

# ESTIMATION OF THE ACCURACY OF THE SRTM TERRAIN MODEL ON THE AREA OF POLAND

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## ABSTRACT:

In order to determine the absolute accuracy of SRTM model on Polish area the research work has been performed on the basis of reference terrain profiles measured by GPS technique. The flat and hilly terrains were examined in administrative borders of fourteen provinces. It was not reference data for mountainous terrains. For the analysis of accuracy of the SRTM model 332 terrain profiles and 29,308 points have been measured. The accuracy of SRTM model presented by RMSE was computed on the basis of the height differences between profiles and models homolog points. The analyses have been done in Modular GIS Environment Intergraph software. The absolute accuracy of SRTM model on Polish area RMSE Z = 2.9 m for flat regions and RMSE Z = 5.4 m for hilly regions were achieved. It was affirmed that this accuracy is depend on the resolution of grid points of DEM and terrain inclination. The statistic estimation showed systematic shift between SRTM data and reference profiles. The RMSE Z without systematic part was found to be 1.0 m for flat regions and 2.7 m for hilly regions of Polish area. The data of SRTM level DTED-1 could be used for DEM and contour lines generation on the topographic maps in scales smaller then 1:50,000 and for SRTM system calibration.

## 1. INTRODUCTION

### 1.1 Target of the mission

The mission of the Endeavour spacecraft well known as SRTM (Shuttle Radar Topography Mission) was ended eight years ago. Based on this data, a DEM for over 80 percent of the Earth has been generated. The mission of SRTM was conducted in cooperation between the National Aeronautics and Space Administration (NASA), German Aerospace Centre (DLR), Italian Space Agency (ASI), and National Geospatial Intelligence Agency (NGA). Shuttle Radar Topography Mission permit to collected radar data set by eleven days. In the sequence of this time the elevation models were generated for over 80% of the Earth's on the basic of interferometer data. SRTM data which were used for research projects are available free for everyone users.

### 1.2 Motivation

Terrain elevation data corresponding to approximately 60x90 meters (3" x 3") are available on Polish area on the DTED-1 elevation data process and was recorded in HGT format. Specified accuracy requirements for guidelines of SRTM mission was 16 m absolute vertical error (90% linear error). Finally it turned out that after calibration system accuracy requirements of SRTM model on Eurasia area was on 6.2 m (Rodrigues et al., 2006) level (absolute height error). Research results of the accuracy of SRTM model described in local and foreign paper, were based on reference height date which did not representative for test area in most case. In order to characterize absolute height accuracy of SRTM model on Polish area was performed research project based on the precise reference date in the form of terrain profile measured by GPS

method. The flat and hilly terrains were examined in administrative borders.

## 2. MAIN BODY

### 2.1 Research area

The research test area of Poland represented difference surface forms which were situated in 14 administration boundary land. Through lack of reference date for forest and mountain area was not carried out the analysis of the accuracy of SRTM model.

### 2.2 Instrumentation

In order to make possible study of SRTM model on the photogrammetric work station (Intergraph Image Station) the source date were computed to USGS format by "3 DEM Terrain Visualization" software author of Richard Horne.

### 2.3 Characteristic of measurement data

In the aim of delimitation of the accuracy of SRTM model of 332 terrain profiles including 29308 height points were used. The points of the profile were measured by GPS technique. Assessment of accuracy of the position of the one point in profile amounted in the horizontal 5 cm and in the vertical 10 cm. The length of the profile amounted 2 kilometres. The profile data was represented strong test material for the mathematical statistic.

### 2.4 Characteristic test data

Data SRTM DTED-1 was determined points set of DEM acquired interferometric technique measurement a C band

system in segment size 1° na 1°. On the area of Poland collected 96 segments from witch every described was a matrix 1201x1201.

**2.5 Assessment of accuracy**

Assessment of the accuracy of SRTM model was presented by root mean square errors, standard deviation and absolute difference between the model  $Z_m$  values and the check point of profile  $Z_p$  value. RMSE was computed on the basic of difference height between points of profile and appropriate model points. Definite regions were assigned the group of local

profiles, from which every one was served to the delimitation of the mean error of the model SRTM. Therefore profiles to each region determined one statistical test. The profile data was represented strong test material for the mathematical statistic. The mean error of the SRTM model for each region was computed on the basis of acquaintances value of these errors. Knowing the value of the mean error of the SRTM model for each region was determined his average value on the area of Poland.

Region	RMSE [m]	Standard deviation [m]	Difference between the model values and check point values [m]	Number of profiles	Number points of profiles
Mazowieckie	4.3	0.9	4.2	45	4345
Łódzkie	4.2	1.2	4.0	19	1685
Wielkopolskie	3.7	1.0	3.6	19	1790
Podlaskie	2.9	1.1	2.7	28	2753
Warmińsko-mazurskie	3.5	1.5	3.3	25	2594
Kujawsko-pomorskie	4.1	1.2	4.0	22	1959
Zachodniopomorskie	3.7	1.4	3.6	18	1585
Lubuskie	3.3	1.3	3.1	3	288
Pomorskie	4.0	1.5	3.7	22	1862
Śląskie	3.6	1.3	3.3	7	586
Małopolskie	3.4	1.7	3.1	3	211
Świętokrzyskie	4.7	1.3	4.5	16	1267
Lubelskie	3.9	1.2	3.7	26	2226
Podkarpackie	3.8	1.3	3.5	11	900

Table 1. Estimation of the SRTM accuracy on the flat terrain

Region	RMSE [m]	Standard deviation [m]	Difference between the model values and check point values [m]	Number of profiles	Number points of profiles
Wielkopolskie	4.8	2.4	4.1	1	79
Podlaskie	3.6	1.3	3.3	6	585
Warmińsko-mazurskie	3.7	2.6	3.1	17	1678
Kujawsko-pomorskie	4.5	2.1	4.0	3	270
Zachodniopomorskie	3.6	2.2	3.2	2	137
Pomorskie	4.1	1.9	3.7	5	391
Śląskie	3.9	3.3	3.0	1	74
Małopolskie	5.4	2.9	5.0	3	242
Świętokrzyskie	4.6	2.8	4.0	2	165
Lubelskie	4.0	1.1	3.8	10	909
Podkarpackie	5.3	3.5	4.5	8	727

Table 2. Estimation of the SRTM accuracy on the hilly terrain

**2.6 Results**

It was affirmed that absolute accuracy of SRTM height model on Polish area amounted 2.9 m for flat area and 5.4 m for hilly area (Table 1 and 2). It was affirmed too, that accuracy of interferometric measure of height grid points is demoting during process of interpolation out of grid, while quantity of degradation is function of relief denivelation and grid points density. Statistic assessment of accuracy of SRTM model showed that interferometric measure includes ingredient systematic error (bias) between SRTM data and reference

profiles. Probably a main source of the occurrence of the component of the bias of the model SRTM was insufficient calibration of the interferometry measuring-system with relation to of scanned ground. The average bias mounted for flat area 3.5 m and for hilly area 3.7 m. After bias elimination the absolute accuracy of SRTM model on Polish area mounted to 1.0 m for flat area and 2.7 m for hilly area.

Regions	RMSE of the model SRTM dependence on slope area [m]	
	to 2°	from 2° to 6°
Mazowieckie	0.8	(•)
Łódzkie	0.9	(•)
Wielkopolskie	0.7	2.4
Podlaskie	1.1	1.7
Warmińsko-mazurskie	0.8	2.3
Kujawsko-pomorskie	0.7	1.8
Zachodniopomorskie	0.9	2.5
Lubuskie	1.4	(•)
Pomorskie	1.2	2.5
Śląskie	1.3	3.7
Małopolskie	1.1	3.4
Świętokrzyskie	1.2	3.5
Lubelskie	1.6	2.4
Podkarpackie	1.1	3.4

Table 3. The values of RMSE after bias elimination

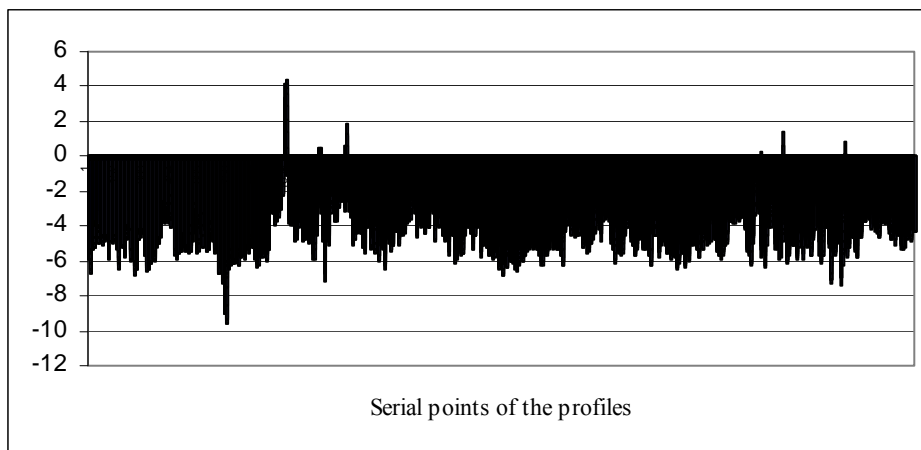


Figure 1. Height differences between DEM and terrain profile points in meters

### 3. CONCLUSION

On the base of investigate research was affirmed that SRTM model include systematic error. Average of bias amounted for flat area 3.5 m and for hilly area 3.7 m. The quality of SRTM model increased after elimination bias.

The accuracy results showed that SRTM DTED-1 data supply by measure of characteristic relief form establish the perfect source material to generate contours lines on the topographical maps in 1:50,000 scales and less. It can be also used to generating of orthoimages on the basis of high resolution satellite data (SPOT 5, Ikonos and QuickBird) which should be collected with small off-nadir viewing angle of the sensor. Obtained result can be used as reference data for calibration of the interferometer and his measuring-system of the SRTM mission on the area of Poland.

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