Comparison of SRTM and ASTER DEM to the Prediction of the Mean Gravity Anomaly

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INTRODUCTION

- Geoid is an equipotential surface of Earth gravity field ...
- The geoid is important for the geodesists to use it as the reference surface of heights and depts.
- Geoid determination can be classified into three sections according to data: Astro-geodetic, gravimetric and GPS-levelling methods.
- In gravimetric method, gravity surveys should be reduced to free-air gravity anomalies, and then these anomalies are evaluated in Stokes function.
- Additionally, free-air anomalies should be interpolated to regular grids. While interpolation process we need to a Digital Elevation Model (**DEM**) in order to provide mean height information.

INTRODUCTION

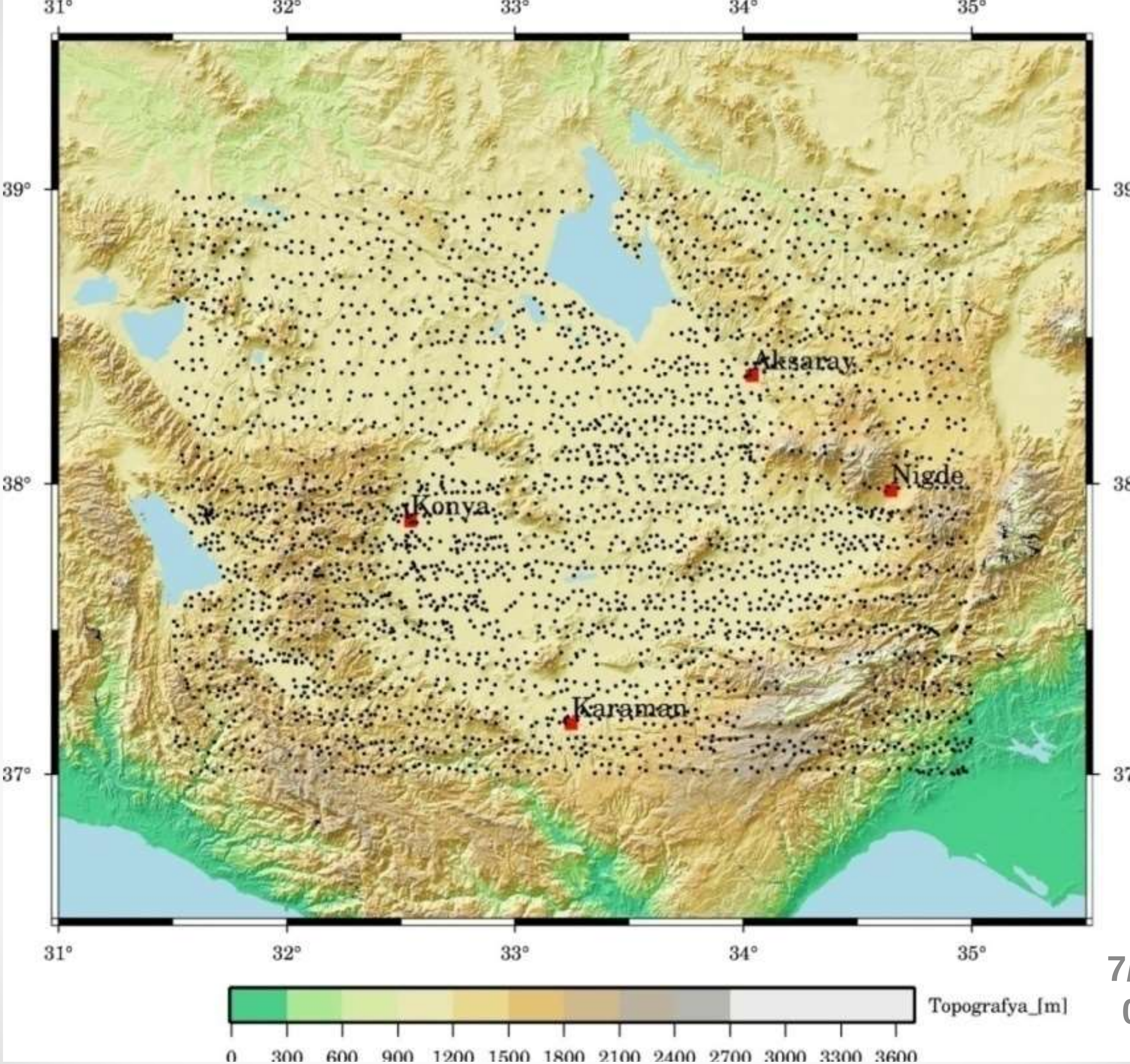
- In geodetic literature, there is a limited amount of paper that concerns effect of any DEM on the gravity field.
- Merry (1999) compares some **global and regional DEMs** in determination of height anomaly in Africa by Molodensky approximation.
- Kiamehr and Sjöberg (2005) examine the contribution of **SRTM DEM** (3 arc-second) to geoid determination by considering some global and regional DEMs.
- Abbak (2014) studied on the comparison of **ASTER and SRTM (at 3 arc-second resolution**) to predict mean gravity anomalies in Auvergne test region (France), which has a moderate rough topography with over-determined gravity surveys.

INTRODUCTION

- In this study, the effect of **ASTER and SRTM DEMs** on the prediction of the mean gravity anomalies was investigated in Konya Closed Basin (Turkey).
- This contribution considers both DEMs at **one-arc second resolutions in a mountainous test area with sparse gravity data** when compared to earlier studies.

INPUT DATA

- **STUDY AREA** is Konya Closed Basin that lies on central Turkey.
- bounded by 37°—39° latitudes and 32°—35° longitudes.
- Covers 50 000 km^2 area.
- Heights ranging from 600 m at Göksu valley to 3500 m at the peak of Taurus Mountains.
- Average height = 1100 m.
- Fig. 1 shows the topography of the study area.


31°
32°
33°
34°
35°
39°
38°
37°
Aksaray
Nigde
Konya
Karaman
Topografya_[m]
0
300
600
900
1200
1500
1800
2100
2400
2700
3000
3300
3600

SRTM DEM

- NASA, NIMA, DLR and ASI jointly performed the SRTM project.
- In 2000, during ten days a radar shuttle collected 3 dimensional images of Earth surface.
- These images were used for the production of a global DEM.
- The DEM wholly covers between **±60°** latitudes.
- vertical and horizontal datum definitions are **EGM96 and WGS84**, respectively.
- Global accuracy of the DEM is approximately **16 m** at 90 % confidence level.

ASTER DEM

- ASTER sensor was placed on the **satellite Terra**.
- an achievement of international project between METI and NASA.
- ASTER produced a DEM, which was generated from a **stereo image pairs** obtained from nadir and backward angles over the same area.
- strategy provided a global DEM with enhanced accuracy due to multiple images.
- covers all land areas ranging from **±83°** latitudes even in steep mountainous areas.
- Vertical and horizontal datum definitions are **EGM96**, and **WGS84**, respectively.
- Vertical accuracy is estimated to be **7–14** m.

Gravity Surveys

- the terrestrial gravity data was supplied from Turkish general command of mapping.
- The data is in the International Gravity Standardization Net 1971 (**IGSN71**), and its geographical datum is **WGS84**.
- The accuracy of gravity values has been estimated as **1–2** mGal.
- The number of available gravity points within the study area is about **3078**, which corresponds to a density of one point per **22** km^2.

METHODS:
Free-air Anomaly

- Gravity survey on the Earth's surface is denoted as g_p. At the same point, normal gravity is denoted as γ_P. Difference among them,

$$\delta g = g_P - \gamma_P$$

is called gravity disturbance.

- gravity anomaly can be calculated as follows,

$$\Delta g = g_P - \gamma_Q$$

where γ_Q is determined on telluride where it has same normal potential with the gravity potential of surface point P ($W_P = U_Q$).

METHODS:
Bouguer Anomaly

- Before using free-air gravity anomaly in geoid determination, it should be interpolated in grid nodes.
- However, free-air anomaly is very sensitive to the point height. Thus Bouguer anomalies representing very smooth surface can be used for the interpolation.
- Free-air anomaly (FA) is converted to Simple Bouguer (SB) anomaly,

$$\Delta g_{SB} = \Delta g_{FA} - 0.1119 * H$$

where *H* represents to orthometric height of the computation point.

METHODS:
Bouguer Anomaly

- Simple Bouguer anomalies are interpolated by using any technique such as near neighbouring, kriging etc
- After interpolating simple Bouguer in grid nodes, Free-air anomaly should be reversed by,

$$\Delta g_{FA} = \Delta g_{SB} + 0.1119 * H$$

where *H* represents to orthometric height of the grid nodes. Grid node height can be taken from any DEM.

NUMERICAL APPLICATION
Absolute Validation

- Gravity surveys covers the orthometric height of the point, which is determined a terrestrial method. Thus this information (**ground truth**) was used for validation of SRTM and ASTER DEMs.
- By using geographical coordinates of points, SRTM and ASTER heights of points were determined with the help of thin plate spline interpolation method. Then **original and DEM-based** heights were compared. Gross errors, which are higher than 50m, were removed from data.

Absolute Validation

Comparison of SRTM and ASTER DEM with respect to levelling points [m]

Model	Min	Max	Mean	RMSE
SRTM	-50.46	47.43	0.00	11.64
ASTER	-52.77	50.47	0.01	12.80

SRTM DEM is slightly better than ASTER DEM with respect to RMS and error distribution.

On the other hand DEMs are compared with each other. Minimum and maximum of the differences at grid node (0.02*0.02 arc-degree resolution) are **-31.84 and 11.29 m**, respectively. This statistic shows that there is no large difference between DEMs.

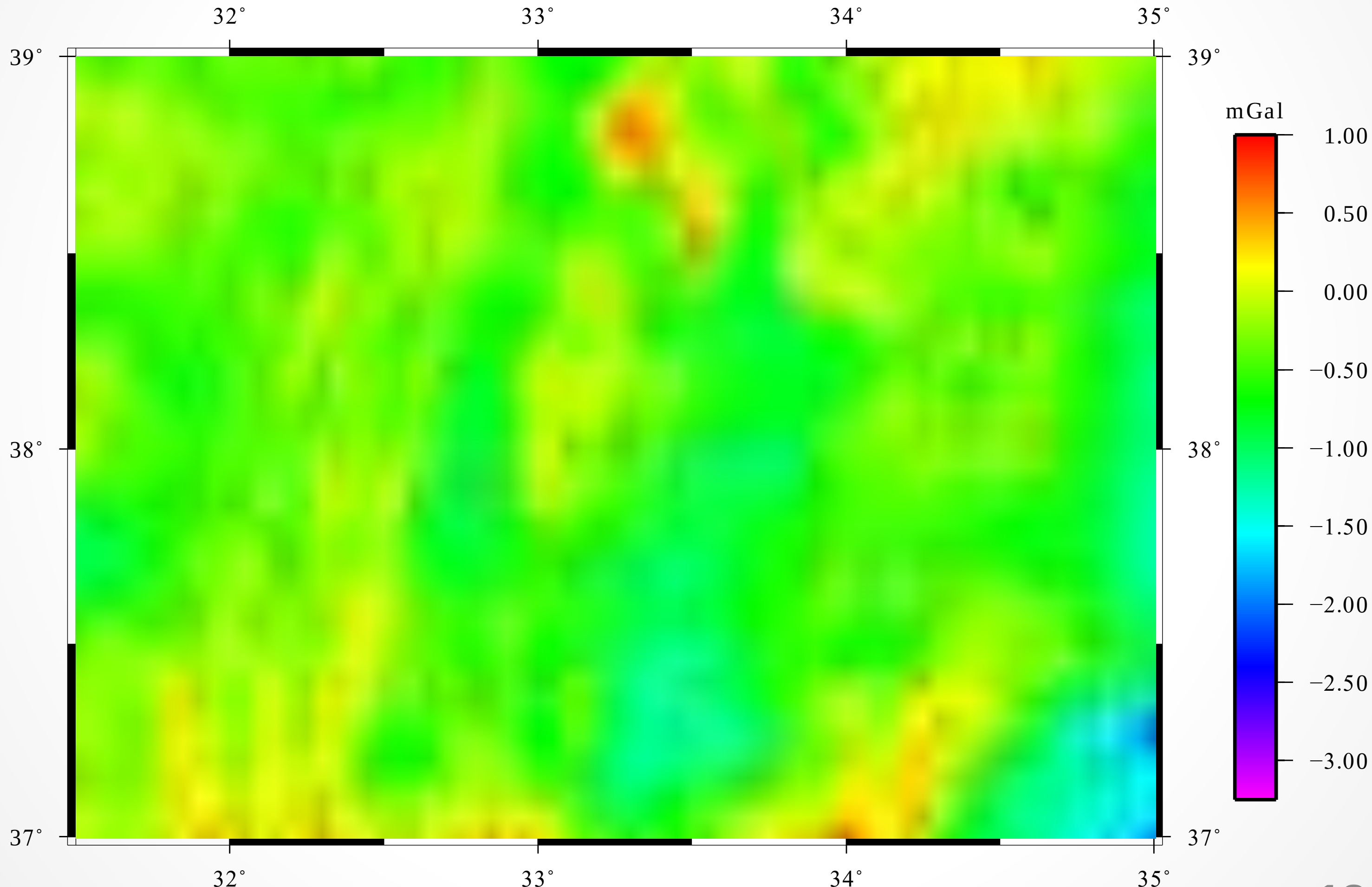
Prediction of Mean Gravity Anomaly

- The gravity observations distributed randomly were directly reduced to the simple Bouguer gravity anomalies. Then, Bouguer gravity anomalies were interpolated to grid nodes by using the nearest neighbouring technique.
- Finally free-air gravity anomalies in grid nodes (0.02*0.02 arc-degree resolution) were obtained from simple Bouguer anomalies by restoring the mean Bouguer plate effects.

Results

- The gridding strategy mentioned above was conducted by using each DEMs in the mean Bouguer plate effects. Then results are compared with each other.
- Minimum and maximum of free-air anomaly differences between DEMs are **-3.564 and 1.263** mGal, respectively.
- Geographical distribution of the differences among the models is depicted in Fig. 2.

Comparison of gravity anomalies obtained via ASTER and SRTM DEMs



CONCLUSIONS

- Two independents SRTM and ASTER DEMs are tested by using levelled control points in Konya Closed Basin.
- Numerical results show that ASTER is slightly worse than SRTM according to our levelling points.
- Differences between DEMs in the prediction of the mean gravity anomaly are ranging from **-3.563 to 1.264 mGal**, which should be considered in geoid modelling studies.
- Suggested that ASTER and SRTM should be compared before they are used in any project.
- In areas where a regional DEM or SRTM DEM is not available, ASTER DEM can be comfortably used in geoid determination.

Thank you for your attention!