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MINCURV: minimum curvature gridding software

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Abstract

MINCURV GX provides a minimum curvature interpolation of randomly-spaced data or data acquired along lines. It is a Geosoft GX implementation of an original FORTRAN routine written by Régis Dumont (unpublished). The minimum curvature gridding method fits a minimum curvature surface to input data points following the method of Briggs (1974) and Swain (1976) and fits the smoothest possible surface to the data points. The output is a Geosoft GRD format grid.

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1. Introduction

MINCURV is a Geosoft GX implementation of minimum curvature gridding routine. The GX requires input data in Geosoft GDB format and produces a Geosoft GRD file.

2. MINCURV GX

The original software used in MINCURV was written as FORTRAN code by Régis Dumont (unpublished). A Geosoft GX implementation of the original code is presented here. The minimum curvature method fits the smoothest possible surface to the data points.. The method finds application with randomly distributed data or data sampled along parallel lines.

The basic requirement of a grid is that it defines a continuous function in x and y that takes the values of the observed points and that grid point values tend to observed point values when the observed point's position tends to the grid point position. The minimum curvature method generates grid values that approach, within a specified tolerance, the smoothest surface passing through, or honouring, the input data points.

Briggs (1974) notes that the cubic spline for the piece-wise polynomial fit of one dimensional data provides both control at observed points as well as optimum smoothness between observations. The smoothness and data point honouring of the spline fit can be achieved in one or two dimensions by solving the difference equations equivalent to a third-order spline. These equations describe the displacement of a thin sheet under the influence of point sources. Boundary conditions required include the observed data points as well as at the grid edges. This forces the solution of the equation to have observed point values at the observed point positions. Briggs (1974) develops difference equations for all seven possible boundary conditions: away from edges and observations, along edges and away from corners, one row from the edge, at the corners, next to the corners, and edges next to corners. The set of equations is solved iteratively. Assigning approximate values to the grid values U (I,J), a new set of U (I,J) is determined and recycled back into the equations. This procedure continues until the grid values at the observed data points are within a user-specified limit.

Swain (1976) introduced a scheme for reducing the number of iterations required by Briggs' difference equations to reach an acceptable solution. The solution of the difference equations is more efficient if the input points are located as close as possible to the specified grid point positions. The method involves the progressive reduction of the grid spacing by a factor of two, with an iterative solution computed for each spacing, and using the results of the previous interpolation to constrain the next.

The start of the procedure involves loading the input data into memory. The grid is represented as an N x M array (U (I,J)) and every Lth array element (where usually L=8 for the first stage and is halved for each subsequent stage) is given a weighted mean value using points within a user-specified search radius. Based on the input data, an iterative solution of Briggs difference equations for this grid spacing (L) is computed. L is reduced by a factor of 2 and the value determined for U(I,J) in the previous stage is assigned to the new grid values U(I+L,J), U(I,J+L), U(I+L,J+L), as well as the new U(I,J). A new iterative solution of the minimum curvature surface is found with only U(I,J) fixed. This new solution is based only on the control points and the computation converges more quickly because the input grid points are closer to the real solution than an arbitrary starting point. This procedure is repeated until L=1, giving the desired grid spacing. Convergence of the solution is tested by noting the largest change over all the U(I,J) that occurs in one iteration and a solution is considered acceptable when this change is less than a user specified threshold or grid tolerance value.

Minimum curvature gridding generates reasonable, 2D representations of the input data, providing the user-specified parameters have been properly chosen. The user-specified parameters are: grid cell size, blanking search radius, tolerance limit for grid adjustment, and the maximum number of iterations.

The optimum grid cell size for the purpose of interpretation of aeromagnetic surveys is generally accepted to be 1/4 to 1/5 the line spacing and is a compromise between under sampling and oversampling of the flight line data. A larger grid interval effectively filters out high frequency information along the flight line. A smaller grid interval, while preserving high frequency information, will tend to produce isolated anomalies that should be continuous across flight lines.

The blanking search radius is the maximum distance a grid value can be from a real observation point without being set to a null value. It is usually chosen to be three times the flight line spacing. If the blanking radius is too large, the grid will contain values not supported by the original data. An insufficient blanking radius will tend to blank out grid cells that don't contain an observed data point, defeating the purpose of gridding the data points.

The tolerance limit for grid adjustment controls how closely the final grid will honour the input data points. The tolerance value should be related to the accuracy of the input data. Data should not be gridded to a tolerance less than the measurement accuracy of those data. For modern, high resolution aeromagnetic data, a tolerance limit 0.01 nT is reasonable. For ground-based gravity data, a tolerance limit of 0.1 mgal is typically used. An excessively smooth grid will result if too high a threshold is chosen.

The minimum curvature routine will iterate until a percentage of the input data points are within the tolerance limit or the maximum number of iterations is reached.

2.1. Input Parameters

MINCURV presents the dialogue box in Figure 1 for the input of gridding parameters:

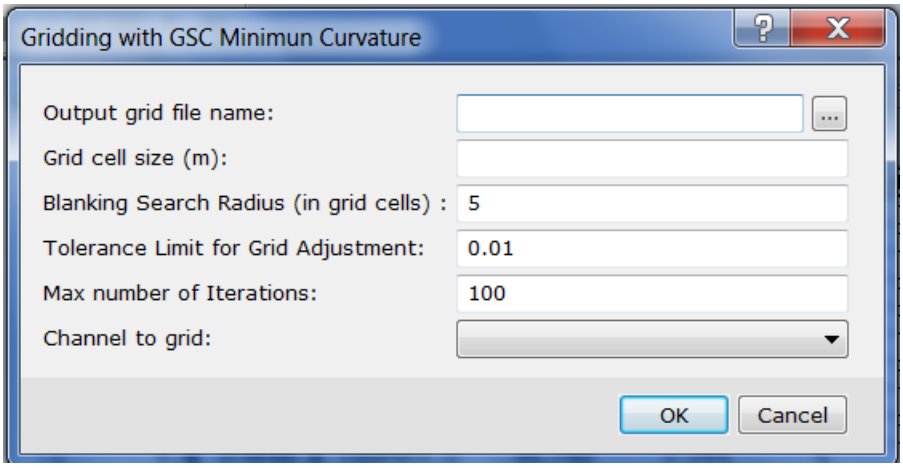

Figure 1. Input parameter dialogue box.

The input parameters are:

Output grid file:

Specify the name of the output grid file.

Grid cell size (m):

Specify the grid cell size. This is typically 1/4 to 1/5 the nominal survey line spacing.

Blanking Search Radius (in grid cells):

The blanking search radius is the maximum distance a grid value can be from a real observation point without being set to a null value. It is usually chosen to be three times the flight line spacing. If the blanking radius is too large, the grid will contain values not supported by the original data. An insufficient blanking radius will tend to blank out grid cells that don't contain an observed data point, defeating the purpose of gridding the data points.

Tolerance Limit for Grid Adjustment:

The tolerance limit for grid adjustment controls how closely the final grid will honour the input data points. The tolerance value should be related to the accuracy of the input data. Data should not be gridded to a tolerance less than the measurement accuracy of those data. Typically, for a modern, high resolution aeromagnetic data, the tolerance limit should be 0.01 nT. An excessively smooth grid will result if too high a threshold is chosen.

Max number of Iterations:

The minimum curvature routine will iterate until a percentage of the input data points are within the tolerance limit or the maximum number of iterations is reached. Most datasets will converge to the tolerance limit in fewer than 300 iterations.

Channel to grid:

Specify the database channel to be interpolated to a regular grid.

3. Gridding Example - Figure 2 shows the flight path of the western half of an aeromagnetic survey flown over the Amittok area, Nunavut.

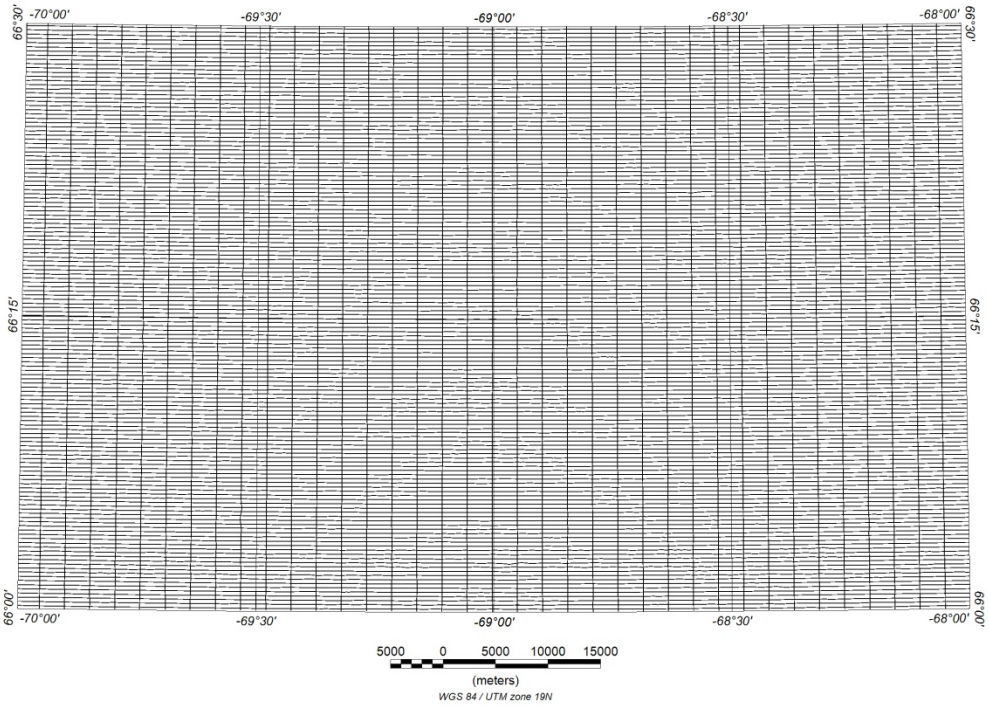

Figure 2. Flight path of the western Amittok, NU, aeromagnetic survey (Kiss and Tschirhart, 2015).

The magnetic data used in the gridding example were acquired in 2015 on a drape surface with a nominal terrain clearance of 150 m (Kiss and Tschirhart, 2015 a,b). These data were used as input to MINCURV GX. The traverse line spacing was 400 m and the control line spacing was 2400 m. The data were gridded to a 100 m interval using MINCURV GX. The area shown in Figure 3 consists of 908 by 562 grid cells. The following parameters were used:

Output grid file: Amittok_RTF.grd

Grid cell size (m): 100

Blanking Search Radius (in grid cells): 12

Tolerance Limit for Grid Adjustment: 0.01

Max number of Iterations: 100

Channel to grid: SRVMGRES

Figure 3 displays the gridded data and represents the residual total magnetic field over the example area.

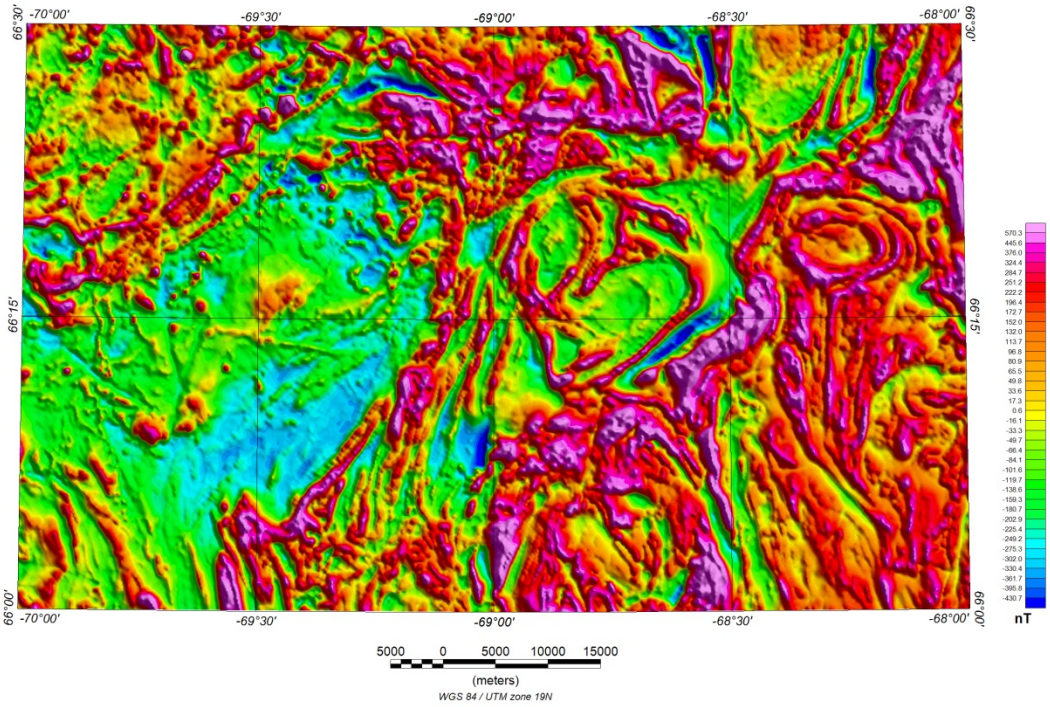

Figure 3. Residual total magnetic field of example area.

4. Conclusion

MINCURV GX interpolates random or data acquired along lines to minimum curvature surface. The GX implementation is straightforward and easy to use. It allows the user to input aeromagnetic data in a widely-used, industry standard format (Geosoft GDB). There are a limited number of variable input parameters that allowing the user grid data appropriately.

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