3-D Euler

Tests Using Simple Boxes

By: John Bain

Bain Geophysical Services, Inc.

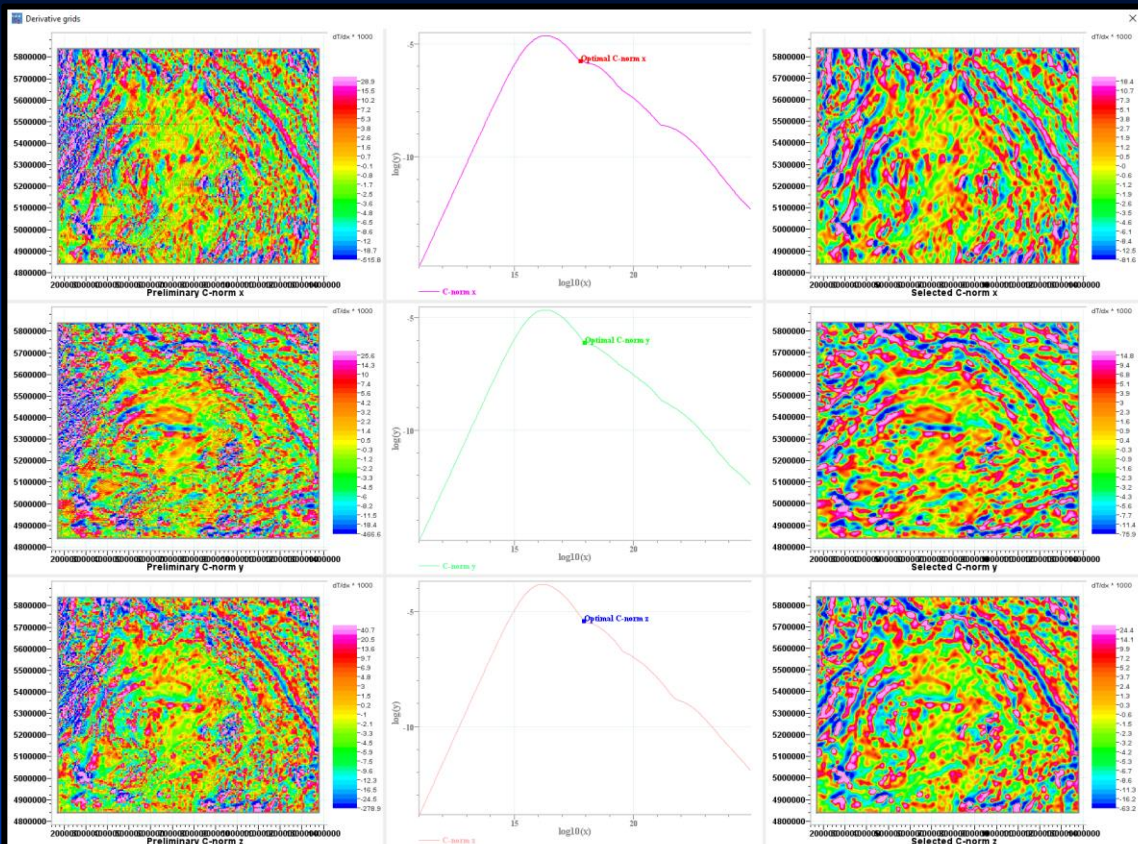
I wish to express my kind thanks for the original input, numerous conversations, guidance and wisdom from Professor Roman Pašteka to assist me in my understanding his and his colleague's great work on Euler Deconvolution. Primary references are provided below.

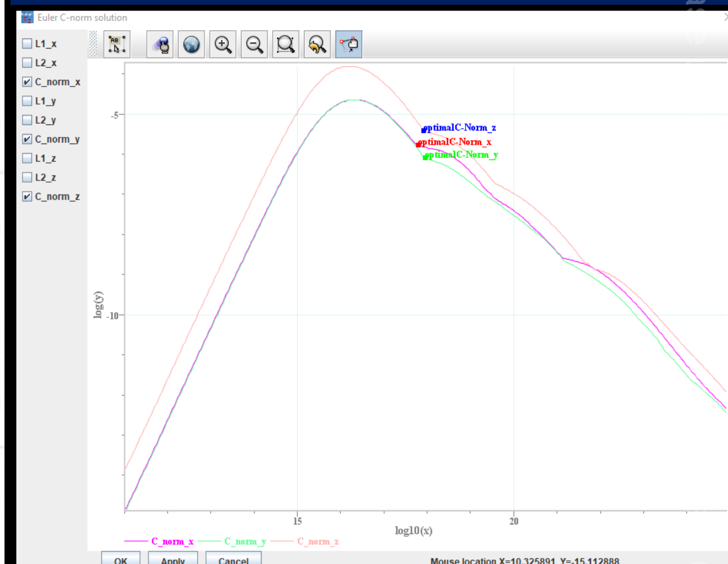
References:

Pašteka, Richter, Karcol, Brazda, Hajach, "Regularized derivatives of potential fields and their role in semi-automated interpretation methods", in *Geophysical Prospecting*, 2009, 57, 507-517.

Roman Pašteka and and David Kušnirák, "Role of Euler Deconvolution in Near Surface Gravity and Magnetic Applications", Chapter 9, in *Advances in Modeling and Interpretation in Near Surface Geophysics, Springer Geophysics*

Use of C-Norms to Derive "Regularized" Derivatives

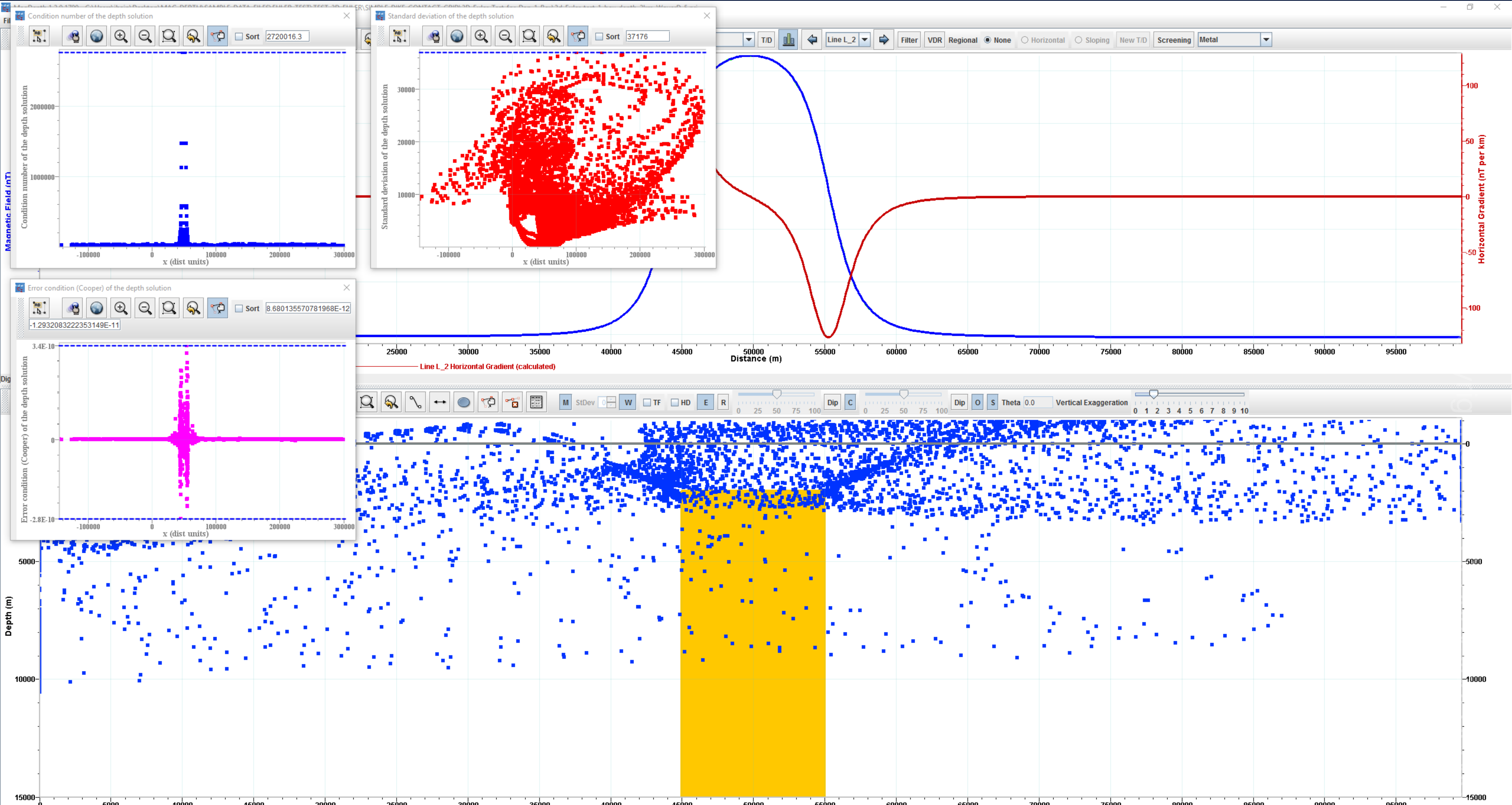




A method after Pašteka (2009, 2020) is implemented within MagDepth™ to compute both 2-D and 3-D Euler depth solutions. The main difference between Pašteka's method versus conventional Euler is the step of improving the derivative computations using a "regularization" approach. In the display on the left, the first column of grids shows the original derivative grids using 0 for the C-norm optimization parameters (this is the technique most other approaches use). The C-norms are computed for each of the X, Y and Z derivatives, and a single profile of the log of the C-norm is plotted, as shown in the middle column (combined on right). The user then selects the optimal C-norm point along this profile, which is generally regarded to be the first local minimum directly after the large maximum, as shown for each C-norm profile. These optimal C-norm points are then used to derive the regularized derivative grids shown in the right column.

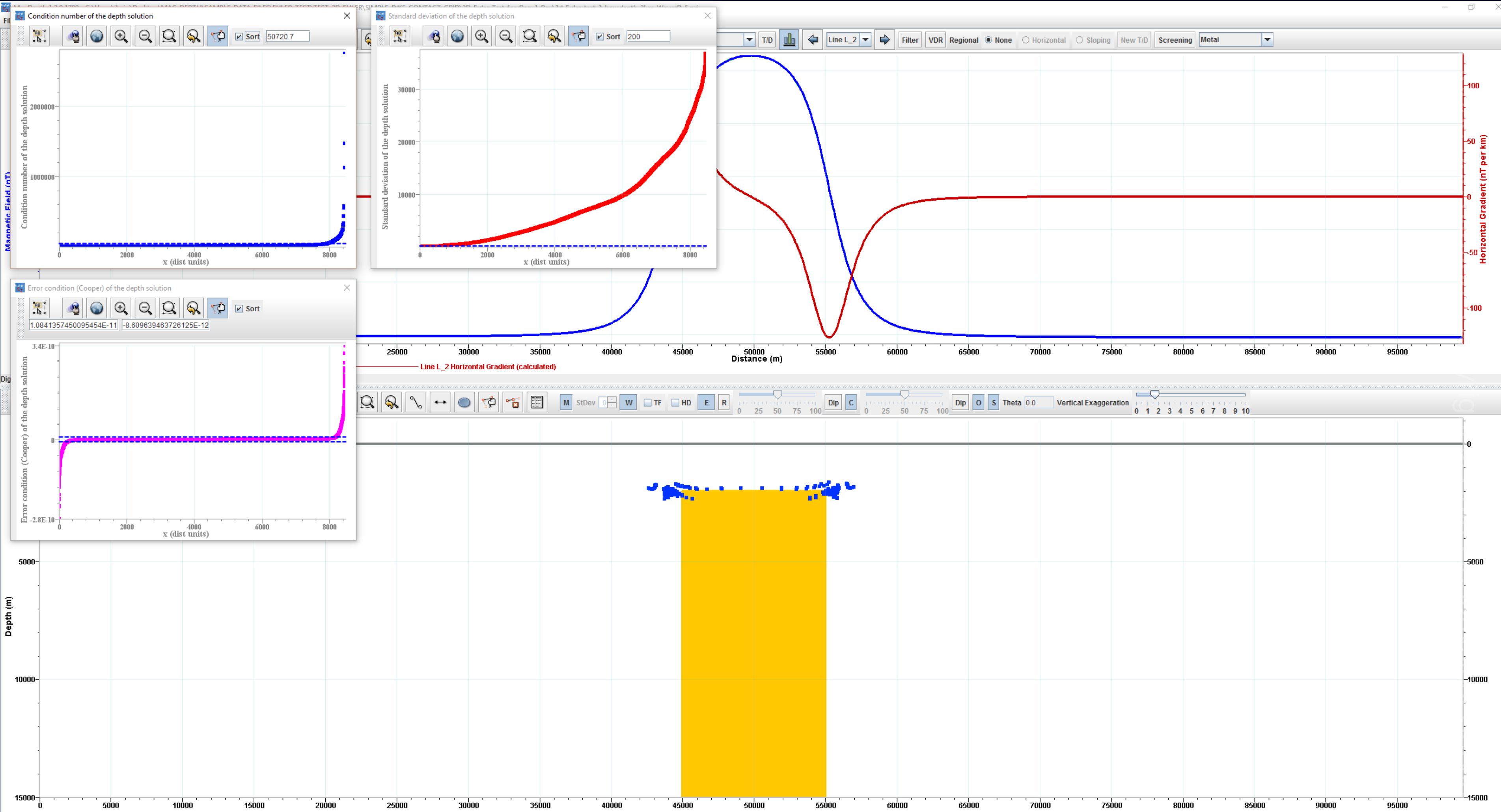
This method has been demonstrated to be significantly better than typical 2-D and 3-D Euler approaches.

Screening Euler Solutions Using Error Conditions



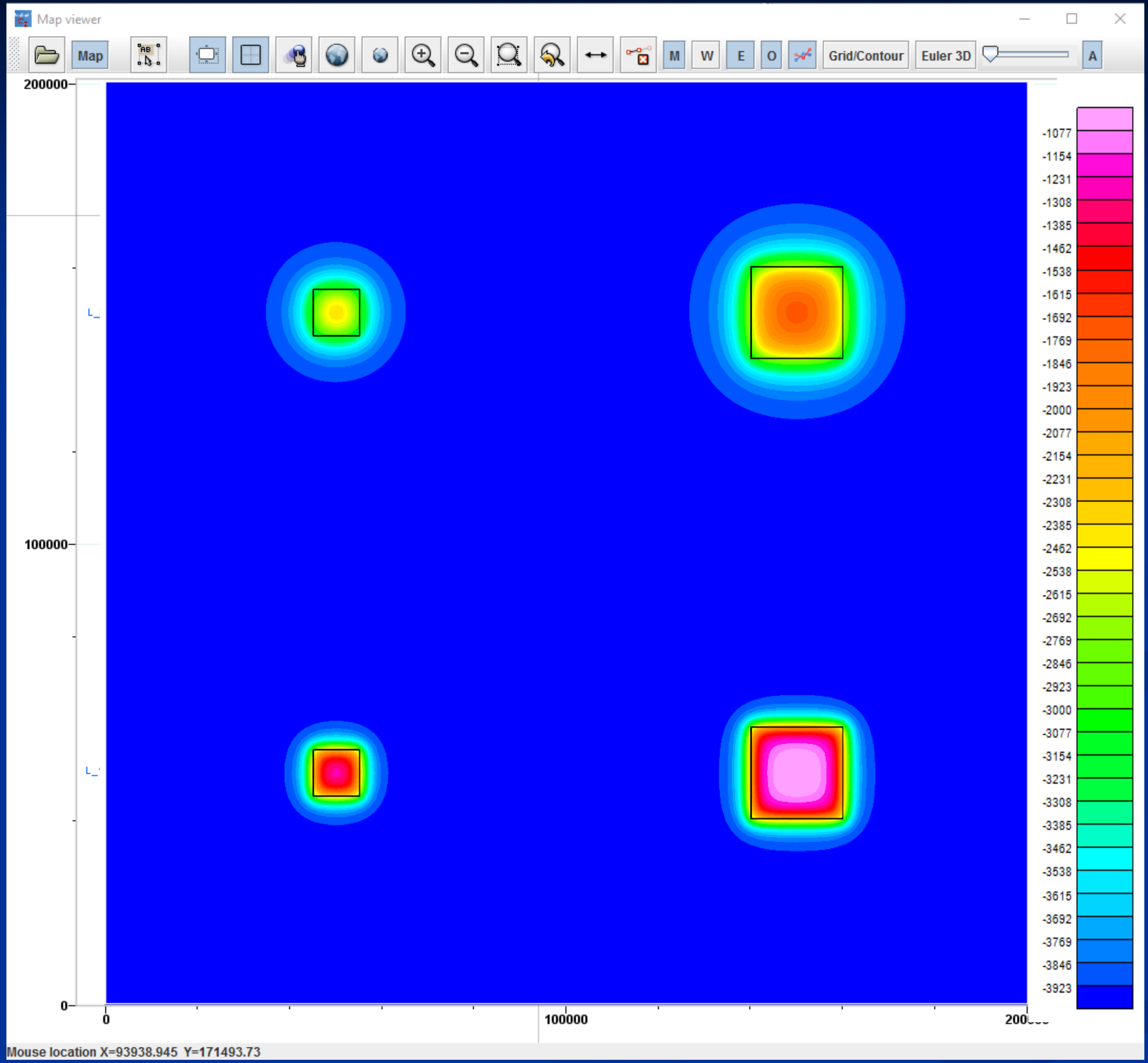
Above shows a simple vertical dike, with a large number of Euler points computed – one point for each moving window. The Euler approach involves over-determined equations, thus allowing an estimate of the depth error to be made. Various measures of the computed depth errors are shown in the 3 companion boxes above left. The upper left box shows the "condition number" – a measure of the quality of the inversion. The upper right shows the standard deviation of the estimates around the mean. The lower left is Cooper's error condition (see Pašteka, et al.). The chaotic nature of these clouds can be improved by using a simple sort, shown on the next slide.

Screening Euler Solutions Using Error Conditions



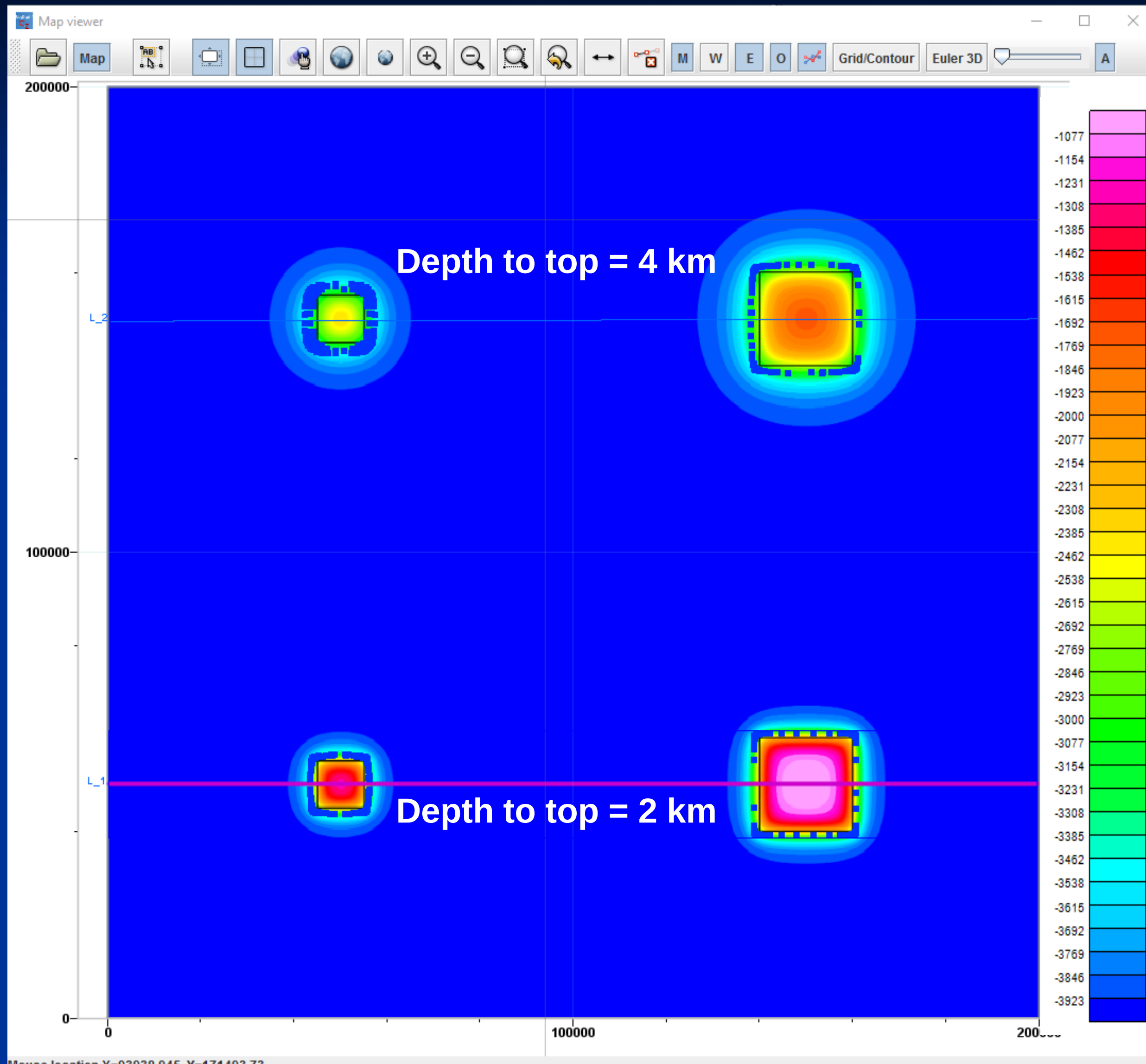
By sorting each error measure, we can easily select areas of coherence to a trend. The blue slider bars are used to "clip" solutions outside of the designated error ranges. This leaves the above solution sets, which agree very well with the depth to top and edges of the anomalous body.

Map Display in MagDepth



Display in MagDepth showing the magnetic field using a linear color bar, with black polygons around the causative sources.

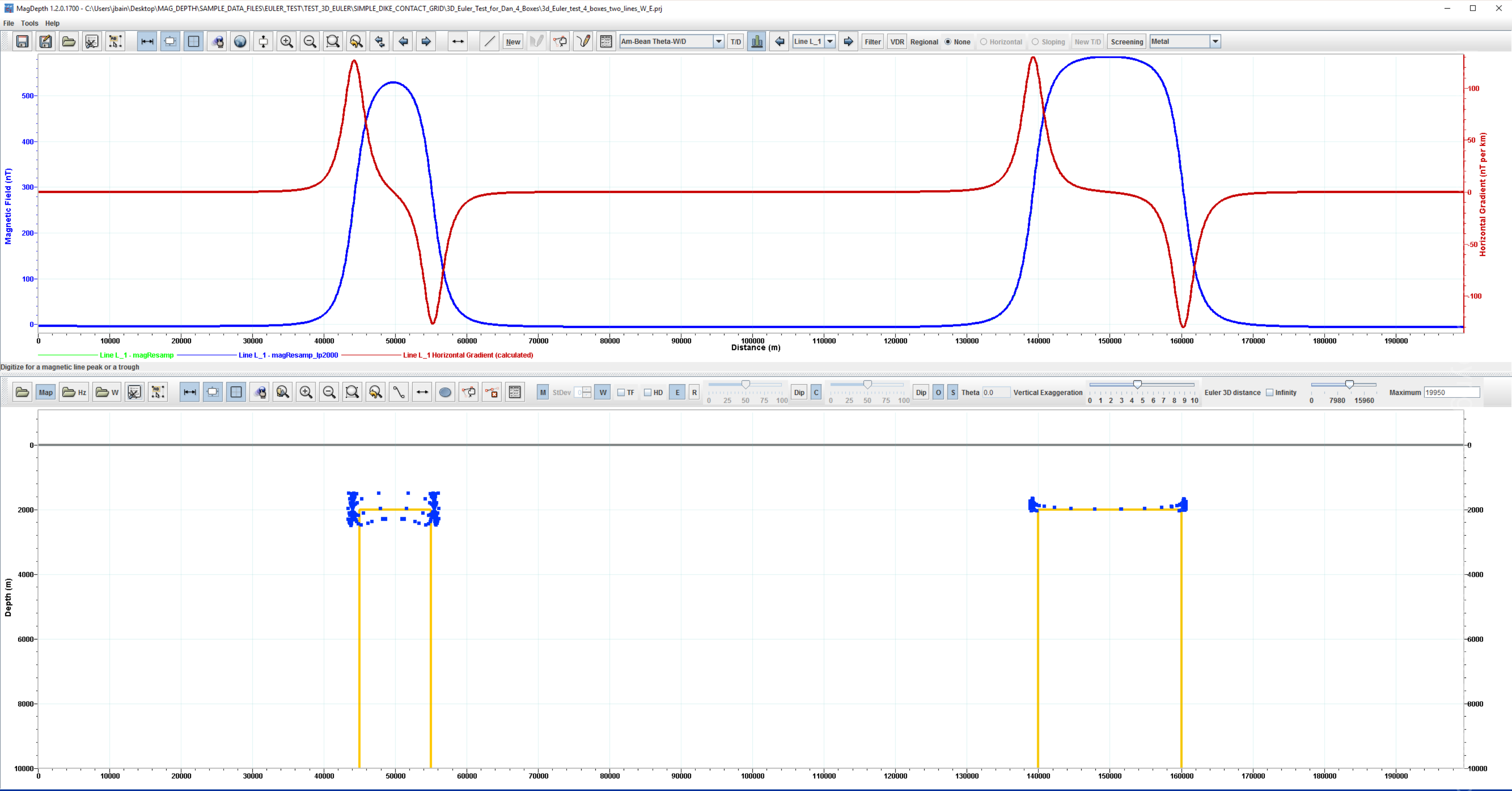
Map Display in MagDepth



3-D Euler solutions are shown by the blue boxes, which nicely outline the causative sources.
Two lines were selected to display solutions in cross section - the lower line is highlighted and is shown on the next slide.

BAIN GEOPHYSICAL SERVICES, INC.

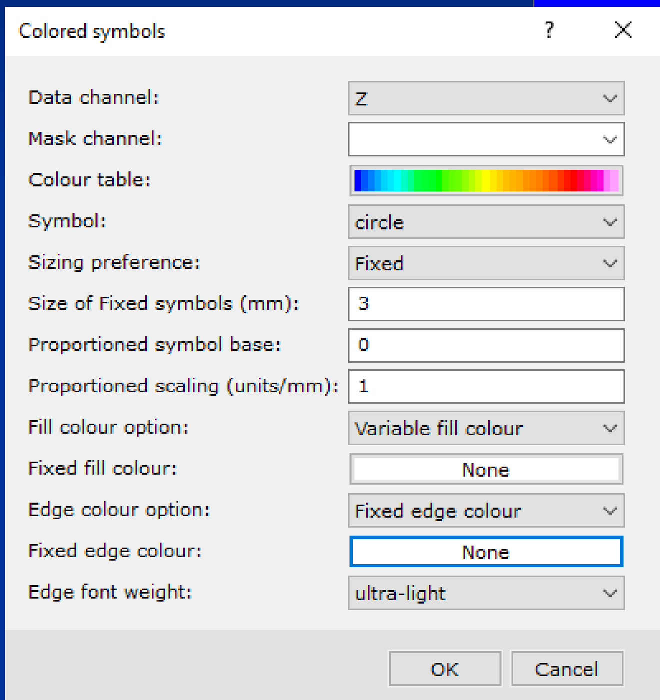
3-D Euler Deconvolution – Solution Results

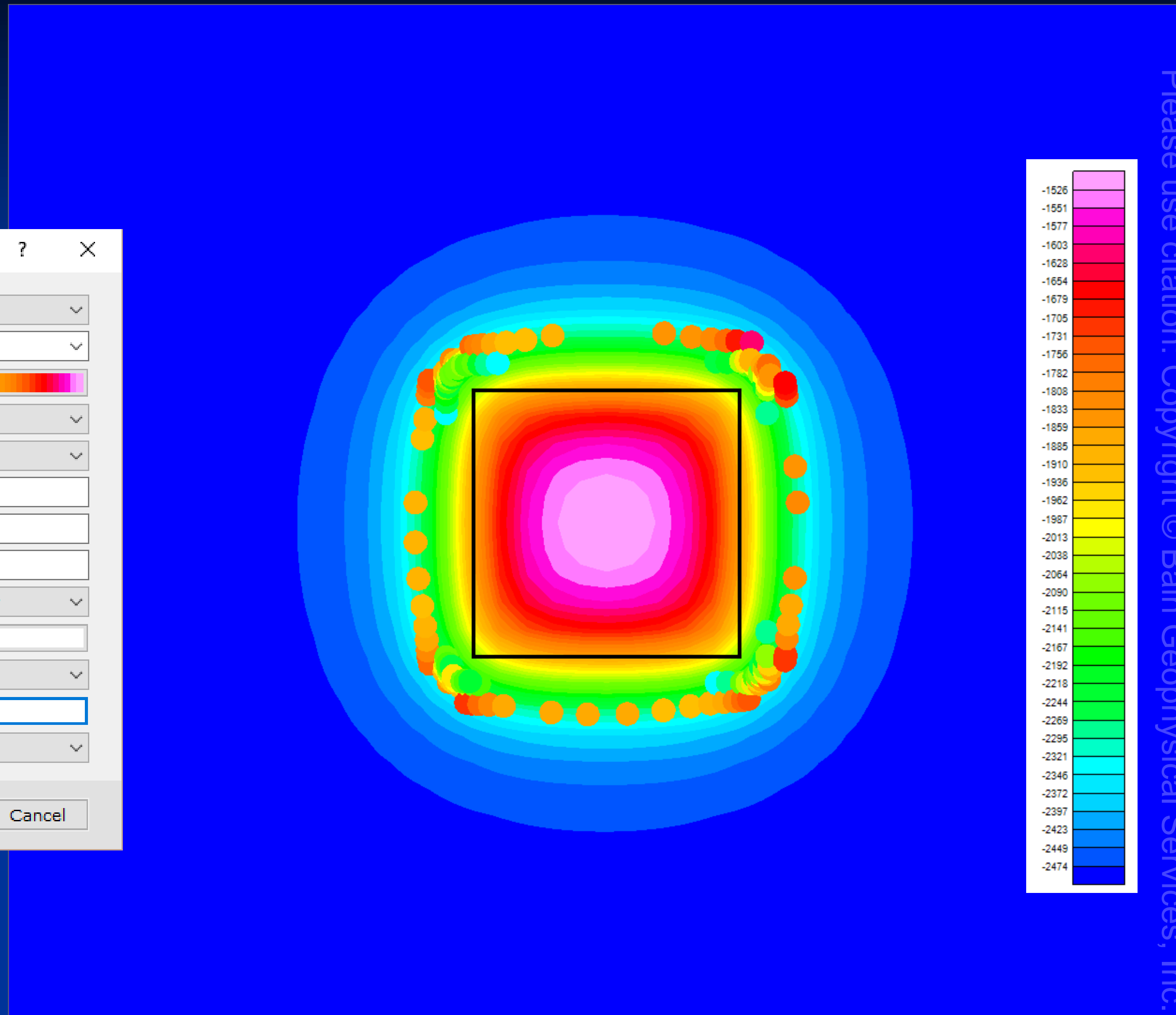


West (left) to east line shown through the 2 km deep bodies on the south of the previous map. Here, we are showing contact solutions with a structural index (SI) of 0.5. The body on the left has a width to depth ratio (W/D) of 5, while the body on the right has a W/D = 10. A rough rule of thumb is that a "dike" is typically defined as a W/D of 2 or less, but oftentimes 1 or less. So we should anticipate that contact solutions would work reasonably well for both bodies, but less so with the thinner body on the left, as expressed by the scatter of the depth solutions.

BAIN GEO
BAIN GEOPHYSICAL SERVICES, INC.

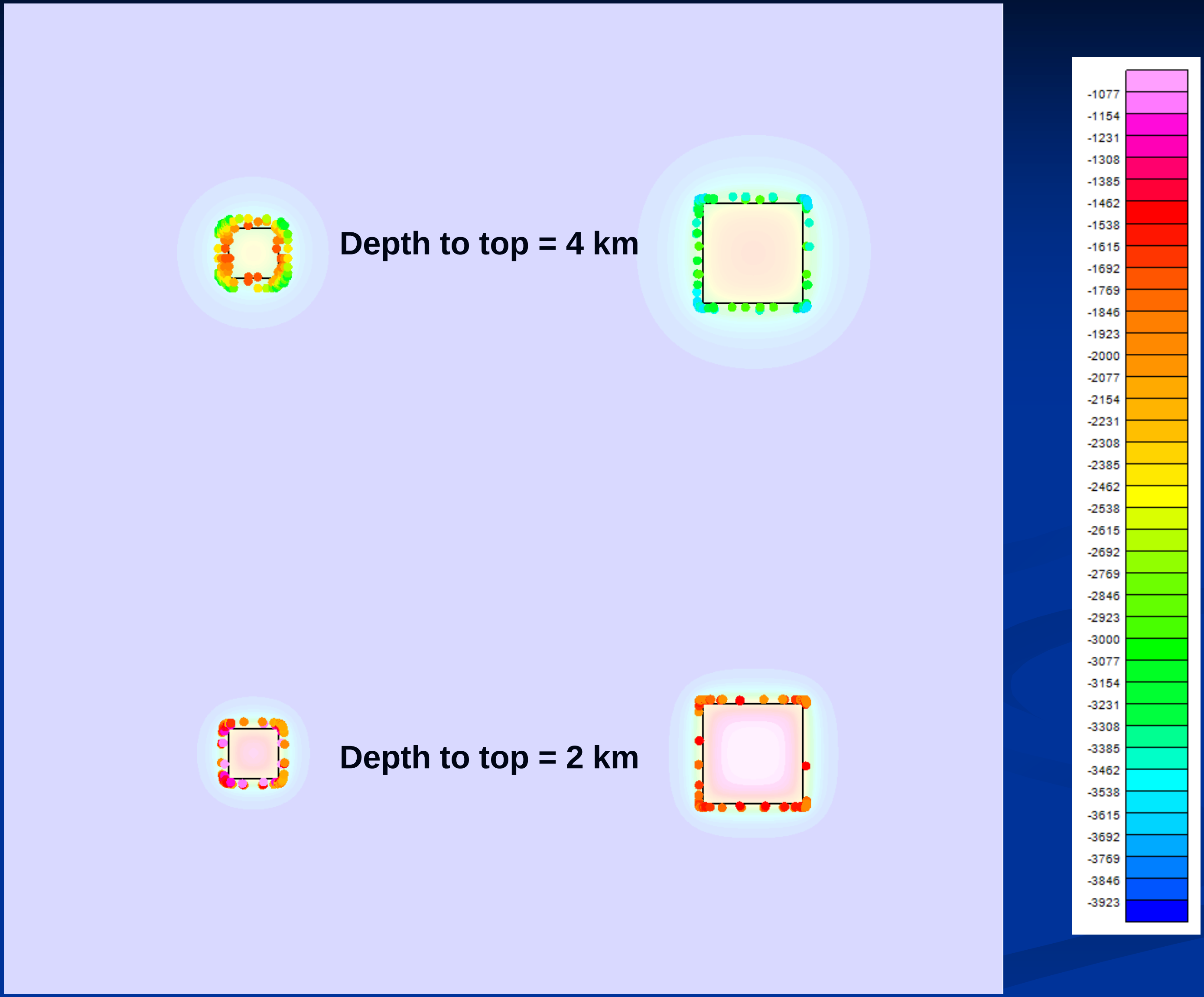
Color-Filled Symbols to Illustrate Depth





Display in Geosoft using the Symbol Zone Coloring option, showing the depth points as circles, colored with their depth. Notice the excellent clustering around the actual depth of -2000 m (orange). The option to change "Sizing preference" allows the symbols to be sized based on their depth value, which can also be useful. However, this is not as critical as color filled symbols.

Color-Filled Symbols to Illustrate Depth



Display in Geosoft using the Symbol Zone Coloring option, showing the depth points as circles, colored with their depth. The bottom two boxes are at a depth of 2 km. The top two boxes are at a depth of 4 km. Left set has width/depth (W/D) = 5 (W = 10 km and D = 2 km), while the right set has W/D = 4 (W = 20 km and D = 5 km). Reasonable depths and edges are obtained with this improved 3-D Euler approach (after Pašteka et. al.).