Final Report

A Detailed Geoid Model for Africa

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One of the main tasks of physical geodesy is the determination of the geoid, which is directly connected with the theory of equipotential surfaces. Besides the scientific interest of determining the geoid, it serves for realizing a height reference system necessary, e.g., for monitoring temporal changes of sea level, geophysical exploration, and monitoring vertical motions and plate tectonics.

A unified accurate geoid model for Africa has not yet been made available due to the lack of data, resources and, to some extent, support. The determination of the spatial position of this surface in Africa is indispensable for realizing the International Height Reference System (IHRS). It would be used for the UN Global Geodetic Reference Frame (GGRF), the European satellite navigation project Galileo, the European initiative Global Monitoring for Environment and Security (GMES), the implementation of information services dealing with environment and security, and will also serve in resources exploration, e.g., oil and ground water.

The basic idea of this research comprises the following technical steps:

1. Reduce the available gravity data for Africa using the window remove-restore technique, in order to get rid of the double consideration of the topographic masses around the computation point.
2. Grid the reduced gravity anomalies, containing large data gaps, on a regular 5' × 5' grid employing the unequal weight least-squares interpolation technique (Moritz, 1980) after filling the gaps on a regular 15' × 15' grid using the most recent combined geopotential model (EIGEN-6C4), complete to degree and order 2190.
3. Use the gridded data to determine an accurate geoid model for Africa employing Stokes integral with Meissl modified kernel, for better combination of gravity field wavelengths, in the framework of the window remove-restore technique.
4. Scale the computed geoid for Africa.

The used, currently available, gravity data set for this project is visualized in Fig. 1. The green colour refers to the land data, the blue colour refers to the shipborne data and the magenta colour refers to the altimetry data.

Figure 1 shows the irregular gravity data distribution with very large gaps, especially on land, which is extremely challenging and requires the specified evaluation process described above. The total number of gravity data stations on land is about 130,000 stations and on sea is about 1.3 million.

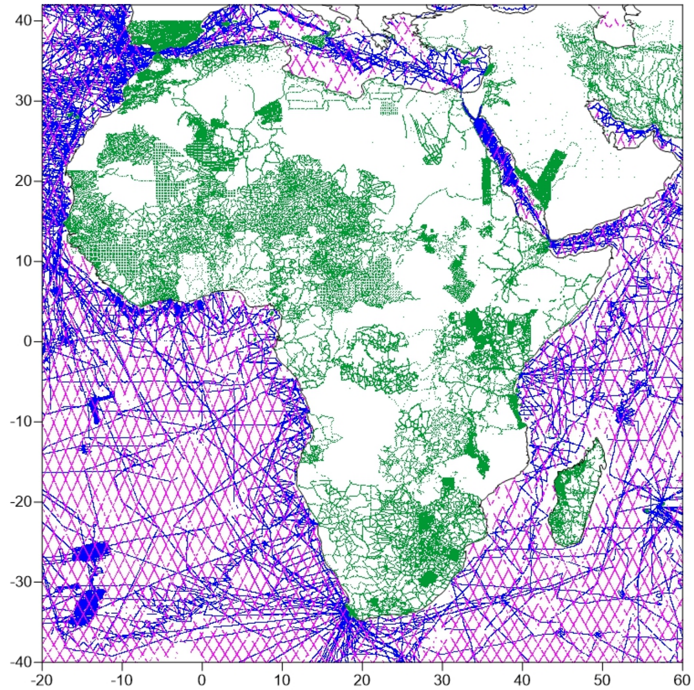

Fig. 1: Distribution of the gravity data for Africa.

The window remove-restore technique for the determination of the Earth's mathematical surface comprises three steps; they are:

1. Remove.
2. Compute.
3. Restore.

The computed geoid model for Africa has been scaled using the GOCE DIR R5 model (Bruinsma et al, 2014), complete to degree and order 280, which represents the best available satellite only global geopotential model approximating the African gravity field (Abd-Elmotaal, 2015). A linear trend function, computed through a least-squares regression technique, has been used to scale the computed geoid within the current investigation.

Figure 2 shows the scaled Earth's mathematical surface for Africa. The values range between -55:34 m and 57.34 m with an average of 11.73 m.

Main results of the carried out research are going to be published in the International Association of Geodesy Symposia series. The paper is under review in the mean time.

Further cooperation with my host professors, Prof. Dr. Bernhard Heck and Prof. Dr. Hansjörg Kutterer and his institute is planned at different scales. One of which is that we are going to apply for a Material Resources Grant funded by DAAD. Another one is that we are going to submit a joint project proposal supported by the Egyptian STDF and the German DAAD.

Finally, I would like to express my thanks to the KIT for supporting this research project. I wish also to thank both Prof. Dr. Bernhard Heck and Prof. Dr. Hansjörg Kutterer and their co-workers, in particular Dr. Kurt Seitz, for their cooperation during my stay in Karlsruhe.

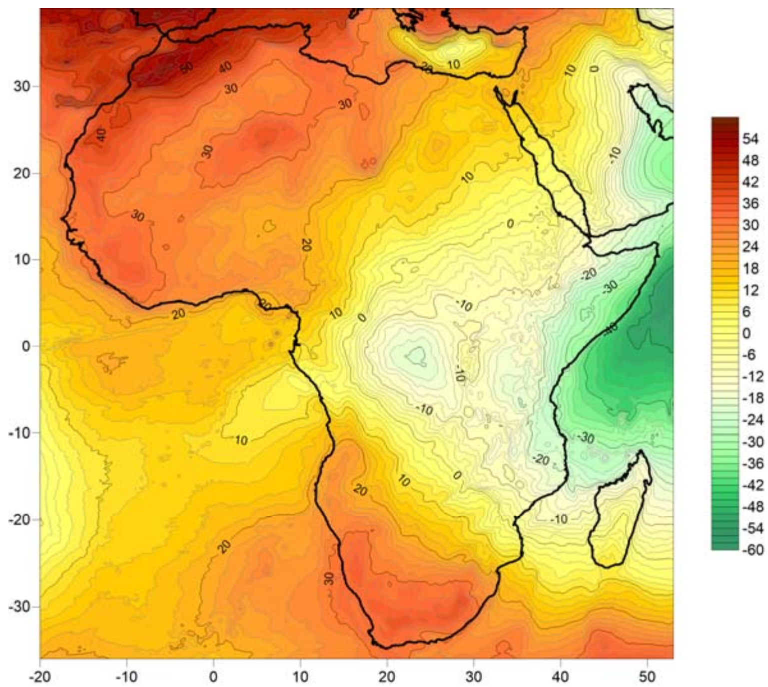

Fig. 2: Preliminary result: scaled geoid model for Africa. Values are in [m].