Separation of sources and 3D gravity data inversion for the Thuringian Basin

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1. Introduction

A novel approach for 3D gravity and magnetic data inversion and a 3D modelling of the Thurigian Basin in Mid-Germany is presented. It includes preliminary separation of sources: i) in depth using upward and downward continuation; ii) in the lateral direction by means of approximation with a field of 3D line segments; iii) according to density and magnetisation contrast on the basis of pseudo-gravity calculation. The inversion algorithms allow retrieving unknown 3D geometry for restricted bodies of arbitrary shape and contact surfaces, which are important constraints for the 3D modelling of the Thurigian Basin with IGMAS (Götze, 1978; Schmidt, 2000).

2. Gravity and magnetic data

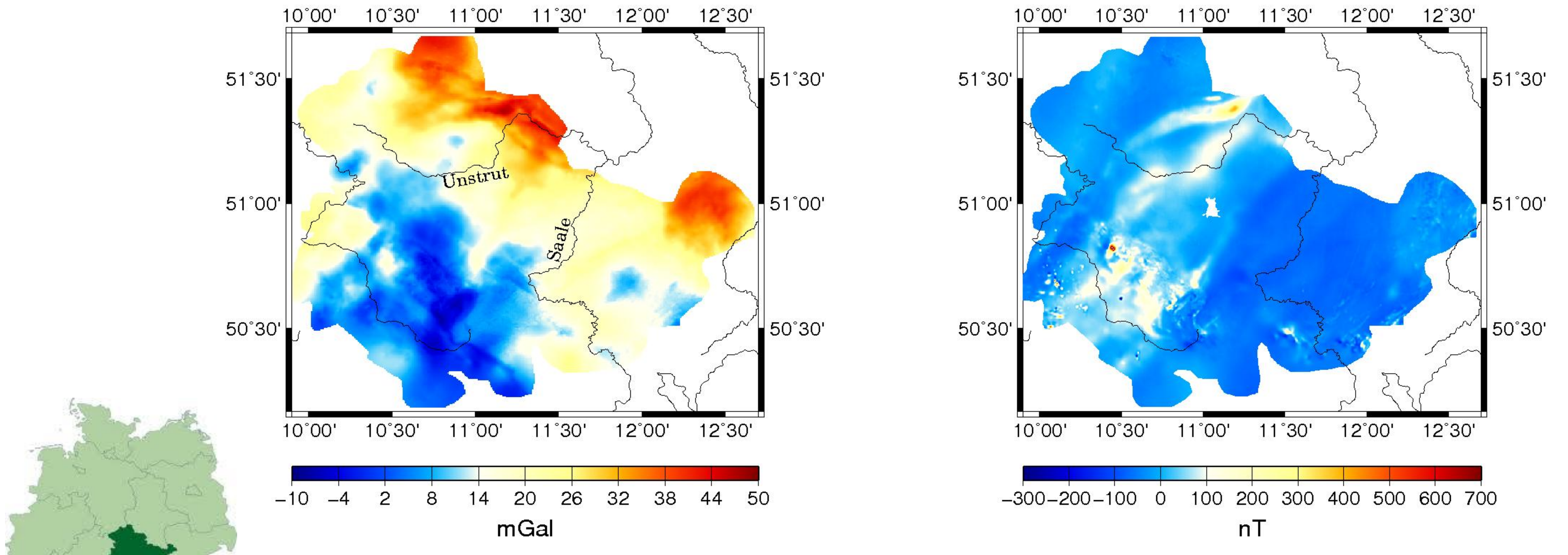

Fig. 1: Initial data for the territory of Thuringia in Germany (GGD, 2010). Left: Bouguer-anomaly on a 500m grid; right: magnetic anomaly (total intensity) on a 250m grid. These data sets are the basis of the 3D inversion and modelling of the Thuringian basin with IGMAS.

3. Separation of sources in depth

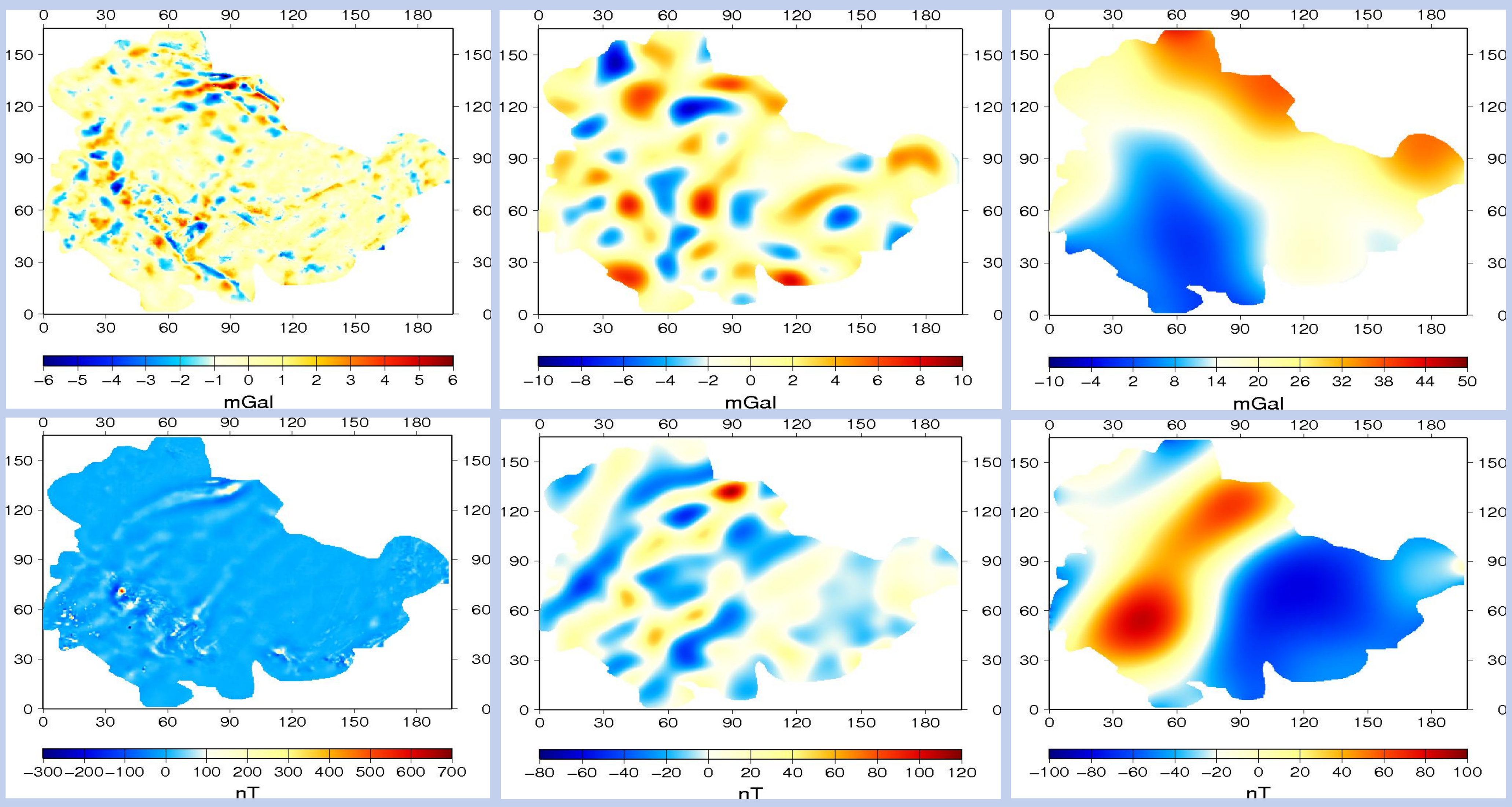

Fig. 2: Estimation of sources in depth. Top – gravity, bottom – magnetic data, left – shallow, middle – intermediate, right – deep sources.

The goal is to find a part of the observed field which is harmonic above a given depth. We remove shallow sources based on the subsequent upward and downward continuation. Integration along the area of investigation only is possible due to subtraction of a model of the regional field prior to the upward continuation, which is treated as 2D harmonic function. Fig. 2 shows the separation of sources into shallow (above 5 km), intermediate (between 5 and 20 km) and deep ones (below 20 km). Their comparison reveals that anomalies are caused partly by different objects. For instance, a component of gravity corresponding to deep sources is caused by an uplift of the Moho, meanwhile the same component of the magnetic field is generated by the Mid-German Crystalline High. The separation of sources in depth is a useful tool for providing constrains for the 3D gravity modelling of the basin and the underlying rocks.

4. Three dimensional inversion and modelling of potential field data

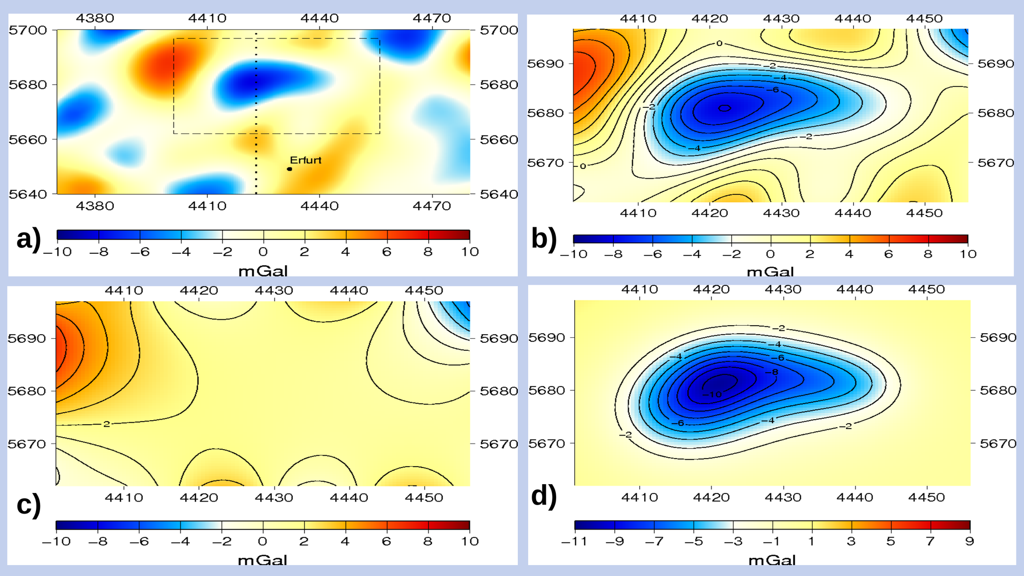

Fig. 3: a) negative anomaly, which belongs to intermediate sources (Fig. 2, middle); b) cut-out gravity field from a); c) the modelled regional field, which is subtracted; d) approx. gravity anomaly using 3D segments (Prutkin, 2008).

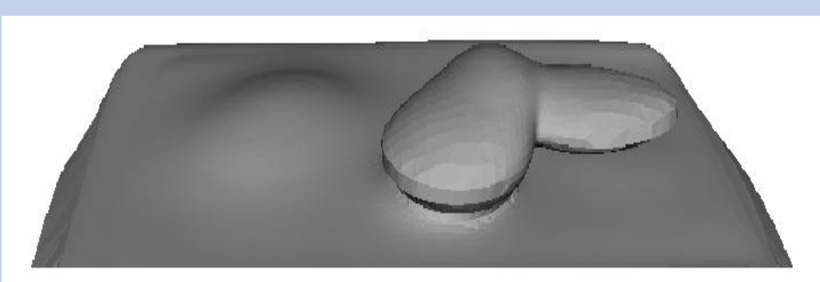

Fig. 4: 3D model of intrusion and contact surface

Using the inversion algorithms, a restricted body with the same gravity effect as two line segments is obtained, interpreted as a granitic intrusion (Fig. 3). The same steps are repeated for a positive anomaly to the west of the negative one. Since approximation provides deeper sources, we attribute the anomaly to an uplift of density interface below the body. A 3D model for the main intermediate sources is shown in Fig. 4.

According to magnetic data (shallow sources), we recover 3D topography of an arc-shaped uplift of crystalline. Its gravitational effect is subtracted from measured gravity. The rest is attributed to near-surface layers (Prutkin & Casten, 2009).

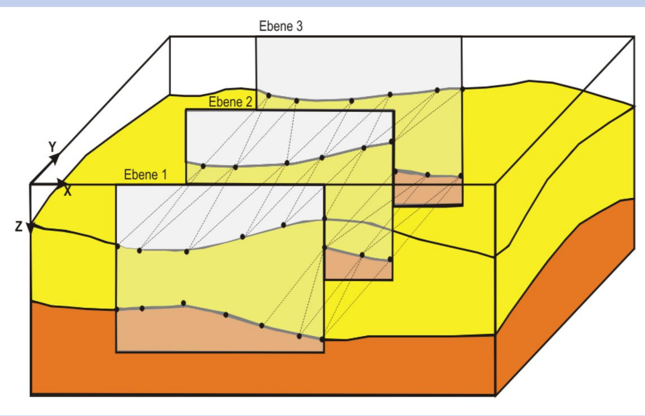

Fig. 5: Principle sketch of the IGMAS modeling – the investigation area is divided by the vertical model planes on which the geological bodies are modelled by geometries and densities. The intrusion, the uplifts of deep contact (Fig. 4), the crystalline and the near-surface layers are transferred into an IGMAS model (Fig. 6).

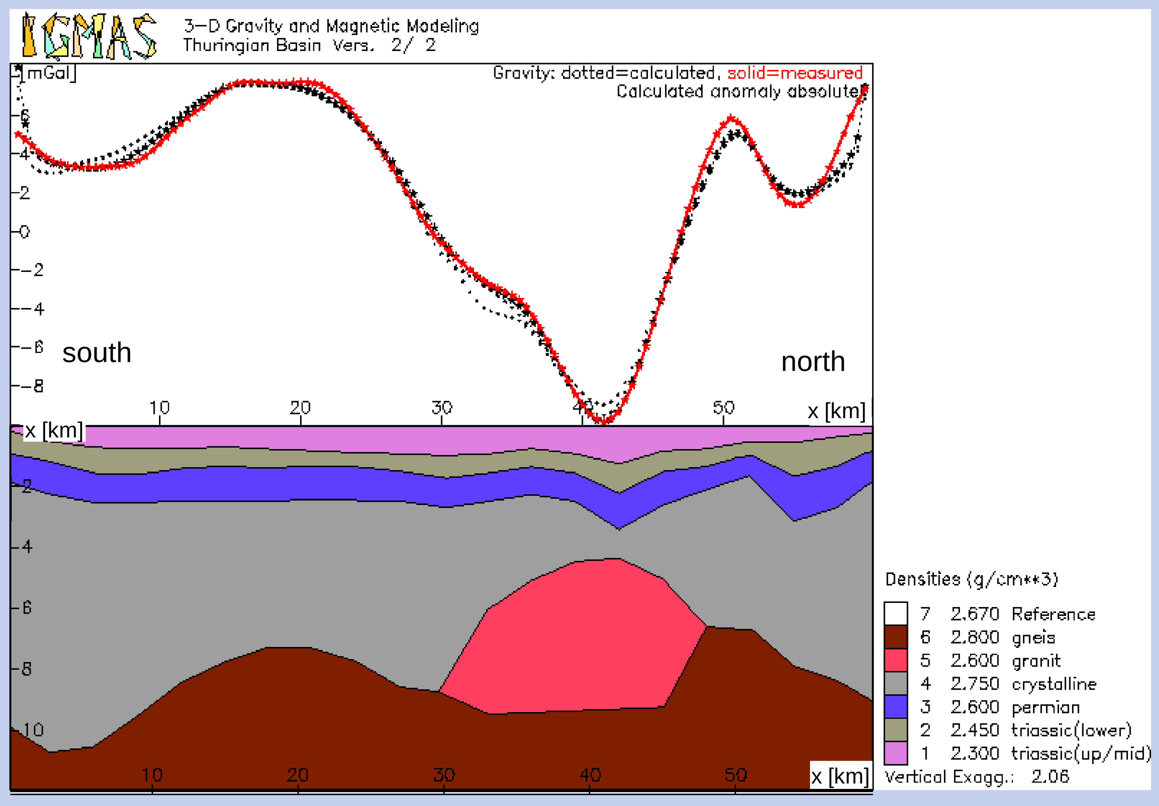

Fig. 6: Geological section, dotted line in Fig. 3a: IGMAS modeling over the intrusion and the contact surface (s.a. Fig. 4). The observed gravity (red curve) is explained by the calculated gravity (dashed black curves).

The obtained 3D model from the inversion provides an initial approximation for IGMAS modeling. The main goal is a 3D model with more than 50 model intersections for the whole area of the Thuringian Basin. Additionally results of all other geoscientific methods will be included as constraints in the modelling process.

5. Conclusions

The new approach of gravity and magnetic inversion provides constraints for geological structure in different depth intervals. The approximated bodies serve as the start model for a high resolution 3D gravity model of the Thuringian Basin in Germany.

6. References

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