. As alternative, define **Bottom Constant** that will used like flat surface for bottom of the layer. Top for the layer will be define from bottom of previous layer or **Z reference** flat surface (constant surface) for first layer.

- b. Select **Property Surface** using pulldown menu that define density function (or magnetic property) of the layer. As alternative, define **Property Constant** that will used like constant property of the layer.
- c. Select **Surface with Property Min** using pulldown menu that define limit of the layer property. As alternative, define **Constant with Property Min** that will used like minimum limit for property of the layer. Minimum limit for property will not allow changing according this limitation.
- d. Select **Surface with Property Max** using pulldown menu that define limit of the layer property. As alternative, define **Constant with Property Max** that will used like maximum limit for property of the layer. Maximum limit for property will not allow changing according this limitation.

10. Click **OK** to start calculation.

Forward model for result layer with corrected property will be created in defined folder under name: "Forward n", where n is current property index.

Message box will displaying the following:

KB iteration, Minutes to go, Error, iterations without changes.

Result surface will be created in defined folder under names: "PropertyResult\_m" , where m is number of layer.

## 5. Inversion for surface position corrections in layers

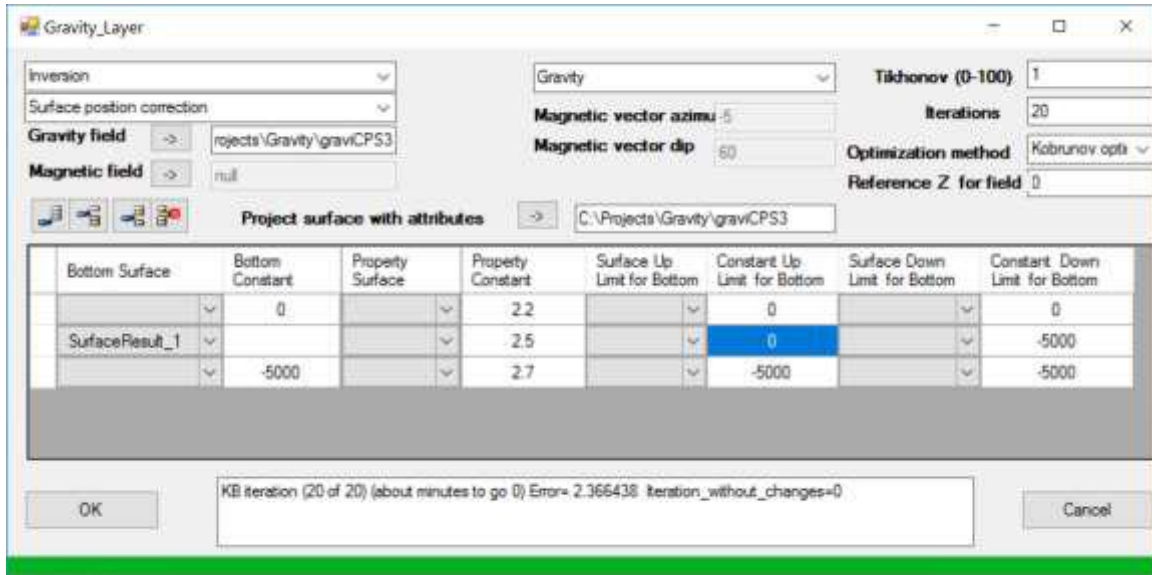


Figure 5. Interface for layers surface corrections.

1. Select **Inversion** in the Calculation method list.
2. Select **Surface position correction** in the Surface property
3. Define number of **Iterations** (from 1 till 100)
4. Define **Gravity** or **Magnetic** or **Join Gravity Magnetic** option for input.
5. Define **Gravity** or/and **Magnetic** surface (surface property) via using Project Tree node selection and push corresponded button.
6. If type pf field is **Magnetic**, define normal magnetic field vector **Azimuth** (0-360) and **Dip** (-90 degrees to 90 degrees).
7. Define **Reference Z** for potential field (default Z =0)
8. Define **Surface project set** by clicking surface with properties that can be used to create layers model.
9. Add new layer rows to layers table clicking corresponded icon.
  - a. Select **Bottom Surface** using pulldown menu that define bottom of the layer. As alternative, define **Bottom Constant** that will used like flat surface for bottom of the layer. Top for the layer will be define from bottom of previous layer or **Z reference** flat surface (constant surface) for first layer.

- b. Select **Property Surface** using pulldown menu that define density function (or magnetic property) of the layer. As alternative, define **Property Constant** that will used like constant property of the layer.
- c. Select **Surface Up limit for Bottom Surface** using pulldown menu that define upper limit of the layer bottom. As alternative, define **Constant Up limit for Bottom Surface** that will used like flat surface for upper limit for bottom of the layer. Upper limit for bottom surface will not allow changing surface position according this limitation.
- d. Select **Surface Down limit for Bottom Surface** using pulldown menu that define down limit of the layer bottom. As alternative, define **Constant Down limit for Bottom Surface** that will used like flat surface for down limit for bottom of the layer. Down limit for bottom surface will not allow changing surface position according this limitation.

11. Click **OK** to start calculation.

Forward model for result layer with corrected property will be created in defined folder under name: "Forward n", where n is current property index.

Message box will displaying the following:

KB iteration, Minutes to go, Error, iterations without changes.

Result surface will be created in defined folder under names:

"SurfaceResult\_m" , where m is number of layer.

## 6. Inversion for combine surface position corrections and property in layers

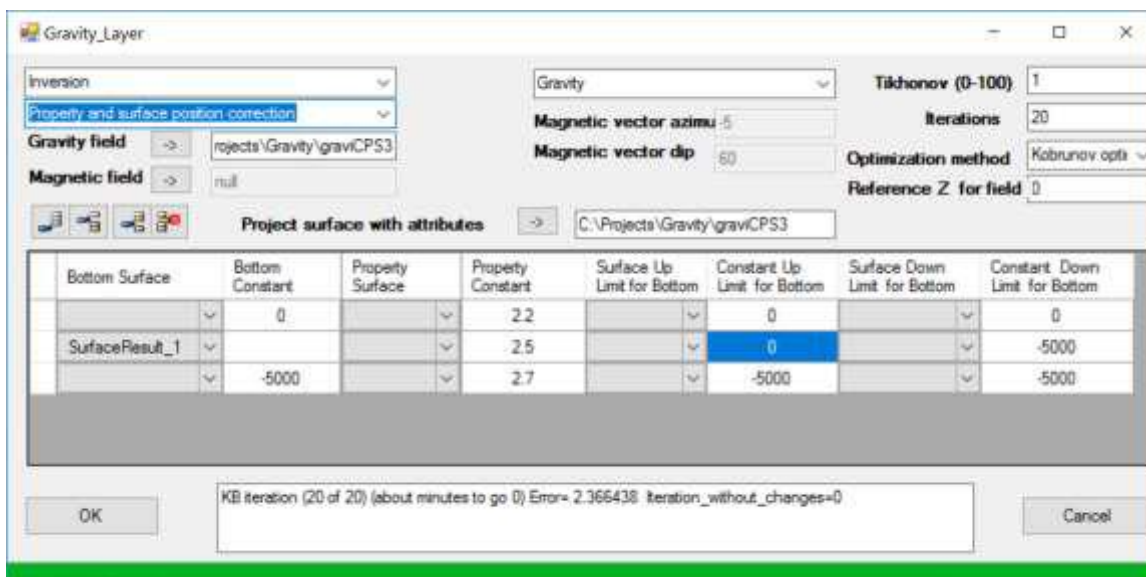


Figure 6. Interface for combine layers surface corrections and property correction.

10. Select **Inversion** in the Calculation method list.
11. Select **Property and surface position correction** in the Surface property
12. Define number of **Iterations** (from 1 till 100)
13. Define **Gravity** or **Magnetic** or **Join Gravity Magnetic** option for input.
14. Define **Gravity** or/and **Magnetic** surface (surface property) via using Project Tree node selection and push corresponded button.
15. If type pf field is **Magnetic**, define normal magnetic field vector **Azimuth** (0-360) and **Dip** (-90 degrees to 90 degrees).
16. Define **Reference Z** for potential field (default Z =0)
17. Define **Surface project set** by clicking surface with properties that can be used to create layers model.
18. Add new layer rows to layers table clicking corresponded icon.
  - a. Select **Bottom Surface** using pulldown menu that define bottom of the layer. As alternative, define **Bottom Constant** that will used like flat surface for bottom of the layer. Top for the layer will be define from bottom of previous layer or **Z reference** flat surface (constant surface) for first layer.

- b. Select **Property Surface** using pulldown menu that define density function (or magnetic property) of the layer. As alternative, define **Property Constant** that will used like constant property of the layer.
- c. Select **Surface Up limit for Bottom Surface** using pulldown menu that define upper limit of the layer bottom. As alternative, define **Constant Up limit for Bottom Surface** that will used like flat surface for upper limit for bottom of the layer. Upper limit for bottom surface will not allow changing surface position according this limitation.
- d. Select **Surface Down limit for Bottom Surface** using pulldown menu that define down limit of the layer bottom. As alternative, define **Constant Down limit for Bottom Surface** that will used like flat surface for down limit for bottom of the layer. Down limit for bottom surface will not allow changing surface position according this limitation.

12. Click **OK** to start calculation.

Forward model for result layer with corrected property will be created in defined folder under name: "Forward n", where n is current property index.

Message box will displaying the following:

KB iteration, Minutes to go, Error, iterations without changes.

Result surface will be created in defined folder under names:

"SurfaceResult\_m" and "PropertyResult\_m" , where m is number of layer.