EVALUATION OF DIFFERENT DIGITAL ELEVATION MODELS

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ABSTRACT

Use of digital elevation models is crucial in fast growing need on developing project documentation to design roads and other buildings. There are a lot of different digital elevation models available online for free download and free use. However the production of such models come from different sources and one can expect different results using different digital elevation models. In this paper evaluation of such digital elevation models will be given. Faculty of Geotechnical Engineering is monitoring exploitation of stonepit in Novi Golubovec, named Lovno II. Measurement are made with classic geodetic instruments and monitoring begun in 2002. Having in mind that online available digital elevation models are obtained in different time period they will be compared to digital elevation models of Lovno II measured in equivalent time period. In this paper evaluation of digital elevation models of state geodetic administration of Republic of Croatia will also be provided. The results will be given in the graph form.

Keywords: digital elevation models, ASTER, ALOS, State geodetic administration of Republic of Croatia, real-time kinematics

1. INTRODUCTION

A wide variety of digital elevation models exist, and each has different characteristics due to data acquisition and processing techniques, which results in different spatial resolutions and accuracies of the elevation values [9]. Since the usage of global digital elevation model is mostly for scientific purposes this paper will give evaluation of two global and one local digital elevation model and define use for each of evaluated digital elevation model. Digital elevation models that will be compared are ASTER, ALOS, SGA and RTK. Having in mind date and procedure of production expected is that local SGA DEM is better than global DEMs. Out of global digital elevation model it is expected that ALOS is better than ASTER. All of the shortcuts mentioned in this Introduction will be explained later in text.

2. DIGITAL ELEVATION MODEL

Digital elevation model (DEM) represents set of points on Earth surface with spatial coordinates suitable for computer calculations [1]. Digital elevation models can be produced with different methods, which results with different accuracy. Today we have a huge amount of digital elevation models available online and for free usage. Hence they are produced with different accuracy it is very important to understand the quality of obtained DEMs. One of the most used DEMs is Shuttle Radar Topography Mission (SRTM) produced in common project of National Aeronautics and Space Administration (NASA), National Geospatial Intelligence Agency (NGS), German Space Agency (DLR) and Italian Space Agency (ASI). Since the data for production of SRTM were acquired in 2000. there are many papers regarding evaluation of this model already made and this paper will focus on other DEMs.

2.1 ADVANCED SPACEBORNE THERMAL EMISSION AND REFLECTION RADIOMETER - GLOBAL DIGITAL ELEVATION MODEL (ASTER GDEM)

The Advanced Spaceborne Thermal Emission and Reflection Radiometer obtains high-resolution images of the Earth in 14 different wavelengths of the Earth in 14 different wavelengths of the electromagnetic spectrum, ranging from visible to thermal infrared light. Scientist use ASTER data to create detailed maps of land surface temperature, emissivity, reflectance and elevation [2]. The first version of the ASTER GDEM was released in June 2009 and it was generated using stereo-pair images collected by ASTER instrument. Second release was in 2011 with improved coverage and reduced occurrence of artifacts [3]. The GDEM for our training site was obtained on 17th October 2011.

2.2 ADVANCED LAND OBSERVING SATELLITE "DAICHI" (ALOS)

The Advanced Land Observing Satellite "DAICHI" (ALOS) has been developed to contribute to the fields of mapping, precise regional land coverage observation, disaster monitoring and resource surveying [4]. ALOS has three sensors:

- the Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM), which is comprised of three sets of optical systems to measure precise land elevation [4]
- the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2), which observes land surface covers [4]
- the Phased Array type L-band Synthetic Aperture Radar (PALSAR), which enables day and night and all-weather land observation [4]

The ALOS GDEM for out training site was released in March 2017.

2.3 CROATIAN STATE GEODETIC ADMINISTRATION DEM (SGA)

Croatian state geodetic administration digital elevation model is produced by photogrammetric restitution from aerial photogrammetry. Digital elevation model

for whole area of Republic of Croatia was updated from 2014. to 2016. [5]. Since ASTER GDEM and ALOS are free of charge one should have in mind that digital elevation model from Croatian state geodetic administration is chargeable. However for purposes of this paper data were free. Main difference to other two DEM, along with type of production, is that SGA DEM is local digital elevation model.

2.4 RTK DEM

Real-time kinematic digital elevation model (RTK DEM) is product of classic geodetic measurement with GNSS receiver. For training site measurements were made from 2002 to this day. Since the measurements are made in CROPOS (CROatian POsitioning System), which guarantee vertical precision ±4cm [6], it is expected that the RTK DEM will have greatest accuracy, and it will be used as ground data.

3. STUDY AREA

Study area is located in Croatia, in Krapinsko-zagorska county. Study area is stonepit located in Novi Golubovec, named "Lovno-Lovno II". The location and the appearance of stonepit is presented on Figure 1 and Figure 2.

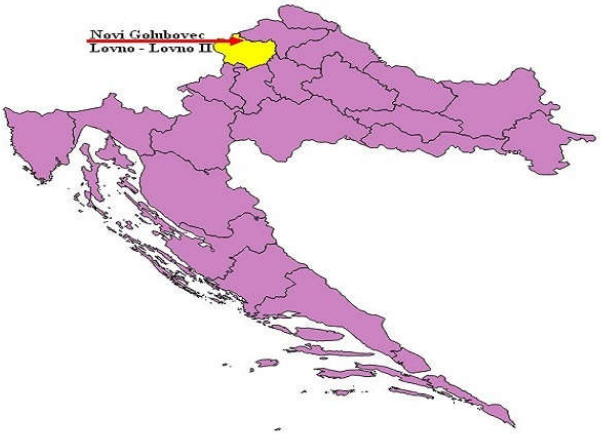

Figure 1 - Location of stonepit Lovno II [7]

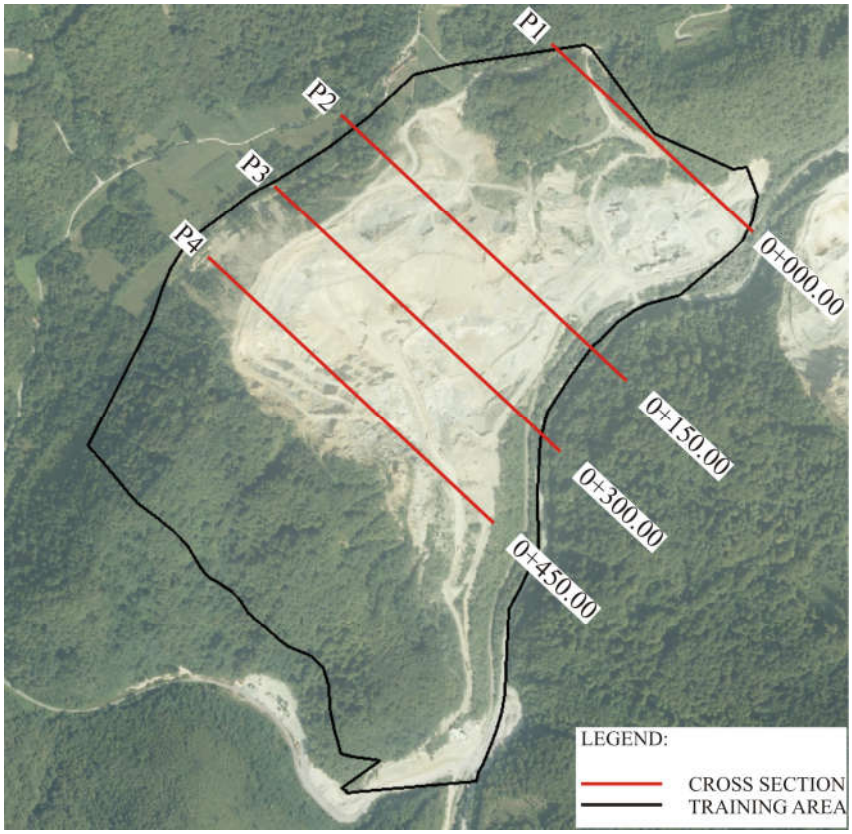

Figure 2 - Study area 1 [8]

3.1 METHODS

On training area four different cross sections were defined. Cross sections were defined having in mind the structure of terrain, so that each cross section represents different terrain (exploited and not exploited part of stonepit) so the evaluation of DEMs could give better results. Position of cross sections is shown on Figure 2. After the cross sections have been defined, they have been calculated for each producer (ASTER, ALOS, SGA, RTK). Reference measurement is RTK DEM cross sections because it has the best accuracy among the given DEMs. Later the difference in volumes between each given DEMs and RTK DEM were calculated. Whole process of evaluation was made in AutoCAD Civil 3D and special software called Plateia.

4. RESULTS

On Figure 3 one can see difference in digital elevation models on cross section P1 and cross section P2. On Figure 4 one can see difference in digital elevation models on cross section P3 and P4. As expected digital elevation model produced by Croatian state geodetic administration is closest to ground data in all four cross sections. Interesting is that ASTER DEM from 2011 have small difference from ALOS DEM which is produced in 2016 and should be higher quality. Therefore ASTER DEM is compared to RTK DEM from 2011 and to RTK DEM from 2016 as well.

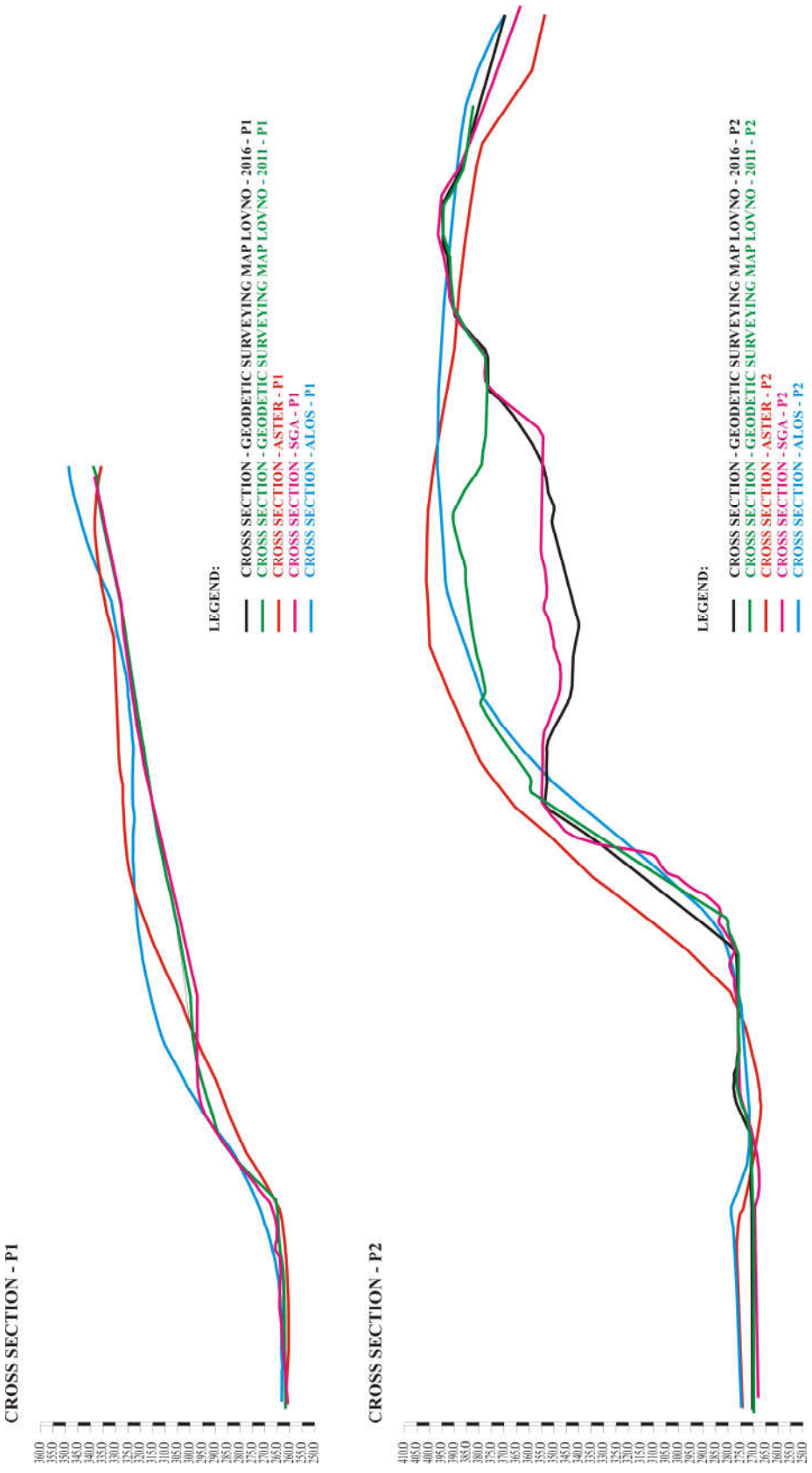

Figure 3 - Cross section P1 & P2

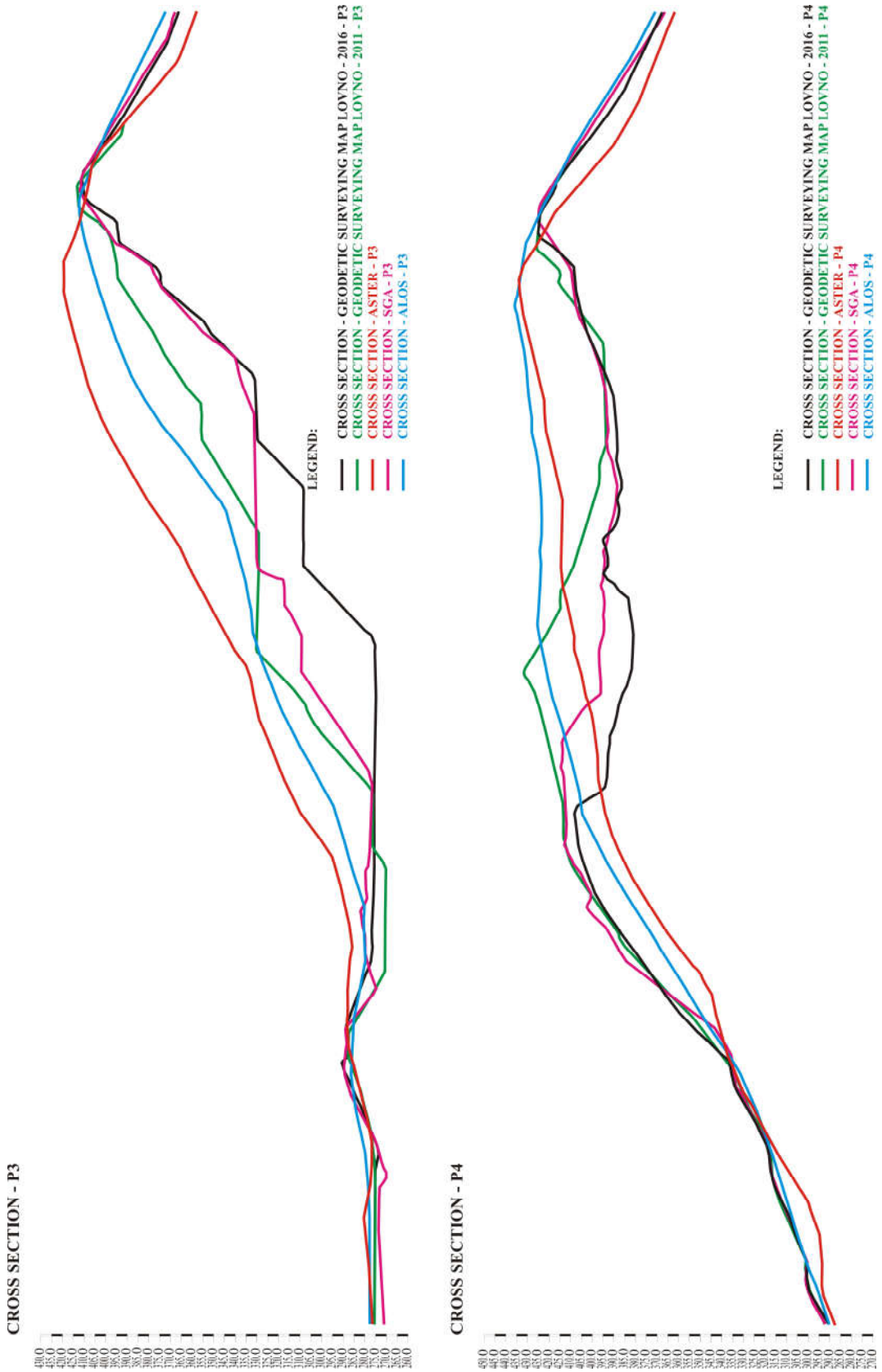

Figure 4 - Cross section P3 & P4

Further more if we compare total volume differences we get results as shown in Table 1 and on Figure 5 which is graphical representation of Table 1.

Table 1 - Total volume difference

Total volume difference (m^3)			
	Cut volume	Fill volume	Volume difference
ASTER-2016	5.666 053,28	1.107 665,97	4.558 287,31
ASTER-2011	3.157 805,49	1.141 236,11	2.307 884,00
SGA	1.175 023,99	519 795,98	931 706,96
ALOS	5.089 473,94	552 706,81	4.536 767,14

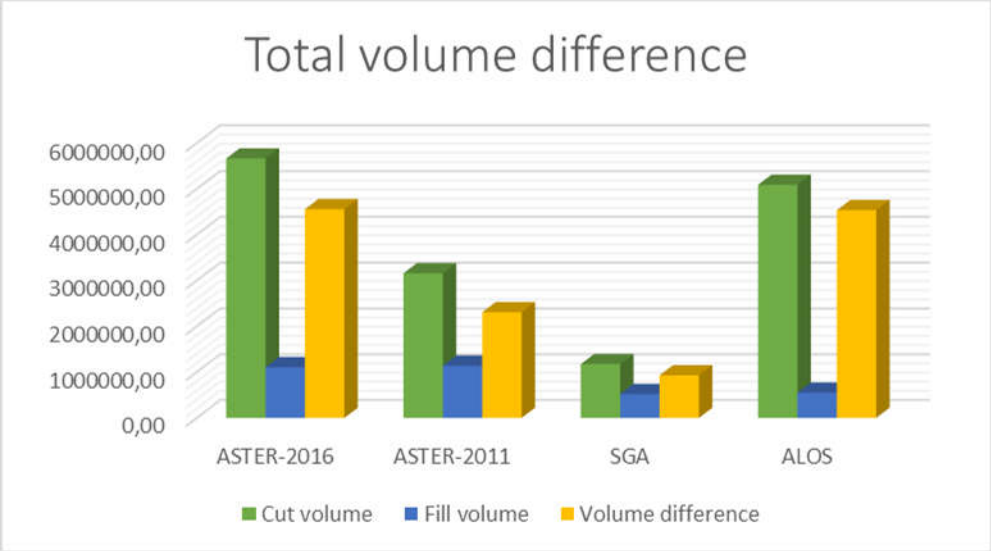

Figure 5 - Total volume difference

Based on results given it is obvious, as expected, that Croatian state geodetic administration digital elevation model is the best compared to other two DEMs, hence it is produced by photogrammetric restitution. Next we have interesting results, since it was expected that ALOS which is produced in 2016 would give much better results than ASTER from 2011. From Table 1 is clear that the ALOS DEM is just slightly better than ASTER 2011 compared to RTK DEM from 2016. Based on all results given, final rank of digital elevation models would be: RTK DEM, SGA DEM, ASTER DEM and finally ALOS DEM.

5. CONCLUSION

In huge amount of online available digital elevation models, key is to understand the quality of each model and therefore decide which ones are suitable for desired purpose. Based on analysis taken it is obvious that digital elevation model produced by Croatian state geodetic administration is the most suitable for various usage in different areas of expertise. Since it is not global and it is chargeable, it can find use only in Republic of Croatia. It can be used for developing ideas for road and other building construction. Between two global digital elevation models better is ASTER, but one should expect

further upgrade of ALOS digital elevation model. Since they are global, they give lesser quality of data, as expected, and for area of Republic of Croatia they should be used purely scientific. Main advantage of global digital elevation models is in coverage, where one can determine dependence between some terrain characteristic in any area in the world. It is important to point out that for any more detailed level of analysis one should use digital elevation models produced by real-time cinematics, or classical geodetic measurements.

6. REFERENCES

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