

## Edge Detection with HGM, AS, LWN & TiltD using USGS GX's in Oasis Montaj

This is a short, step-by-step, guide to using some of the edge detection techniques in the USGS (Phillips, 2007) extensions for Oasis Montaj in combination with Surfer. In each case, when the window for entering the file name and other information opens, there is access to a help file which you should read. For these applications, at a minimum, it is best to first remove the mean value of the data or a least squares, best-fit plane (Grid < polynomial). Ideally, you will have a processed and filtered grid with anomalies at the characteristic wavelength of interest that you wish to interpret.

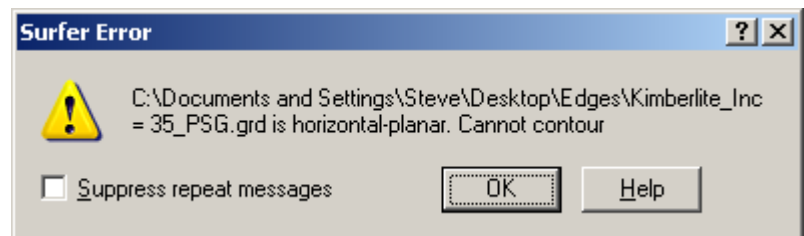
Preliminary steps include calculating the pseudogravity and reduction to pole transforms. Note that all of the techniques are implemented during the Local Wavenumber calculation so you can avoid the independent calculations for AS and HGM. I list them here one-by-one to match my sequence in the lecture.

### PREPARATION: USGSV/Grid Fourier Filtering/All in one/

#### Pseudogravity Transformation (PSG)

Fill in the appropriate values, including interpretable grid names and types. For “ratio of magnetization to density” try 2700 ( $\text{kg/m}^3$ )/A/m). Typically assume no remanent magnetization.

Note that sometimes when trying to contour results in Surfer, Surfer comes up with the **error message** to the right. I don't know why, but looking at such a grid in Oasis Montaj first seems to solve the problem.



#### Reduction to the Pole Transformation (RTP)

Fill in the appropriate values and file names typically assuming no remanent magnetization.

#### Horizontal Gradient Method – apply to pseudogravity or RTP results

USGSV/Grid Spatial Filtering/Horizontal Gradient – fill in the blank file names.

The horizontal gradient method (HGM) is that of Blakely and Simpson (1986) as implemented in the USGS software (Phillips, 2007). Your data have to be transformed to pseudogravity, or reduced to pole (RTP), to use this method. If you intend to use them for depth estimates and you are looking for edges of thin horizontal sheets (say in a thrust terrane) use HGM on the pseudogravity transformation. If you are looking for edges of vertical contacts with large depth extent, use RTP. Either way, HGM is good for horizontal locations of edges.

#### Analytic Signal method (aka Total Gradient) – apply directly to TMI, RTP, or PSG.

USGSV/Grid Fourier Filtering/All in one/Total Gradient & Gradient Components – also produces HGM.

The analytic signal (Roest et al. 1992) can be applied directly to your total field anomaly; those data do not need to be reduced to pole or made into pseudogravity. when applied to the observed total field anomaly, the analytic signal method generally produces good horizontal locations for contacts and layer edges independent of dip and inclination. The analytic signal depends on the first derivative of the vertical component of the magnetic field as well as the horizontal derivatives so is thus more susceptible

to noise than the horizontal gradient method. When used for depth estimates, it should be applied to the pseudogravity or RTP dependent on assumed source types.

**Local Wavenumber method – apply directly to TMI, RTP, or PSG; yields all three (HGM, AS, LWN)**

USGSV/Grid Fourier Filtering/All in one/Local Wavenumber & Gradient Components (& AS, HGM).

Thurston and Smith (1997) invented the local wavenumber method. Like the analytic signal, this can be applied directly to the total field anomaly. Also like the analytic signal, the local wavenumber method has high order derivatives of the anomalous field (second derivative in the vertical) so is susceptible to noise.

**Tilt Derivative (TiltD) is explained well in Verduzco et al. (2004).**

You can calculate TiltD using the dz and HGM results from the previous calculations in Oasis. When you have the components (dz, HGM) use them in Surfer's Grid Math tool. There, in Grid Math, the calculation is:

- Grid A = dz.grd
- Grid B = HGM.grd
- Grid C = atan(A/B) – give it a reasonable name (e.g. TiltD.grd)

Total Field Anomaly

Pseudogravity

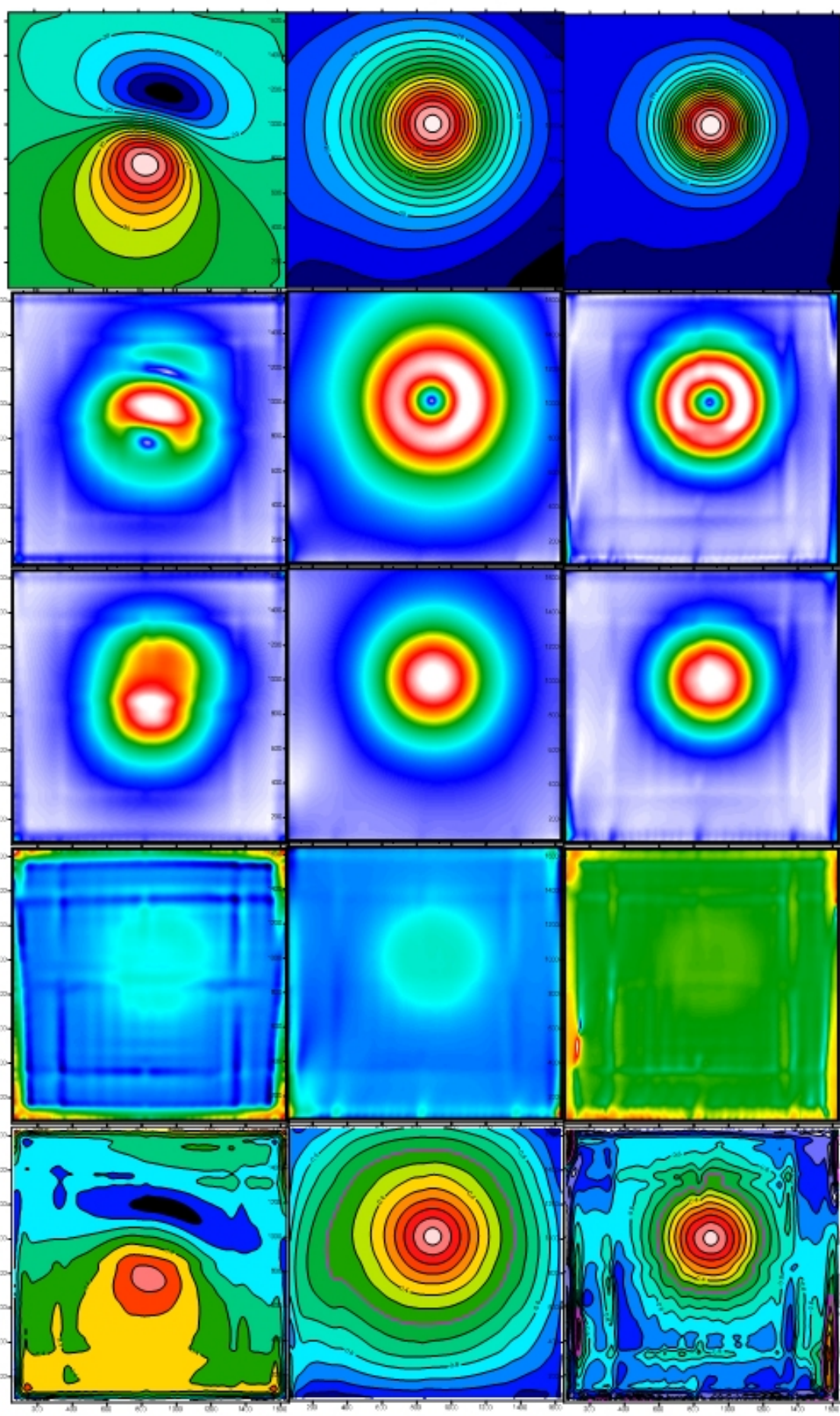
RTP

HGM

AS

LWN

TiTD



## Plotting the Maxima of any of the Above Edge Detection Grids.

### USGSV/Grid Interpretation/Grid Extrema from Curvature Analysis

This yields an image of a worksheet like database page with the file extension .gdb and 10 columns.

Now: **Database/Export/as GEOSOFTE .xyz**

Here: **Export it** as *Filename.dat* and Surfer will see it and like it. Open it in a Surfer worksheet, delete the top three lines, and supply header information for the columns from the information at the bottom of this page.

If you don't export this now, you can get it back later with:

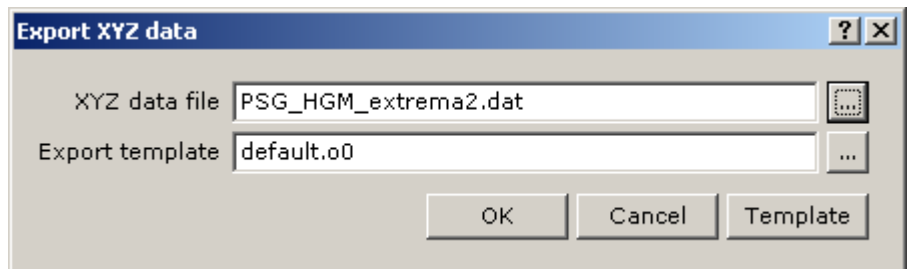
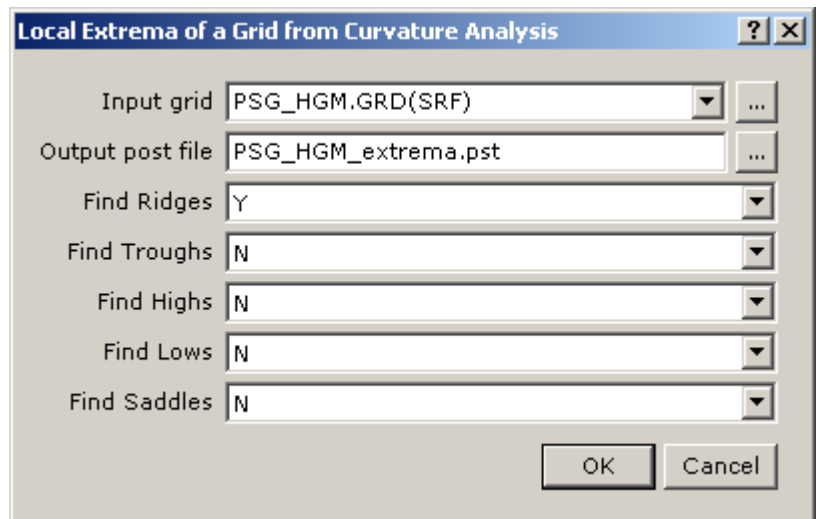
USGSV/Database Utilities/OPEN USGS Post File into a sized database and return to the above instructions.

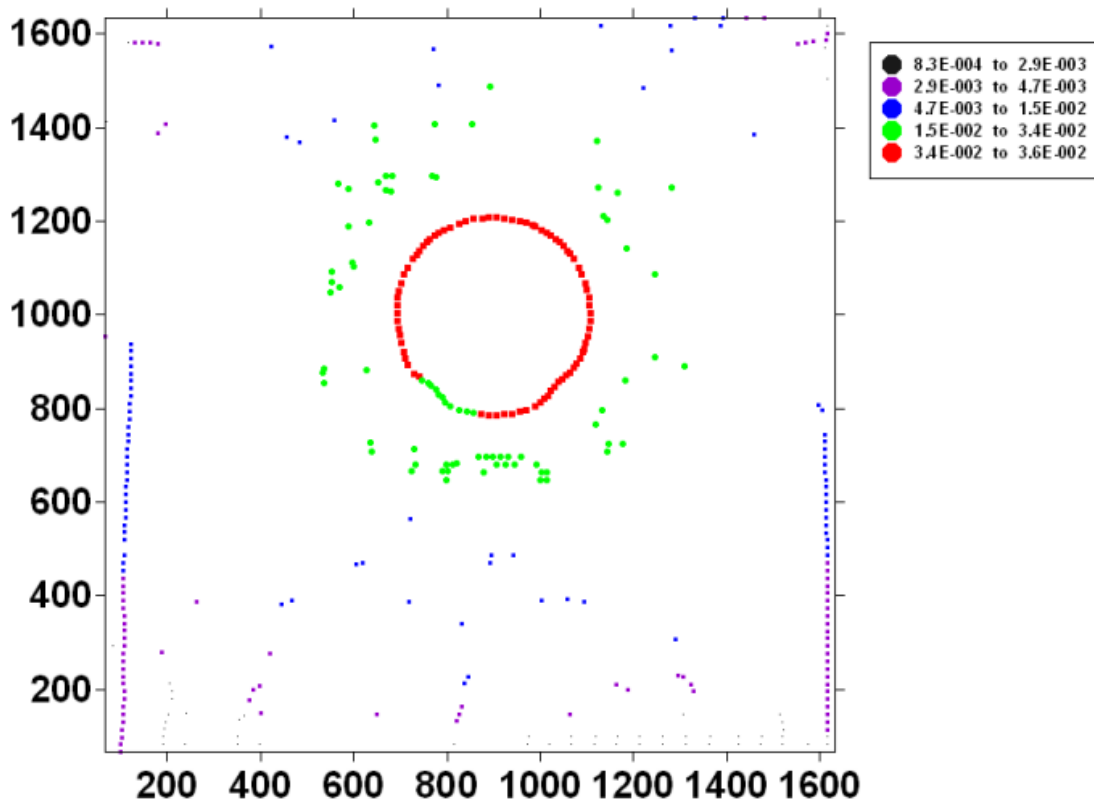
This is what is in the columns:

The output post file and database have the following channels:

id		type of feature (ridge, high, etc)
x		x(east)-coordinate of solution
y		y(north)-coordinate of solution
z1	g(x,y)	grid value at the solution as estimated from the quadratic surface
z2	elong	elongation factor of the feature from the ratio of the two eigenvalues
z3	strike	degrees clockwise from north
z4	e1	first eigenvalue of the curvature matrix
z5	e2	second eigenvalue of the curvature matrix
z6	type	integer value indicating type of feature (ridge=1, trough=2, etc)

Now you can make POST MAPS in Surfer, or CLASSED POST MAPS, and look at the maxima of the edge detection method you calculated the extrema for. Typically use the upper 40 – 60% of the values, often omitting the greatest values.





Maxima of the horizontal gradient. using the upper 40% would yield pretty good edge detection for this example. The result could be overlain on a Surfer image or contour map. If there are point-source or other high amplitude anomalies which dominate the contour map, the upper several percent of the maxima can be deleted by sorting and deleting in a Surfer worksheet.

## References:

Blakely, R. J., and Simpson, R. W., 1986, Approximating edges of source bodies from magnetic or gravity anomalies. *Geophysics* 51, 1494–1498.

Phillips, J.D., 1997, Potential- field geophysical software for the PC, version 2.2: U.S. Geological Survey Open-File Report 97-725, 34p. (online at <ftp://greenwood.cr.usgs.gov/pub/openfilereports/ofr-97-0725/pfofr.htm>).

Phillips, J.D., 1998, Processing and Interpretation of Aeromagnetic Data for the Santa Cruz Basin—Patagonia Mountains Area, South-Central Arizona, USGS Open File Report 02-98. Available online at: <http://geopubs.wr.usgs.gov/open-file/of02-98/>

Phillips, J. D., 2000, Locating magnetic contacts: a comparison of the horizontal gradient, analytic signal, and local wavenumber methods: Society of Exploration Geophysicists, Expanded Abstracts, 2000 Technical Program, 1, 402–405. Online: [ftp://ftpext.usgs.gov/pub/cr/co/denver/musette/pub/outside\\_pubs/jeff/Phillips\\_SEG2000.pdf](ftp://ftpext.usgs.gov/pub/cr/co/denver/musette/pub/outside_pubs/jeff/Phillips_SEG2000.pdf)

Roest, W. R., Verhoef, J., and Pilkington, M., 1992, Magnetic interpretation using the 3-D analytic signal: *Geophysics* 57, 116–125.

Thurston, J.B., and Smith, R.S., 1997, Automatic conversion of magnetic data to depth, dip, and susceptibility contrast using the SPI (TM) method: *Geophysics*, v.62, no.3, p.807-813.

Verduzco, B., Fairhead, D., and C. MacKenzie, 2004, New Insights into Magnetic Derivatives for Structural Mapping, SEG's The Leading Edge, February 2004, p. 116-119.