Detailed update summary: DCIP3D v5.0

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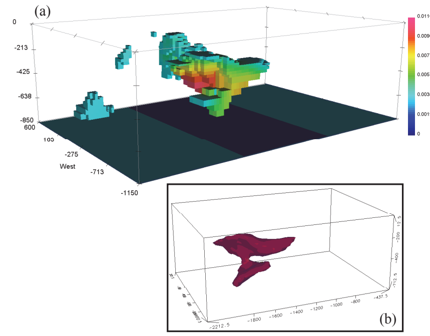
gif.eos.ubc.ca



Overview

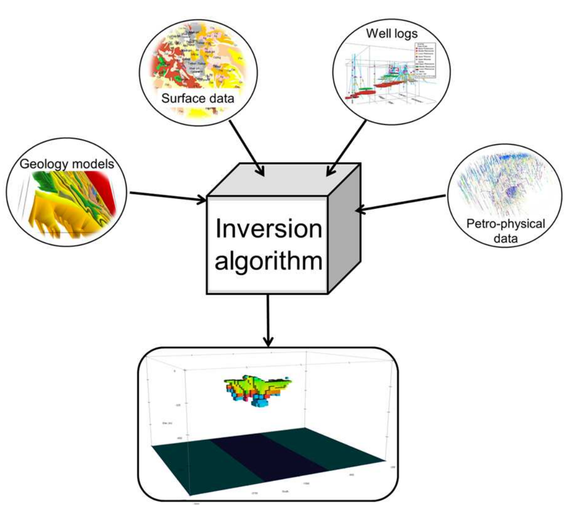
DCIP3D v5.0: A program library for forward modelling and inversion of direct current and induced polarization data over 3D structures. Significant upgrades reduce computation time through parallelization and increase the flexibility to incorporate geologic information have been made.

Background

UBC-GIF inversions solve the inverse problem by minimizing a global objective function

$$\min \psi = \psi_d + \beta \psi_m$$
$$\text{s.t. } m^l \leq m \leq m^u$$

created from the combination of a data misfit term, ψ_d, (quantifying the reproduction of the observed data) and model objective function, ψ_m. The latter gives the user a unique opportunity to include other geological, petrophysical, and geophysical information into the inversion framework. The trade-off parameter β balances the data fit and model smoothness. Lower (m^l) and upper (m^u) bounds can be also be specified throughout the model region.



Parallelization

The forward modelling and inversion programs have been parallelized using OpenMP. The time required to calculate the forward modelling decreases linearly with the number of processors. The inverse calculation reduced significantly due to the sensitivity calculations at each step. Note that times will vary based on problem specifics and computer performance. Figure 1 shows the time it takes for an inversion of DC data and the sensitivity matrix calculation for IP. The sensitivity matrix is no longer written to file for DC inversion resulting in a further gain in performance.

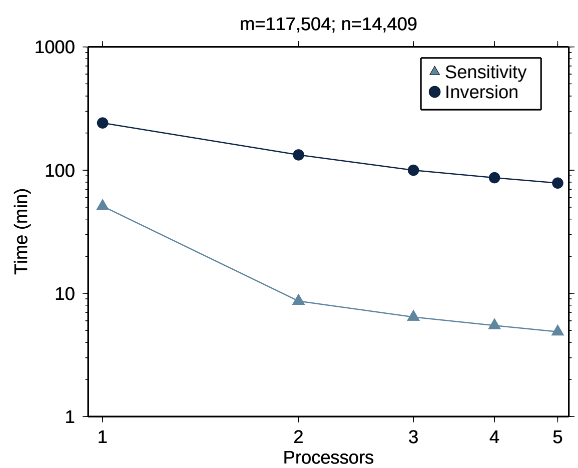


Figure 1: Computation time vs number of processors (threads). Number of cells: 117,504; number of data: 14,470. Processing done on a PC with 3.2 GHz Intel Core i7 790 with six dual-core processors.

# of Cores	DC inversion	IP sensitivity
1	14,485	3,050
2	7,980	520
3	5,976	386
4	5,194	328
5	4,710	293

Table 1: Number of CPU cores versus time (sec) of calculations.

Incorporate geologic information

Drill-hole constraints: Information is incorporated as upper and lower bounds with the projected-gradient method (Vogel, 2002), allowing the recovered model to reach the bounds. Bounds can be given on a cell-by-cell basis throughout the model region.

Reference models: Previously assumed geologic structure can be incorporated through reference models and/or weighting matrices.

Inactive and active cells: Particular cells, or regions of the model, may be held fixed during the inversion. This reduces the size of the problem and provides an alternative method for incorporating prior information.

Forward modelling

The forward (and inversion) code uses a nodal-based finite volume technique in which the current is input on a node. This is illustrated in Figure 2 by showing the different meshes that would be required in plan view. Electrodes can now be located anywhere and are not restricted to mesh node locations. This greatly enhances the useability of the code and allows for more uniform meshes with fewer cells to be used in the modelling.

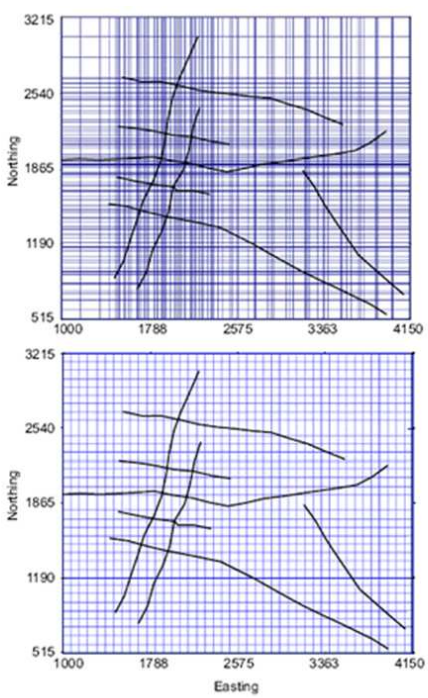


Figure 2: (top) The original version of `DCIP3D` (v1.0) would require electrodes on nodes. (bottom) Version 5.0 allows electrodes anywhere.

Output files

The average sensitivity for each cell is now written out to a file. This aids the user in understanding the depth of investigation or even in survey design, particularly in areas of high topographic relief (Figure 3). The model and data at each iteration is written for both the DC and IP inversions.

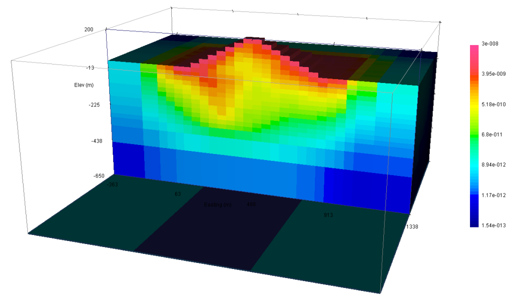


Figure 3: Average sensitivity for each cell for a 3D DC data set that includes a borehole.

Maintenance and future releases

`DCIP3D v5.0` is released with a maintenance agreement that includes support for carrying out the inversions as well as receiving upgrades for the software. Planned improvements for `DCIP3D` include:

- Further flexibility in incorporating geologic knowledge and petrophysical constraints,
- Robust norms for evaluating misfit, and
- Further improvements in computation speed.

Contact information

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