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Accuracy Assessment of SRTM Data
Case Study: New Cairo , Hurghada and Toshka in Egypt

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Abstract: Nowadays, the development in Egypt needs up to date maps. SRTM data were collected during 11-day mission in February 2000. Since this date, the SRTM data were available for the whole world. On the other hand, the accuracy these SRTM height data was not tested in Egypt. So, the current research paper is focused on the Accuracy Assessment of SRTM Data in Egypt. In this context, eight sights in Egypt were investigated. These eight sights lie in three different parts of Egypt. Grid leveling by ground surveying was captured for these eight sights. Then accuracy assessment between the actual field data and the SRTM data was made. The results shows that, the accuracy of SRTM data after removing systematic errors from the SRTM data was in the range of sub-meter in flat terrain and three meter in rough terrain.

Key words: SRTM, Digital Elevation Model, Terrain Classification

INTRODUCTION

Nowadays, Egypt development are growing quickly especially in the desert areas, etc. These developments suffer from variety of problems, like the need of up to date maps required for planning, design, and execution. To overcome such problems it has been found that it is necessary to resort to fast map processing and updating techniques such as the use of available satellite data to produce maps as well as digital elevation models.

The Digital Elevation Model (DEM) is a very important precondition for many applications as map generation, three dimensional GIS, environmental monitoring, geo-spatial analysis etc. Geospatial applications such as mapping, hydrology, geology, navigation, GIS, mission planning and simulation require the construction of a high resolution DEM of land surfaces of the Earth. Digital elevation models (DEM) are used in a wide range of applications. The accuracy of the DEM is determined by the used application but yet restricted by technical and economical aspects.

The "open source" Shuttle Radar Topographic Mission (SRTM) C-band (3 arc second, approx. 90m grid size) version II data, released to the general public via the internet seems to provide an appealing data source for DEM's generation. However, careful investigation into the quality of SRTM elevation data is considered important in order to determine the applications it can be used in. Digital Elevation Models (DEM) derived from the Shuttle Radar Topographic Mission (SRTM) are now freely available in a resolution of 3 arc-seconds. These data can be very useful for research purposes as well as to supply basic topographic mapping data for poorly mapped countries.

SRTM data were collected during 11-day mission in February 2000. Since then, they were described in details [Farr and Kobrick, 2000, Rabus et al., 2003; Werner, 2001] and became accessible for free download over the Internet (e.g. at ftp://e0srp01u.ecs.nasa.gov and http://seamless.usgs.gov/). However, between two SRTM products that include raster data with 30 and 90m spatial resolution, only 90m data is available globally (80% of the Earth surface) while the 30m data are available only for the USA territory.

Although the absolute accuracy specifications were stated as ±16 m vertical linear error and ±20 m horizontal circular error at the 90% confidence levels [Kretsch, 2000], many accuracy tests showed that the performance of SRTM data against with real data is better than expected [see e.g., Rodriguez et al. 2005; Brown and Sarabandi, 2005; Gorokhovich and Voustianiouk, 2006]. That the comparison results yield lower than the anticipated error characteristics has raised the demands of end-users from the SRTM.

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Hence, the main objective of the current research is to study the accuracy of the SRTM data with different terrains classes. In this context, here, the paper will follow two major branches. The first one is the accuracy assessment of the SRTM data as it is, without systematic errors treatment. The second branch will deal with the accuracy assessment of the SRTM data after removing the systematic errors treatment.

2- Terrain Classification:

The terrain is very irregular surface and changes from point to another, so that the terrain is classified into some category from very smooth surface (flat terrain) to very mountainous surface (very rough terrain) [Kassim, 1980]. Therefore the terrain classification is an important step before processing the DEM, because, it helps in choosing the most suitable processing method for each terrain type. The classification process has to be done according to some values of selected parameters, which have indications to terrain relief.

2-1- Requirements for a Good Classification Method:

There are some specification controls the choice of classification method. According to [Hassan, 1982] the terrain relief classification model should reflect the following requirements:

A good classification system must be simple and logical, so that it can be applied economically to DEM data.

1. It must have finite number of classes with no overlaps.
2. It must contain all categories of the terrain relief, i.e. from totally flat terrain to extremely rough ones.
3. The parameters used should describe efficiently the relief characteristics of the terrain and are preferred to have clear physical meaning.
4. The method of classification must be objective, i.e. based on quantitative (not the qualitative) characteristics of the terrain.
5. The system must be well defined from the point of view of the purpose behind classification. Different purposes may require different parameters.
6. Classification must be applied to discrete raw data before any smoothing or fitting is performed. This condition implies that classification techniques must be applied to dense, high quality DEM's which are considered as a good representation of the terrain surface. The reason for this condition is that smoothing and fitting may produce unrealistically smooth or rough surfaces which depend on the method used and not solely on the information provided by the DEM itself.

2-2 Methods of Classification:

Describing the terrain surface using objective or quantitative parameters is the first step in terrain classification. It should be noticed here that as the only information available about the terrain surface is the DTM, we are determining parameters that describe this particular DTM and not the real terrain, which is unknown to us. This means that different values of the same parameters may be obtained from different DTM's that represent the same terrain surface. If the DEM is considered as a good representation of the terrain surface, the parameters obtained for classification may be considered as representing the terrain itself [Mohamed, 1993]. There are many quantitative parameters that can be used to describe the terrain. According to [Abdelwahab, 2000] he said that the best method of terrain classification is "Roughness factor method (average slope method)". This method will be discussed in detail in the following section.

2-2-1 Roughness Factor Method (Average Slope Method):

This method is considered the preferable methods for the terrain classification specially in case of, the irregular data points.. In order to compute the roughness factor the following parameters should be determined:

1. The average height difference (Zave) between successive significant breakpoints.
2. The average distances (dave) between successive significant breakpoints.
3. Roughness factor (average slope),

$$(R\ .F) = (Zave/\ dave)\ 100\ \% \qquad (1)$$

2-2-2 Roughness Factor by Using the Circle Method:

This method depends on computing the R.F within circle with an assumed radius. The Zave and the dave are computing from center point of the circle to other points within same circle then, the R.F to this circle is computed using equation (1). The previous procedure is repeated from all points of study area. Then, every point (circle) has a significant R.F. The percentage, of the points have R.F less than 0.05 %, is computed, also the percentage, of the points have R.F less than 0.1 %, is computed and so on until the percentage of the points have R.F less than 100 %. The relation, between different slopes and percentage of the points have R.F less than specific slops, is drown. From this relation, it can determine percentage of the points have R.F less than any significant slope. From this percentage the terrain type can be determined according to classification of the highway engineering in table (1). **[Oglesby and Hicks, 1982]**.

Table 1: Maximum permissible grades for highways (%) [Oglesby and Hicks, 1982]

Terrain type	Max. grad %
Flat Terrain	< 5
Rolling Terrain	5-12
Mountainous Terrain	>12

3- The Used Data:

In this research, two sets of data are used; the first set is grid leveling data of four sites in New Cairo city , two sites in Hurghada city in Egypt and two sites in Toshka region in Egypt, see figure (1). The positions as well as the levels of the six sites were established using ground surveying techniques (construction of triangles networks, observing using total stations, …etc.). The horizontal coordinate system of the four sites in New Cairo city and the two sites in Toshka region is the Egyptian Transverse Mercator (ETM). On the other hand, the horizontal coordinate system of the two sites in Hurghada city is the Universal Transverse Mercator (UTM).

Fig. 1: The position of New Cairo city, Hurgada, and Toshka in Egypt.

The second set of data was captured using the SRTM data for the six sites mentioned before. A transformation is made for the four sites in New Cairo city and the two sites in Toshka region to the Egyptian Transverse Mercator (ETM). Also A transformation is made for the two sites in Hurghada city to the UTM coordinate system.

Figures from 2 to 9 show the contour map of the ground surveying data.

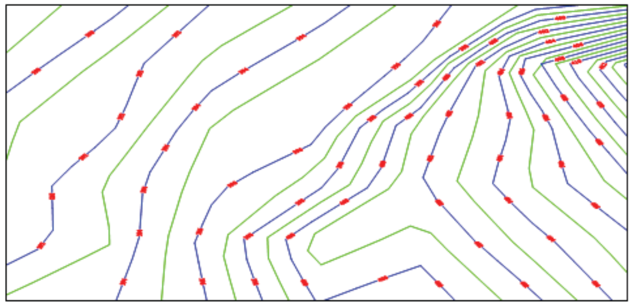

Fig. 2: Contour Map of terrain of site no.1 (Contour interval =1m)

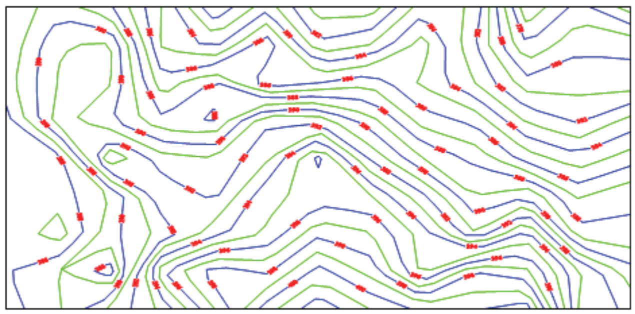

Fig. 3: Contour Map of terrain of site no.2 (Contour interval =1m)

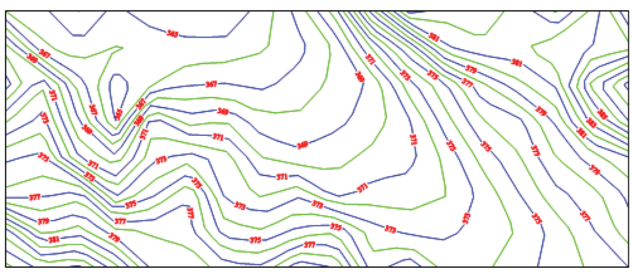

Fig. 4: Contour Map of terrain of site no.3 (Contour interval =1m)

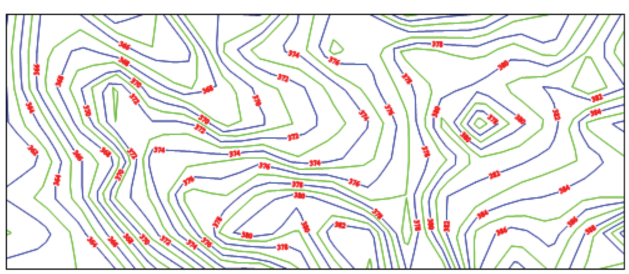

Fig 5: Contour Map of terrain of site no.4 (Contour interval =1m)

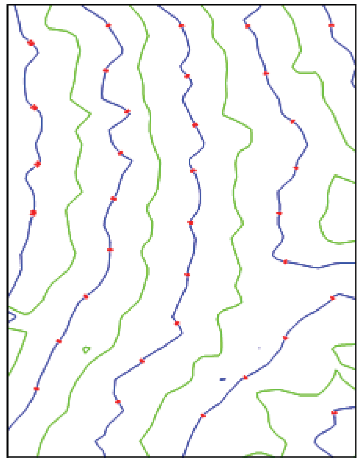

Fig. 6: Contour Map of terrain of site no.5 (Contour interval =1m)

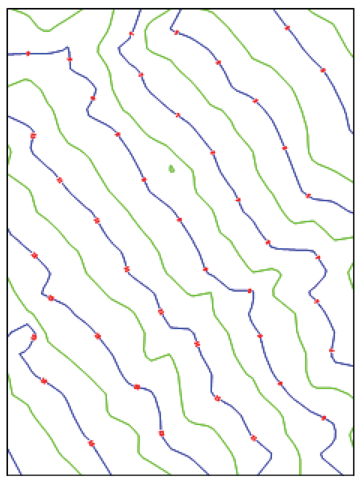

Fig. 7: Contour Map of terrain of site no.6 (Contour interval =1m)

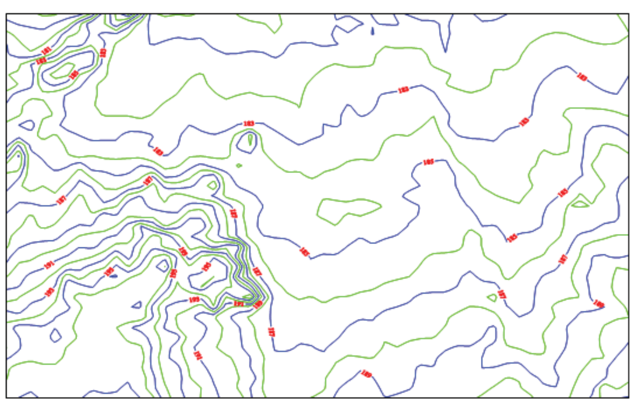

Fig. 8: Contour Map of terrain of site no.7 (Contour interval =1m)

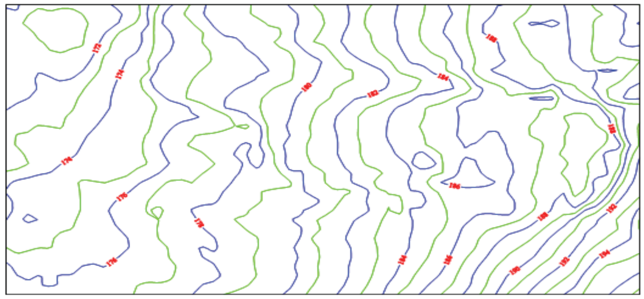

Fig. 9: Contour Map of terrain of site no.8 (Contour interval =1m)

4- Data Processing, Results and Analysis of Results:

For each site of the eight sites mentioned above, the steps of the process were as follow:

1. Terrain classification was made using the Roughness Factor by Using the Circle Method mentioned before in section 2-2-2. Table (2) illustrates the results of terrain classification.

Table 2: Statistical analysis of elevation values for different terrain type.

Terrain No.	Area m2	Zmax (m)	Zmin (m)	Z mean (m)	Diff(Zmax-Zmin) (m)	R.M.S
G1	300000	414.25	388.39	397.68	25.86	6.16
G2	960000	402.25	376.18	389.19	26.07	5.8
G3	1190000	389.41	363.98	374.16	25.43	5.93
G4	1190000	392.55	360.91	374.95	31.64	7.46
G5	5220000	10.92	0.93	5.93	9.99	2.4
G6	3910000	17.29	1.23	9.24	16.06	3.59
G7	19380000	198.03	177.87	186.37	20.16	4.36
G8	17980000	197.42	170.16	181.53	27.26	6.15

2. Two grid leveling meshes 90 m * 90 m were established.

2-1. The first mesh was constructed using the ground surveying data.

2-2. The second mesh contained the SRTM data.

3. The difference in levels between the meshes was computed at each grid point.

4. The maximum, minimum, mean, and RMS of the difference was computed, see Table (3).

Table 3: The maximum, minimum, mean, and RMS of the difference between ground survey data and SRTM data.

Site No.	Terrain Degree (R.M.S)	Max.	Min.	Mean	RMS
1	6.16	3.94	-6.91	-1.51	3.52
2	5.8	3.25	-5.33	-1.35	2.44
3	5.93	4.49	-7.28	-1.62	3.22
4	7.46	3.7	-3.12	0.23	1.56
5	2.4	-0.32	-5.11	-3.00	3.11
6	3.59	0.33	-6.11	-3.28	3.42
7	4.36	2.83	-5.39	-3.24	3.54
8	6.15	0.52	-6.52	-4.12	4.32

The investigation of Table (2) reveals that, the difference between ground survey data and SRTM data are suffer from systematic errors. In other words, there is a shift component between the two surfaces. In this context, these shift are removed from the difference and the statistics are computed, again, see Table (3).

Table 3: The maximum, minimum, mean, and RMS of the difference between ground survey data and SRTM data after removing the systematic error.

Site No.	TerrainDegree (R.M.S)	Max.	Min.	Mean	RMS
1	6.16	5.45	-5.40	0.00	3.18
2	5.8	4.60	-3.98	0.00	2.03
3	5.93	6.11	-5.66	0.00	2.78
4	7.46	3.47	-3.35	0.00	1.54
5	2.4	2.68	-2.11	0.00	0.82
6	3.59	3.61	-2.83	0.00	0.96
7	4.36	6.07	-2.15	0.00	1.43
8	6.15	4.64	-2.40	0.00	1.32

The examination of Table (3) as well as figure from (2) to (9) reveals that the accuracy of SRTM data increases with the decreasing of the terrain degree (R.M.S.). In other words, the accuracy of SRTM data is in the range of sub-meter in the flat terrain. On the other hand, it reaches 3 meters accuracy in rough terrain.

5- Conclusions:

One of the main problems, facing the workers in map production is the missing of height data in many parts in Egypt. Some of this important task has been solved in the present paper, through the evaluations of SRTM data accuracy for eight sites in Egypt. Based on the results of our practical investigation contained here, concerning the development and applications of the evaluated techniques using the SRTM data, the following important conclusions can be enumerated:

1. The accuracy of the SRTM data heights increases by removing the systematic errors by using some ground surveying heights.
2. The accuracy of SRTM data height is in the range of sub-meter in flat terrain in Egypt.
3. The accuracy of SRTM data heights in the range of 3 meters in rough terrain in Egypt.

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