

Research Article

# Comparison in terms of accuracy of DEMs extracted from SRTM/X-SAR data and SRTM/C-SAR data: A Case Study of the Thi-Qar Governorate /AL-Shtra City

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## Abstract

*It is important to investigate the accuracy of Digital Elevation Models (DEMs) because of their high impact on all engineering and scientific disciplines Photogrammetry, traditional surveying, remote sensing systems and satellite whole DEMs output methods. In this paper include the DEM data produced by the shuttle radar topography mission (SRTM) data, Where tested and evaluation DEM data for an area of 100 square kilometers in Iraq /Thi-Qar Governorate - Al-Shtra city. The result of root mean square error (RMSE) is 0.902 m for the digital elevation models (DEM) derived from the SRTM/C-SAR data (SRTM-DEM (V4.1)) and (RMSE) is 3.141 m for the digital elevation models (DEM) derived from the SRTM/X-SAR data (DTED (L2)). So clearly, the DEM product from the SRTM/C-SAR data a more accurate representation of the topography of the ground.*

**Keywords:** Remote sensing, Digital Elevation Models (DEMs), SRTM/C-SAR data, SRTM/C-SAR data.

## 1. Introduction

Since the 1950s Digital Elevation Models (DEM) have been widely used in studying topography, Urban Planning, classification and distribution of land as well as the DEMs enters the agricultural practices, vegetation cover, earthquake hazards, hydrological analysis, land sliding ,flash floods and Climate Study. is no doubt that the DEMs has a significant role in the civil engineering works in general and survey work is particularly .Which it is of extreme importance in the production of topographical maps and road works planning. DEMs has a significant impact on the estimate cost the establishment of dams and reservoirs, roads, canals and other works that are accompanied by earthworks where DEMs enters as an essential element. Also considered important tool in Geographic Information Systems (GIS) (Fernando J. Aguilar, 1989). Means and techniques used to produce DEM data are varied. Active refinement of the methods and means used to acquire DEM data continues. Methods for generating DEM data can be classified into two categories. These categories are ground surveyed elevation data and remotely sensed elevation data. Indeed interested in this research study of Digital

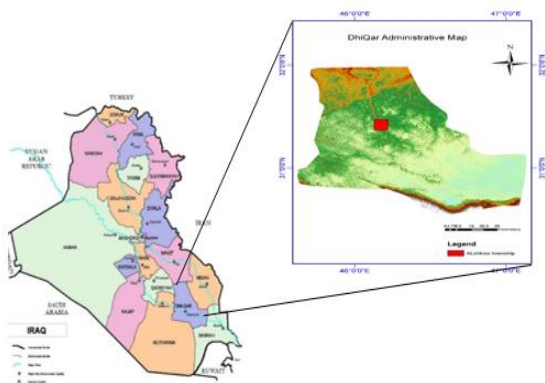
Elevation Models (DEM) Produced from shuttle radar topography mission (SRTM) data.

The Shuttle Radar Topography Mission (SRTM) is a joint project between the National Imagery and Mapping Agency (NIMA) (Called nowadays National Geospatial-Intelligence Agency (NGA)) and the National Aeronautics and Space Administration (NASA). The objective of this project is to produce digital topographic data for 80% of the Earth's land surface (all land areas between 60 north and 56 south latitude), with data points located every 1-arc-second (approximately 30 meters) on a latitude/longitude grid (Farr, T. G., *et al*, 2007). The shuttle provides data in different formats (DTED and SRTM-DEM).The digital elevation models (DEM) derived from the SRTM/X-SAR data are provided in the DTED-format [4].at variance SRTM-DEM format ware derived from the SRTM/C-SAR (Natlia Kolecka & Jacek Kozak, 2014).

## 2. The area of study

The area of study is located at the south of Iraq Republic with flat terrain topography (Figure No.1), Thi-Qar Governorate /AL-Shtra city ( $31^{\circ}24'30.17'' N, 46^{\circ}10'32.45'' E$ ) which is located from the Baghdad city [Capital of Iraq Republic] about 360 kilometer, the average of the elevation is about 10 meter from the mean sea level. The area of the case study is about  $100 km^2$  with low terrain.

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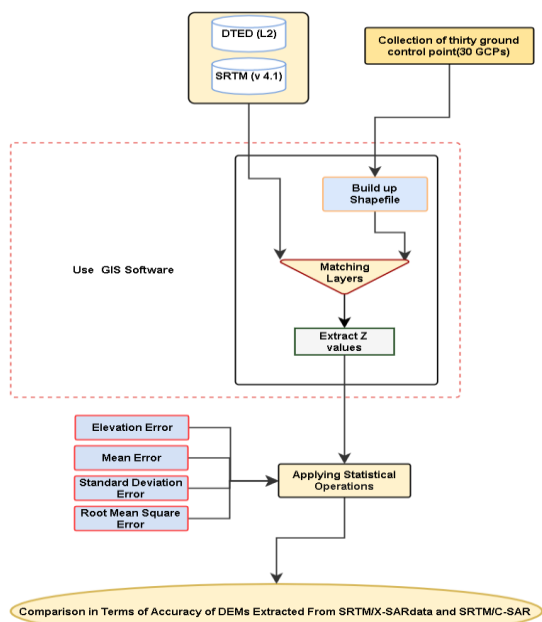
**Fig.1** The study site Thi-Qar Governorate / AL-Shtra city

**3. The Aim of research**

Diversity difference in the production of DEMs led to the difference in precision represents a real shape of the earth's surface, therefore the variation in the investigation of the accuracy of DEMs. The Shuttle Radar Topography Mission (SRTM) which was launched in February 2000 produced the most complete digital elevation model of the Earth Using remote sensing techniques, particularly the use of radar waves (SRTM/C-SAR and SRTM/X-SAR). So the goal of this research is a comparison in terms of accuracy of such methods DEMs production.

**4. Methodology**

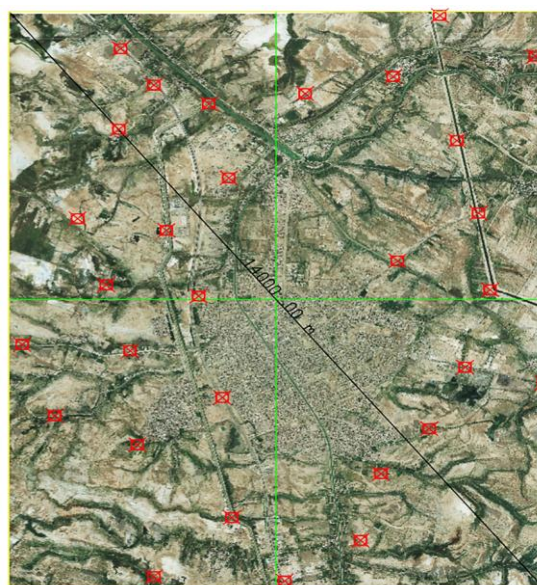
The comparison of the digital elevation models (DEM) derived from the SRTM/X-SAR(DTED format) and SRTM-DEM format were derived from the SRTM/C-SAR applied according to the chart below ( Figure No.2).



**Fig.2** The methodology work

**4.1 Data Collection and Fields Works**

The digital elevation models (DEM) derived from the SRTM/X-SAR (DTED-format) and digital elevation models (DEM) derived from the SRTM/C-SAR (SRTM-DEM format) are available is free for the study site Thi-Qar Governorate / AL-Shtra city. The digital elevation models (DEM) derived from the SRTM/X-SAR is being as (Digital Terrain Elevation Data (DTED)) format and spatial resolution is 90 m, the so-called DTED LEVEL 2. Whilst the digital elevation models (DEM) derived from the SRTM/C-SAR is being as Geotiff format to the user and Spatial resolution is 90 m, the so-called (SRTM-DEM version 4.1). The DTED (level 2) is referenced to the WGS84/ EGM96 geoid whereas the SRTM-DEM (version 4.1) is referenced to the WGS84/WGS 84.



**Fig.3** Select sites for (GCPs), according to (ASPRS) Standard

To achieve the 95 percent (95%) confidence level, there are require to collect thirty Ground Control Point (30 GCPs) for study area. According to The National Standard for Spatial Data Accuracy (NSSDA), American Society of Photogrammetry and Remote Sensing (ASPRS) and National Map Accuracy Standard (NMAS) requirements, choose those points in open areas-free residential buildings in low-gradient land, in addition to its proximity to the facilities of an important nature, Intersections on roads and major transportation. ASPRS-suggested (1989) systematic sampling method, which ensures that the sample points are well distributed throughout the image being assessed. To implement the ASPRS sample distribution, first, the image is divided into quadrants. Next, minimum of 20% of the sample points are allocated to each quadrant. To ensure adequate spacing between the sample points, no two points should be closer than  $d/10$  distance from each other, where  $d$  is the diagonal dimension of the map or image. This spacing will

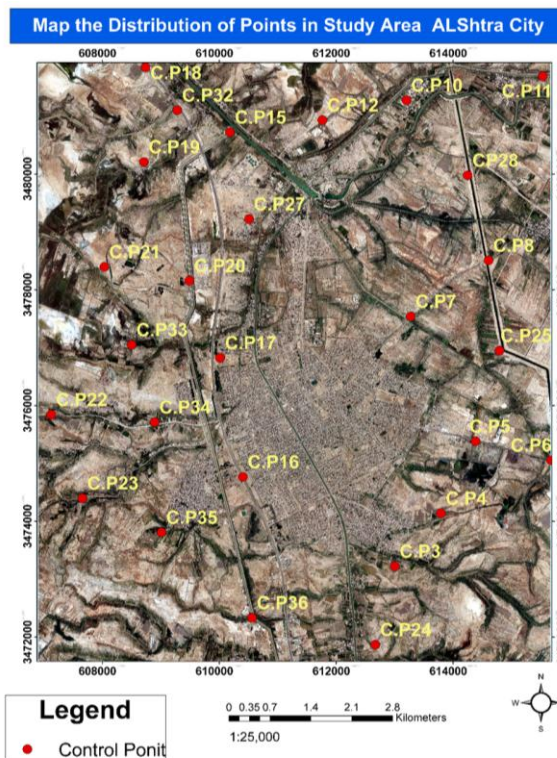
minimize spatial autocorrelation .In addition, using the ASPRS systematic sample distribution requires assuming that the sample distribution is not correlated with map or image error. This is a reasonable assumption because most positional error is correlated with topography, and topography is rarely distributed on a grid pattern (Russell G. Congalton Kass Green, 2009). On this basis, in the study area Thi-Qar Governorate /AL-Shtra city It will be the distribution of ground control points (GCPs) as shown in Figure (No.3), Where the image of study area which covers about 100 km<sup>2</sup> was divided into four quarters, each segment includes the equivalent of 20% of the total number of points, in other words six (6) points at least in every part. The diagonal distance of the study area in the 14,000 meters, so it will be the distance between the points is (1400/10=1400 m).

Adoption of Static GPS observation when the base line more than 15 kilometers, Rapid Static GPS Observation be effective when the base line less than 15 kilometres (Ahmed El-Rabbany, 2002). Wherefore Static method was considered to observe Basis point ( precisely Network approach),for 10 hours in Coincided with adjusted the observation refer to CORS(continuously operating reference stations), Using Global Positioning System differential(DGPS) device type Topcon device model GR3 Dual-frequency ( Figure No. 4).



**Fig.4** Topcon GR3 Dual-frequency

And next download the raw data from the device to a computer to complete the correction and processing, to be processed and sent to the Online Positioning User Service (OPUS) to complete the correction and processing. Ten kilometer (10 km) average distance between the Base point and Thirty-control points distributed throughout the Al-Shtra city, Rapid static observation is suitable in terms of accuracy and time. About 30 minutes to monitor fast static (use a radial baseline technique) for each point (Figure No.5).



**Fig.5** Ground Control Points located on Satellite image of Al-Shtra city

**4.2 Z-extract value from the SRTM/X-SAR [DTED (L2)] and SRTM/C-SAR [DEM (V4.1)].**

Four basic steps to extract the value of Z: (1) Data entry, (2) data management, (3) analysis and (4) output data, for that, the GIS environment are ideal to complete the task (Robert J. Peckham, 2007). Enter the SRTM/X-SAR [DTED (L2)] and SRTM/C-SAR [DEM (V4.1)] layer simultaneously with creation of shpfile (shp\*) that contains thirty Ground controller Points (GCPs) information (Enter and data management stage). Matching layers (DEM layers and feature point layer), use Spatial Analyst Tools to extract the Z value (Table No.1) It is the stage of analysis and data output.

**Table 1** The value Z extracted from SRTM/X-SAR [DTED (L2)] and SRTM/C-SAR [DEM (V4.1)]

PIONT	Z_actual(m)	Z_SRTM/X-SAR (m)	Z_SRTM/C-SAR (m)
GCP1	9.954	11	10
GCP2	8.678	11	8
GCP3	8.755	12	8
GCP4	7.558	10	8
GCP5	9.478	10	8
GCP6	6.389	10	7
GCP7	7.892	12	8
GCP8	8.404	12	8
GCP9	8.384	13	8
GCP10	7.589	12	8
GCP11	8.916	10	8
GCP13	8.9	13	9
GCP14	8.005	11	8
GCP15	7.901	11	7

GCP16	8.503	12	9
GCP17	7.784	11	9
GCP18	8.625	12	10
GCP20	8.598	13	9
GCP21	10.379	14	10
GCP22	8.489	11	8
GCP23	8.113	11	7
GCP25	11.103	13	11
GCP26	7.39	10	6
GCP27	8.05	11	7
GCP28	8.17	9	9
GCP29	7.028	11	7
GCP30	8.062	11	9
GCP31	11.608	12	9
GCP33	9.962	12	10
GCP36	7.95	12	8

### 4.3 Statistically operations

The definition of the concept of bias: It is the extent of gap and variation data from each other, if bias meter close to zero can say that is this kind of data is homogeneous (Taha Ahmed Abdel Samie, 2008).

Measures of bias:

$$\text{Range } z = \text{MAX}_z - \text{MIN}_z \tag{1}$$

Equation (1) Depends on maximum and minimal value only and this may cause problems when abnormal value (Bosahh Nymph, 2008), wherefore use the Mean error, Standard deviation error and Root mean square error be more effective, based on standards for evaluating the accuracy (NSSDA, NSSDA and NMAS). Mean error formula:

$$M \text{ err.} = \frac{\sum_{i=1}^n Z_{dff(i)}}{n} \tag{2}$$

Standard deviation error formula

$$STD_{err} = \sqrt{\frac{\sum_{i=1}^n (Z_{dff(i)} - ME)^2}{n-1}} \tag{3}$$

Root mean square error formula

$$RMS_{err.} = \sqrt{\frac{\sum_{i=1}^n (Z_{dff(i)})^2}{n-1}} \tag{4}$$

Where:

$$Z_{dff} = Z_{DEM} - Z_{GCP} \tag{5}$$

n=the number of samples (points)

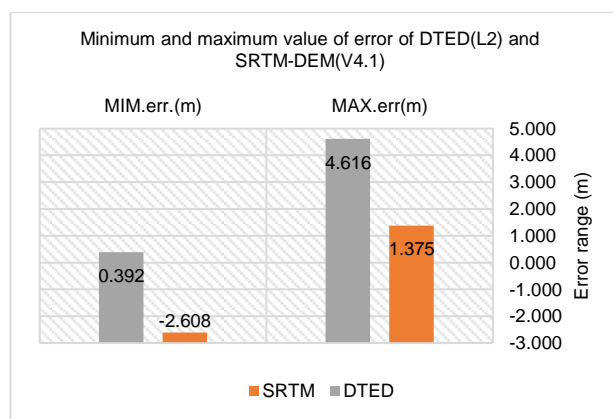
## 5. Results

The maximum value of the error (or difference) recorded SRTM/X-SAR [DTED (L2)] is 4.616 m and minimum value was 0.392 m (Figure No.6). While the SRTM/C-SAR [DEM (V4.1)] achieved maximum value error by 1.375 m and 0.392 m as minimum error value (table No.2).

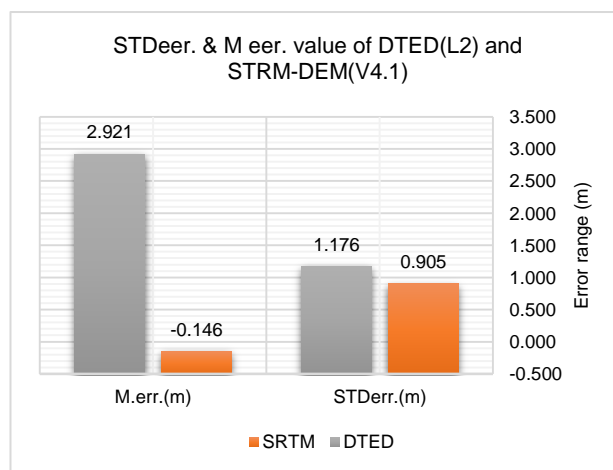
**Table 1** The results of statistical operations of SRTM/X-SAR [DTED (L2)] and SRTM/C-SAR [DEM (V4.1)]

Version or Level	DEMs Source	
	v4.1	Level 2
STD err.(m)	0.905	1.176
M.err.(m)	-0.146	2.921
RMSE.err(m)	0.902	3.141
MAX.err(m)	1.375	4.616
MIM.err.(m)	-2.608	0.392

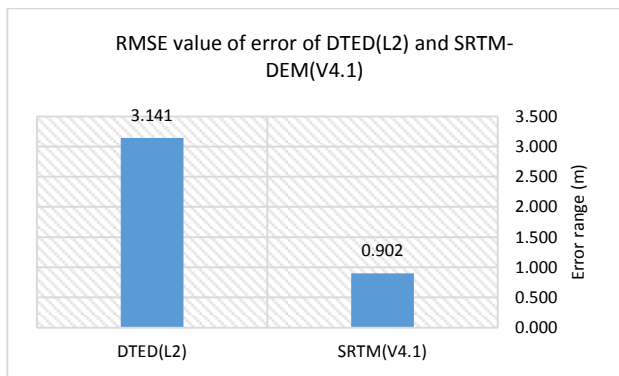
Standard deviation error for SRTM/C-SAR [DEM (V4.1)] is 0.905 m and Mean error is -0.146 m, as well Standard deviation error for SRTM/X-SAR [DTED (L2)] is 1.176m and Mean error is 2.921m (Figure No.7). The RMSE of SRTM/X-SAR [DTED (L2)] was 3.141 m and The RMSE of SRTM/C-SAR [DEM (V4.1)] was 0.902 m (Figure No.8).



**Fig.6** Diagrams shows Minimum and maximum value of error of SRTM/X-SAR [DTED (L2)] and SRTM/C-SAR [DEM (V4.1)]



**Fig.7** Diagrams shows STD and Mean value of error of SRTM/X-SAR [DTED (L2)] and SRTM/C-SAR [DEM (V4.1)]



**Fig.8** Diagrams shows RMSE value of SRTM/X-SAR [DTED (L2)] and SRTM/C-SAR [DEM (V4.1)]

**Conclusion**

In the open land with low terrain, The digital elevation models (DEM) derived from the SRTM/C-SAR data (SRTM-DEM(V4.1)) is more accurate representation of the earth's surface shape from the digital elevation models (DEM) derived from the SRTM/X-SAR data (DTED(L2)).

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