

Crustal structure in Africa from satellite gravity modelling



Introduction

In earth sciences, the static earth gravity field can be used to resolve the compositional, thermal, and mechanical structure of the deep crust and upper mantle, and to investigate fundamental aspects of the plate tectonic process. Therefore global gravity models driven from the static field satellite gravity data can be used to get first hand crustal thickness and structure information in locations where, for various reasons, limited knowledge is available. Africa is one example where the crustal thickness and structure known with large uncertainties. This results in limited knowledge on African tectonic processes and their relation with and influence on crustal structures. In this study we investigate the crustal structure using

a combined global geo-potential model derived from the GRACE satellite, combined with terrestrial data.

Euler Deconvolution Results

This study has two main scientific goals. First, to develop a new African continental crustal model using an approach that works in regions where there are not enough, or none, a priori constraints, and evaluate its reliability through comparison with available crustal thickness estimates from receiver function analysis and deep seismic profiles. The second goal is to compare the new model

with existing local and global models and discuss potential impact of differences between them.

As our main interest is the depth of the crust-mantle boundary, the retrieved gravity anomaly data is high pass filtered using a 1000 km cut off wave length to remove information from deeper structures. Undesired tapering effects are minimized by expanding the grid up to 20% of the total grid area. We then calculate the X, Y, Z derivatives of the filtered gravity anomaly and use them as input to the 3D Euler inversion.

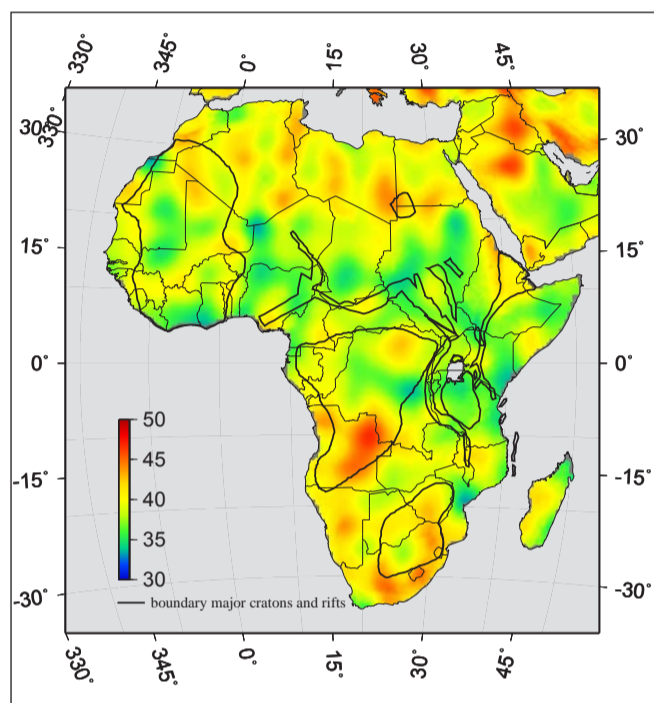


Figure 1: Euler derived crustal thickness for Africa based on GRACE data. Posted are boundaries for major rifts, and cratons. Crust is thick in the northern part of Africa such as the Atlas, northern part of Sahara and in the southern part of the Kaapvaal craton. The crust thickness is lower at the Man shield, and partly in the Taoudeni basin and Volta basin;

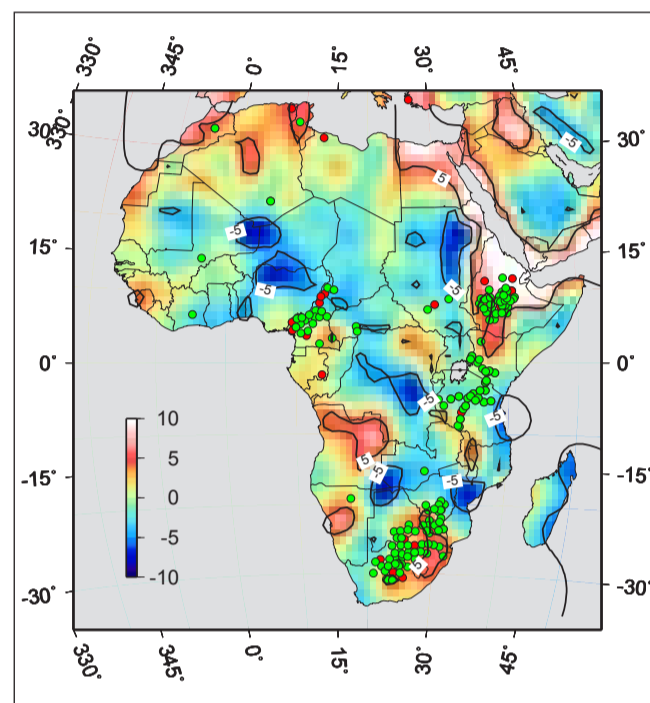


Figure 2: Difference between Euler driven crust thickness estimates and crust2. The difference is higher in the rift and at the margin of continental and oceanic crust. Larger part of the map is with in the range of 3 to 5 km. Superimposed are the used crustal constraints for assessing accuracy of satellite derived model. Posted points indicate difference between our estimate and RF. In green shaded points the difference is below 5 Km and in the Red points it is greater than 5 Km

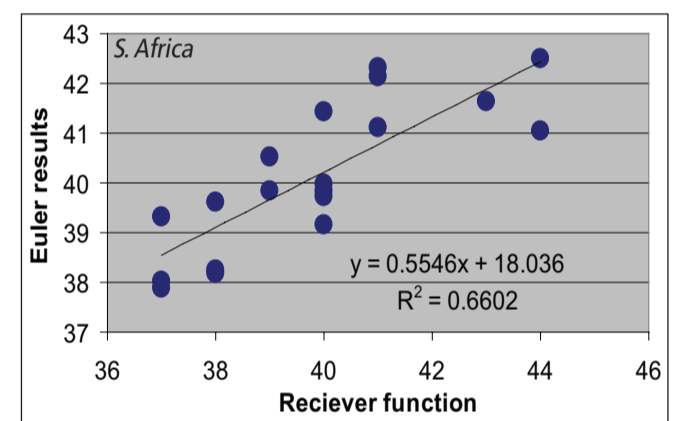
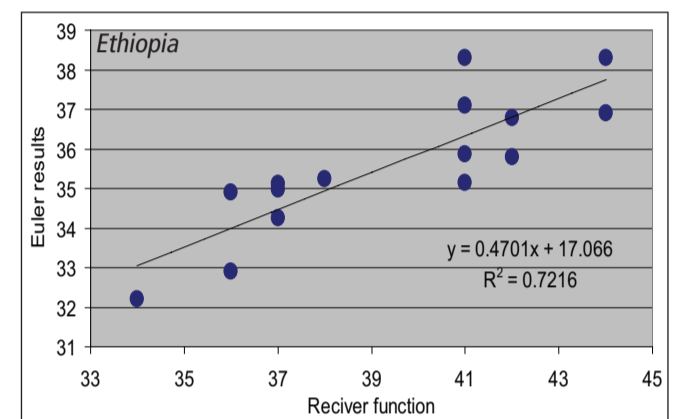


Figure 3. Correlation of Euler based crustal thickness estimates with seismologically derived crustal thickness estimates for two regions in Africa.

Results for East-Africa from isostasy calculations

The rapid method of Fullea et al (2007) is used to estimate the spatial variations in crust thickness. According to this method, the earth is considered as a four-layered lithospheric model composed of crust, lithospheric mantle, sea water and the asthenosphere. The main assumption with in this method is that the depths to the base of the crust and lithosphere are related with elevation under local isostasy and it has been previously applied at a complex tectonic setting in the Gibraltar Arc system, Atlas Mountains and adjacent zones Fullea et al (2007).

Figure 4: Spatial variation of crust thickness in the eastern part of Africa derived from geoid and topography. Crust thickness generally varies from 20 km to 44 km. The highest thickness is observed in the Ethiopian plateau, and the Tanzanian dome, but in larger part of the region it is greater than 28 km. Posted point maps illustrate deviations from seismological constraints (part of the validation process). In green and red points it is below 5 km, and it is greater than 5 km in blue and black shaded points.

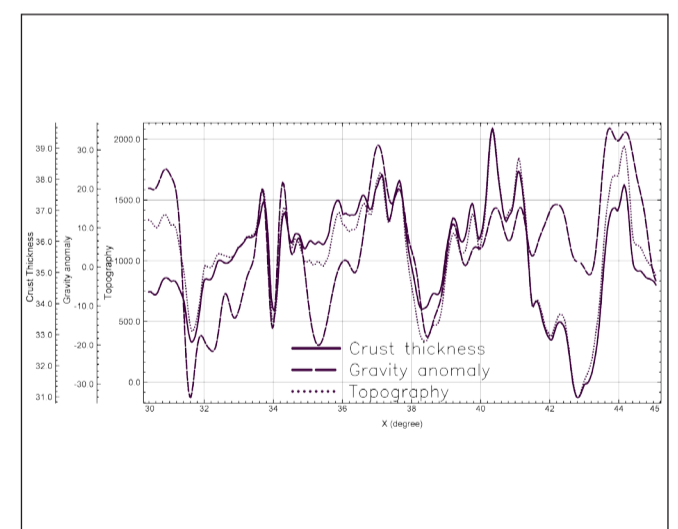
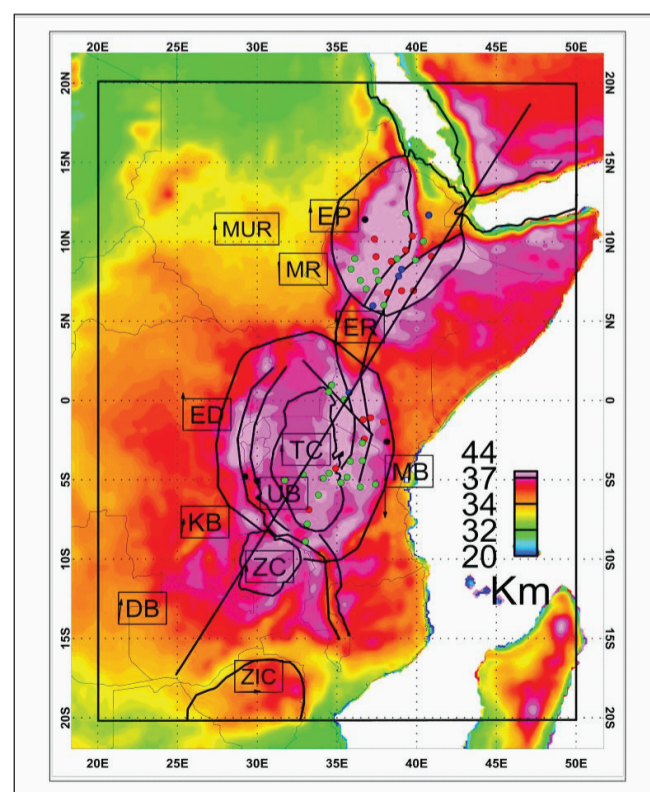


Figure 5: Spatial variation of gravity anomaly, crust thickness and topography along a profile line which extends from South west to North east of the of the study area (see Figure 4). The correlation between gravity anomaly and crustal thickness is positive at larger wave lengths. The smaller variation at shorter wavelengths may show the support of loads by the lithosphere. In general the profile shows an isostatic compensation of the region.



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