The Accuracy of SRTM Water Body Data over the Turkish Territory with Respect to Topographic Maps

Ibrahim Oztug BILDIRICI, Ramazan Alpay ABBAK, Sevgi BOGE
Selcuk University, Engineering Faculty, Konya, Turkey

Key words: Digital Elevation Model, Water Body Data, Line Simplification, Earth Topography, SRTM

SUMMARY

On February 2000, in terms of the Shuttle Radar Topography Mission (SRTM), Space Shuttle Endeavour was launched into space. With its onboard radars, SRTM collected data during ten days of operation to gather the most complete near-global high-resolution digital elevation data. The SRTM Water Body Data (SWBD) was subsequently created by data editing that are performed by the National Geospatial-Intelligence Agency (NGA) to produce the finished SRTM Digital Terrain Elevation Data Level 2 (DTED 2). In accordance with the DTED 2 specification, the elevation data have been edited to describe water bodies according to capture criteria. The lines delineating water bodies are attained from SRTM 1 Arc-Second Global DEM, and were organized in vector format by using ESRI 3-D Shapefile format. SWBD has been publicly available since 2015. The horizontal datum of the SRTM data is WGS84, vertical datum is EGM96 geoid.

The accuracy of the data depends on its source, i.e. the digital elevation model (SRTM DEM). The height accuracy of SRTM has been investigated in a number of studies. But there are few reports about the horizontal accuracy. The SWBD is a rich data source, and its horizontal accuracy needs to be checked.

In this study the SWBD data is checked against to coastline data digitized by using 25K National Topographic Maps of Turkey. Considering the data collection time of the SRTM, coast lines, whose temporal changes are minimal, are selected for comparison. The 25K coastline data was collected by manual digitizing and assumed as ground truths or reference line. Differences between SWBD points and reference lines are computed by using an in-house program developed with C programming language. Digitizing and datum conversions were performed with NetCAD GIS programming package. The reference data are within 4 tiles of SWBD. The total number of points in the statistical evaluation is about 8000. The RMS values for each tile are about 35m, which is a bit higher than the spatial accuracy of 1 arc-second SRTM DEM (about 30m).

The Accuracy of SRTM Water Body Data over the Turkish Territory with Respect to Topographic Maps

Ibrahim Oztug BILDIRICI, Ramazan Alpay ABBAK, Sevgi BOGE
Selcuk University, Engineering Faculty, Konya, Turkey

1. INTRODUCTION

Space Shuttle Endeavour was launched into space on February 2000, in terms of the Shuttle Radar Topography Mission (SRTM). During ten days of operation radar data was collected to form the most complete near-global high-resolution digital elevation data. The SRTM Water Body Data (SWBD) was subsequently created by data editing that are performed by the National Geospatial-Intelligence Agency (NGA) to produce the finished SRTM Digital Terrain Elevation Data Level 2 (DTED 2). In accordance with the DTED 2 specification, the elevation data have been edited to describe water bodies that satisfy minimum capture criteria. The lines delineating water bodies are obtained from SRTM 1 Arc-Second Global DEM, and were stored in vector format in the same tile structure of DEM. The vector data format is ESRI 3-D Shapefile. SWBD has been open to public since 2015 via EarthExplorer data portal of USGS (United States Geological Survey). The horizontal datum is WGS84, whereas the vertical datum is EGM96 geoid.

The accuracy of the data depends on its source, SRTM 1 Arc-Second Global DEM. The height accuracy of SRTM DEMs has been investigated in a number of studies. But there are few reports about the horizontal accuracy (Rodriguez, 2005, Bildirici&Abbak, 2017a, Bildirici&Abbak, 2017b, etc.). The SWBD is a rich data source, and its horizontal accuracy needs to be checked. Since the lines attained from the DEM grid, these follow pixels of 1x1 arc-seconds size. Therefore the data contain straight lines in meridian and parallel directions, representing an orthogonal structure. In order to use this data in geographical information system applications, line simplification is necessary. Due to orthogonal straight lines within the data, common line simplification techniques are not applicable, special attention is needed. Another aspect is the data collection time. SRTM data dates back to February 2000. The SWBD data represents the water bodies at that time. Therefore change detection studies can be undertaken.

In this study the SWBD data is compared to coastline data digitized by using 25K National Topographic Maps of Turkey. Considering the data collection time of the SRTM, coast lines, in which temporal changes are minimal, are selected for comparison. The 25K coast line data was collected by manual digitizing and assumed as ground truths or reference line. Differences between SWBD points and reference lines are computed by using an in-house computer program. Digitizing and datum conversions were performed with NetCAD GIS programming package.

In the following sections SRTM data products are introduced. Then, our comparison methodology and the capture methodology of reference data are explained. At the end results are discussed.

MATERIAL AND METHOD

1.1 SRTM Data Products

Nowadays following data products are available to public at USGS EarthExplorer portal (URL1, URL2):

SRTM Non-Void Filled elevation data were obtained from raw C-band radar signals distributed at intervals of 1 arc-second in geographical coordinates at NASA's (National Aeronautics and Space Administration) Jet Propulsion Laboratory (JPL). This version was then corrected by the NGA to delineate and flatten water bodies, better define coastlines, remove spikes and wells, and fill small voids. Data for regions outside the United States were sampled at 3 arc-seconds for public distribution.

SRTM Void-Filled elevation data are the result of additional processing to address areas of missing data or voids in the SRTM Non-Void Filled data. The voids occur in places where the initial processing did not meet quality specifications. The resolution for SRTM Void Filled data is 1 arc-second for the United States and 3 arc-seconds for global coverage.

SRTM 1 Arc-Second Global elevation data offer worldwide coverage of void filled data at a resolution of 1 arc-second and is distributed to public. Some tiles still include voids. Tiles above 50° north and below 50° south latitude are sampled at a resolution of 2 arc-second by 1 arc-second.

USGS EarthExplorer data portal (URL1) offers SRTM data in three grid file formats:

Digital Terrain Elevation Data (DTED) is a standard mapping format designed by the NGA. Each file or tile contains a matrix of vertical elevation values spaced at regular horizontal intervals measured in geographic latitude and longitude units.

Band interleaved by line (BIL) is a binary raster format with an accompanying header file which describes the layout and formatting of the file.

Georeferenced Tagged Image File Format (GeoTIFF) is a TIFF file with embedded geographic information. This is a standard image format for GIS applications.

SRTM data specification is given in table 1.

SRTM (C-band) data for research purposes are also available through NASA JPL. These data were sampled at 3 arc-seconds for global coverage. The German and Italian space agencies operated the X-band hardware and processed the data separately. This data is maintained by the German Aerospace Center (DLR), and not publicly available.

The **SRTM Water Body Data** (SWBD) files are a by-product of the data editing performed by the National Geospatial-Intelligence Agency (NGA) to produce the finished SRTM Digital Terrain Elevation Data Level 2 (DTED2). According to the DTED 2 specification, the terrain elevation data have been edited to portray water bodies according to minimum capture criteria. Ocean, lake and river coastlines were identified and delineated. Lake elevations were set to a constant value. Ocean elevations were set to zero. Rivers were stepped down monotonically to maintain suitable flow. After this processing was done, the delineating lines from the 1 arc-second elevation data were saved as vectors in ESRI 3-D Shapefile format (URL3).

Table 1: SRTM Data Specification

Projection	Geographic
Horizontal Datum	WGS84
Vertical Datum	EGM96 (Earth Gravitational Model 1996)
Vertical Units	Meters
Spatial Resolution	1 arc-second for global coverage (~30 meters) 3 arc-seconds for global coverage (~90 meters)
Raster Size	1 degree tiles
C-band Wavelength	5.6 cm

In most cases, two orthorectified image mosaics (one for ascending passes and one for descending passes) at a one arc second resolution were available for identifying water bodies and delineating coastlines. These were used as the main source for water body editing. The guiding principle for this editing was that water must be depicted as it was in February 2000 at the time of the shuttle operation. A land cover water layer and medium-scale maps were used as additional data sources, usually as supporting evidence for water identified in the image mosaics. Since the land cover water layer was derived mostly from Landsat 5 data that was collected a decade earlier than the Shuttle mission and the map sources had similar up-to-date problems, there were significant seasonal and temporal differences between the depiction of water in the additional sources and the actual extent of water bodies in February 2000 in many cases (URL3).

SWBD files can be downloaded from USGS EarthExplorer portal at no cost. Tiles are available in land areas between 60° North and South. The coverage map is given in Figure 1.

Since the delineating lines of water bodies follow pixels at 1 arc second size, SWBD data has a zigzag structure. No line simplification is performed. Figure 2 shows a part of SWBD data laid on the satellite imagery in GoogleEarth.

1.2 Comparison Methodology

In order to check SWBD against a reference data (ground truths), shortest distances from SWBD points to nearest lines or points of reference data are calculated. Two types of differences can be used that are depicted in Figure 3. Here, d_l shows the distance to the nearest line, d_p to the nerest point. Smaller one of d_p or d_l is used in the statistical evaluation. Distances falling at the left side of the SWBD line are assumed negative. For the statistical evaluation an in-house program with C language was developed. Similar approaches have been used for matching different data sets with line objects (Hacar, 2015).
RMS, mean, maximum and minimum of the differences are calculated.

$$RMS = \sqrt{\frac{\Sigma d_i^2}{n}} \qquad Mean = \frac{\Sigma d_i}{n} \tag{1}$$

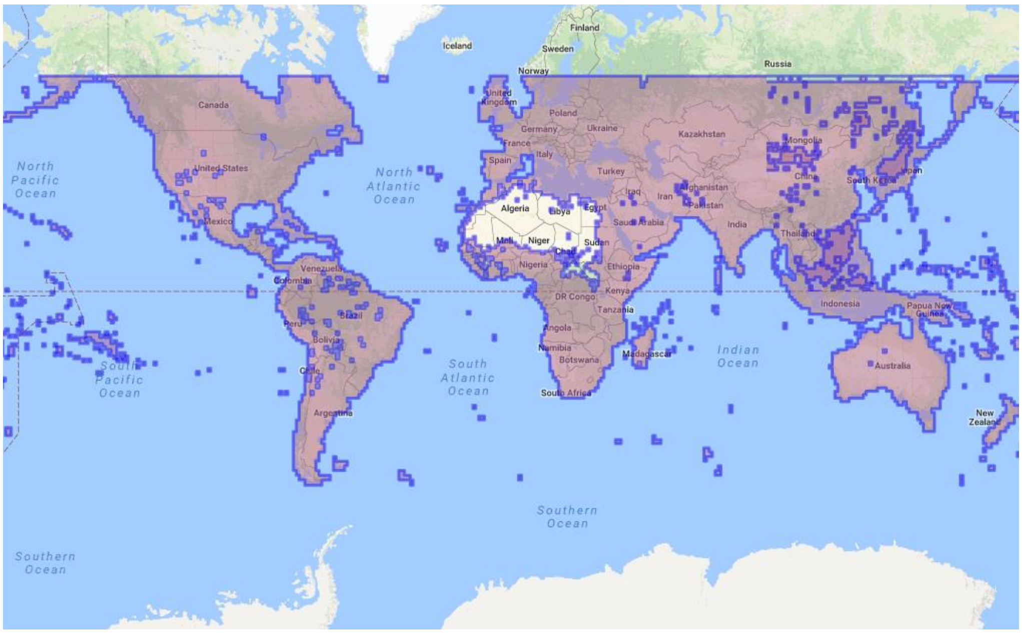

Figure 1: SRTM Water Body Data coverage shown in GoogleMaps

Figure 2: A sample of SWBD (Notice the zigzag structure)

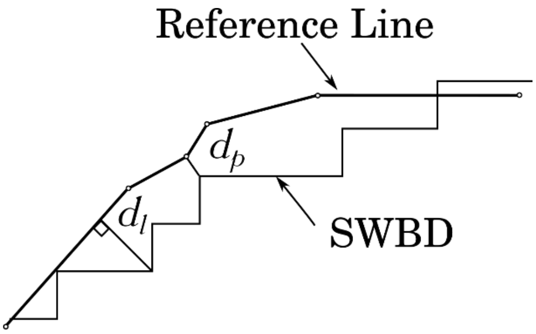

Figure 3: Distances from SWD points to reference line

2. APPLICATION

Parts of the SWBD within south-west Turkey are checked against 25K national topographic maps, being the reference data or ground truths. The reference data is obtained by manual digitizing by using NetCAD7.0 programming package. Figure 5 shows an excerpt of a 25K sheet with SWBD on it.

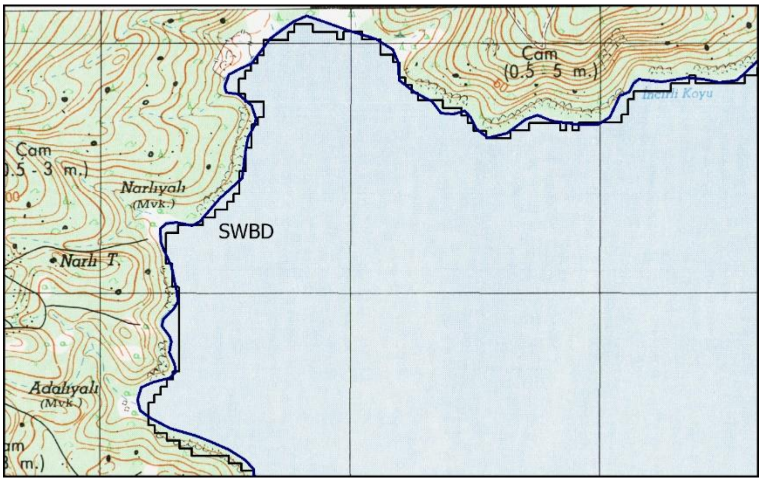

Figure 5: SWBD and 25K topographic map sheet

The study area is shown in Figure 6. 30 topographic sheets that cover the coastline were registered, and manual digitizing was performed. The sheets are within 4 SWBD tiles. Since the topographic maps are in the UTM system on ED50 datum, the reference data was converted to geographical coordinates on WGS84 datum by using NetCAD7.0 package. Figure 6 shows the digitized reference data.

In the previous study of the authors similar comparisons were undertaken by using GoogleEarth imagery and 25K map sheets (Bildirici & Abbak, 2017b). That paper reveals an horizontal accuracy about 45m, 1.5 times of the resolution of the SRTM 1 Arc-Second Global elevation data (30m).

The reference data obtained in this study are within 4 tiles of SWBD, e027n37e, e028n37e, e027e36e, e028n36e (Figure 6). By using the in-house developed program, differences are calculated from SWBD points to reference data, if available. If not, SWBD points are omitted. To ensure to have correct distances, a seach radius of 100 m (about 3 times of the spatial resolution) around a SWBD point is used. So distances within this range are taken into consideration. Table 2 shows the results. The total number of points used in the evaluation is 8363. RMS values are about 35m which is slightly higher than the spatial resolution of the SRTM DEM (30m). The results are better than those of our previous study (Bildirici & Abbak, 2017b).

Table 2: Results of the statistical evaluation

Tile	RMS (m)	Mean (m)	Max. Diff (m)	Min. Diff. (m)	Number of points
e027n36e	34.28	8.19	99.63	-99.36	4391
e027n37e	33.68	-12.81	99.83	-84.87	921
e028n36e	34.51	4.72	98.13	-99.30	1878
e028n37e	42.96	-15.96	99.19	-99.95	1173

3. CONCLUSION

SWBD is a by-product of SRTM DEM. It is a valuable source for GIS applications. The vertical accuracy of SRTM DEM's has been investigated well, but there are few studies about the horizontal accuarcy. This and our prevous study (Bildirici & Abbak, 2017b) reveal that the RMS values are slightly higher than the spatial resolution of the DEM. As a result it can be said that the SWBD has enough accuracy for coastal shorelines. In terms of lake shorelines, the situation is not the same. Because of changing depts of the lakes, their shorelines are not stable over time. Therefore SWBD may not be reliable especially in lakes with small depths, and prone to seasonal changes.

SWBD depicts the situation in year 2000. In this study we used topographic maps older than SWBD. We selected coastlines where temporal changes are minimal. It should also be mentioned that SWBD has a potential to be used in change detection studies.

Acknowledgement

This study is supported by the Coordinatorship of Scientific Research Projects of Selcuk University (Project Nr. 17401083). The authors also thank to NetCAD Software Company for their software support.

REFERENCES

Bildirici, I.O., Abbak, R.A (2017a) Comparison of ASTER and SRTM Digital Elevation Models at One-Arc-Second Resolution Over Turkey, SUJEST, v.5, n.1, ISSN: 2147-9364 (Electronic).

Bildirici, I.O., Abbak, R.A (2017b) Evaluation of the SRTM Water Body Data over Turkey, 19th International Symposium on Environmental Pollution and its Impact on Life in the Mediterranean Region October 4-6, 2017 Rome – Italy.

Hacar, M. (2015) Geometrical integration within spatial data infrastructures, MSc Thesis, Yıldız Teknik Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.

Rodriguez, E., C.S. Morris, J.E. Belz, E.C. Chapin, J.M. Martin, W.Daffer, S. Hensley, (2005) An assessment of the SRTM topographic products, Technical Report JPL D-31639, Jet Propulsion Laboratory, Pasadena, California, 143 pp

URL1: https://earthexplorer.usgs.gov, accessed: February 1, 2018

URL2: https://lta.cr.usgs.gov/SRTM1Arc, accessed: February 1, 2018

URL3: https://lta.cr.usgs.gov/srtm_water_body_dataset, accessed: February 1, 2018

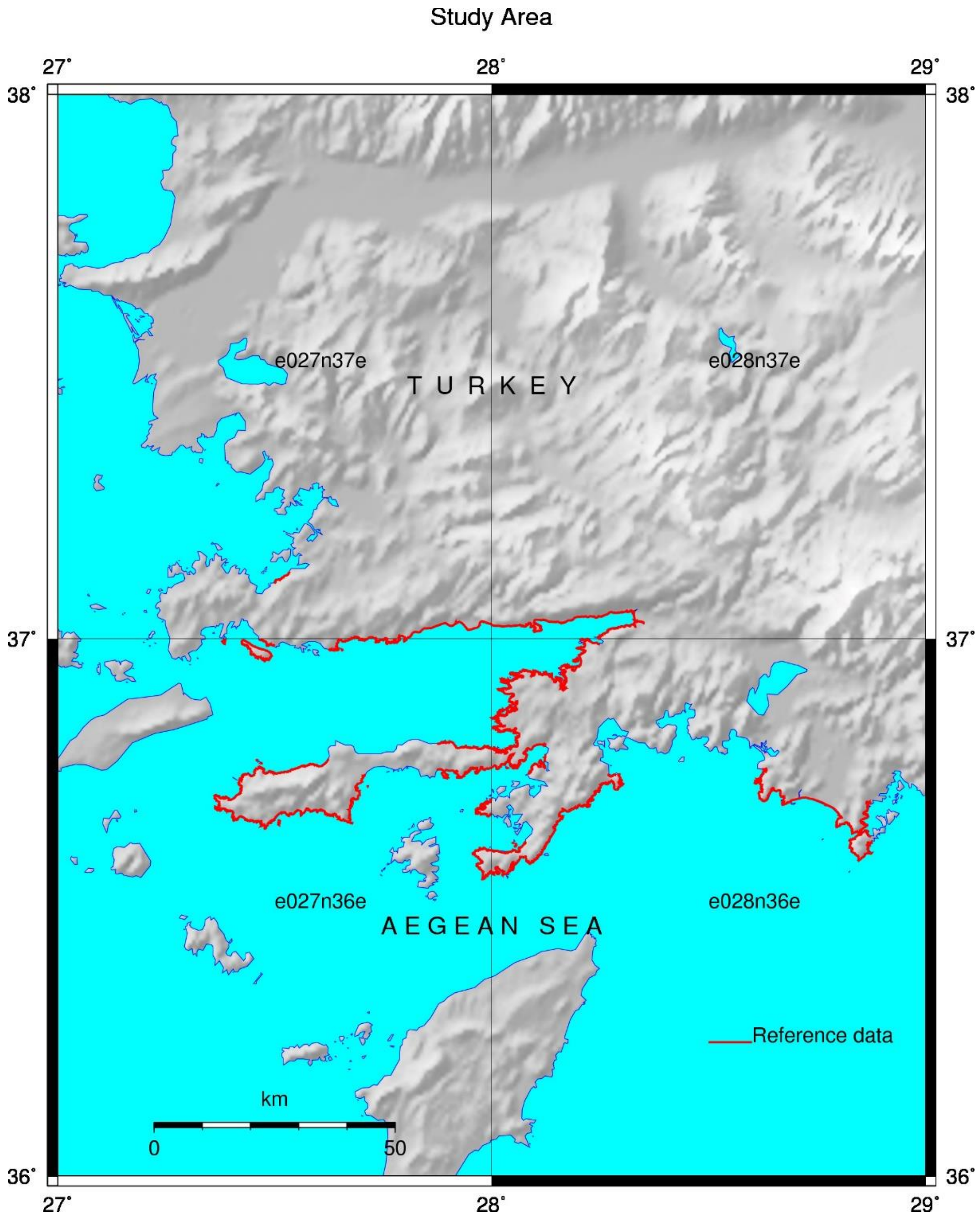

Figure 6: Study area and digitized data from 25K sheets (reference data)

CONTACTS

Prof.Dr. Ibrahim Öztuğ BILDIRICI
Selcuk University Engineering Faculty
Kampus Selcuklu
Konya
TURKEY
Tel. +90 533 4671074
Email: bildirici@selcuk.edu.tr
Web site: http://www.iobildirici.com

Doç.Dr. Ramazan Alpay ABBAK
Selcuk University Engineering Faculty
Kampus Selcuklu
Konya
TURKEY
Tel. +90 332 223 1898
Email: aabbak@selcuk.edu.tr

Sevgi BOGE
Selcuk University Kadinhani Faik Icil Vocational School
Kadinhani
Konya
TURKEY
Tel. +
Email: sevgiboge@hotmail.com