Comparison of Digital Terrain and Surface Models for next Usage in a Chosen Locality

Alessandro Valetta 1, Jakub Chromcak 2, Peter Danisovic 3, Gabriel Gaspar 4

1 University of Parma, Parco Area d. Scienze, Via delle Scienze, 181/a, 43124 Parma, Italy
2 Department of Geodesy, Faculty of Civil Engineering, University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovakia
3 Department of Construction Management, Faculty of Civil Engineering, University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovakia
4 Research Centre of the University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovakia
alessandro.valletta@unipr.it

Abstract. There are many possibilities for applications of digital terrain model and digital surface model due to their georeferenced character. The informational system of georeferenced data of Slovakia called ZBGIS gives new opportunities of downloading digital data in various formats. It is possible to download ortophotomosaics, ZBGIS raster at various scales, point cloud but digital terrain models and digital surface models with great possibilities of their application in GIS calculations as well.

1. Introduction

Digital terrain model (DTM) and digital surface model (DSM) offer new possibilities to perform spatial analysis in various fields. These analyses offer very detailed and limitless opportunities to study the land and surface from a different point of view. According to the chosen analysis, it is necessary to choose the proper digital model with the sufficient precision represented by the grid size of the model [1]. Firstly, the difference between the DTM and DSM must be explained. DTM represents the Earth’s terrain without the vegetation, buildings and all anthropogenic subjects. On the other hand, DSM includes all objects on the Earth’s surface. ZBGIS (Base of Geographic Information System) enables the users to export DSM and DTM for the chosen cadastre area or custom selected range. From this point of view, it is interesting to study the differences between these models displaying the same locality. The differences calculated between them represent the objects located in the examined area. According to the known parameters of the objects (buildings, trees, etc.), it can be considered the models’ sufficient contribution when they are used in the next analysis.

There are many suitable localities for demonstration of advantages of comparison of DTM and DSM models, eg. localities of by-products or mineral waste from the mining industry (deposits and tailing dams) and civil engineering works (demolition works) may be efficiently measured and controlled by means of remote sensing. The necessity of utilization of mineral waste and some beneficial effects for the environment related to expanding the resource base is presented in [2, 3].
2. The examined locality

To ensure the informative value of the models’ comparison, it was necessary to choose the locality including both, significant vegetation and urban environment. According to the pre-set conditions, the locality chosen for the analysis was Sklené, district Turčianske Teplice (Figure 1). The locality was selected due to its balanced ratio between urban area, non-urban areas with low vegetation such as grasslands meadows, etc., and non-urban areas with high vegetation such as forests. The range of selected area is appropriate and the shape is homogenous and not extended in any direction with almost a regular shape.

![Figure 1. The shape of the examined area - Sklené, district Turčianske Teplice](image)

The examined area is defined and characterised by consequent parameters: the elevation acquires values from 502.16 to 913.52 metres in the Baltic vertical datum after adjustment, the total area is 40.95 km\(^2\) and DTM and DSM data were downloaded as a raster with grid 1 by 1 meter with a total sum of 40,950,359 pixels.

3. ZBGIS database

A map client ZBGIS is web mapping application for the interactive usage with ZBGIS data, digital data of cadastre of real estates, address register, LPIS (Forest and Soil Information System) soil register, reference geodetic points, raster maps from historical archive as well as digital terrain or relief models, orthophotos and oikonyms. It is a complex tool for displaying, searching and spatial data analysis and map services ZBGIS and ESKN (Electronic System of Cadastre of Real Estates).

The application enables importing the external data in various formats (SHP, DGN, DXF, GML, GPX) or in format of web mapping services (WMS, WMTS). It is possible to create preprints and exports to PDF format, perform the basic analysis such as simple length and area measuring, profile displaying and acquiring of the point coordinates in S-JTSK (Datum of Unified Trigonometric Cadastral Net(work)) coordinate system and information of map objects [4].
The mapping service ZBGIS offers six various opportunities with different map layers with associated attributes. The first layer includes the basic map which represents the topographic parameters of land based on the ZMVM in scale 1:5000. Next layer called Cadastre of real estate’s includes information about parcels, possibilities of the folios of proprietary rights and displaying the current status of C and E parcels and contains information of SGI (file of survey data) and SPI (file of descriptive information). Another layer “Geodetic basis“ shows the position of permanent points of ŠTS (The State Trigonometric Network), ŠNS (The State Levelling Network), ŠGS (The State Gravimetric Network) and the SKPOS (The State Permanent Observation Network) permanent points. Within this layer, it is possible to find out the information about these points (their coordinates, elevation, geodetic data about their location in the terrain, their status – existing, damaged, etc.). These data may also be useful within the raster georeferencing. The next layer called Archive contains historical map documents created during the last century including ŠMD (The State Map Series), TM (Technical Maps), ZM (Basic Maps), etc. The layer “List of oikonyms“ includes residential and non-residential names, commune names, historical names and standard geographical names.

The very last layer called “Terrain“ offers DTM, slopes and orientations, but also the possibility to download DTM, DSM and also point clouds. It is possible to download these files for the chosen cadastral district, for the custom selected range or the actually displayed desktop window. These data are not possible to be downloaded for the whole area but only in the areas where these models are already created as it is shown in the Figure 2.

![Figure 2. Actual available DTM and DSM models in Slovakia](image)

4. Data Analysis
For the analysis purposes, the DTM and DSM models of the examined area Sklené were downloaded. Raster files were imported into ArcMap, a program that offers simple or complex raster math analysis. Both models were downloaded in the same grid density, so it was not necessary to edit the shape of the raster. In addition, the georeferencing was not necessary due to the identical georeference of the base data.

DTM model contains level values in the range from 501.83 m to 892.39 m in the total count of 40,951,790 pixels. DSM model includes almost identical data. The level range is from 502.16 m to
913.52 m with the same total pixel sum. The histograms presenting characters of both models are displayed below. (Figure 3)

There are different deviations between the both histogram models that can be caused by the presence of the captured objects such as vegetation and buildings. To compare these models, the mutual calculation was done.
5. Results and discussions
The analysis shows that the major part of the examined area has an elevation deviation in the range from -0.2 m to 0.2 m represented in the Figure 4 by the light blue colour. The differences are probably caused by the low vegetation and these areas are according to the orthophotos meadows and grasslands. The questions are presence of the values between -0.2 - -5 m (the dark blue colour) as well as the reason why the DSM is lower than DTM. This has to be the point of the future research. It is possible to see the that the urban areas including houses and other buildings have the influence on the values mostly in scale 0.2 m – 5.0 m (light green colour). The range 5.0 m – 20.0 m represented by the orange colour may be caused by the higher vegetation such as woodland and some higher buildings that are also able to be seen in the orthophotos. According to the presumption that usual tree-height is up to 20 m, the range over the value 20 m is presented by the red colour. It is possible to see these kinds of areas, which may be caused by the presence of the above standard high vegetation, or this should be the subject of the future research.

6. Conclusions
The existence of DTM and DSM models with a high precision offers great opportunities for future GIS applications. The paper shows other ZBGIS download possibilities but mostly the possibilities of available terrain models. It is only the question of time, when the whole area of Slovak republic will be able to be downloaded. These models are opening various possibilities for raster calculations. As it is shown in the paper, the legal differences between DTM and DSM caused by existence of the objects are expected.

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