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Interactive 3D potential field modelling and visualization of complex geological structures

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We are describing a new approach for joint inversion. This technique is user-friendly because it is highly interactive, ideally real-time and topology conserving and can be used for both flat and spherical models in 3D. These are important requirements for joint inversion not only for gravity and magnetic modelling of fields and derivatives, constrained by seismic and structural input from independent data sources, but also essential toward a true integration of Full Waveform Inversion. A borehole tool for magnetic and gravity modelling will also be introduced. We are close to the demand of treating all geophysical methods in a single model for the subsurface and aim for fulfilling most of the constraints: measurements and geological plausibility.

For 3D modelling polyhedrons built by triangles are used. All elements of the gravity and magnetic tensor can be included. In the modelling interface, after geometry changes the effect of the model can quickly be updated because only the changed triangles have to be recalculated. Because of the triangular model structure the new approach can handle complex structures very well (e.g. overhangs of salt domes). For regional models the use of spherical geometries and calculations can be necessary and is provided.

Inversion can either be run over the whole model, but typically it is used in smaller parts of the model, helping to solve local problems and/or proving/disproving local hypotheses. Instead of optimizing the position of model vertices, interactive inversion uses a different parameterization of the model. The inner points of a lattice are used to define a distortion of space. The resolution of lattice can be adjusted to work in detail or to make more regional changes. The user can monitor model updates live on screen and stop the process at any time. The base principles behind this interactive approach are highly performance optimized algorithms (CMA-ES: Covariance-matrix-adoption-evolution-strategy). The efficiency of algorithm is very good in terms of stable convergence due to topological model validity.

Potential field modelling is always influenced by the area outside the core area of investigation, causing edge effects. A simple but very robust method has been developed: Derive a density/susceptibility-depth function by taking the mean value of the borders of depth slices through the model. The focus is set on practical examples from the international KTB – Project, Germany´s deep continental borehole.

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