

Calculating the Analytic Signal and Generalised and Tilt Derivatives in MAGMAP

This *Calculating the Analytic Signal and Generalised and Tilt Derivatives in MAGMAP* guide describes how to calculate the Analytic Signal and the Generalised and Tilt Derivatives for your processed grids.

Calculate Analytic Signal

The Analytic Signal is the square root of the sum of squares of the data derivatives in the x, y, and z directions:

$$asig = \sqrt{dx \cdot dx + dy \cdot dy + dz \cdot dz}$$

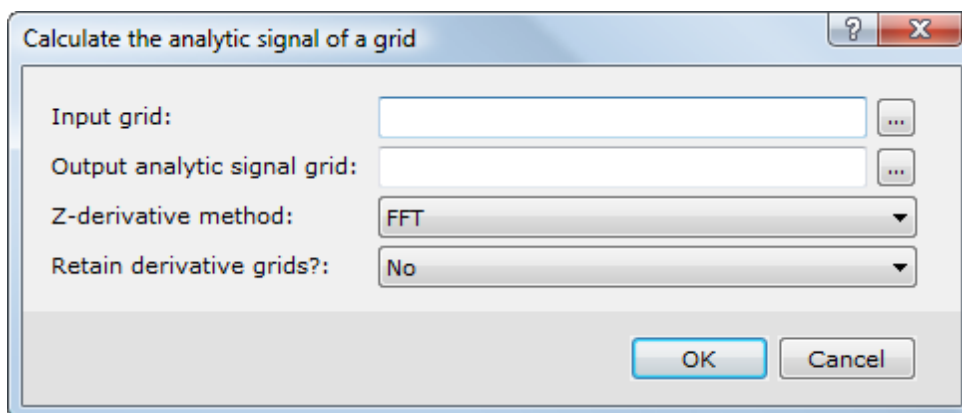
The analytic signal is useful in locating the edges of magnetic source bodies, particularly where remanence and/or low magnetic latitudes complicate interpretation. The analytic signal calculation is immune of the IGRF field direction, that is, you do not need to precede this calculation with a reduction to the magnetic pole to properly shift the anomalies over top of the causative bodies.

The default Z-derivative method is FFT. However, for very large grids (over 4000 x 4000 cells), using the Convolution method saves a lot of processing memory and time.

To Calculate the Analytic Signal for a Grid

1. From the *MAGMAP* menu, select **Analytic Signal**.

The *Calculate the analytic signal for a grid* dialog appears.



2. Use the *Browse* button to select the *Input grid*.
3. Specify the *Output analytic signal grid*.
4. Use the *Z-derivative method* dropdown list, to select the Z-derivative method.
5. Use the *Retain derivative grids* dropdown list, to select:

- ▶ Yes – To keep the intermediate derivative grids (dx.grd, dy.grd, and dz.grd) (recommended to speed up subsequent runs of this process).
 - ▶ No – To delete the intermediate derivative grids on exit
6. Click **OK**. The analytic signal grid is created at the defined location.

Calculating Generalised Derivative

The Generalized Derivative can be thought of as a directional Analytic signal. Whereas the analytic signal produces an equivalent amplitude at each grid point, the generalized derivative projects the amplitude along a user defined direction, defined by an azimuth and a dip angle.

The Generalized Derivative can be used to enhance the signal along a specific direction and bring out the small detail obscured by large amplitude anomalies. It has the form:

$$(\partial f/\partial x \sin \theta + \partial f/\partial y \cos \theta) \cos \varphi + \partial f/\partial z \sin \varphi / \sqrt{(\partial f/\partial x)^2 + (\partial f/\partial y)^2 + (\partial f/\partial z)^2}$$

Where,

φ is the dip

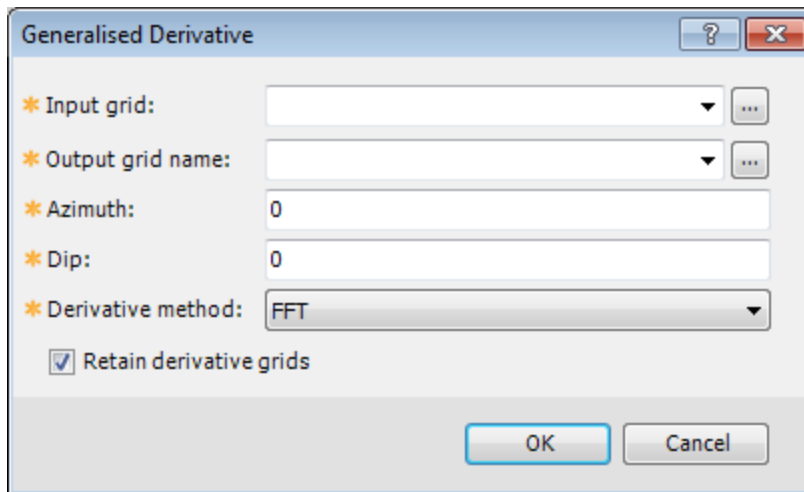
θ is the azimuth of the direction to emphasize

If $\varphi = 0$ then the GDO reduces to the horizontal component of the field and has its maximum direction sensitivity along θ .

If $\varphi = 90$ the GDO reduces to the Z component of the field and like the analytic signal has no directional bias.

To Calculate the Generalised Derivative

1. From the *MAGMAP* menu, select **Generalised Derivative**.
The *Generalised Derivative* dialog appears.



2. Use the *Browse* button to select the *Input grid* to filter.
3. Specify the *Output grid name* in the text box.
4. Specify the horizontal *Azimuth* angle, relative to East, in the counter clockwise direction.
5. Specify the vertical *Dip* angle along the normal to the positive Azimuth direction. When looking towards the positive

direction, the dip angle is specified on your right hand side, from the horizontal.

6. Use the *Derivative method* dropdown list to select either FFT (default) or Convolution method for generating the vertical derivative of the input grid.
7. Select *Retain derivative grids* to save the X,Y,Z derivative grids, which are created as a by-product of this process, when exiting the dialog.



For more information on this, or any of the parameters, click the **Help** button on the *Generalized Derivative dialog*.

Calculating Tilt Derivative

The Tilt Derivative is the generalized local phase. The Tilt angle of a residual magnetic field enhances weak magnetic anomalies, otherwise overshadowed by stronger structures. The calculated tilt angles are within the range -90° to $+90^\circ$ from the horizontal, irrespective of the amplitude or wavelength of the magnetic field. To obtain a good estimate of both the location and depth of magnetic sources, we recommended to apply the Tilt angle calculation to a pole reduced grid.

The approach assumes the source is a buried vertical contact model. The zero contours indicate the location of source edges and the half distance between the -45° and $+45^\circ$ contours provides an estimate of the depth to top of the buried contact.

The Tilt Derivative option calculates the tilt derivative of a grid and optionally, the total horizontal derivative of the tilt derivative grid. The tilt derivative and its total horizontal derivative are used for mapping shallow basement structures and mineral exploration targets.

The default Z-derivative method is FFT. However, for very large grids (over 4000 x 4000 cells), using the Convolution method saves a lot of processing memory and time.

The tilt derivative is defined as:

$$TDR = \tan^{-1} \left(\frac{VDR}{THDR} \right)$$

where VDR and THDR are the first vertical and total horizontal derivatives, respectively, of the total magnetic intensity T.

$$VDR = \frac{dT}{dz}$$

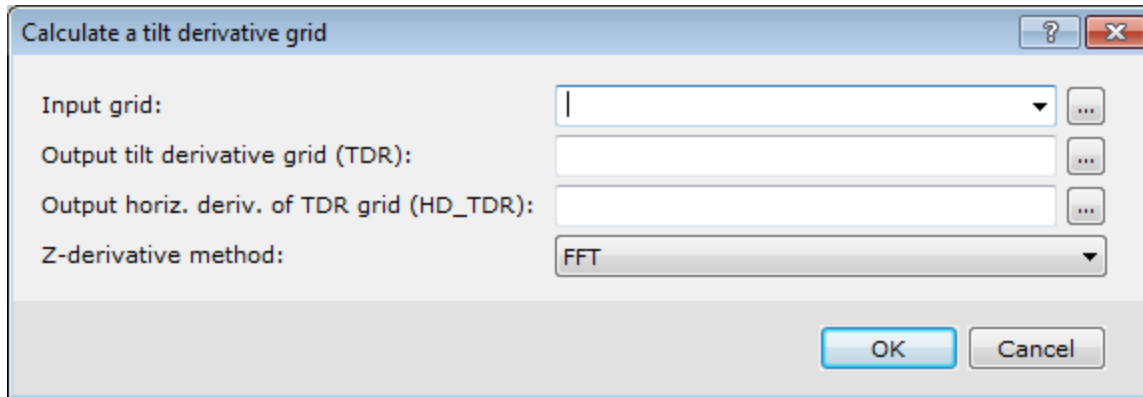
$$THDR = \sqrt{\left(\frac{dT}{dx} \right)^2 + \left(\frac{dT}{dy} \right)^2}$$

The total horizontal derivative of the tilt derivative is defined as:

$$HD_TDR = \sqrt{\left(\frac{dTDR}{dx} \right)^2 + \left(\frac{dTDR}{dy} \right)^2}$$

To Calculate Tilt Derivative for a Grid

1. From the *MAGMAP* menu, select **Tilt Derivative**.
The *Calculate a tilt derivative grid* dialog appears.



2. Use the *Browse* button to select the *Input grid*.
3. Specify the *Output tilt derivative grid (TDR)* name.
4. Optionally, to create the horizontal derivative grid of the tilt derivative grid, in the *Output horiz. deriv. of TDR grid (HD_TDR)* field, enter a new grid name. If you leave this field blank, the HD TDR grid will not be created.
5. Use the *Z-derivative method* dropdown list to select “*FFT*” (default) or “*Convolution*”.
6. Click **OK**. The tilt derivative grid (and, optionally, horizontal derivative grid) is created at the defined location, and is displayed in the workspace.

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