Title:

Creating a Model of Anomalous Gravitational Field Based on GNSS Measurements and Gravimetry Results

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Level of study or work: Master thesis

Information about you (and your team): I am Vasil Dimitrov and I am a newly graduated engineer with a Master's degree in Geodesy from the University of Architecture, Civil Engineering and Geodesy (UACEG) in Sofia, Bulgaria. At the age of 24 on 10th July 2024 I successfully defended my master thesis with an excellent note. My scientific supervisor, Prof. Slaveyko Gospodinov, is a distinguished Bulgarian scientist and practicing geodetic engineer who teaches geodynamics, geodetic astronomy, and gravimetry. Under his mentorship, I have developed a profound understanding and passion for these fields. My primary interests lie in gravimetry, GIS, applied geodesy, and geodetic education methodologies. I am particularly fascinated by the potential of these disciplines to solve real-world problems and improve our understanding of the Earth's dynamics. I am about to begin my teaching career at the Sofia High School of Construction, Architecture and Geodesy "Hristo Botev", where I aim to inspire and educate the next generation of geodesists. Through my research and teaching, I aspire to contribute to the advancement of geodetic science and its applications.

Area of interest

Anomalies in the gravitational field are pivotal in locating mineral deposits, groundwater, and other subsurface resources. This approach represents a specific solution to the inverse problem in potential theory. By analysing gravimetric and GNSS measurements, the aim is to localize roughly anomalous masses beneath the Earth's surface. This method holds significant potential for addressing pressing environmental and economic challenges.

In Bulgaria, the issue of water-deprived areas is particularly acute, especially in the context of enhancing the region around the town of Zlatograd, the southernmost Bulgarian town situated in the Rhodope Mountains. Identifying groundwater and mineral resources here is crucial for revitalizing and sustaining local communities and ecosystems. The importance of this problem cannot be overstated, as it directly impacts

agricultural productivity, local water supplies, and the overall economic development of the area.

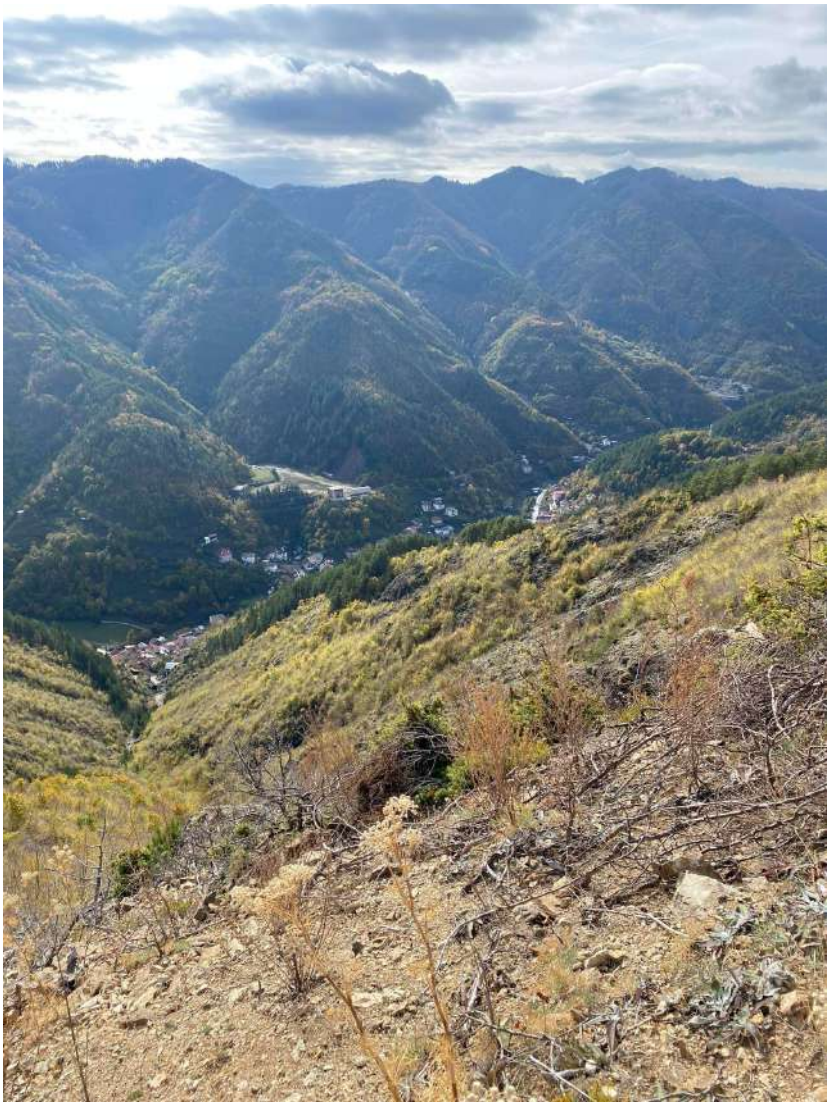

Fig. 1 – The town of Zlatograd seen from above

Currently, with the growing relevance of sustainable resource management and environmental preservation, utilizing advanced geophysical techniques to uncover hidden resources is more pertinent than ever. The integration of gravimetric and GNSS data provides a powerful toolset for geophysicists and environmental scientists aiming to address these challenges. By improving our ability to detect and analyse subsurface anomalies, we can better manage natural resources, mitigate environmental issues, and promote sustainable development in regions like Zlatograd. Thus, this area of research not only contributes to scientific advancement but also has immediate practical implications for societal well-being and economic growth.

Approach to the problem

We meticulously planned the field measurements, which included gathering initial data, surveying the area, and determining the study section. A total

of 260 points were selected within the land of Zlatograd, aiming for an even distribution. The average distance between points is 400-500m. Due to the significant elevation changes in the area, the points were positioned on levels where possible, ensuring extensive coverage and good reach.

The chosen method for geodetic tying of the points was GNSS in RTK mode. As a result of the measurements, the coordinates of the points were determined in the BGS2005 coordinate system with nadir ellipsoid heights.

For the project, two instruments were used. The first was a GNSS receiver, STONEX model S900A, equipped with a controller for real-time operation (for determining the planar and height positions of the points). Its accuracy in RTK mode is 5 mm + 0.5 ppm RMS in planar terms and 10 mm + 0.5 ppm RMS in height. For the gravimetric measurements, a relative gravimeter "LaCoste&Romberg" Model G was used, with an accuracy of 0.04 mGal per single measurement.

Since these are relative gravimetric measurements, it was necessary to tie them to a point from the Bulgarian State Gravimetric Network – point № 88 near Kardzhali, in the IGSN1971 system. Corrections were then applied: tidal correction, zero drift correction (zero point deviation), calibration of the gravimeter reading, and conversion to mGal. The coordinates at the gravimetric points were determined using the kinematic method in real-time (RTK). A virtual reference station (VRS) with data from the "GeoVara" infrastructure network was used, as the manufacturer guarantees good coverage for border areas, especially with Greece. The nadir ellipsoid heights and coordinates of the detailed points were determined in the BGS2005 coordinate system. This facilitated the creation of "Free-Air" and "Bouguer" anomaly models.

Results, conclusions and next steps

Based on the conducted measurements and their subsequent processing, it can be concluded that relative gravimetric measurements combined with GNSS determinations are a reliable source of empirical data that aid in the localization of anomalous masses located beneath the Earth's physical surface. In areas where there is a contrast between the topographic surface of the object and the surface of the Bouguer anomaly field, it can be assumed that anomalous masses are present at depth.

Defining the field of differences between the "free-air" anomalies and the "assumed" gravity values allows for the construction of a model identical to the Bouguer anomaly field. This suggests that if a correction with the assumed gravity values is applied to the "free-air" anomalies, a field will be obtained that carries similar information about the possible presence of cavities at depth.

The obtained results provide a solid foundation for further studies (geological, geophysical) aimed at the detailed localization of potential groundwater zones.

Based on the measurements and all calculations, 2D and 3D models of the "free-air" and "Bouguer" anomalies have been created. The change in gravity is clearly visible on these models. The proposed potential zones with groundwater presence have the smallest anomalies and are coloured in blue.

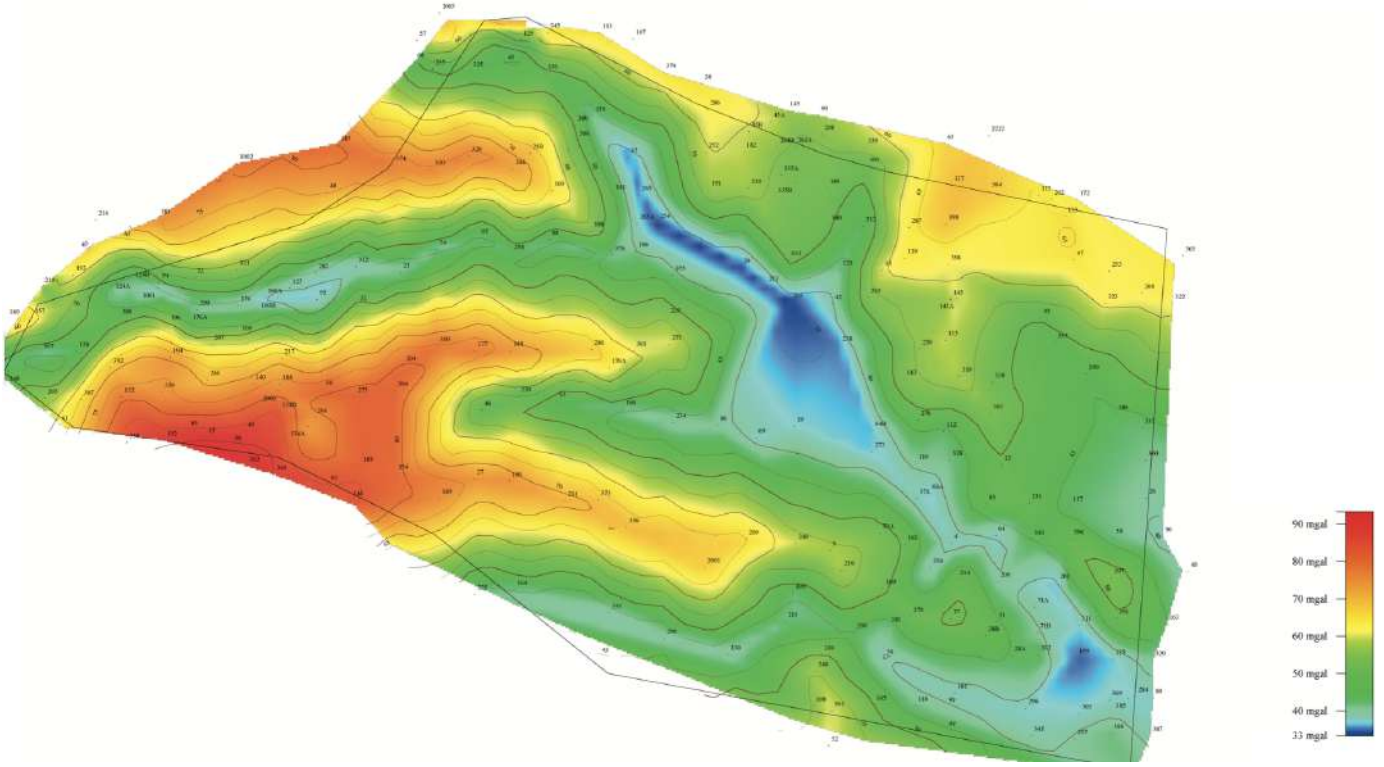

Fig. 2 – 2D model of the "free-air" anomalies in Zlatograd

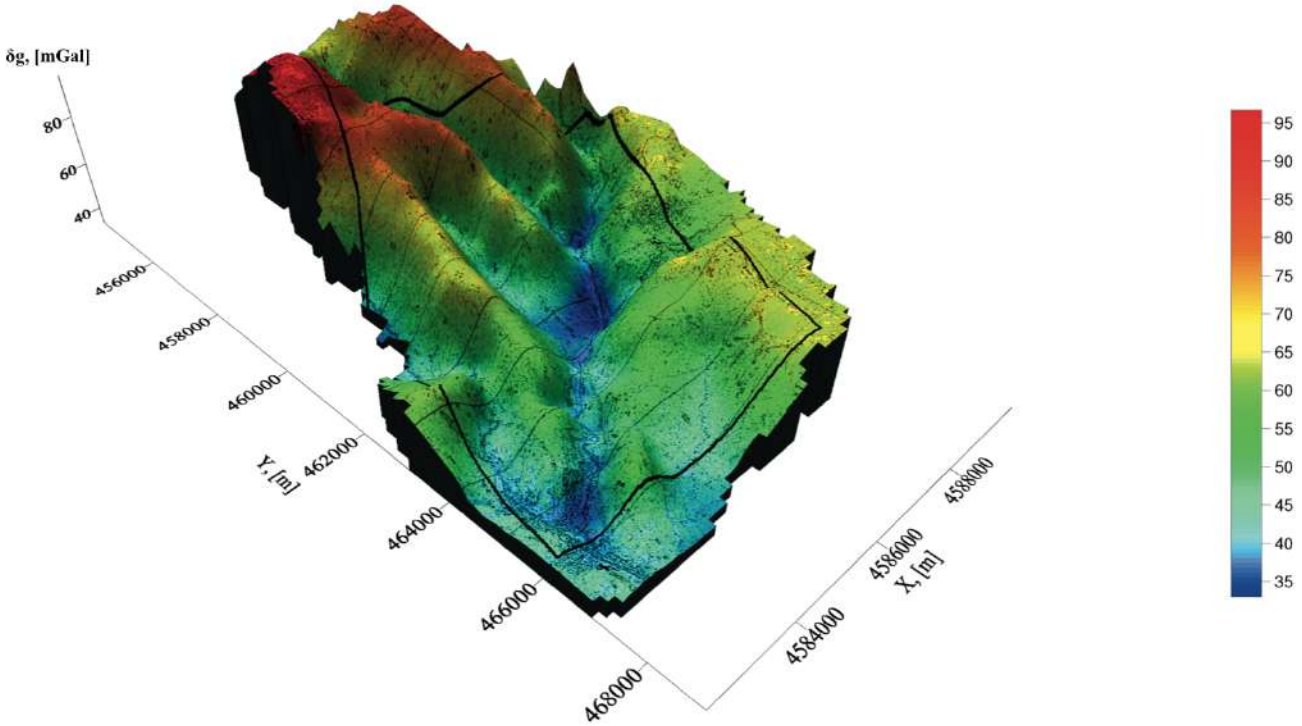

Fig. 3 – 3D model of the "free-air" anomalies in Zlatograd

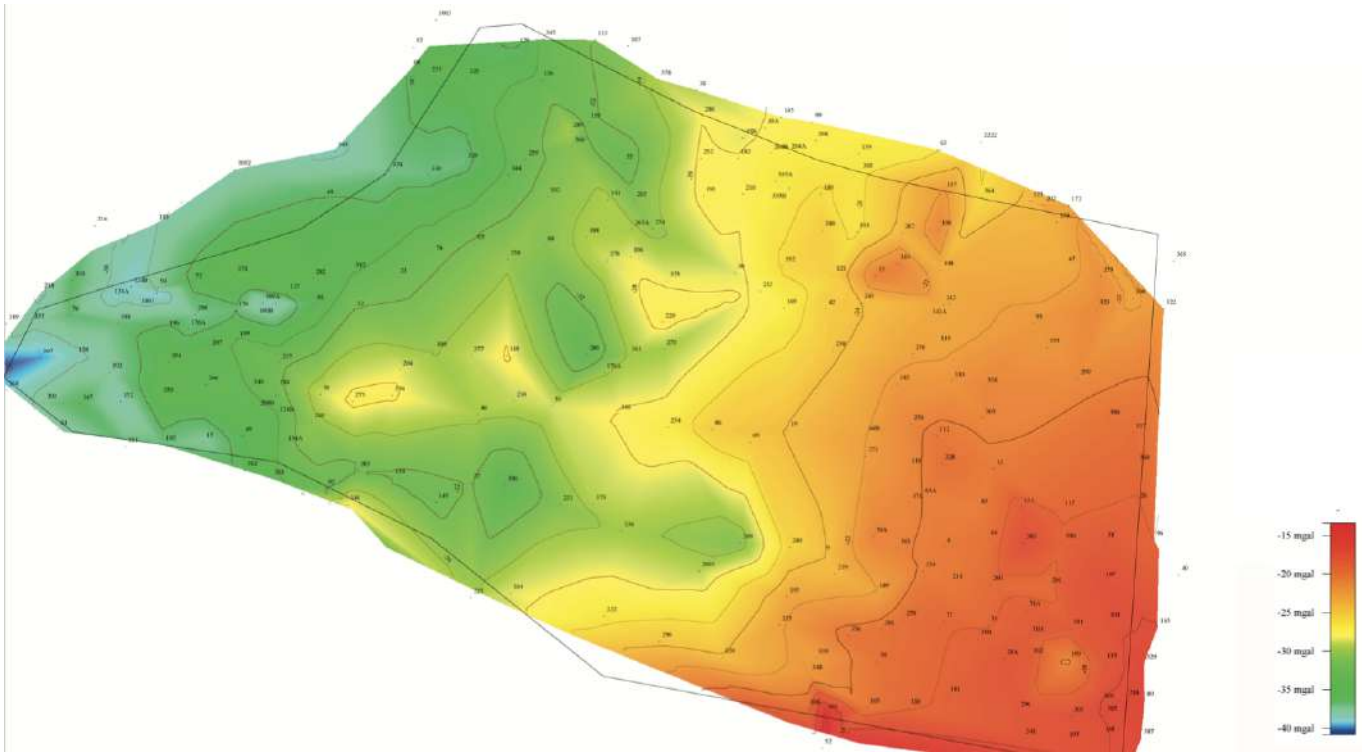

Fig. 4 – 2D model of the "Bouguer" anomalies in Zlatograd

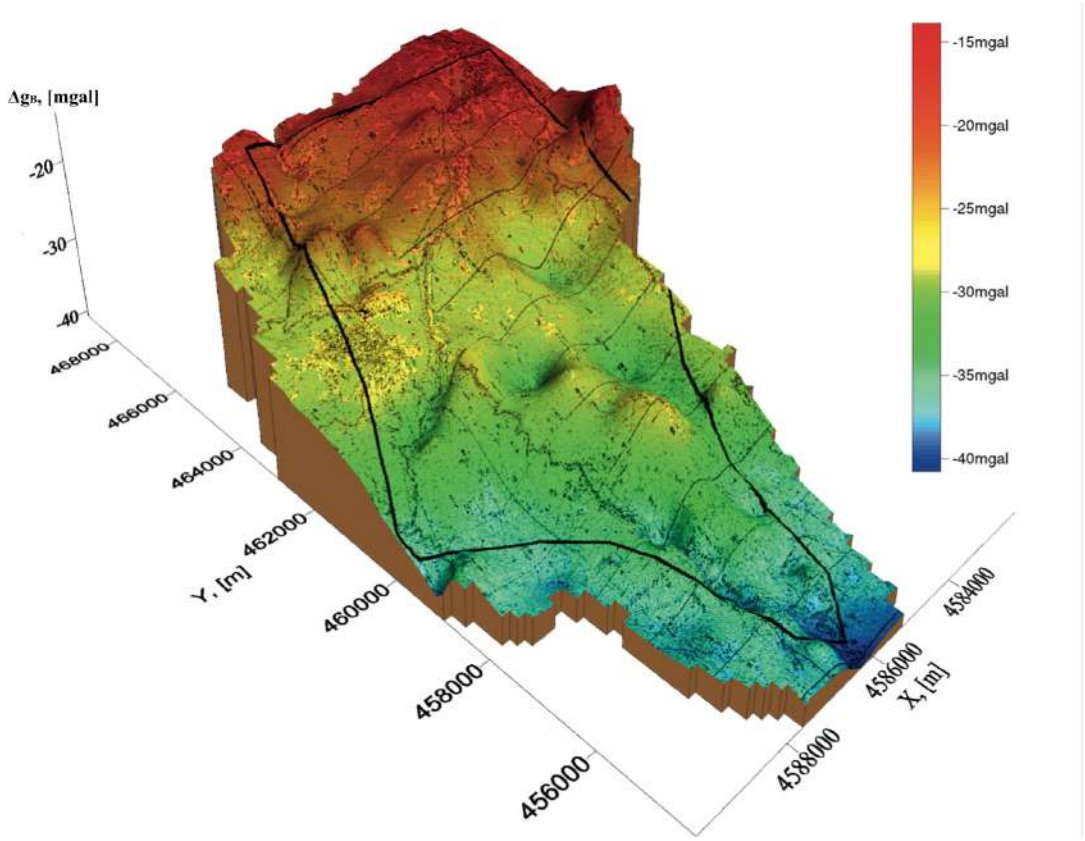

Fig. 5 – 3D model of the "Bouguer" anomalies in Zlatograd

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