The Abdus Salam
International Centre for Theoretical Physics

United Nations
Educational, Scientific and
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2053-28

Advanced Workshop on Evaluating, Monitoring and Communicating Volcanic and Seismic Hazards in East Africa

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The contribution of gravimeteric work at IGSSA in the quest to understanding the tectonic setup in Ethiopia

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The Contribution of Gravimeteric Work at IGSSA in the Quest to Understand the Tectonic Setup in Ethiopia

Advanced Workshop on Evaluating, Monitoring and Communicating Volcanic and Seismic Hazards in East Africa

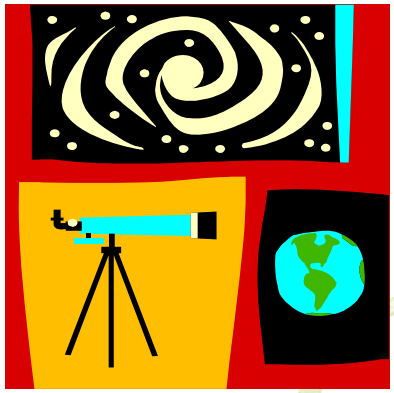
The Abdus Salam International Centre for Theoretical Physics (ICTP)
Trieste, Italy

Session: Geodetic monitoring and Modelling

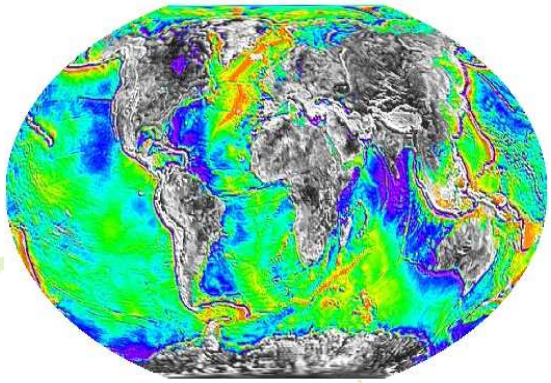
August 19, 2009

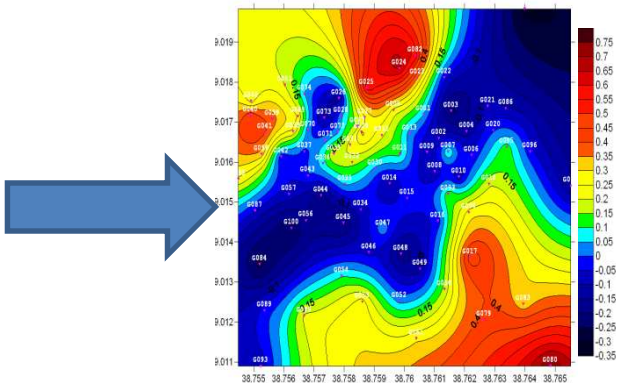
By Elias Lewi
Institute of Geophysics Space Science and Astronomy (IGSSA)
Addis Ababa University

It is my believe that, unless we study our planet earth



in its entirety





From Global to very detail

It might take us as many years as it is needed for events to happen, to understand our mother planet earth.

and

that is even possible if we use our sense organs timely

Outline:

Part1: Introducing IGSSA

- The geophysical Observatory of Addis Ababa University (GOAAU) and the past 52 years
- Why IGSSA and what is its structure
- The Department of Geomatics, Geodesy and Gravimetery (DGGG) in IGSSA and Current activities

Part2: An attempt to utilize global gravimetric models in the effort to understand the tectonic setup in North-eastern part of Africa

Part3: The Digdiga–Ado Ale gravity profile across the active Dabbahu-Manda-Hararo segment

Milestones in the Geophysical Observatory's lifetime

A tribute to the numerous **local** and **international collaborators** without whom the following achievements were impossible.

(Special tribute goes to Prof. Father Pierre **Gouin** S.J. and Dr. Laike Marian **Asfaw**)

- Established in 1957 during the International Geophysical Year (IGY) from 1957 to 1958
- It was established as geomagnetic station on the campus of University College of Addis Ababa.
- Seismological Observation Started in 1959.
  - It was then followed by the installation of the WWSSN Station AAE in 1962.
  -
  - AAE was upgrading to FURI Tunnel at Furi Mountain with IRIS/USGS in 1997

Milestones in the Geophysical Observatory's lifetime cont.

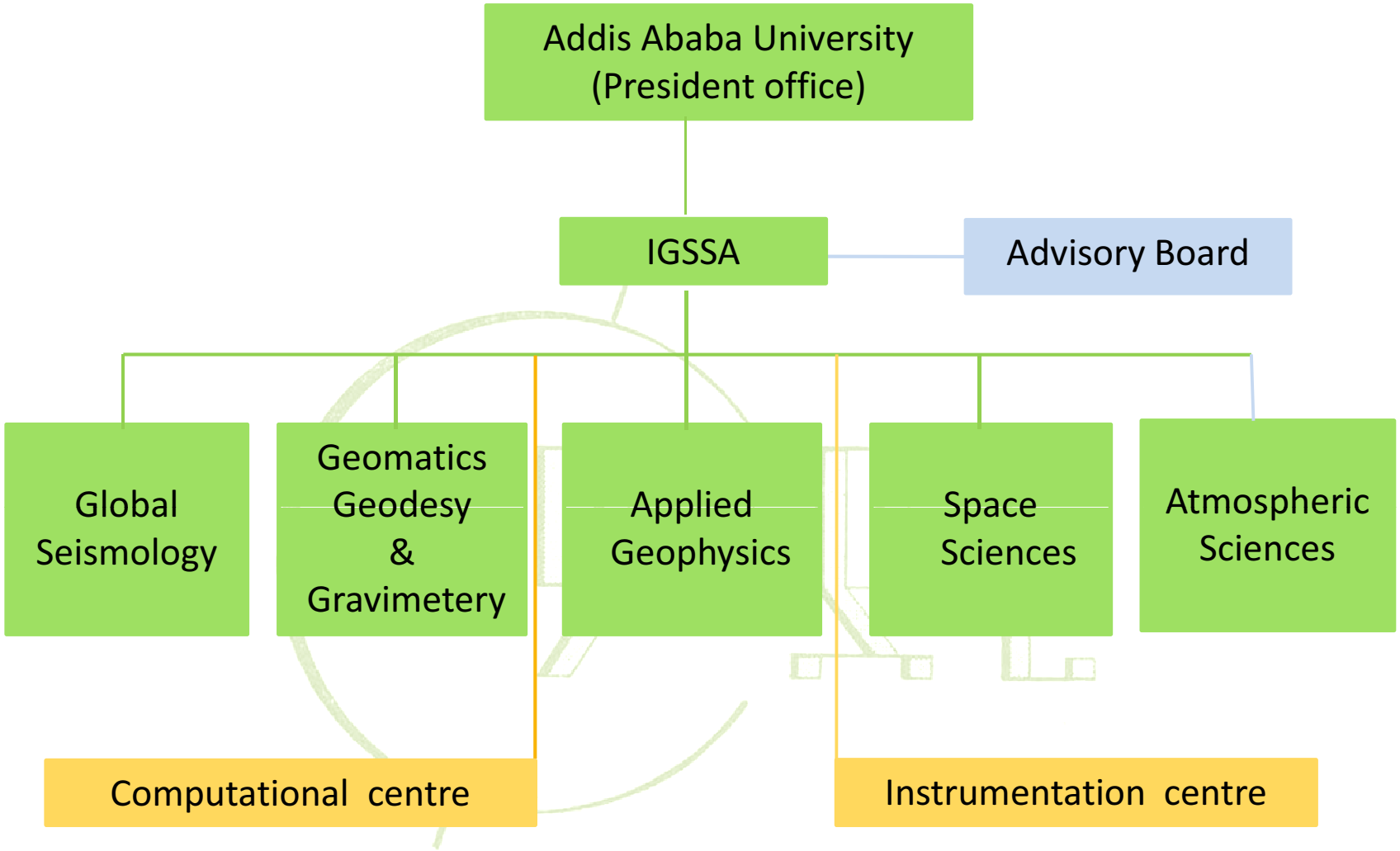
- Geodetic surveys were carried out as early as 1969.
  - Geodimeter Survey from 1969 to 1976
  - The gravimetery survey from 1970-1974
  - The GPS measurements 1989-2004
- The 1998 to 2001 Broadband Seismic Experiments
- The EAGLE project (2001-2004) with consortium of universities
- The Afar Consortium born as a result of the 2005 seismo-tectonic event in Dabbahu region

Milestones in the Geophysical Observatory's lifetime cont.

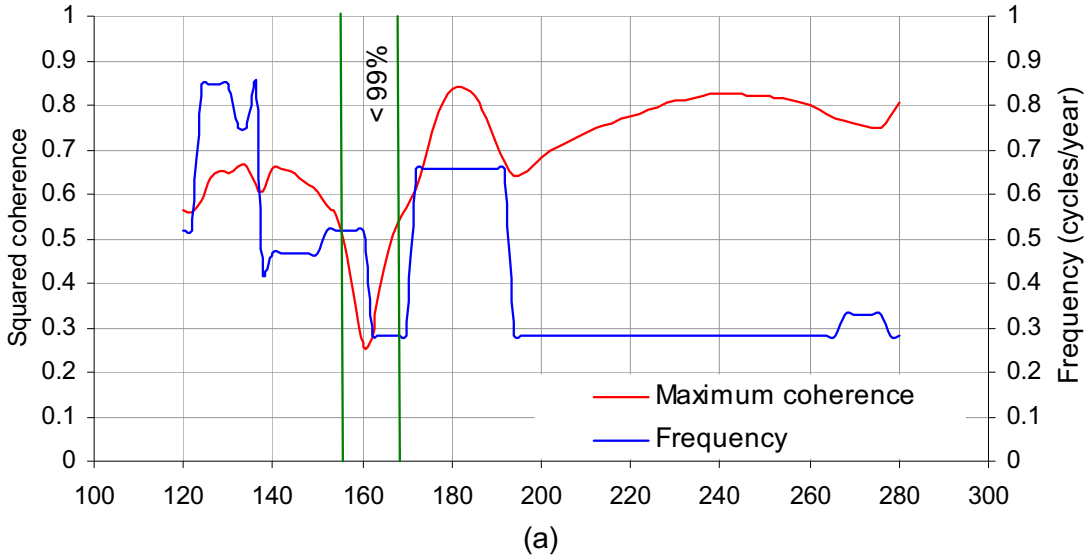
- The IGS station in Addis Ababa since 2007
- The new program of Geomagnetic observation MAGDAS since 2006
- Designated as the National Data Centre (NDC) to manage Seismic and Radionuclide data in connection with CTBTO
- The Airborne gravity survey flown all over Ethiopia from 2006-2008
- The expansion of GPS continuous station network since 2006
- The establishment of the atmosphere scanning system in 2009 at the premises of the Observatory
- During all its life time the observatory has participated in numerous applied geophysical work

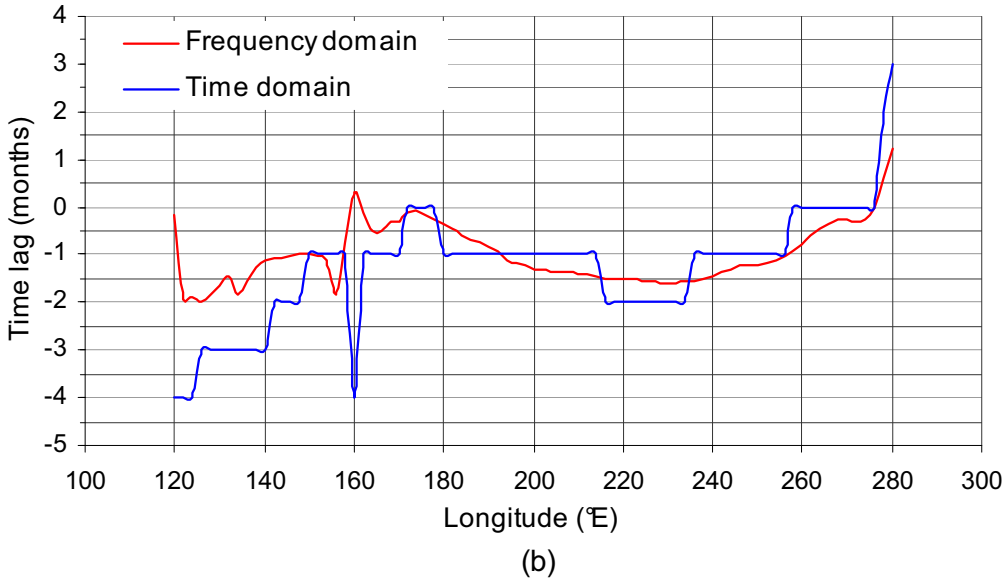
Why IGSSA ?

- This 50 years long **dedicated** and **successful culture of research**
- The sense of responsibility to strengthen the long-lived effort being **societal problem solvers**
- The need to reinforce the effort made in **advancing the forefront of the research activates in geosciences**
- The need to **expand the areas of research activates in an organized manner**
- A dedicated **support from the Addis Ababa University**
- supported by **the committed local and international collaborations**
- Gave birth to the Institute of Geophysics Space Sciences and Astronomy (IGSSA) of the Addis Ababa University (AAU)


Addis Ababa University
(President office)
IGSSA
Advisory Board
Global Seismology
Geomatics Geodesy & Gravimetery
Applied Geophysics
Space Sciences
Atmospheric Sciences
Computational centre
Instrumentation centre

Research activities in earth rotation area



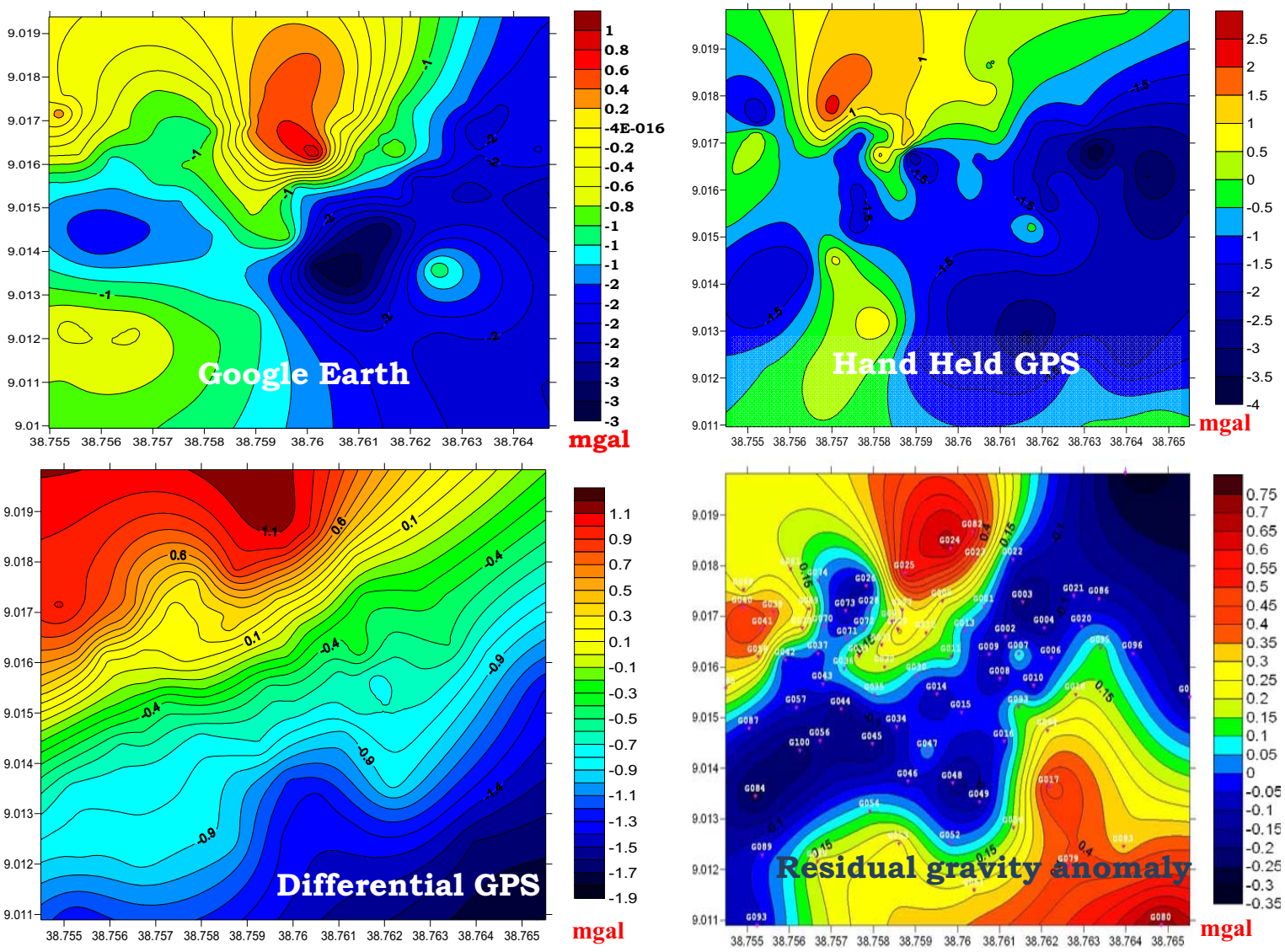


Result of the coherence analysis on studying the effect of El Nino La Nina Southern oscillation on the length of day

(a) Maximum squared coherence and the frequency band at which it occurs

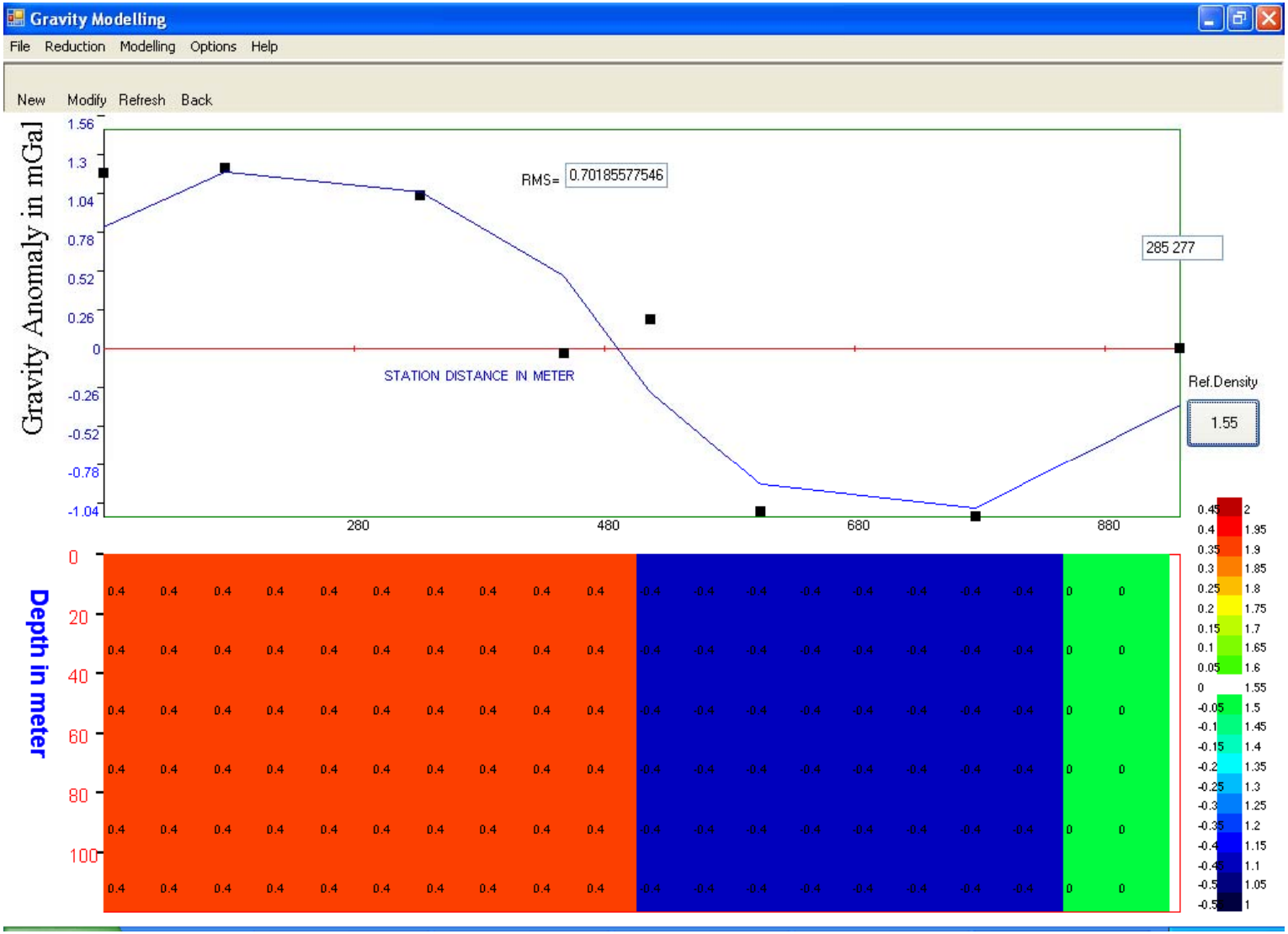
(b) The comparison of the time lag obtained from the coherence analysis and correlation analysis.

The DGGG in Applied Geophysics



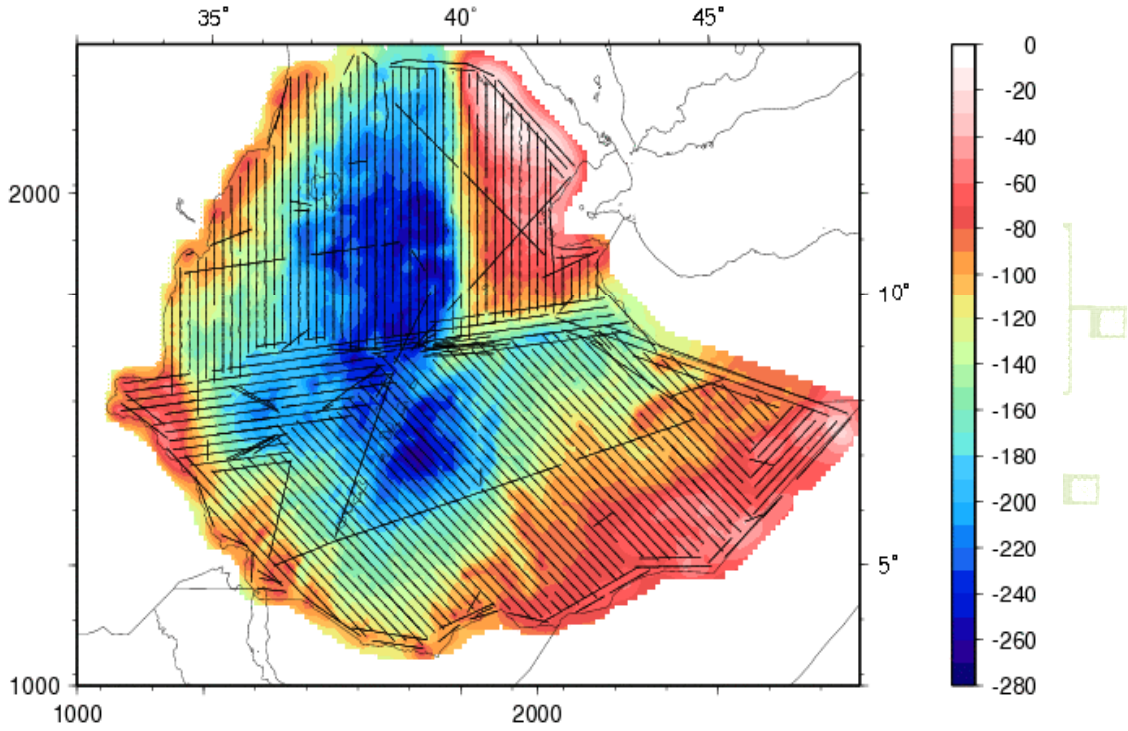
The role of high precision gravimetery, where other geophysical techniques can not be implemented

Development of modelling software

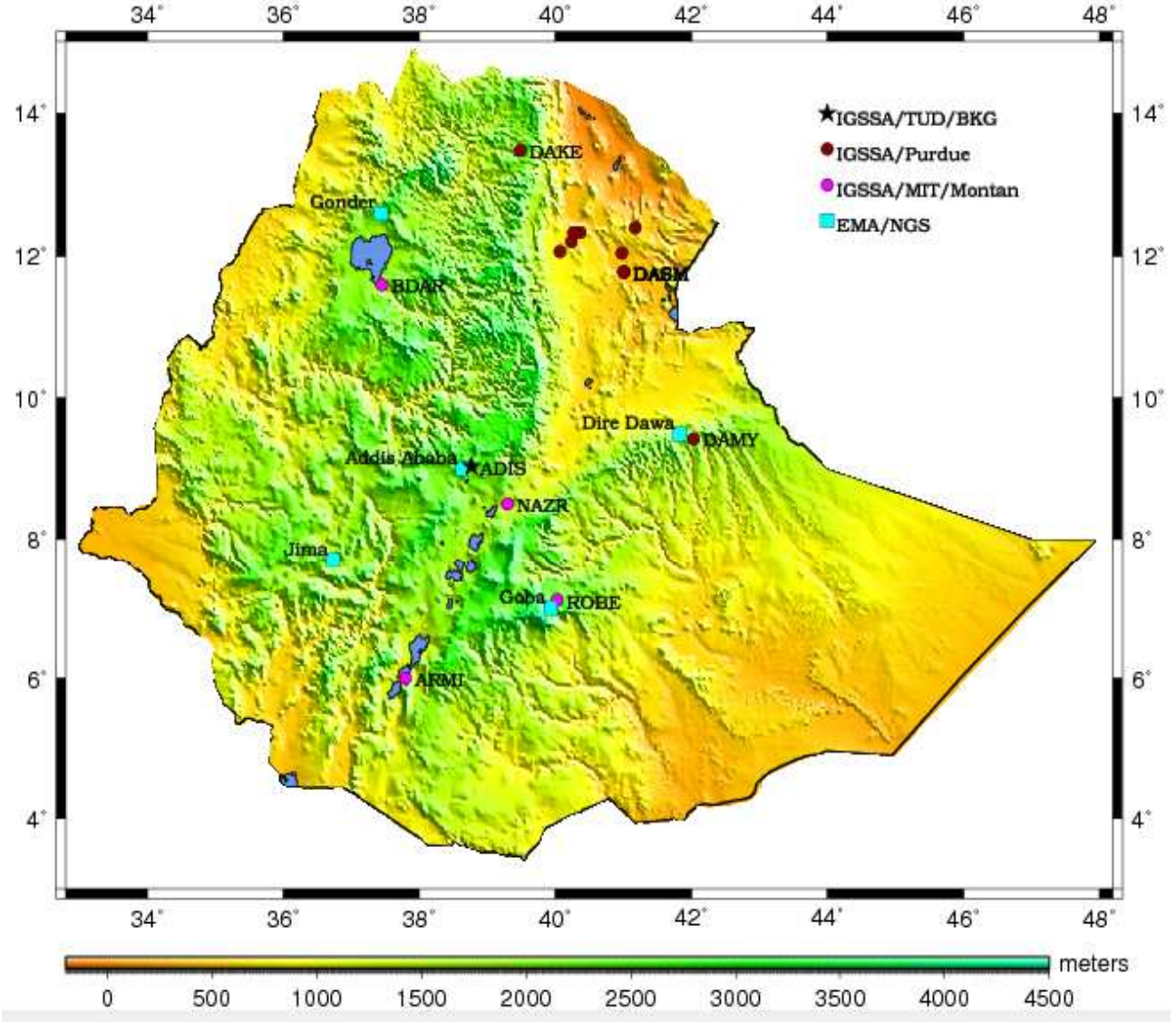


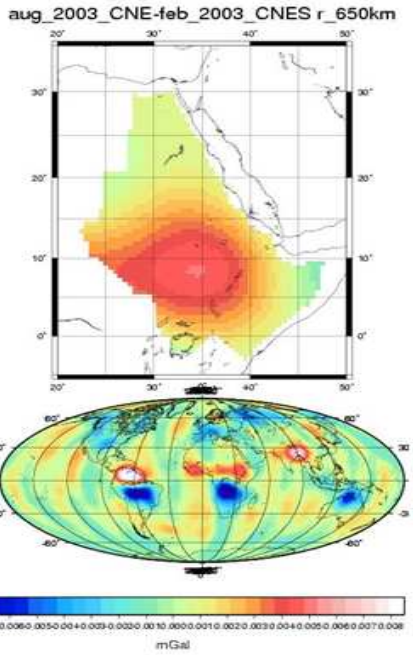
The airborne gravity survey of Ethiopia

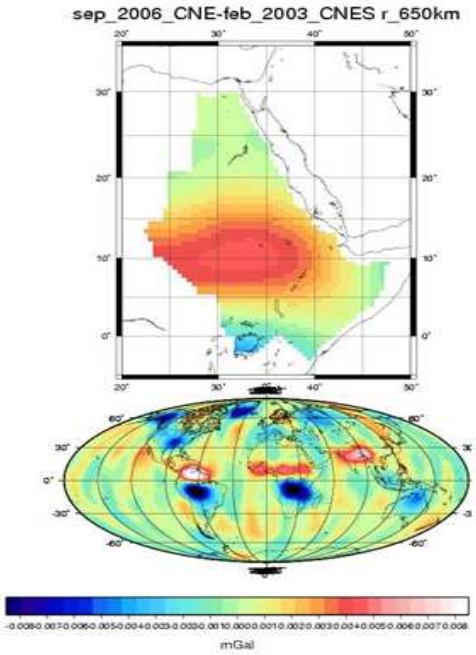
Here shown as gravity disturbances corrected for the gravity effect of topography derived from the Shuttle Radar Topography Mission (SRTM) using the 'hedgehog' algorithm.

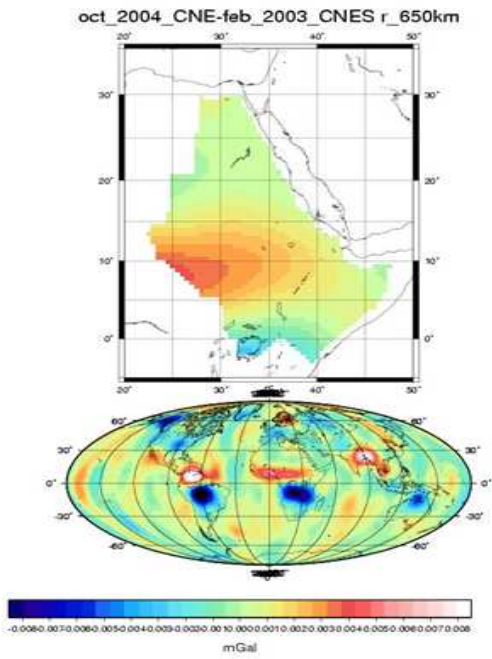


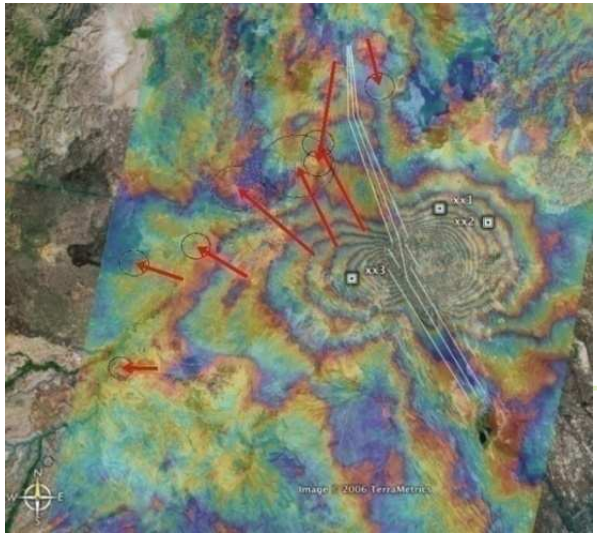
Present day continuous GPS station in Ethiopia











Top: A test study on the water mass balance of the Nile Basin within Ethiopia using time varying Gravity signal from GRACE Satellite (In collaboration with university of Edinburgh)

Left: The June 17, 2006 Seismo-Tectonic event in Afar, as interpreated from INSAR data (In collaboration with Leeds University)

Global gravimeteric models and their role in understanding the East African tectonic setup

The aims of the study are:

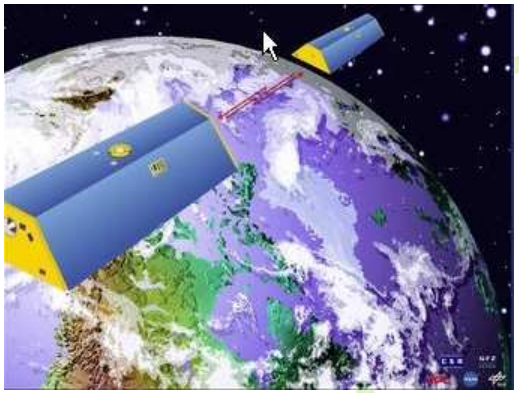
- To analyze the usability of the gravity data from the EIGEN-Gl04C model for geodynamic studies in northeastern Africa region
- To remove topographic effects from the data and anlayze the underlying structures
- To analyze deep seated dynamic process
- To assist study the plate formation process in the different rift systems

What is EIGEN-GL04C ?

EIGEN = European Improved Gravity model of the Earth by New techniques

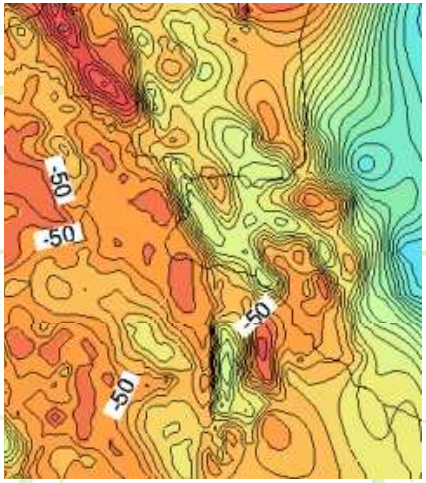
GL04C = GRACE LAGEOS 04 Combined (Satellite +surface)

GRACE twin satellites



GRACE
Gravity Recovery And Climate Experiment

30 months GRACE



30' x 30' grid surface data
+
Ocean Data (direct Altimetry)

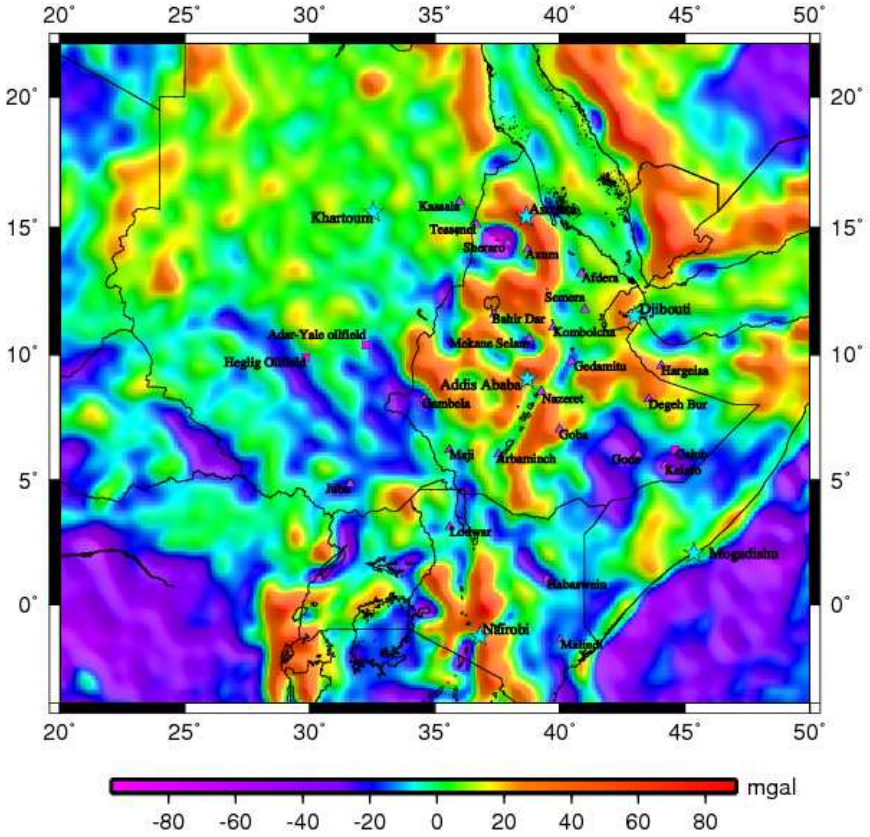
LAGEOS
LAser GEOdynamics Satellite

24 months LAGEOS

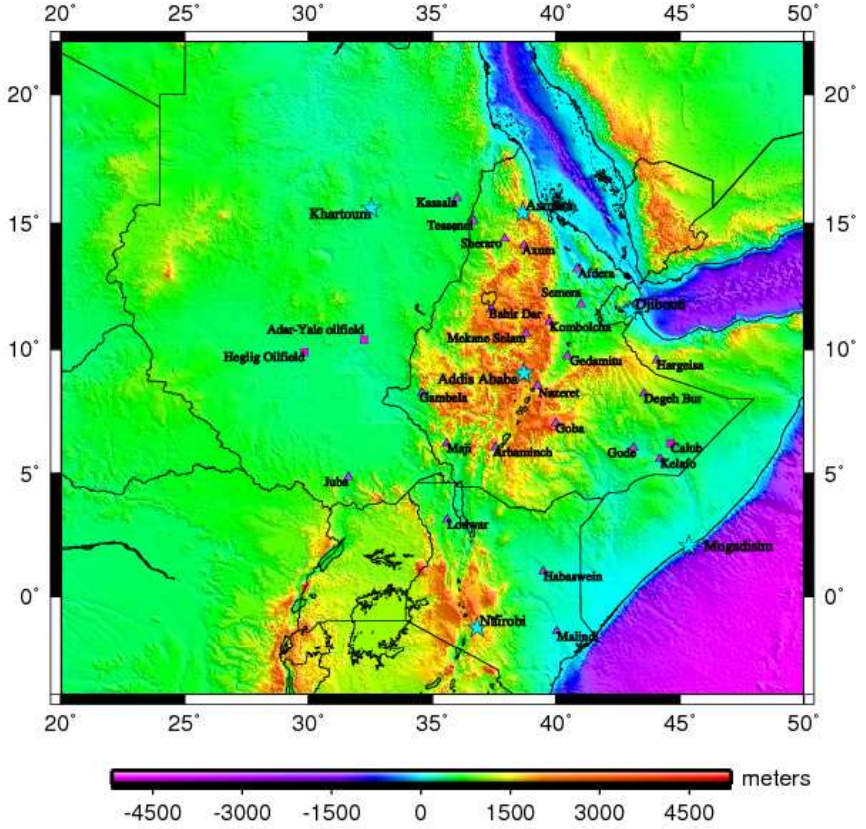
It is complete to degree and order = 360
Full wavelength = **111 km** **which means** it can resolve spatial features **to 55 km**

http://op.gfz-potsdam.de/grace/results/index_RESULTS.html

Satellite pictures: http://msl.jpl.nasa.gov/...

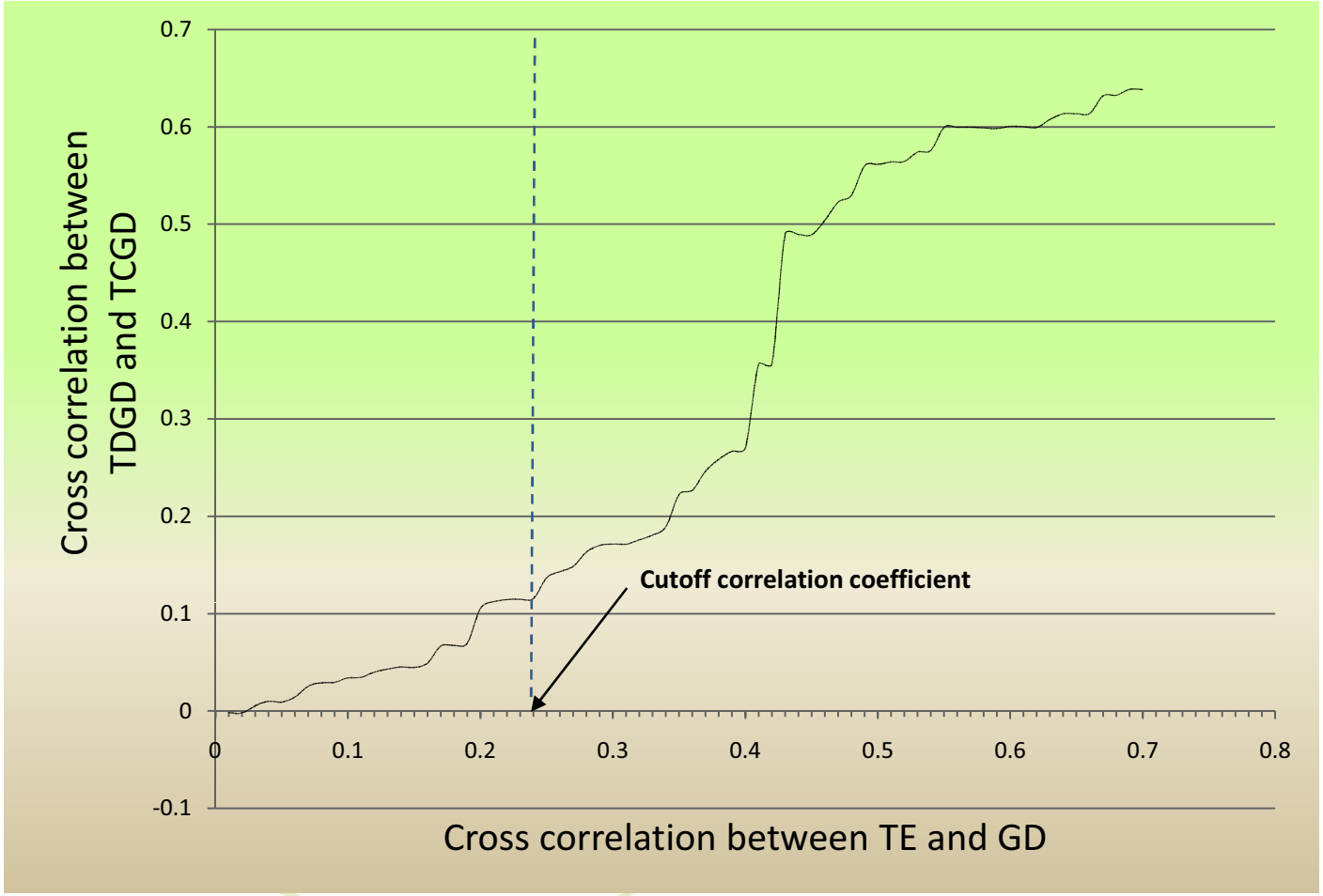


The gravity disturbance at 15 Km height over northeastern part of Africa

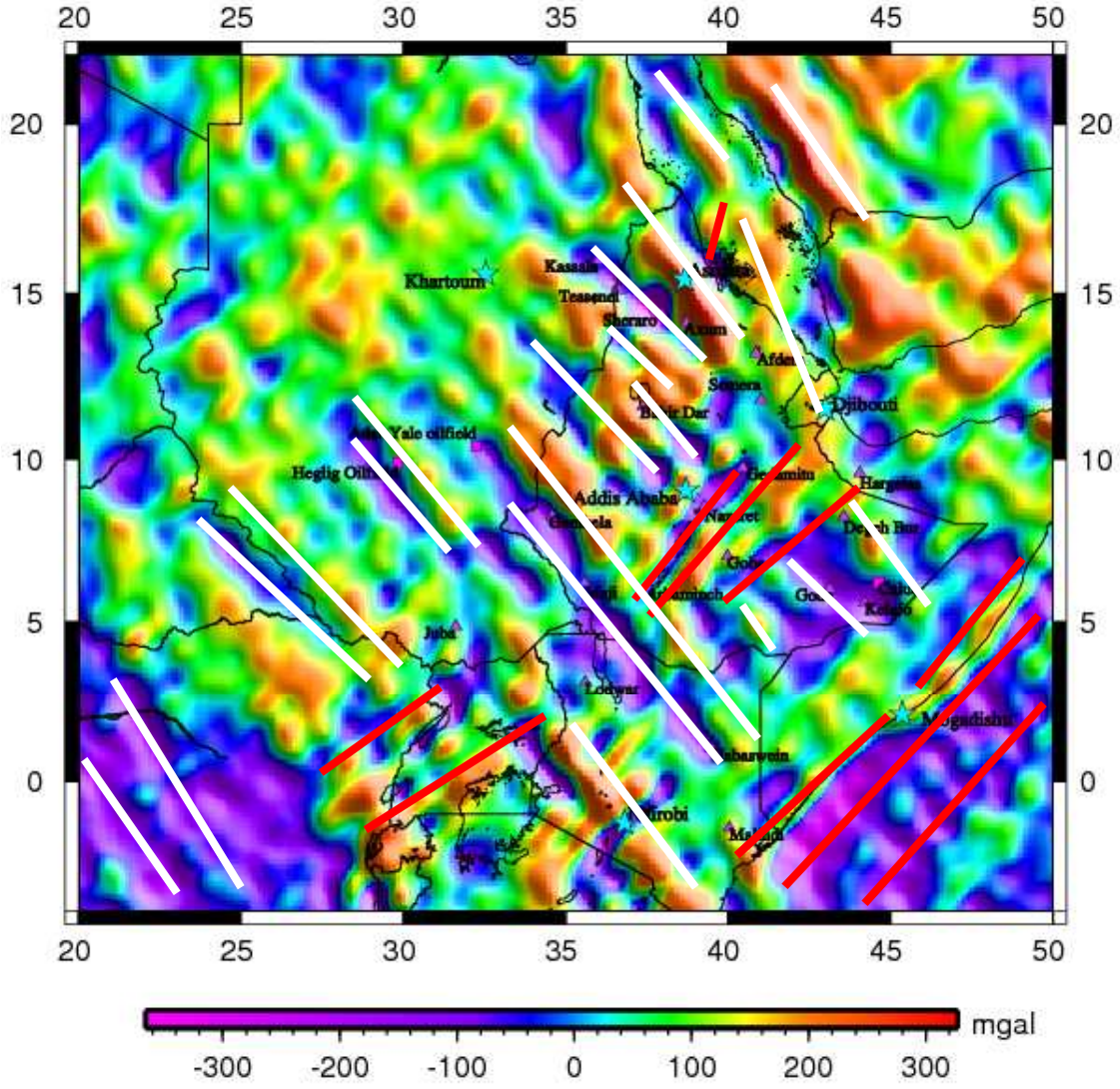


The topography of northeastern part of Africa (ETOPO2)

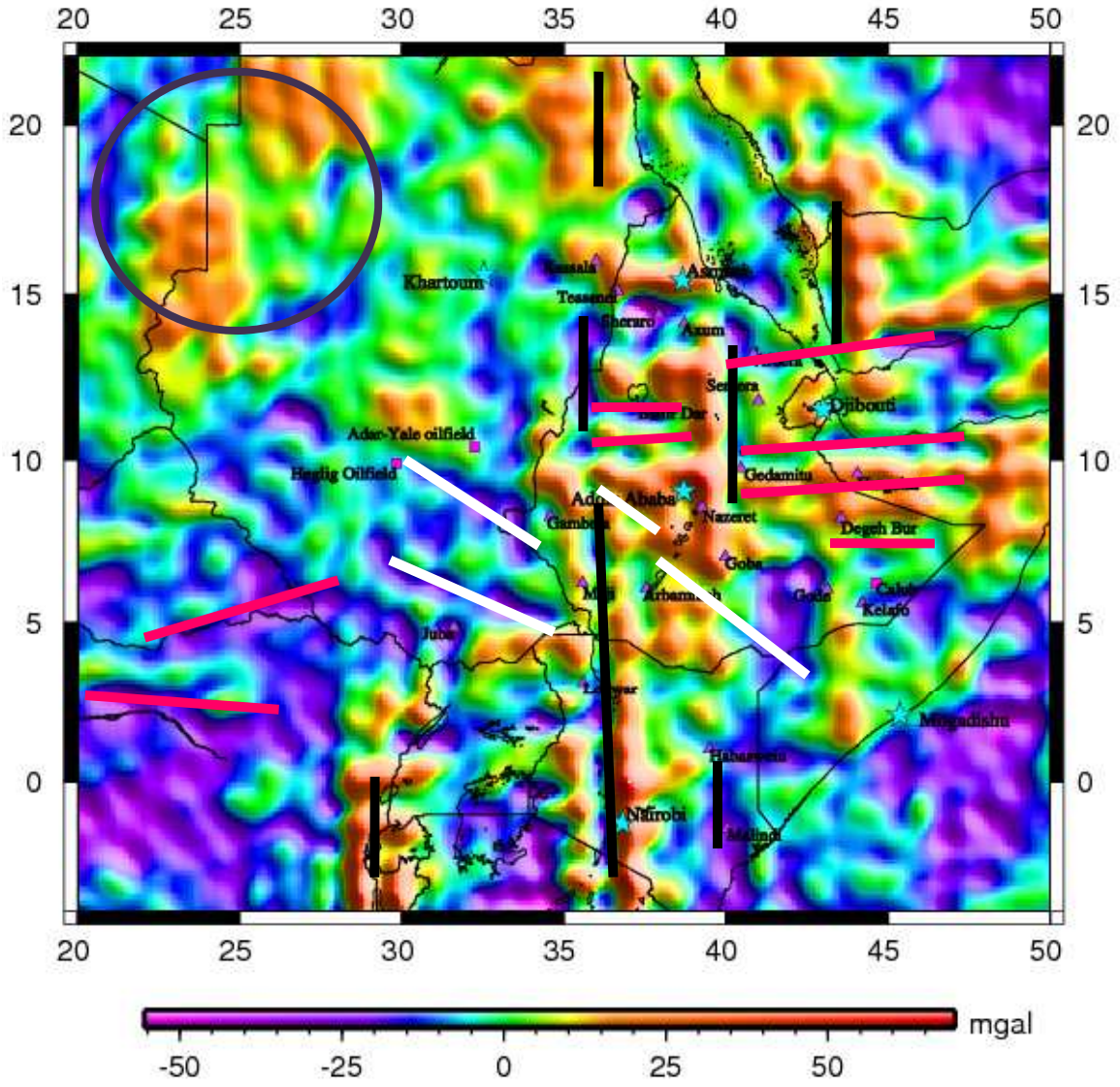
Acknowledge the usage of data **EIGEN-GL04C** from GFZ Germany http://op.gfz-potsdam.de



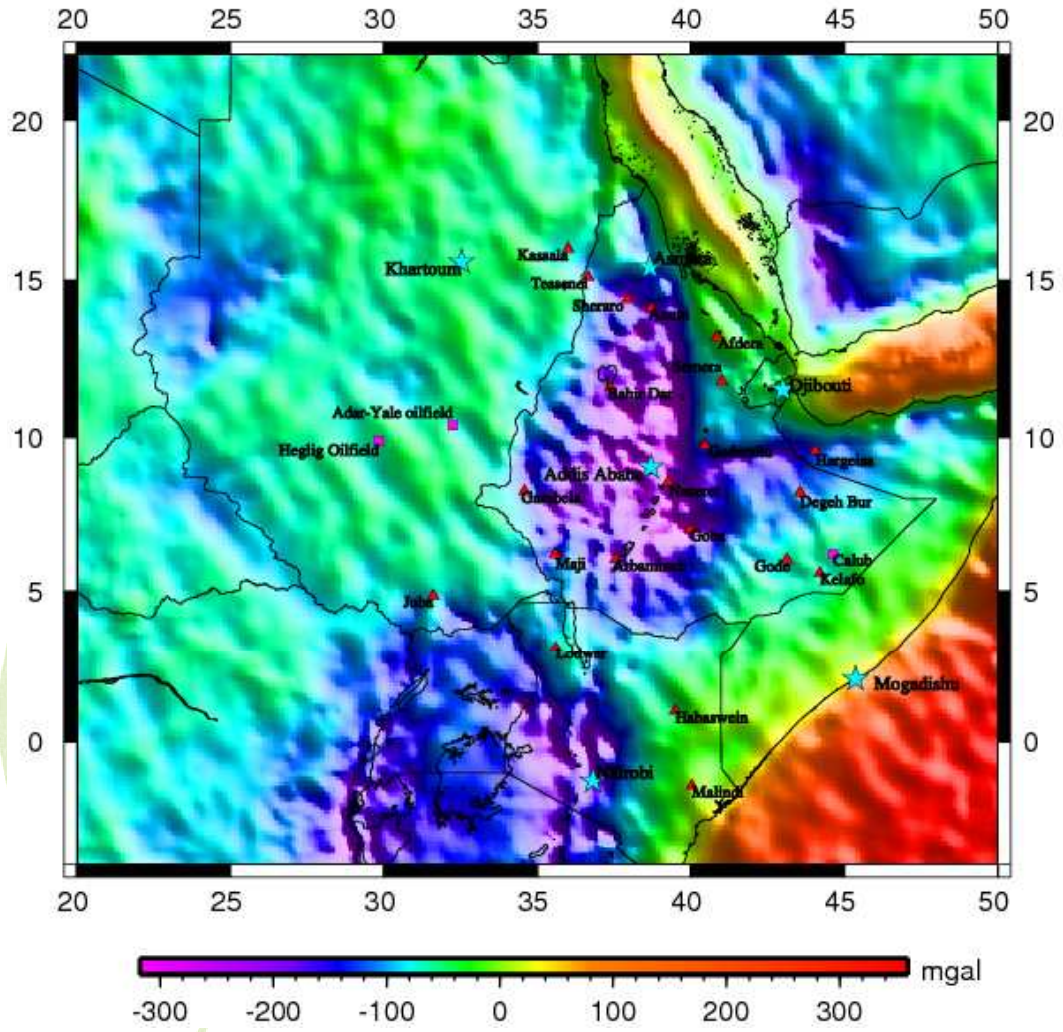
The cutoff correlation coefficient used to separate the terrain correlated signal from the gravity disturbance



The terrain correlated gravity disturbance



The terrain de-correlated gravity disturbance



The compensating signal

Major findings:

- The method is sucessful in unreaviling the continuation of structures under the highlands.

- A positive high anomaly that is not correlated with the topography and which is belived to be caused by deep lying structures is observed in the central part of the western Ethiopian highland

- Because of north-south striation, which is a common problem over oceans in pre EIGEN-GL04C model, interpretation of north-south structures should be made with great care

- Regarding age of the rift systems and compensation:

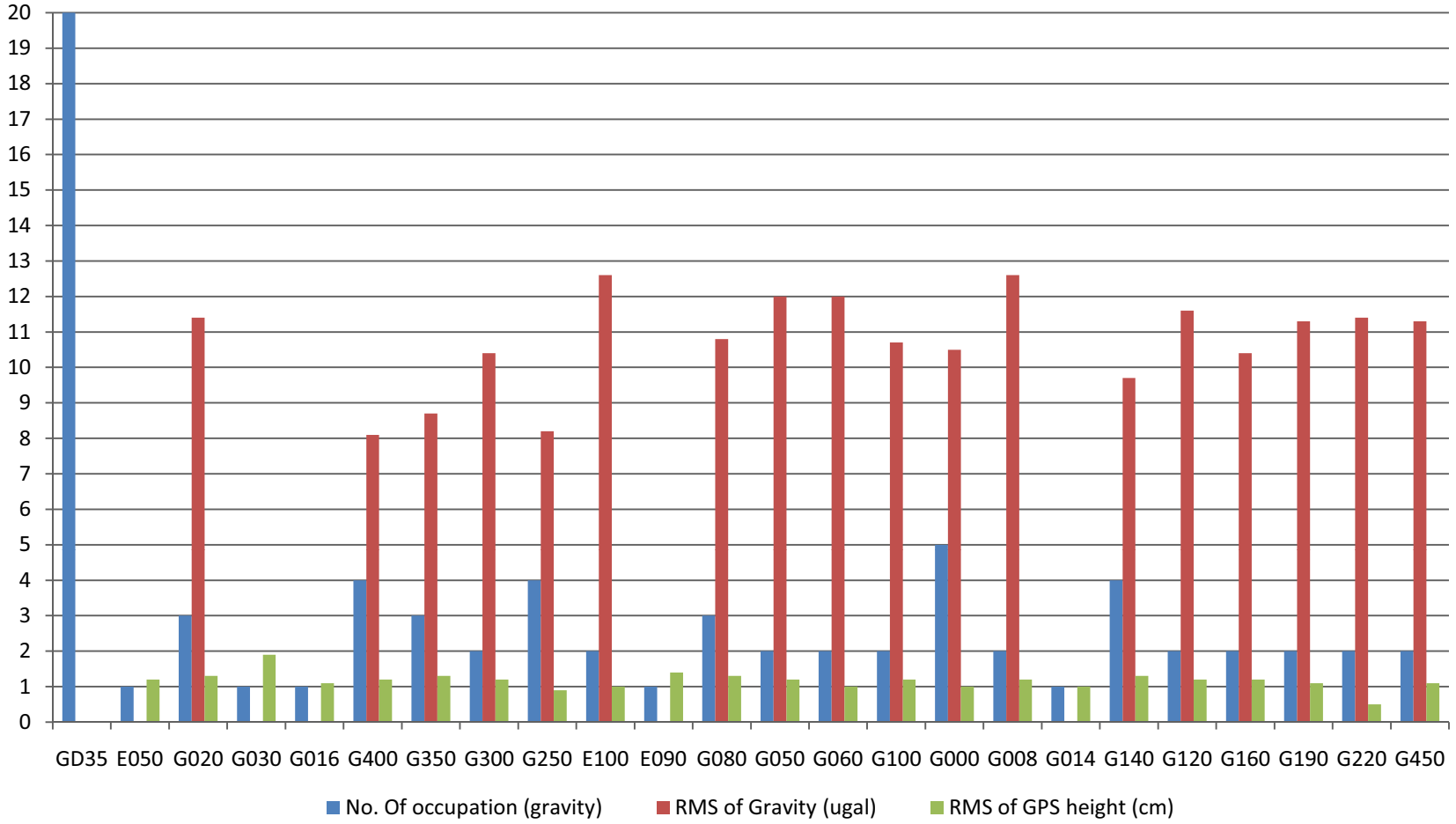
  - The east Africa Rift is at a early stage and is not yet compensated

  - The Afar Rift, which is part of the Red Sea arm of the triple junction, is in a transition period and is at the early stage of compensation

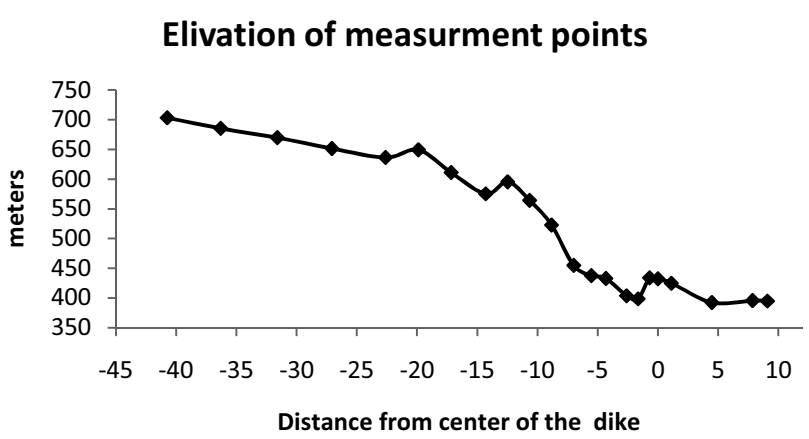
  - The Gulf of Eden is a matured system shows advanced compensation

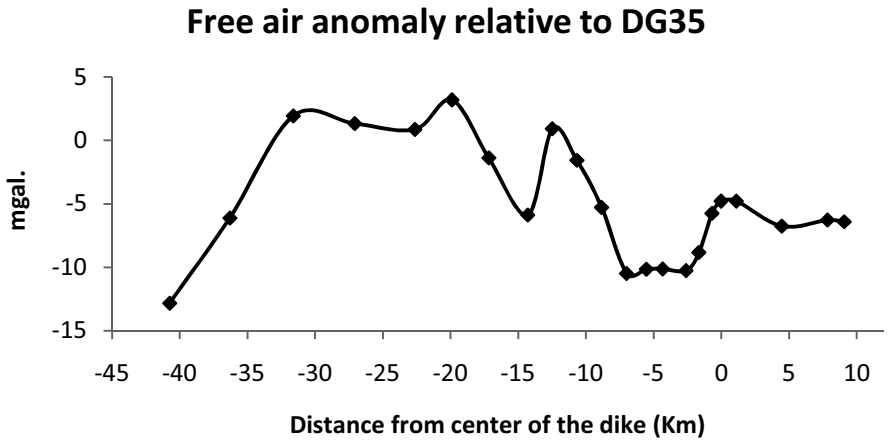
The Digdiga–Ado Ale gravity profile across the active Dabbahu-Manda-Hararo segment

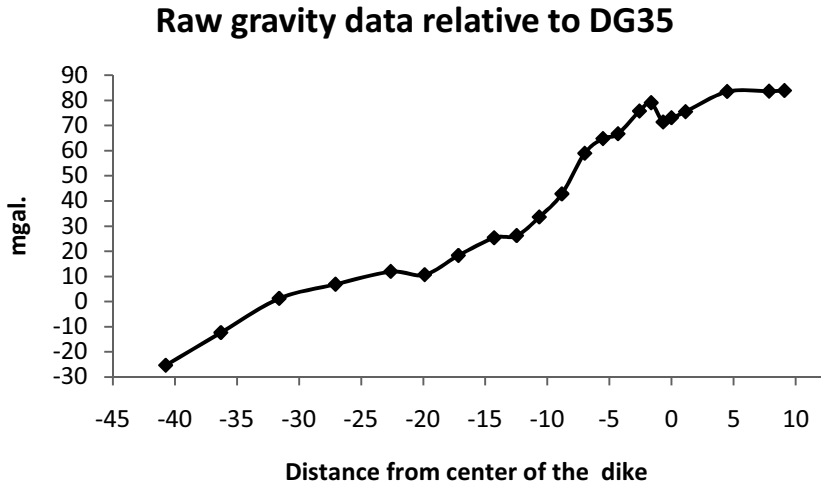
Location of measurement points

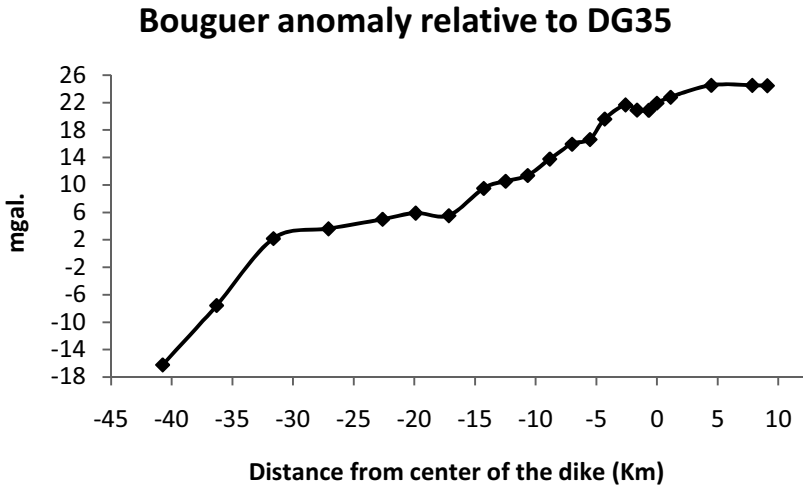


Gravity and GPS measurement data quality

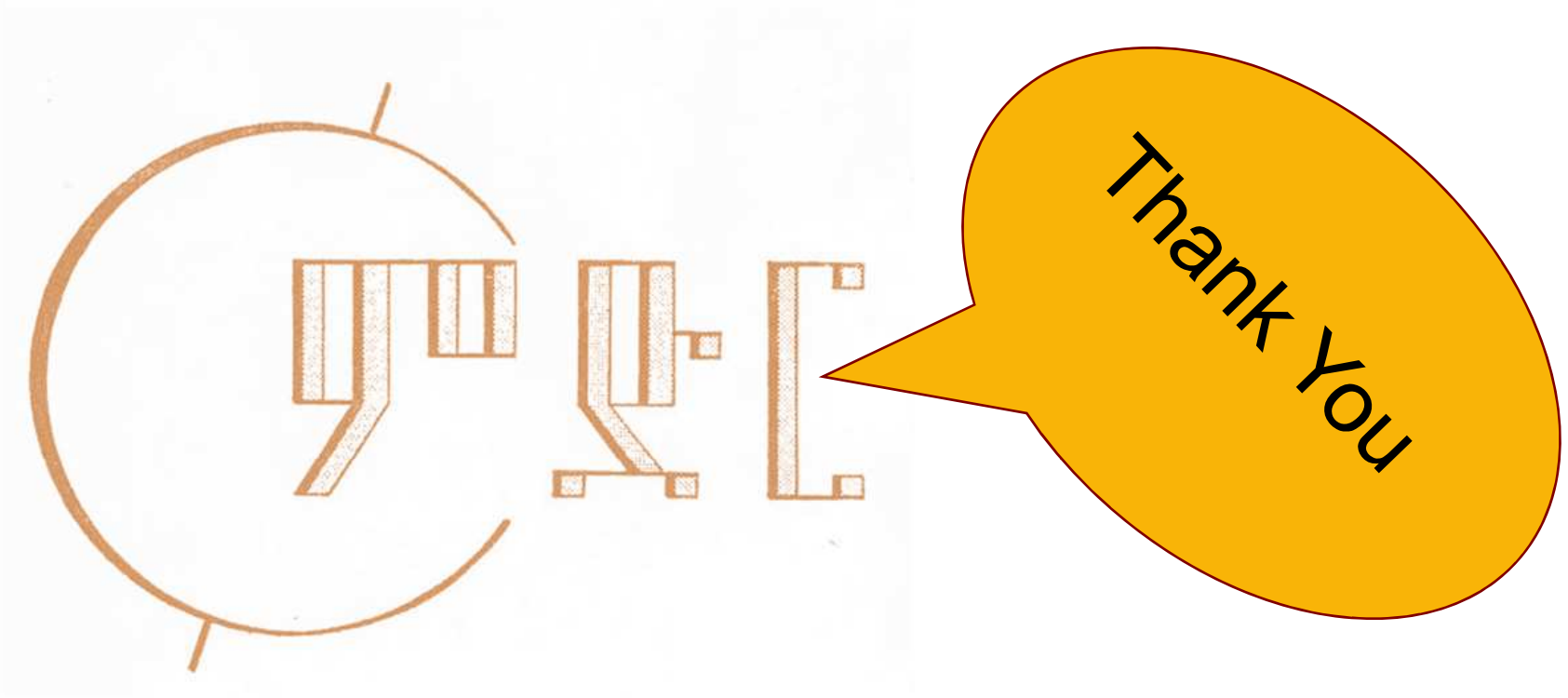








Preliminary gravity results after the removal of topographic effects


Thank You