EGU21-2964
https://doi.org/10.5194/egusphere-egu21-2964
EGU General Assembly 2021

Interdisciplinary data-constrained 3-D potential field modelling with IGMAS+

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We introduce a modelling concept for the construction of 3-D data-constrained subsurface structural density models at different spatial scales: from large-scale models (thousands of square km) to regional (hundreds of square km) and small-scale (tens of square km) models used in applied geophysics. These models are important for understanding the drivers of geohazards, for efficient and sustainable extraction of resources from sedimentary basins such as groundwater, hydrocarbons or deep geothermal energy, as well as for investigation of capabilities of long-term underground storage of gas and radioactive materials.

The modelling concept involves interactive fitting of potential fields (gravity and magnetics) and their derivatives within IGMAS+ (Interactive Gravity and Magnetic Application System), a well-known software tool with almost 40 years of development behind it. The core of IGMAS+ is the analytical solution of the volume integral for gravity and magnetic effects of homogeneous bodies, bounded by polyhedrons of triangulated model interfaces. The backbone model is constrained by interdisciplinary data, e.g. geological maps, seismic reflection and refraction profiles, structural signatures obtained from seismic receiver functions, local surveys etc. The software supports spherical geometries to resolve the first-order effects related to the curvature of the Earth, which is especially important for large-scale models.

Currently being developed and maintained at the Helmholtz Centre Potsdam – GFZ German Research Centre, IGMAS+ has a cross-platform implementation with parallelization of computations and optimized storage. The powerful graphical interface makes the interactive modelling and geometry modification process user-friendly and robust. Historically IGMAS+ is free for research and education purposes and has a long-term plan to remain so.

IGMAS+ has been used in various tectonic settings and we demonstrate its flexibility and usability on several lithospheric-scale case studies in South America and Europe.

Both science and industry are close to the goal of treating all available geoscientific data and

geophysical methods inside a single subsurface model that aims to integrate most of the interdisciplinary measurement-based constraints and essential structural trends coming from geology. This approach presents challenges for both its implementation within the modelling software and the usability and plausibility of generated results, requiring a modelling concept that integrates the data methods in a feasible way together with recent advances in data science methods. As such, we present the future outlook of our modelling concept in regards to these challenges.