

## Magnetotelluric and EM interpretation software

**Geotools™** is a modern, interactive platform for the analysis of magnetotelluric (MT) and time-domain electromagnetic (TDEM) data, featuring 1D, 2D and 3D inversion modeling.

**Geotools** encourages explorers to view and manipulate multiple data types, allowing ancillary information to be integrated into MT data analysis.

### Key features

Integrated:

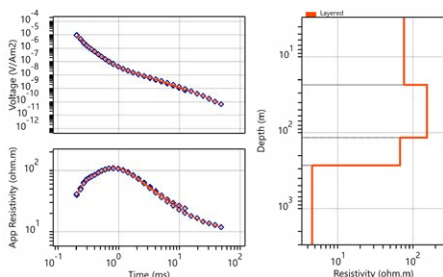
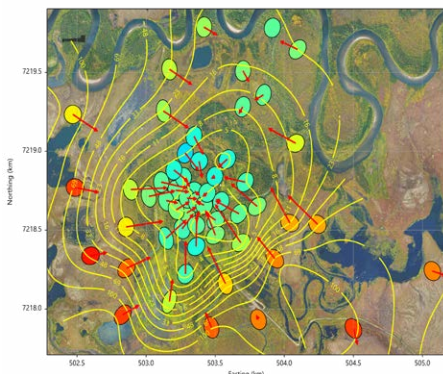
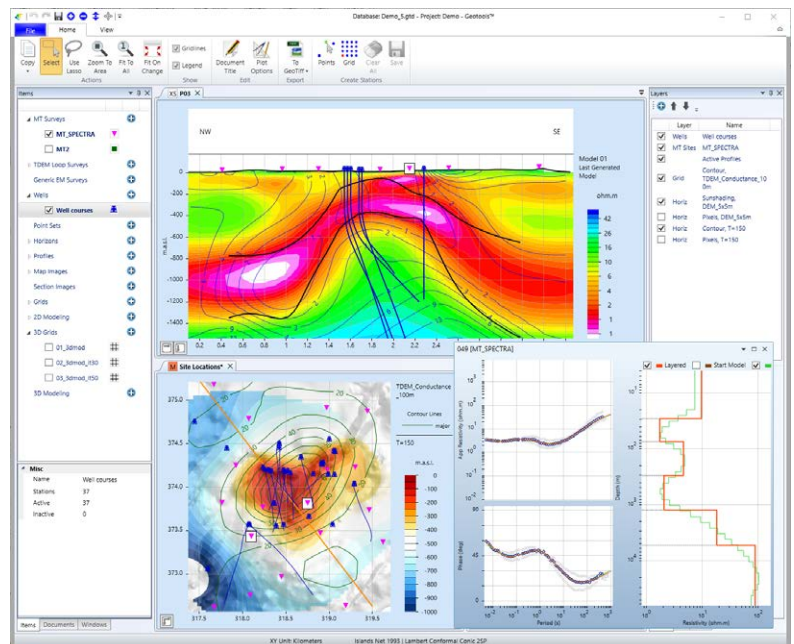
- Import of MT and TDEM data, 1D and 3D models, 2D grids, point and line features, georeferenced images and well traces
- 3D MT inversion setup to run on the CGG Cloud, with user-friendly I/O and progress monitoring
- Multi-property 2D and 3D models, with property calculation functions

Fast:

- Multi-threaded inversion modeling, real-time in 1D and 2D

Convenient:

- Designed to run on Windows OS
- I/O compatibility with standard formats such as EDI and USF soundings



### Data analysis and 1D modeling

Sounding plots, maps and cross-sections of data and models.

#### MT

- Supports single and multi-site soundings, full and partial tensor
- Apparent resistivity, phase, tipper, azimuth, induction arrows, polar diagrams and phase tensor plots
- Multi-dataset concept (observed, 1D/2D/3D synthetic)
- Rotation, masking, static shift correction, re-sampling, Rho+ fit
- Interactive real-time 1D forward and inverse modeling for discrete layer models
- Non-linear, smooth, multi-layer 1D inversions

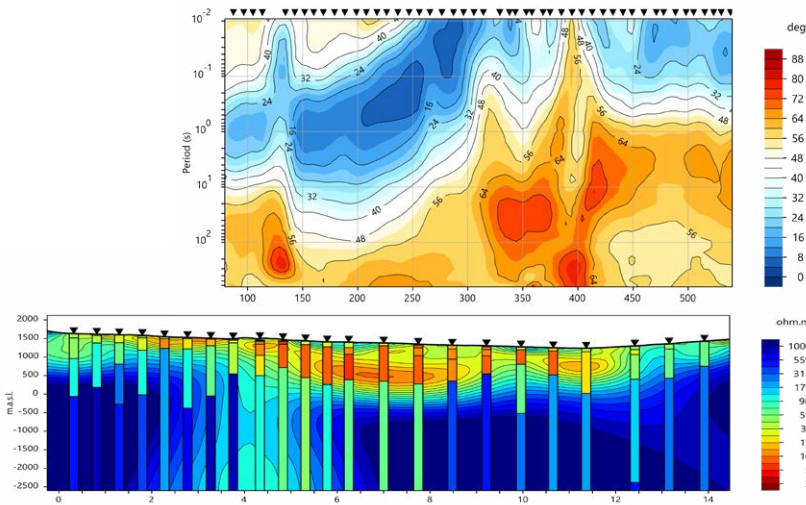
#### TDEM

- Central and coincident loop configurations
- Multiple sweeps and repetition rates supported
- Interactive, real time 1D forward and inverse modeling for discrete layer models
- Joint inversion of multiple sweeps at different repetition rates
- Display of pseudo-MT curve derived from co-located TDEM sites for simple MT statics estimation

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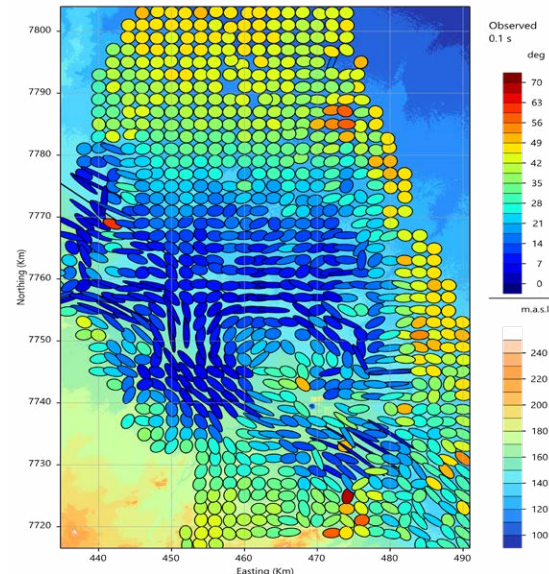
## Advanced display capabilities

- User-selected multi-property overlays (maps, sections) allowing quick, customized comparisons
- Interactive views with immediate update of all linked data across all open documents: all data- and model-based display layers are updated real-time upon source modification
- Extraction of slices or fences from 3D models in map and cross-section
- Pixel, contoured and sun-shaded layers with variable transparency
- High quality vector graphics output

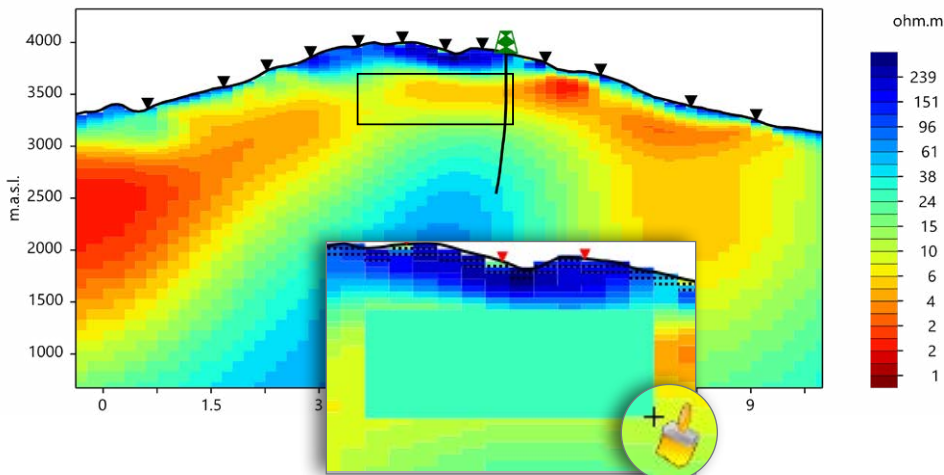


## MT 2D real-time inversion modeling

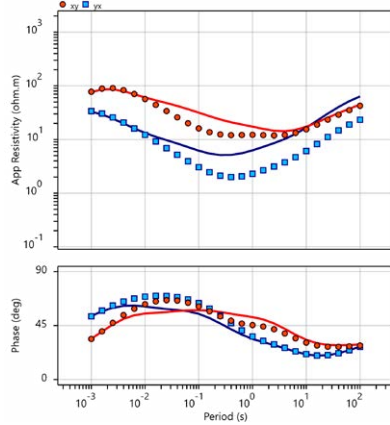
- Multi-threaded 2D smooth inversion code, solving on all available processor cores: inversions completed in a few minutes on a laptop
- Easy-to-use mesh builder, property population using horizons and/or existing 2D and 3D resistivity models
- Immediate model view update at each inversion iteration
- Model property editing and painting tools
- Survey design, synthetic 2D sensitivity study
- Storage of resistivity models, synthetic data, inversion parameters and detailed statistics in recallable snap-shots
- Display georeferenced image overlays to compare existing interpretations



2D MT inversion



2D sensitivity study



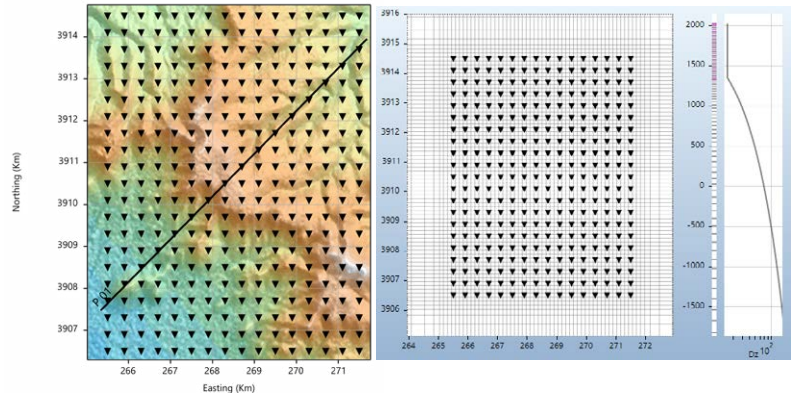
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3D MT Modeling allows to build detailed 3D resistivity models and setup jobs for 3D inversion on the CGG cloud. Forward calculations may be run on the local machine, e.g. for feasibility studies.

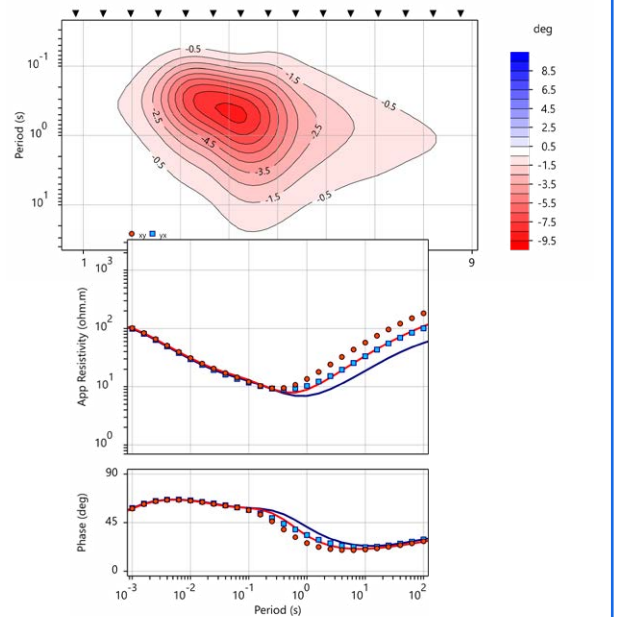
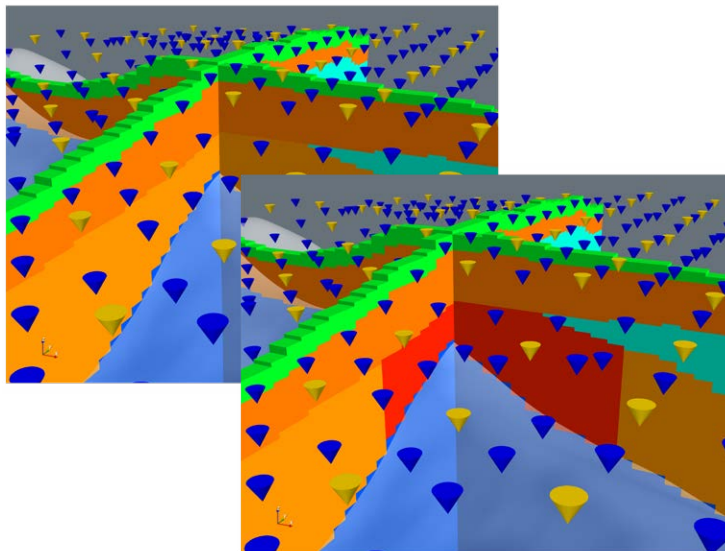
3D Modeling employs **RLM-3D**, industry-proven on many land and marine 3D projects. RLM-3D uses a finite difference solver to calculate forward responses, and non-linear conjugate gradients in the inversion engine.

## 3D Model Builder

- Guided workflow to create 3D models in a few clicks
- 3D mesh definition from MT survey geometry
- Variable vertical discretization to efficiently sample topography and features of interest
- *A priori* property population based on imported or picked horizons, or manual model painting, optionally starting from existing 3D inversion models
- Tools to modify existing models by applying value replacement or 3D smoothing filters



3D sensitivity study, Geotools 3D view



## Response comparisons

- Produce maps and pseudo-sections of responses
- Display misfit with measured or other calculated responses in sounding view or normalized data plots

## 3D MT Forward runtime examples

Model size (cells)	Run-time (16 frequencies)		
	PC1	PC2	PC3
250,000	1 min	3 min	4 min
500,000	3 min	7 min	10 min
1,000,000	6 min	27 min	39 min

PC1: Workstation (2019)	2 x Intel Xeon Gold 5218 CPU	32 total cores	128GB RAM
PC2: Laptop (2018)	Intel Core i7-8650U CPU	4 cores	16GB RAM
PC3: Legacy PC (2012)	Intel Xeon X5650 CPU	6 cores	24GB RAM

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## 3D MT Inversion

- Convenient workflow to generate 3D job packets to run on the secure CGG-hosted cloud
- Flexible model regularization options and use of resistivity bounds
- Inversion for smoothest model or smoothest variations from a *a priori* model
- Inversion for galvanic distortion matrices
- Review of inverted 3D resistivity structures, and compare to imported ancillary data and 1D/2D inversion models



## 3D job setup and model review

Job Seed Name: 03 Advanced Mode:

Maximum number of iterations: 60 Restart log file reporting at iteration: 0

Save models every: 20 NLGG Preconditioner: L-BFGS

Update adjoints every: 10 Correct input models if outside specified bounds:

Data parameters | Model parameters | Regularization parameters

Survey

MT sites

MT sites - edited 2D

MT sites - edited 3D

Minimum frequency: 0.001

Maximum frequency: 1000

Points per decade: 5

Number of frequencies -> 31

Model impedance tensor (Z)  Model vertical magnetic data (Tz)  Use data error

Error (%) Zxx: 5 Zyy: 5 Zzz: 5

Absolute Tz error: 0.02 Relative Tz error (%) 0

Invert for real 2x2 distortion matrix for each site

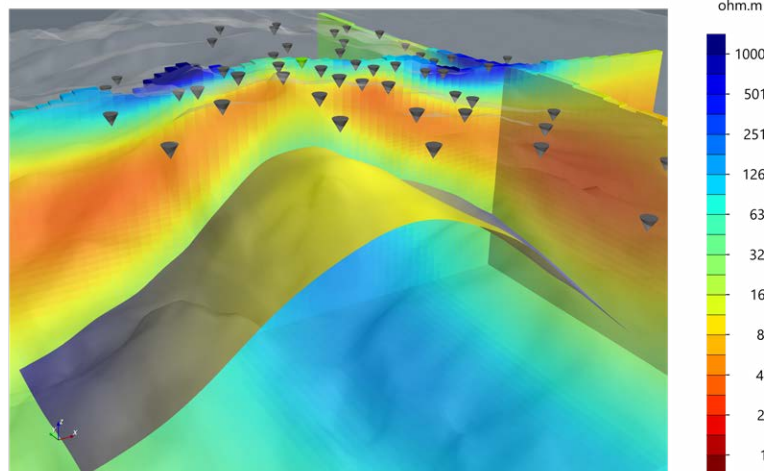
Weight to keep matrices close to identity: 2000 Damping: 1

Use 1D adjoint solutions for approximate preconditioner

Forward solver tolerance: 1E-06 Max iterations: 1000

Jacobian solver tolerance: 1E-05

Ok Cancel



## RLM-3D on the CGG cloud

CGG Cloud Services

Home My Data My Jobs File Manager

Job Upload

Data Download

Job Monitoring

Job Status

Job resources

Project: EMDP

Job Name: (job name cannot start with numbers)

Cluster resources

num of CPUs: 192

Num of Subcomm: 4

Notification Email: (multiple email separated by commas)

Data Files

Job packet file (.pkt file)

Select files

Drop a file here

Job Submit

Home My Data My Jobs File Manager

Project Job Name Cores/Out Log Time Elapsed It Time Remaining RMS Iterations Evolution J Iterations Evolution I

EMDP D06 120 05h 13m 23 / 60 05h 03m 1.884

Iteration number 23 / 60

Distance along x-axis (km)

Distance along y-axis (km)

Iteration 114

## Contact

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