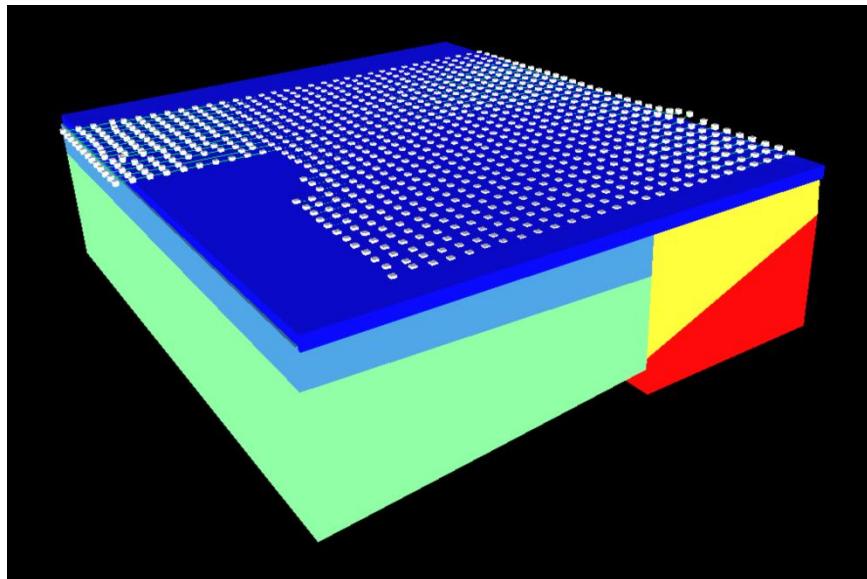


## EMIGMA for Gravity

**EMIGMA for Gravity** license is a comprehensive package that offers a wide array of processing, visualization and interpretation tools. The package includes a license for QCTool for processing and basic mapping as well as a license for EMIGMA for quantitative interpretation. The Premium product allows for processing and interpretation of ground, borehole, airborne and marine data.



## QCTool

QCTool is a comprehensive processing and data analyses tool for many types of data including gravity data. Gravity data can be imported into QCTool using various formats including:

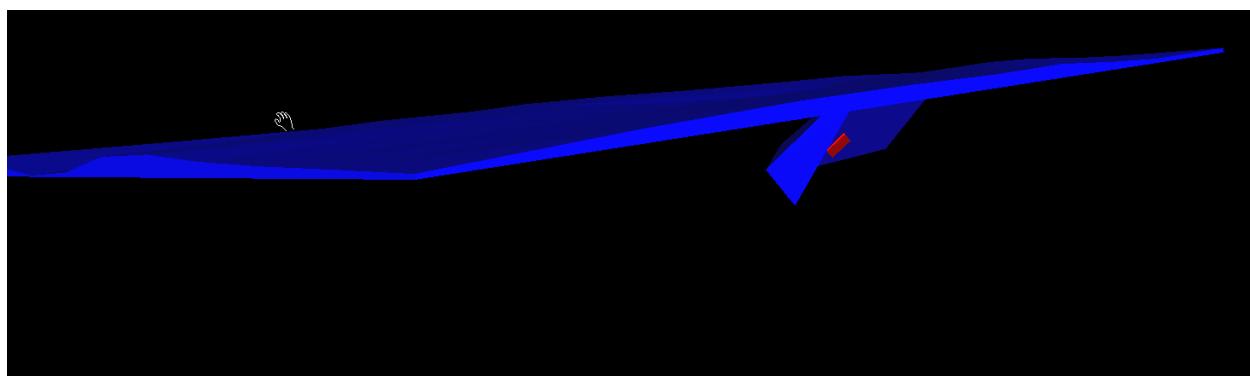
- ASCII formats (.xyz, .txt, .dat, .csv and .asc)
- Geosoft GDB and Grid (.grd) formats
- Scintrex's CG-3/CG-5/CG-G formats
- Micro-g LaCoste Air-Sea formats (.DAT, .ENV)

Then data may be corrected and merged from different survey days to perform the necessary basic and advanced gravity corrections allow the generation of maps.

Following data import, the user can perform the following basic corrections in QCTool:

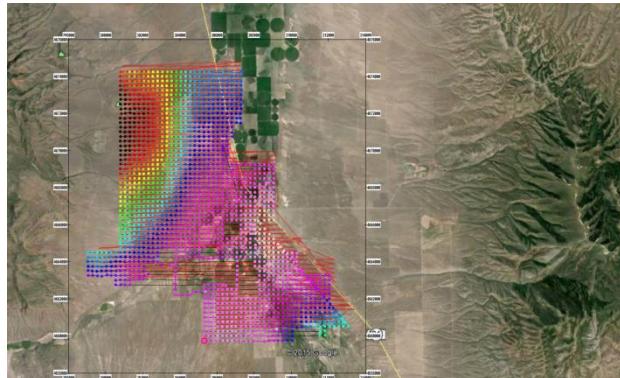
- Drift corrections
- Tidal Corrections
- Latitude correction
- Free-Air correction
- Bouguer correction
- Eotvos correction
- Isostatic correction
- Bathymetry correction
- Data averaging ( simple or bootstrap techniques)
- Correction for absolute gravity measurements
- Terrain correction (feature) supports:
  - Import SRTM grids – 1 arc-sec or approximately (30m) (EarthExplorer is suitable site)
  - Import of regional DEM from the USGS ( 1km grids)
  - Import of higher density DEM grids such as U.S. state grids, Canadian topographic grids, Mexican state grids, Australian grids, Japanese grids
  - Local (terrain) correction option for small grids from surveyed GPS data
  - Traditional use of survey information for local terrain corrections
  - User-specified topographic file formats. Please [email us](#) for more info.

Our topographic corrections utilize the most modern techniques. The topography is not modeled as a series of rectilinear cells with constant height as it is done in some other commercial applications. Rather, the topography grids are used to produce a continuous 3D topographic surface consisting of tetrahedral cells. The gravity contribution of each cell with a curved upper surface is then computed by an accurate integration routine. Common commercial applications represent the gravity effect by first using a rectilinear grid cell with a flat top as mentioned above but then simply compute the gravity effect by assuming that the integrated geometric effect is equal to the volume times the geometric effect at the centre of the prism. For large cells or for measurement positions on the topography, this can often produce considerable errors.



## **EMIGMA**

Relational Database application allowing multiple data sets and associated processes, models and inversions. All Maps and Grids are linked to the database and loaded automatically in the various apps within EMIGMA.



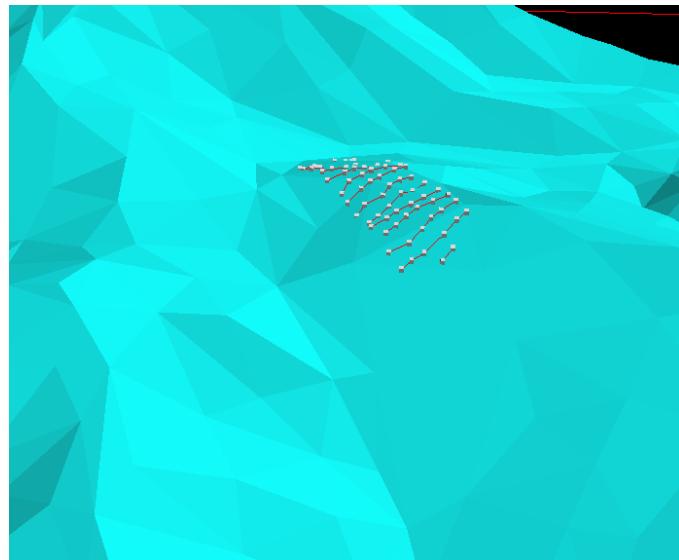
The processed and merged data for the entire survey are imported into EMIGMA from the QCTool file with relative ease. Once in EMIGMA, the user can harness the true power of the software by taking advantage of its advanced gridding and modeling features as well as state-of-the-art inversion techniques as well as some features not generally available for potential field software.

Gridding and interpolation of geophysical data is very important not only for map creation for analyses, but also for generating grids for FFT processing and Euler depth processing. EMIGMA has some important and not common features for gridding. First, and most important, is that grid cells need not be square but rectangular with user-selected aspect ratio. This is very important in today's world as data is often collected in very high density along the profile/survey line direction with a much larger distance between lines. To take advantage of this high density along the line, the grid should be orientated so that one grid direction is along the survey line direction and the grid size is appropriately small for the inline data sampling. Secondly, when collecting geophysical data, we wish to focus on local differences in the data. Thus, a local region interpolation technique is appropriate and not a technique which essentially uses global basis functions (splines) such as the Minimum Curvature technique.

The gridding features of EMIGMA include the automatic but selectable creation of a grid suitable for FFT processing and again allows for finer grid size in the profile direction to enable the user to maintain the high resolution when entering into processing. The FFT tools include the use of a sophisticated Tukey tapered filter and advanced processing routines such as first, second and arbitrary higher-order derivatives calculation, upward/downward continuation with derivatives and wave number/wave length filtering. All FFT-processing routines allow the generation of associated derivatives. FFT- processed grids may be

used to remove filtered data from the original data such as removing low wave number or upward continued grids. EMIGMA allows the generation of any derivative you might desire.

Furthermore, EMIGMA also offers enhanced modeling capabilities that facilitate importing of topography files as well as simple and complex polyhedra files from CAD or AutoCAD modeling as well as synthetic 2D/3D model generation features. Models can be exported to .dxf (AutoCAD), .asc (Vulcan) and .str (Surpac) formats for easy integration with other modeling software. Similarly, maps can be saved in GeoTIFF, DXF (AutoCAD) and KML (Google) formats from measured and processed data. Map import from these formats is also supported.

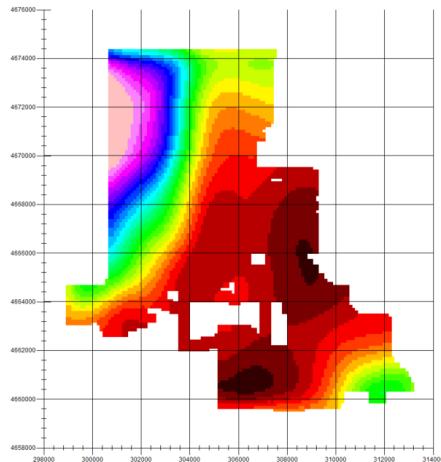


Another key feature of the package is the Forward Simulation (often referred to as 'forward modeling') capability which offers robust algorithms to simulate the gravity response. Two algorithms are provided, one utilizing the traditional Numerical Integration method and the much faster and more accurate Analytic method, which solves the problem without numerical integration. The Numerical approach integrates over the anomaly and is simply provided as a means to check the Analytic option (for troubleshooting purposes).

However, EMIGMA's 3D inversion is by far, the most powerful feature of the package. The inversion methods allow the user to invert not only the measured data but also the processed FFT-data (including first- and second-order derivatives) as well as measured derivatives (airborne). Three algorithms are provided. All techniques allow rectilinear cells with user-chosen dimensions, arbitrary grid azimuth, and varying cell thicknesses with depth.

*Linear Fast CG (Matrix)* – Utilizes a linear, physical operator based Conjugate Gradient technique, which divides the grid into cells and limits the number of data points and (grid) cells for fast processing

*Linear CG (slow)* – Uses the linear Conjugate Gradient technique to find a solution for larger data sets and larger number of grid cells without any limitation on the number of data points or the number of cells while still utilizing a matrix operator from first principles

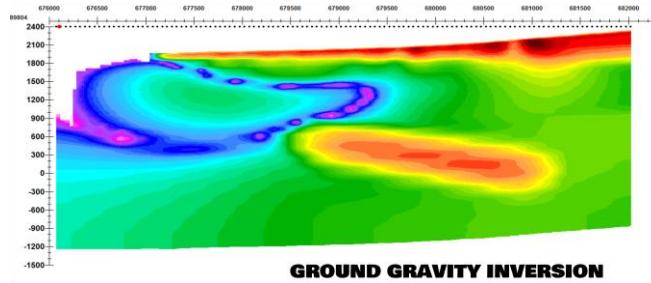


**Gzz Upward Continued 1km**

*Non-linear CG* – Starts with an initial model and then finds the best fitting model using a line search method. The given function is minimized using an iterative process, which is a more traditional approach for geophysics.

The method does not invert the physical operator, but rather performs a search through model space.

While non-uniqueness in potential field inversions is inherent, the first two methods, 'Linear Fast CG' and 'Linear CG' provide a more reliable solution due to the inversion of a physical operator matrix combined with the use of density constraints. Thus, they are more suited to find a global minimum as compared to the traditional search through model space. Also, as the user is allowed to choose a starting model and smoothing parameters, it is quite easy to study the characteristics of the inverse solution. This constrained approach is a state-of-the-art technique offered with our EMIGMA for Gravity package or with any of our licenses, which include the gravity option. Other comparable 3D inversion software packages utilize the 'Non-linear CG' technique, which has been found to be ineffective due to its gradient search approach. Furthermore, this approach is a bit out-of-date as it does not take full advantage of the advances in computing power and memory size enhancements over the last decade.



Additionally, the inversion features also provide useful tools in order to constrain the inversion:

- i) Geological Structures - Users may import or define structures by including drill log information or surface density distribution details by specifying the position, density and radius of the objects, which can be saved and imported later, as needed
- ii) Inversion Settings Log – Settings such as density constraints, topographic information, search volume settings, type of method, etc can also be saved as a log file and then imported later for subsequent runs
- iii) Preliminary Models – Supports utilization of preliminary forward models (normally based on geological knowledge) as a starting model
- iv) Coarse Grid - Ability to use a coarse inversion grid as a starting model for a more refined inversion model
- v) Study of structures within topography – This is particularly important in mountainous environments but also for airborne and marine studies. In EMIGMA, one may end the corrections at free air and then import the data with the elevation information. Then, the variation in topography is imported and the topographic structure becomes part of the model. In this way, structure within a mountain can be accurately studied.

EMIGMA for Gravity is now also available as part of EMIGMA Premium Complete, as a standalone product or as an add-on to other EMIGMA Premium packages.

**Comprehensive Software for a very economical price!**

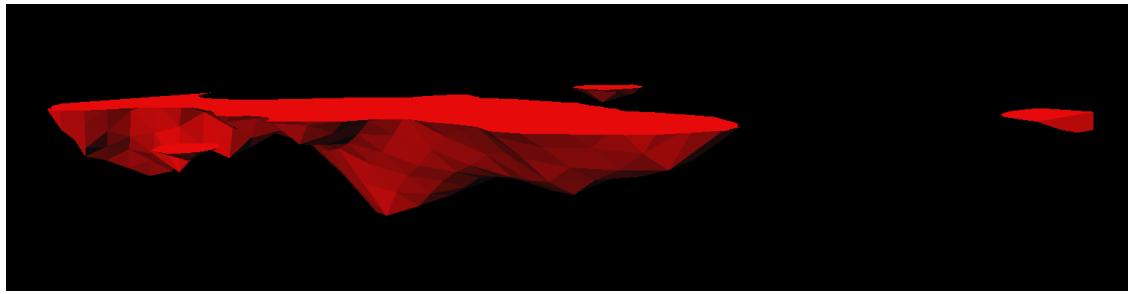
**Unlimited number of survey data points**

**Suitable for Ground, Airborne, Marine and Borehole data!**

**Extensive built-in support through 'Help Topics' and 'Tutorials'**

**User-friendly and intuitive interface!**

**On-Line training !**



## Data Import

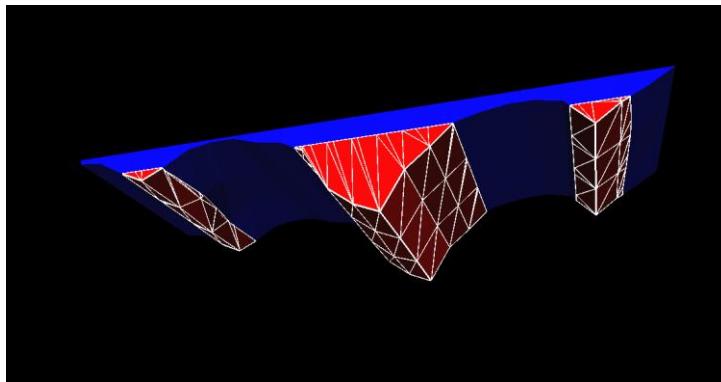
- ASCII format (.xyz, .txt), including full tensor gradients
- Instrument formats (manufacturer specified)
- QCTool format (.qct)
- Geosoft grid file (.grd)
- Additional ASCII support (.xyz, .txt, .csv) for borehole gravity

## Data Processing

- Basic corrections through QCTool:  
Drift, latitude, free-air, Bouguer,  
terrain/topography , tidal  
Eötvös correction  
Isostatic correction  
Bathymetry – **NEW!**  
Gradient removal
- FFT -processing tools include:
- DFT processing – reduce artifacts, increase accuracy – **NEW!**
- FFT/DFT -processing tools include:
  - Grid tapering
    - Wavelength/wave number filtering
    - Upward/downward continuation
    - Derivative calculation
    - Grid differences
    - Spectral analyses and filtering
- 1D, 2D spatial digital filters
- Survey Editor (2D-viewer for editing or planning surveys)

## Data Display and Analyses

- Rectangular grid cells – enhance map resolution
- Gridding with 4 algorithms: Natural Neighbor, Delaunay Triangulation, Minimum Curvature and Thin-Plate-Splines
- 2D Grid/Map displays
  - Displays gridded data including Analytic Signal and Horizontal Analytic Signal derivatives
  - Supports export to raster and Georeferenced formats including KML and DXF
- 3D contour display
  - Displays gridded data as a smooth 3D surface
  - Export to raster and 2D/3D vector formats supported
- Line Plots and data Residual Plots (2D Plotter). The most sophisticated geophysical plotting tool available.



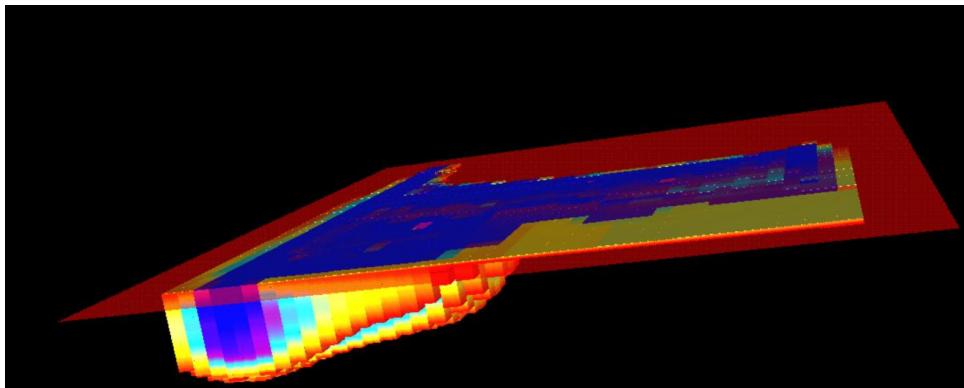
- 3D Visualization
  - 3D model building and visualization with associated measured and simulated data
  - 3D visualization of 3D inversions and Euler solutions
  - Inversion slicing and exporting of slices

## Gradients/Components

- Derivation of FFT/DFT gradients
- Leveling with vertical gradients
- Enhanced contouring with horizontal gradients
- Modeling of gradients
- Inversion using gradients
- Model and Invert component data

## 3D Modeling

- 3D Visualizer
- Modeling of large data sets
- Geophysical model building tool in 3D space
  - Unlimited prism and polyhedra targets
  - Import of polyhedron objects using DXF (AutoCAD), ASC (Vulcan), TRI (Surface Mesh) formats as well as Poly (.xyz) and QCTool grid (.egr) formats
  - Easy export to DXF, ASC and STR (Surpac) formats
- Fast and accurate 3D simulations using:
  - Advanced algorithms
  - Model suite generation options
  - Batch Mode simulation and 'Noise Range' features
  - Models with density properties attached to database
- Topography effects
  - Supports import and modeling of topographic files in ASCII column XYZ and QCTool grid (.egr) formats, thus allowing for non-uniform density effects of topography

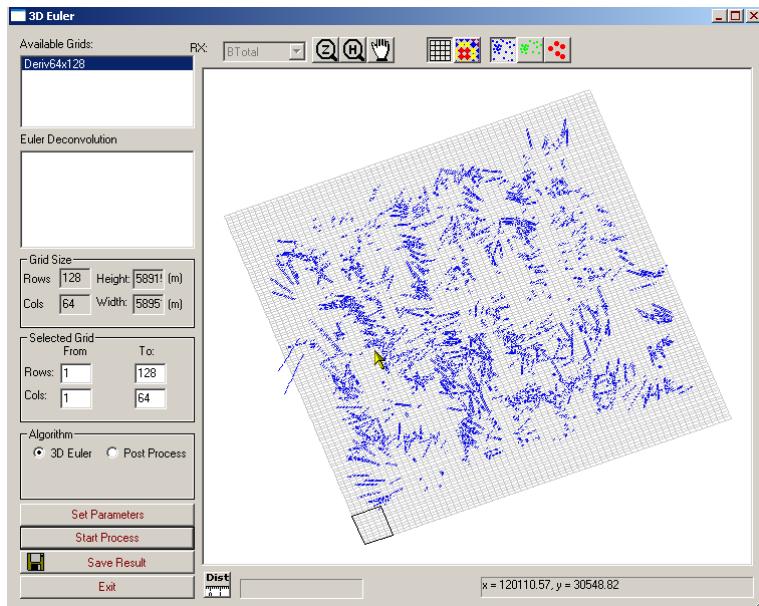


## 3D Gravity Inversion

- Improved constrained inversion techniques employing both measured and processed derivatives
- Sensitivity to geology and topography effects
- Post-inversion removal of grid cells **NEW FEATURE**
- User-defined search settings and 'Save settings' features for subsequent model enhancements
- Post editing of inversion grids
- Export as voxel file

## 3D Euler Deconvolution

- 3D Extended Euler solutions for profile and gridded data (FFT-derived derivatives or measured derivatives may be used)
- Post-processing with 2D and 3D visualization



## Mapping

- Export/Import of ArcMap, MapInfo and Gesoft map files
- Underlays, transparencies
- Contours, contour lines