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Complex crustal structures: their 3D grav/mag modelling and 3D printing

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Our new techniques for modelling and visualization 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 for gravity and magnetic modelling of fields and their derivatives, constrained by seismic and structural input from independent data sources. A borehole tool for magnetic and gravity modelling will also be introduced. We are already 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: consistency of modelling results and measurements and geological plausibility as well.

For 3D 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 flexible (e.g. overhangs of salt domes or plumes). For regional models, the use of spherical geometries and calculations is necessary and available. 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. 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 rather good in terms of stable convergence due to topological model validity.

Potential field modelling is always influenced by edge effects. To avoid this, 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 of the presentation is set on two practical examples: From the international KTB – Project, Germany′s deep continental borehole as well as a very complex salt structure in the Northwest German Basin.