Evaluating ASTER GDEM accuracy for two areas in western Peloponnese, Greece

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Abstract. In this study the accuracy of ASTER GDEM was examined. For two areas with different geomorphologic characteristics DSM from ASTER stereo pairs were created with classical photogrammetric techniques. Those DSMs were compared with the ASTER GDEM. Points of certified elevation collected with DGPS have been used to estimate the accuracy of the DSM. The elevation difference between the two DSMs was calculated. 2D RMSE, correlation and the percentile value were also computed and the results are presented.

Keywords. ASTER GDEM, 2D RMSE, photogrammetry, accuracy, percentile.

1. Introduction

ASTER Global Digital Elevation Model (GDEM) was released on June 29, 2009. The GDEM was created by stereo-correlating the 1.3 million scene ASTER VNIR archive, covering the Earth's land surface between 83N and 83S latitudes. The GDEM is produced with 30 meter postings, and is formatted in 1 x 1 degree tiles as GeoTIFF files. Each GDEM file is accompanied by a Quality Assessment file, either giving the number of ASTER scenes used to calculate a pixel's value, or indicating the source of external DEM data used to fill the ASTER voids.

In this study the accuracy of ASTER GDEM was examined. For two areas with different geomorphologic characteristics DSM from ASTER stereo pairs were created with classical photogrammetric techniques. Those DSMs were compared with the ASTER GDEM. Points of certified elevation collected with DGPS have been used to estimate the accuracy of the DSM. The validation process includes the visual and the statistical comparison of the DSMs, the comparison of elevation profiles and the calculation of different accuracy values such as 2D RMSE, correlation, percentile etc.

Both study areas are situated at the Peloponnese, Greece (Figure 1). The first scene covers the Northwest part of Peloponnese a part of Patraikos Gulf and the south coast of Central Greece. The area has a quite high relief with steep slopes and the elevation ranges from 10 to more than 2450m. The second study area is situated in Western Peloponnese. The east part is highly and the elevation raise up to 1500m while the west part is flat and the terrain leading to the Kyparissiakos Gulf. Both areas present complex geomorphology and thus they are appropriate for the accuracy control of ASTER GDEM.

2. ASTER GDEM

According to the official release documents the ASTER GDEM covers land surfaces between 83°N and 83°S and is comprised of 22,600 1°-by-1° tiles. Tiles that contain at least 0.01% land area are included. The ASTER GDEM is in GeoTIFF format with geographic lat/long coordinates and a 1 arcsecond (approximately 30 m) grid. It is referenced to the WGS84/EGM96 geoid. Pre-production

ISBN 978-83-63245-65-8, DOI: 10.12760/03-2014-04, Zagajewski B., Kycko M., Reuter R. (eds.)

estimated (but not guaranteed) accuracies for this global product were 20 m at 95 % confidence for vertical data and 30 m at 95 % confidence for horizontal data. Some tiles have substantially better than 20 m accuracy, and some tiles have substantially worse than 20 m vertical accuracy.

Those accuracies are in harmony with the results of a previous study [1]. The results show that the standard deviation is about 10 m, and therefore the vertical accuracy of DEM is about 20m with 95% confidence (2σ) without the use of GCPs. The horizontal geolocation accuracy appears to be limited by the spacecraft position accuracy, which is considered to be better than 50 m.

The ASTER GDEM contains anomalies and artifacts that will reduce its usability for certain applications, because they can introduce large elevation errors on local scales. However, in spite of its flaws, the ASTER GDEM will be a very useful product for many applications, including those requiring a true global DEM.

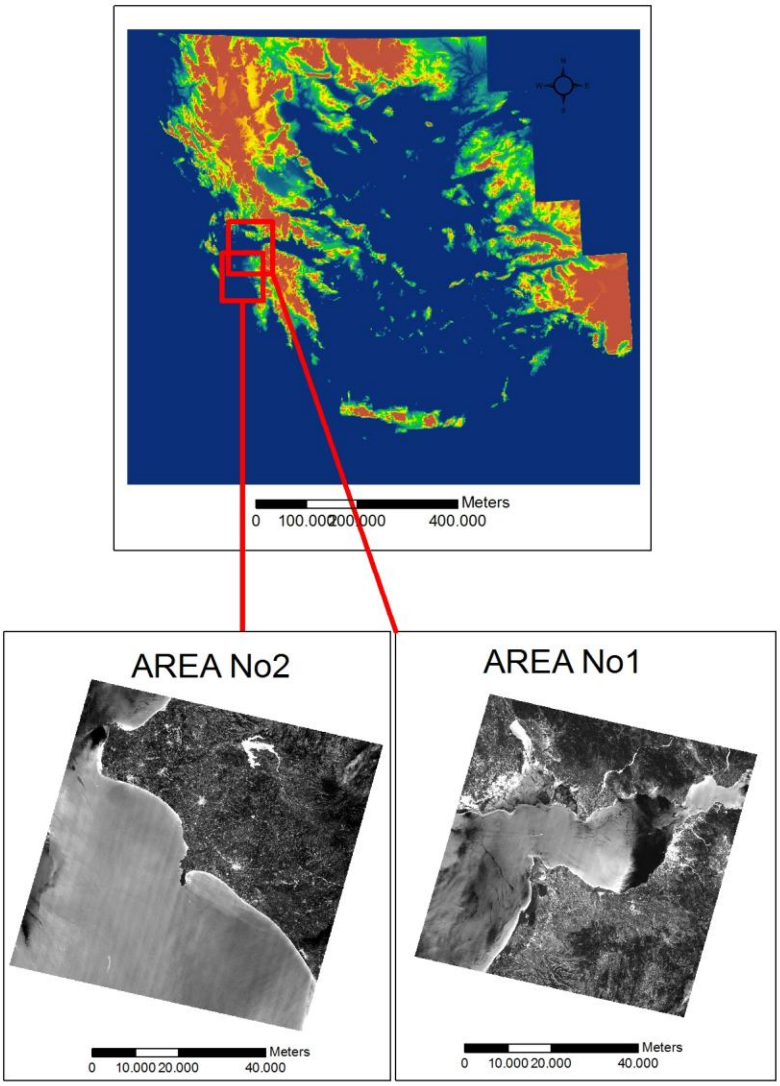

Figure 1: The two study areas in Peloponnese, Greece.

3. ASTER DSM produced with classical photogrammetric techniques.

The use of Ground Control Points (gcp's) for the production of ASTER DSM with classical photogrammetric techniques ameliorates both the horizontal and vertical accuracies. As a part of

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REALDSMS project, high spatial resolution ASTER stereo imagery was analyzed to produce DSM for Heraklion and Sitia areas in Crete Island. Differentially corrected GPS measurements were performed to provide GCPs for DSM correction and geo-location. The planimetric and elevation accuracy of the produced DSMs was 15.0 m and 12.4 m, respectively [2], [3]. It was also proved that ASTER data have very good accuracy that depends on the accuracy of the ground control points. In the case of Milos Island Greece, the accuracy ranged between 4.3 and 32.7 meters[4] and in the case of Lefkas Island the accuracy ranged between 10 and 24 meters [5].

For both study areas about thirty ground control points and 20 tie points (Figure 2) were inserted in Leica Photogrammetry Suite software in order to perform the necessary triangulations for the DSM extraction.

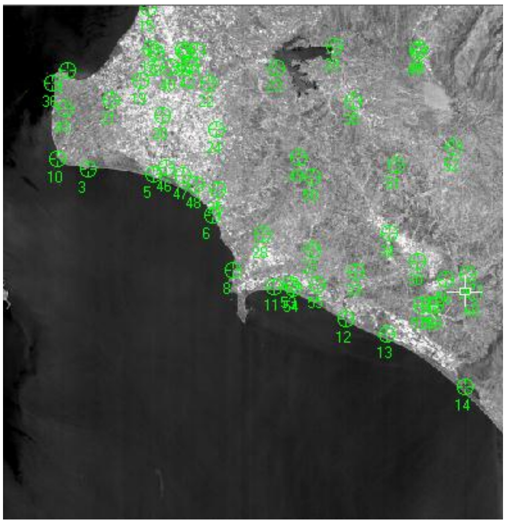

Figure 2: Allocation of ground control points and tie points.

4. First study area

4.1. Visual Comparison

As we can see in Figure 3 both the ASTER GDEM and the ASTER DSM give very good representation of the topography of the study area and the appearance of the two DSM is almost identical.

4.2. Statistical Comparison

The statistical parameters of the two DSMs were examined. As it can be observed in Table 1, the two DSMs present almost the same statistical values. The minimum value is 0 for all the DSMs. The maximum values are 1998 and 2104 for the ASTER DSM and the ASTER GDEM respectively. The mean and the standard deviation values present very small differences and in general the ASTER DSM presents a little higher elevation values except of the maximum.

Table 1. Statistical Parameters of the DSMs

	MEAN	ST. DEVIATION	MAX	MIN
ASTER DSM	171,5	271,5	1998	0
ASTER GDEM	170,3	282,4	2104	0

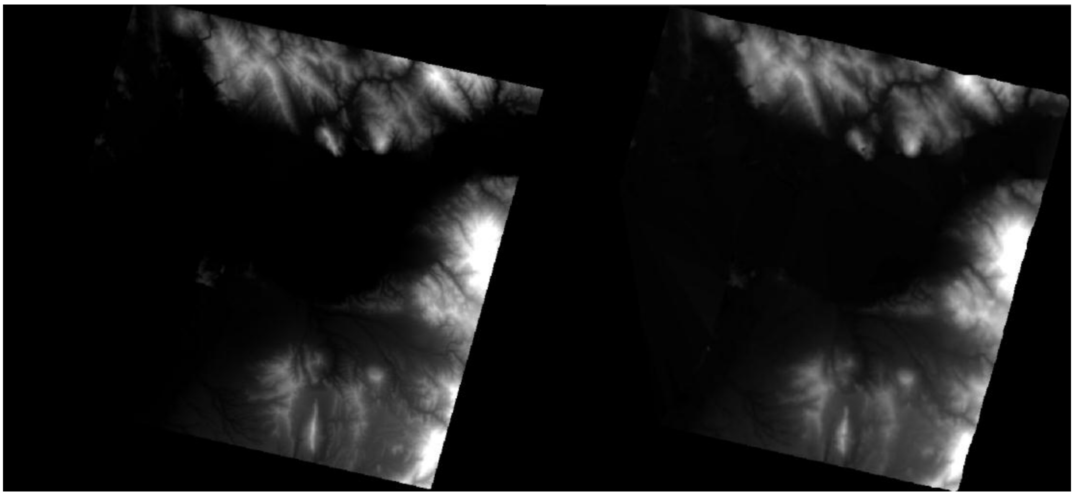

Figure 3: At the left the ASTER GDEM and at the right the ASTER DSM .

4.3. Accuracy control

A data set of points of known elevation (control points) has been used to estimate the accuracy of the DSM's. The data set is composed from 531 points of certified elevation (Figure 4). Those points cover the whole area. In order to control the accuracy of ALOS DSMs, the elevation difference between the control points and the relative points (pixels) of the DSMs was calculated. Then, the 2D RMSE and the percentile values were calculated. All the statistical results are presented in Table 2.

Observing the statistics it is quite interesting to pinpoint that the ASTER GDEM presents a higher accuracy than the ASTER DSM created with classical photogrammetric techniques. ASTER GDEM presents a 2D RMSE of 36m while the ASTER DSM present a 2D RMSE of 48m. It is also remarkable that ASTER GDEM presents an average elevation difference of 19,8m while the ASTER DSM presents almost the double (37,7m).

Table 2. Elevation difference between points of certified elevation and the respective pixels in the two DSMs.

	PERCENTILE	AVERAGE	MAX	MIN	2DRMSE
ASTER DSM	49,2	37,7	99,6	-23	48
ASTER GDEM	42,7	19,8	83	-42	36

4.4. Elevation profile generation and comparison

Two different elevation profiles were generated and compared for the DSMs. The first profile starts with an E-W direction and turns to a N-S direction while the second one has a E-W direction, The profiles are presented in Figures 5 and 6 respectively.

As it can be observed, the two DSMs present almost identical profiles. In every direction the shape of the profiles is exactly the same. It is notable that the ASTER GDEM present less edges and it is in general smoother than the ASTER DSM.

5. Second study area

5.1. Visual Comparison

As we can see in Figure 7 both the ASTER GDEM and the ASTER DSM give very good representation of the topography of the study area and the appearance of the two DSM is almost identical.

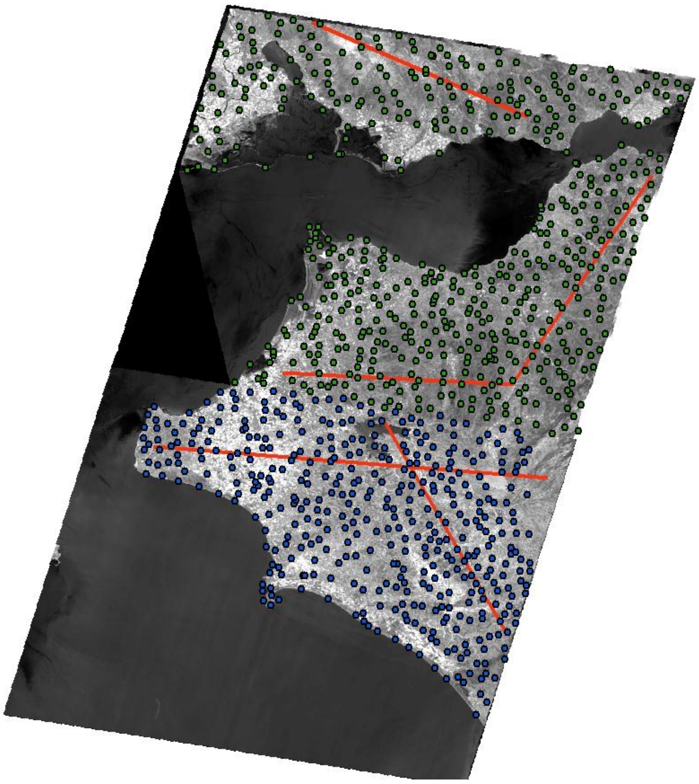

Figure 4. Allocation of the control points. With green color the points in area 1 and with blue color the points in area 2.

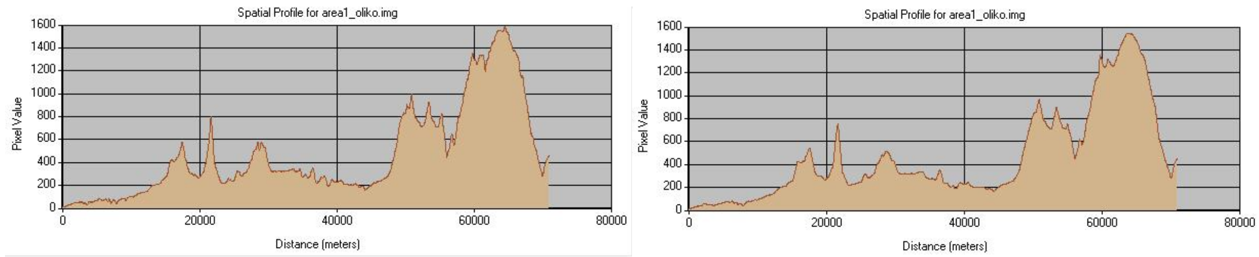

Figure 5. The E-W and S-N elevation profile. At the left ASTER GDEM and at the right ASTER DSM created with photogrammetric techniques.

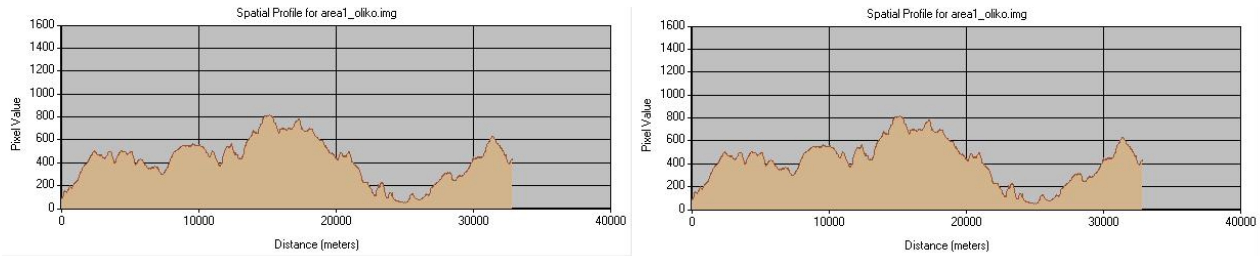

Figure 6. The E-W elevation profile. At the left ASTER GDEM and at the right ASTER DSM created with photogrammetric techniques.

5.2. Statistical Comparison

The statistical parameters of the two DSMs were examined. As it can be observed in Table 3, the two DSMs present similar statistical values. The minimum value for all the DSMs is, as expected, zero. The standard deviation values and the mean values of the two DSM's present very small differences around 10m. It has to be marked that the ASTER GDEM present a quite higher maximum value compared to the ASTER DSM. The maximum value of the ASTER GDEM is 1597 while the respective value of ASTER DSM is 1475.

Table 3. Statistical Parameters of the three DSMs

	MEAN	ST. DEVIATION	MAX	MIN
ASTER DSM	74	164	1475	0,00
ASTER GDEM	82,1	176,4	1597	0,00

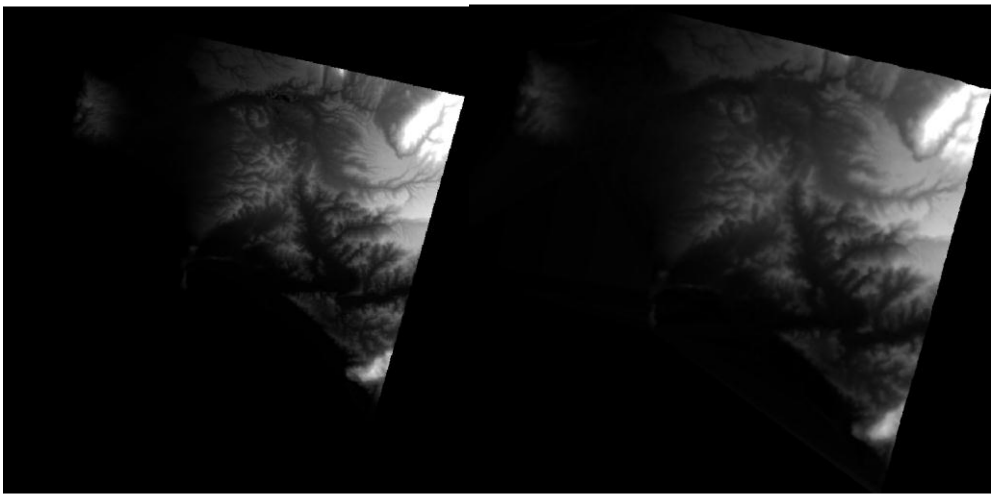

Figure 7. At the left the ASTER GDEM and at the right the ASTER DSM.

5.3. Accuracy control

A data set of points of known elevation (control points) has been used to estimate the accuracy of the DSM's. The data set is composed from 432 points of certified elevation (Figure 4). Those points cover the whole area. In order to control the accuracy of ALOS DSMs, the elevation difference between the control points and the relative points (pixels) of the DSMs was calculated. Then, the 2D RMSE and the percentile values were calculated. All the statistical results are presented in Table 4.

Observing the statistics it is quite interesting to pinpoint that the results are very similar with the results from the first area. The ASTER DSM present an average difference of 28,1m, higher than than the ASTER GDEM (19,9). The ASTER DSM present a 2D RMSE of 37.3m while the ASTER GDEM present a 2D RMSE of 31.2m. It has to be marked that the ASTER DSM has also a higher percentile value compared to the ASTER GDEM.

Table 4. Elevation difference between points of certified elevation and the respective pixels in the three DSMs.

	2DRME	AVERAGE	MIN	MAX	PERCENTILE
ASTER DSM	37,3	28,1	-25,5	93	52,31
ASTER GDEM	31,20	19,9	-15	69	45,3

5.4. Elevation profile generation and comparison

Two different elevation profiles were generated and compared for the DSMs. The first profile has an E-W direction while the second one has a NW-SW direction. The profiles are presented in Figures 8 and 9 respectively.

As it can be observed, the two DSMs present almost identical profiles. In every direction the shape of the profiles is exactly the same. It is notable that the ASTER GDEM present less edges and it is in general smoother than the ASTER DSM.

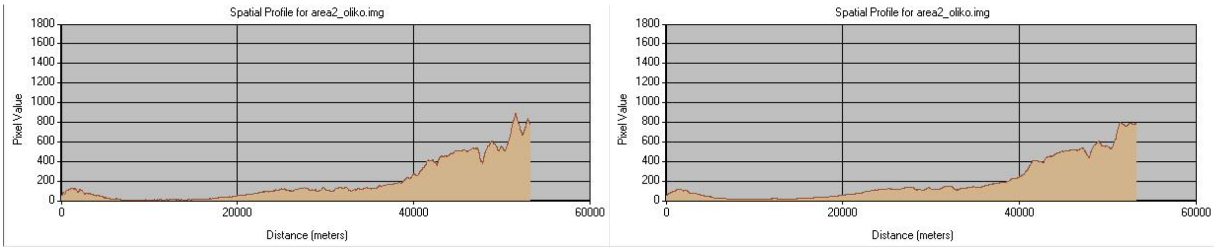

Figure 8. The E-W elevation profile. At the left ASTER GDEM and at the right ASTER DSM created with photogrammetric techniques.

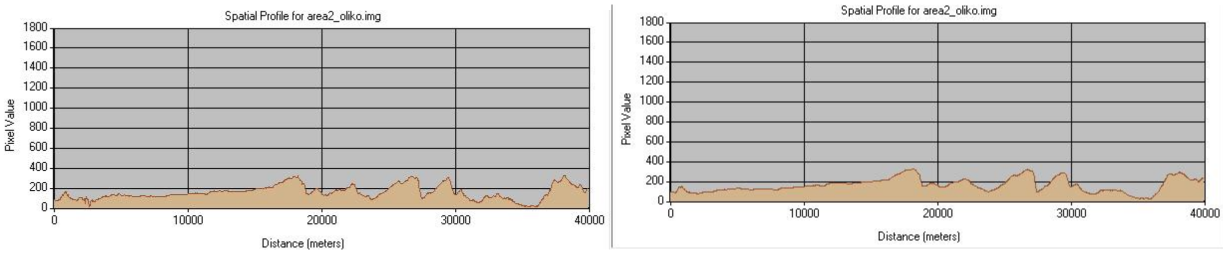

Figure 8. The NW-SE elevation profile. At the left ASTER GDEM and at the right ASTER DSM created with photogrammetric techniques.

6. Conclusions

The vertical accuracy of the ASTER GDEM was controlled for two areas with different geomorphologic characteristics but with a complex relief. The ASTER GDEM was compared to DSMs from ASTER stereopairs created with classic photogrammetric techniques. Hundred control points of certified elevation were used for the vertical accuracy control.
The vertical accuracy of the ASTER GDEM was calculated between 30 and 36m and it is acceptable according to its specifications. It has to be marked that in both cases the ASTER GDEM present better vertical accuracy in comparison with a DSM created from ASTER stereopair.

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