March, 2026

FDEM Tools

Considerable rework has been made to the FDEM tools which has been done in consideration of the release of several new FDEM instruments with new levels of accuracy and capability beyond older instruments. We have augmented the data import dialogues, smoothed out the user import procedures and cleaned out any errors in the import functions. We have also improved the accuracy of the FDEM halfspace inversions, extended their functionality to more configurations and improved computation speeds. In particular, we have added PRP configurations considering for, in particular, the Promis and DualEM systems. We have also augmented the LIN apparent resistivity conversions for PRP configurations to and from instrument units.

Major improvements have been made to layered earth inversions for these instruments. This has been done for both the Trust and Occam style inversions. New instrument configurations are now supported and one particular new and very useful capability is selectable Inphase and Out of Phase data for each component and frequency individually. This augmentation is due to the presence, on the market, of instruments that now gather quantifiable Inphase data. In addition, alterations and improvements have been made to the freespace plate inversions for FDEM data in particular considering MaxMin and Promis data.

3D Inversion Interfaces:

Interface dialogues have been enhanced and additional inversion options added for all our 3D inversion applications [Resistivity, Gravity, Magnetics, CSEM, CSAMT].

Magnetic Data Tools

Work has been done to improve and extend the ability to perform complex model simulations including augmentation to the multi-core and array processing components. The enhanced simulation of magnetic models containing DEM topography allowing for the inclusion of magnetic property contrasts within the topography which is particularly useful in areas of elevated terrain. The 3D inversion tools have also been augmented with issues including; the provision to provide susceptibility continuity across boundaries in the inversion grid when cell thickness changes. Inversion to a constant depth in surveys with high topographic variations has been added, improved cross-sectioning with augmented 2D viewing of the cross-sections, editing of inversion grids to extract critical structures, provision to export extracted grids to CAD format including support for AutoCAD. Other processing issues include the addition of the calculation of derivatives via DFT which uses rectangular grid cells to maintain along profile data resolution and significantly reducing cross line artifacts. This capability now provides significantly increased clean and accurate derivatives over traditional FFT techniques. New extraction techniques have been added to remove extrapolated derivatives outside the survey area particularly for irregular survey lines thus removing artifacts at the edges particularly when using the derivative inversion grids in an inversion. Additionally, we now provide aeromagnetic compensation for drone data and gradient data. IGRF14 has been enabled allowing determination throughout a survey for changes in date, elevation and time.

Filtering tools

New filtering capabilities have been added. These include a data extrapolation algorithm and two interpolation algorithms when data stations are irregularly distributed. One algorithm is for along profile and the other are 2D spatial interpolation. These algorithms can interpolate both your data and your stations positions.

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Gravity Data Tools

We have considerably improved the isostatic corrections introducing new simulation techniques allowing for larger and more detailed corrections. These corrections are extremely important in areas of high elevation as well as in areas near ocean coasts and for marine surveys. Additionally, we have added improved bathymetry corrections and added corrections for the effects of marine sediments. These latter corrections being important not just for marine and harbour work but also for island and coast line data.

In terms of the gravity inversions we have augmented memory allocation as well as the use of more extensive and detailed DEM topography in the user model grid. We have also enhanced simulation of gravity models with DEM topography grids and enabled inversion of gravity derivatives to be suitable for airborne tensor systems as well as for DFT derived derivatives from ground data. The derivation of DFT derivatives has been significantly improved particularly in terms of removing edge effects.

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Display and Filtering Tools

There are many items in this area of development but some of these improvements include:

- Augmented cross section visualization tools for both 3D and 1D inversions principally for gravity, magnetics, resistivity and CSEM inversions as well 1D stacked TDEM and FDEM inversions
- Extended tools to export models and model data
- Augmented grid information display
- Improved cleaning of DFT processed grids such as derivatives, RTP, upward continuation
- New precision extrapolation removal tools for multi-parameter grids

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General Features

- Augmented and improved plotting tools
- Improved changing of system configurations for inversion and simulation
- Enlarged system configuration capabilities
- Changes to controls and interfaces to improve readability and functionality
- Improvements to imports as well as augmentation of imports. Examples include FDEM, VLF, MT, AFMAG, airborne TDEM and the import of AMIRA formatted data
- Improved conversion of one 3D algorithm primitive to another
- Improved editing capabilities of models in a plan section survey display
- added classic Geotiff file export for maps

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EM Simulation Issues

In addition to a new algorithm with dramatically increased capabilities, there has been a variety of improvements to older versions of some of the EM simulation algorithms. These include:

- improved accuracy of low frequency background response of magnetic dipole sources
- improved background response accuracies for FD and TD IP models
- improved storage and recovery of Greens functions [.dmp archives]
- improved background responses for grounded sources - i.e. CSEM, CSAMT, IP
- improved prism/poly simulation when the top of a target crosses near or immediately at a layer interface. Note that in these cases, current flow between the top and bottom part of the target is maintained .
- we have enhanced VLF survey configuration tools
- we have added VLF Controlled Source capabilities
- major improvements to simulation of edited 3D Resistivity inversion models

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Visualization Additions

Our visualization tools have been improved in order to enable visualization of 3D models and inversions from different survey types. For example, the joint visualization of a 3D resistivity inversion models with an EM model (e.g. thin sheets or spheres) from a borehole survey. Or the joint visualization of 3D focused airborne magnetic inversions with airborne TDEM plate models. These additions include

- Visualization of mixed 3D primitives which allows for visualization of primitives from different algorithms
- Mixing inversion grids with 3D primitives
- Inversion grid editing. This allows to remove, for example, small contrast cells to focus on the more important cells or the removal of cells above or below certain depths or the removal of portions of the inversion volume conversion to CAD formats

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New 3D EM/IP Complete and Exact Simulation Algorithm

Gustav Mie (1908, Annalen Der Physik, 330) first presented the complete and exact solution for EM scattering from a sphere due to a plane wave in terms of an infinite series of spherical harmonics. Peter Debye's work (1909) contributed to the understanding and introduced the Debye series using Debye potentials enabling a physical interpretation of the solution in terms of physical processes. These works followed the introductory work of Ludvig Lorenz and thus the solutions are often referred to as the Lorenze-Mie-Debye (LMD) theory. However, the work was virtually ignored until the 1950's and not until the 1970's was it well known. Later work expanded the solution to a dipole source following the idea of Mie-type expansions and is now used extensively throughout many areas of physics and engineering. For small spheres, the problem simplifies and in geophysics early approximate solutions for "small" spheres were provided by James Wait (1951, 1960, and 1969). Of course, even this work had limited practical uses until the advent of the computer. Other approximations have also been presented by various authors in geophysics.

When exploring a strong scattering extension to the Born and Rytov approximations for EM scattering, R.Groom and T. Habashy worked to provide a computational solution to the dipole excitation of a conducting sphere in the frequency domain. A method was devised to solve the series up to 200 harmonics and determine if the solution has converged. This solution was for electric and magnetic dipole sources and dipole electric and magnetic fields. The method of solution was found to be accurate at frequencies below several megahertz and was subsequently to study the accuracy of the Localized Nonlinear Approximation (LN) solution and push the initial development of this algorithm. This sphere solution was used extensively to expand the capabilities of the LN solution.

The approach that was taken was a generalization to a uniform sphere of contrasting conductivity, permeability and permittivity to a homogenous background. The spherical series expansion following Mie's techniques but using Debye potentials is not a monotonically convergent series leading to convergence. A simple addition of the initial terms does not produce a sufficiently converged solution except for "small" spheres. But, the series can be solved for a converged limit by utilizing the starting and ending terms like a rope tied at both ends. Introduced into the solution was examination of convergence and thus the present algorithm does not provide a solution if the calculated series does not converge for any particular scattering problem (i.e. sphere and background characteristics, dipole source characteristics, location and type of dipole receiver and frequency). Comparisons of this Mie approach to scattering by a sphere to the Born, Rytov and the Nonlinear approximations can be found in Habashy, Groom and Spies (1993, JGR, Vol 98).

This solution for scattering by a sphere due to a dipole source has been used for 30 years by ourselves and other researchers to study numerical solution approaches and the nature of EM scattering as it pertains to geophysics. In particular, it has been used to study the accuracy of quite a number of simulation algorithms. It has been used for crosshole RIM studies, crosshole resistivity surveys, cross hole FEM studies with small downhole sources and other experimental geophysical methods.

In recent years, we have encountered numerous cases in EM data, particularly in airborne TDEM, where responses are clearly due to both conductive and magnetic materials within the anomaly. Thus, extending the solution to loop sources was necessary for our clients' needs. Also, researchers have been interested to use the algorithm but extended to more common sources such as loops and grounded current dipoles.