3D potential field modelling and 3D prints of complex geological structures

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Abstract

This presentation summarizes the outcome of the DGMK project 771 with the title: “Towards an integrative interpretation of potential fields and corresponding gradients by the aid of three-dimensional modelling and visualization, TIPot3D”, which finished recently after 2.5 years research.

The new gravmag modelling techniques are user-friendly because they are 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 towards a true integration with Full Waveform Inversion. A borehole tool for magnetic and gravity modelling has also been introduced. We are close to satisfying the demand of treating several geophysical methods in a single model for subsurface evaluation purposes and aim now for fulfilling most of the constraints: i.e. consistency between measurements and geological plausibility.

For 3D gravity and magnetic modelling, polyhedrons built by triangles are used. All elements of the gravity and magnetic tensors can be included. In the modelling interface, after geometry changes the effect on the model is quickly updated because only the changed triangles have to be recalculated. Because of the triangular model structure, our approach can handle complex structures very well and it is rather flexible (e.g. overhangs of salt domes). For regional models, the use of spherical geometries and calculations is provided. 3D visualization is performed with a 3D-printer (Ultimaker 2) and gives new insights into even rather complicated Earth subsurface structures.

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 utilised to define a distortion of space. The user can monitor model updates live on screen and stop the process at any time. The basic principles behind this interactive approach are high-performance optimized algorithms (CMA-ES: Covariance-matrix-adoption-evolution-strategy). The efficiency of the algorithm is very good in terms of stable convergence due to topological model validity.

The focus of the presentation is set on two practical study examples: One from the international KTB – Project, Germany´s deep continental borehole, as well as a very complex salt structure in the Northwest German Basin.