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Review paper

COMPARISON OF DEMS GENERATED USING DIFFERENT DATA SOURCES AT A MOUNTAIN SITE

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Abstract. *The paper analyzes digital elevation models (DEM) of the same area based on different sources and methods of geospatial data collection. An open-source DEM was created in the mountainous area of Colus County, which is the northern part of the US state of California. At the same time, the data on terrain elevation refer to LiDAR surveys and the content of topographic maps, while ASTER data are based on ellipsoidal heights. Also, the source data contain a certain error of the chosen collection method and the processing process itself, as well as errors related to mutual deviations of the height reference systems. Ignoring the height system, it is observed that the error of the data source significantly affects the quality of the model display as well as the terrain details. The display of DEM based on LiDAR data is very close to DEM based on data from topographic maps, in contrast to the elevation model obtained based on ASTER images.*

Key words: *quality comparison, DEM, different data sources, same area.*

1. INTRODUCTION

The development of new techniques and technologies is accelerating the process of collecting and modeling geospatial data, and thus improving the quality of digital elevation models (DEMs) visualization. In recent years, there have been two fundamental advancements. On one hand, modern techniques such as LiDAR (Light Detection and Ranging) determine elevation through direct distance measurements, providing much greater accuracy in determining elevation. On the other hand, there is the ability to

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generate global DEMs. For example, SRTM (Shuttle Radar Topography Mission), ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer), and similar technologies offer the capability to create DEMs with great ease and precision [1].

DEM products have applications in a wide range of disciplines, including civil engineering, hydrology, geomorphology, environmental protection, forestry, and more. Some of their applications include modeling for natural disaster prevention (such as floods and fires), soil erosion, weather forecasting, climate change, etc. Additionally, DEMs are considered a global fundamental topic in United Nations geospatial data. Therefore, one of the basic premises is the need for DEMs to have sufficient quality to meet the requirements of many applications [2].

Many times, it can be the case that a DEM with a certain level of quality is used in a study that requires a different level of quality. Specifically, two scenarios can occur. First, a higher-resolution and more accurate DEM may be used than what the study's requirements dictate, leading to an overutilization of DEM capabilities and the consumption of additional resources (e.g., memory and disk space, computation time, etc.). Second, an insufficiently detailed and accurate DEM may be employed for the study's needs, resulting in a study that produces inaccurate results, potentially leading to incorrect conclusions. To address this issue, users need to understand the quality of the DEM [2].

2. Methods and Technologies for Representing DEMs

DEMs are a specific case of interpolated continuous surfaces. Variations in the elevation of an area's surface can be modeled in several ways. DEMs can be represented as mathematically defined surfaces, as point or linear images. Linear data can be used to represent contour lines and profiles, as well as critical features such as streams, ridges, coastlines, and slope breaks. In geographic information systems (GIS), DEMs are modeled as regular grids (elevation matrices) or irregular triangulated networks (TINs). These two forms can be transformed into each other, and the choice depends on the type of data analysis required [14].

For continuous fields, there are two main ways of representing spatial data. The first is Delaunay triangulation, i.e., TIN (Triangular Irregular Network) digital elevation modeling, and the second, which is more commonly used, is an elevation matrix or grid, employed in raster-based GIS and image analysis. Delaunay's networks are often used independently of GIS to support finite element modeling of dynamic processes like groundwater flow, flooding in flood-prone areas, or air quality.

Elevation matrices are the most common form of discretized elevation surfaces. They were originally derived from quantitative stereoscopic measurements on aerial photographs. Today, there are modern ways of collecting elevation data. In particular, many experiences show that LiDAR technology and remote sensing efficiently replace conventional techniques and methods for gathering geospatial data, such as digitizing topographic maps and aerial photogrammetry. The subject of this work is elevation models, comparing DEMs obtained from different data sources, all in an effort to determine the quality of modern and conventional data collection and modeling technologies. Elevation models are created based on data collected from LiDAR technology, data obtained from remote sensing, and data digitized from topographic maps.

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The paradigm of continuous (uninterrupted) fields provides a rich basis for spatial modeling, especially when data is stored in regular square grids. Mathematical operations on continuous fields can be divided into point and spatial operations. Point operations are the same as those performed in spatial operations of geographic entities, where the point is one of the basic geographic primitives. Spatial operations include spatial filtering, surface derivative calculations, slope, aspect, curvature, surface topology and drainage network analysis, spatial proximity, linear and non-linear closeness, and properties of the entire surface, such as line of sight and terrain exposure.

The most commonly used continuous field is the digital elevation model, as was the case in this study. Analyzing the attributes it carries can yield a large amount of new data. However, these operators can be equally well applied to any continuous field, such as remote sensing imagery or the results of interpolation and spatial modeling. Table 2 provides an overview of attributes that can be calculated from DEMs, as well as possible applications of these attributes [14].

Table 1 Overview of attributes that can be calculated from DMV and its applications

Attribute	Definition	Application
Height	Height above sea level or local reference	Determining potential energy; climate changes – pressure, temperature, vegetation and soil trends, material volume, embankment and cut calculations
Slope	Rate of altitude change	Slope of the terrain, aboveground and underground flows, land capability classification, vegetation types, resistance to upstream transport, remote sensing image correction
Aspect	Azimuth of the steepest descent	Sunlight exposure, Evaporation, Vegetation attributes, Correction of remote sensing images
Profile curvature	Rate of change in land slope	River flow acceleration, areas of increased erosion, sedimentation, vegetation, valuation indices
Horizontal curvature	Rate of change in aspect	Convergence and divergence of flow, soil moisture properties
Local drainage direction	Direction of the steepest descending flow	Calculating watershed attributes based on flow topology, estimating lateral material transport along locally defined networks
Upstream elements/Areas/Specific catchment areas	Number of cells/areas upstream of a given cell/upstream area per unit contour line width	Watershed areas upstream of a given location, in case of outlet, the entire watershed area, volume of material exiting the watershed
Length of the flow	Length of the longest path along the LDD upstream of the given cell	Flow acceleration, erosion rate, sediment quantity
Flow channel	Cells with flowing water/cells with more than predefined upstream elements	Flow intensity, flow location, erosion, and sedimentation
Ridge	Cells without upstream areas	Watersheds, vegetation research, soil, erosion, geological analysis, connectivity
Moisture indices	Specific catchment area and slope	Moisture retention index
Stream power index	Specific catchment area and slope	Measure of the erosive power of overland flow
Sediment transport index	$(n+1)(\frac{A_s}{22.13})^n(\frac{\sin\beta}{0.0896})^m$	Characterizes erosion and deposition processes
Watershed length	Distance from the highest point to the outlet	Reduction of overland flow

Line of sight	Areas of mutual visibility	Locating microwave transmitters, fire monitoring stations, hotels, military applications
Sunlight exposure	Amount of solar energy received per unit area	Vegetation and soil research, evaporation, energy-efficient building locations, terrain shading

3. Procedures and Results

3.1. Area of interest

The area of interest in this study is a selected part of a mountainous region in Colusa County, Northern California (Figure 1), located at approximately 39° 7' 18" North latitude and 122° 20' 10" West longitude.

(a)

(b)

Fig. 1 California State (a) and Colusa County (b) Territory [2]

The surface where elevation models were formed covers an area of approximately 10,000 square meters, with dimensions of 1000m x 1000m. Google Earth data can be viewed and shared using Keyhole Markup Language (KML) files (Figure 2).

Three elevation models were created in this area. The first model was generated using airborne laser scanning. The second elevation model was obtained from ASTER satellite sensors, and the third elevation model was derived from digitizing existing topographic maps. All data was georeferenced in the UTM zone 10 N projection.

Fig. 2 Mountain Research Site [2]

3.2. Formation of DEMs based on LiDAR data

Data collection and processing were carried out by the National Center for Airborne Laser Mapping (NCALM) in 2017, using a scanner attached to an aircraft that recorded data at a density of 626 points per square meter. The data were downloaded from the Open Topography website and classified into three classes: Class 2 - Ground, Class 9 - Water, and Class 1 - Unclassified, encompassing everything above the Ground class, i.e., the terrain. This includes low, medium, and high vegetation depending on the landscape. Only the Ground class was used for creating the DEM, so no additional classification was needed.

Given the large number of recorded points (over 69 million), it was necessary to select software capable of handling a significant amount of data efficiently. Considering the required computational performance and desired features, MicroStation V8i software, developed by Bentley Systems, proved to be an effective solution. The primary data format is DGN, but various data types, including raster data like TIFF and GeoTIFF, can be imported and exported, which is essential for DEM creation, subsequent analysis, and comparisons.

The applications TerraScan, TerraModeler, and TerraPhoto were also used, all of which are compatible with Bentley Systems products. One of their advantages is their user-friendly interface, fully integrated into MicroStation, making data management much more straightforward.

Before loading the point clouds, it was necessary to configure the coordinate system, i.e., the coordinate system range in which the point cloud is located. To determine the necessary coordinate system parameters, appropriate tools from the application group had to be selected, and after specifying the location, a point cloud file was chosen. By further selecting options and processing, the DEM in its original form was obtained (Figure 3).

For displaying the DEM, options providing a hypsometric representation of the terrain were used (Figure4). These options simultaneously combine the elevation and slope of the terrain represented in the form of triangles. The HSV (Hue - Saturation - Value) principle is used, where elevation is shown by color and the slope of the terrain by the shade of that color. Furthermore, the illumination of triangles represents sunlight exposure.

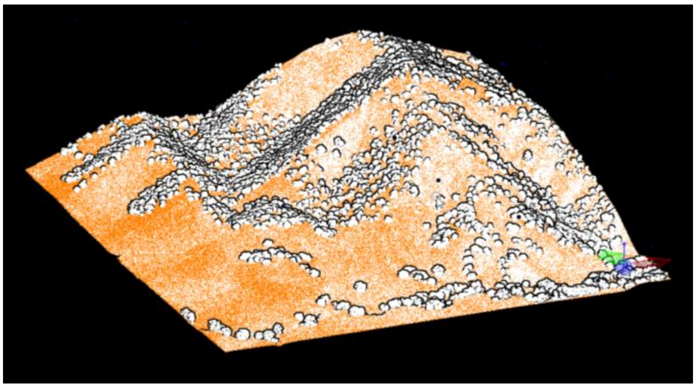

Fig. 3 LiDAR Data in Original Form

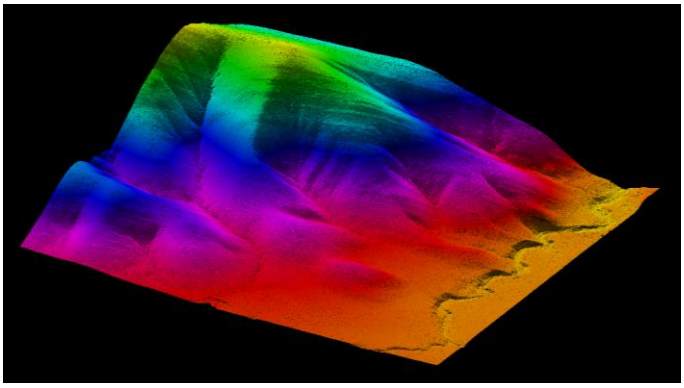

Fig. 4 Hypsometric Representation of Terrain

For further analysis, the final DEM model is exported as a raster image, lattice, or xyz file to make it usable for comparisons and quality assessment with other models of the same area obtained by different techniques.

After exporting the DEM as a raster image, a range of values from 0 to 255 is obtained for each pixel (Figure 5). Each pixel contains elevation data, which will be used in the next step to create a model. Based on this, it can be concluded that black pixels represent lower elevations, while white pixels are reserved for displaying higher elevations. The shades of white and black pixels proportionally represent the difference in elevations.

Subsequently, tools from the ArcGIS software environment were used. Based on the previously exported DEM in the form of a raster image from MicroStation, a DEM was created in the ArcMap program. The display of the model was initiated and realized in the ArcScene program (Figure 6).

The created elevation model has a dynamic form, meaning that any changes in point classification are reflected in the final representation of elevations and geomorphological features of the terrain. The Ground class, from which the DEM in TIN structure was created, was chosen as the final DEM and was subsequently used as one of the three elevation models for analysis and comparison in further research.

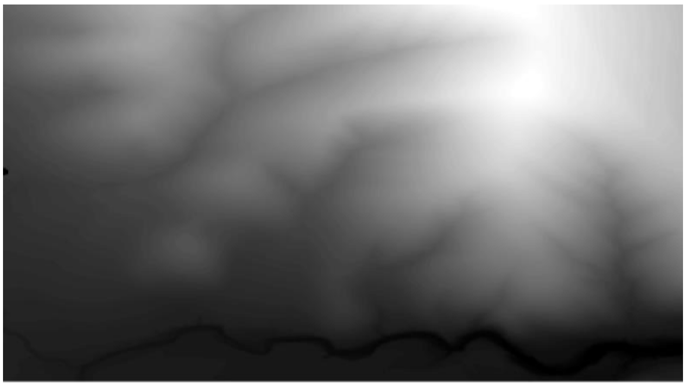

Fig. 5 Exported DEM Generated from LiDAR Data

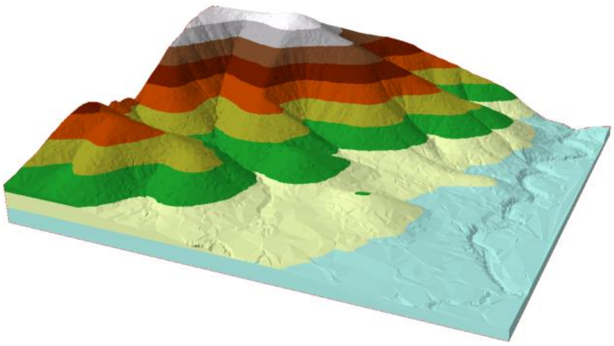

Fig. 6 Formed DEM Based on LiDAR Data in TIN Structure

3.3. Creating a Digital Elevation Model (DEM) based on satellite imagery

A satellite image for the same area was obtained by the Terra satellite [7], specifically using its ASTER sensor, during the period from March 1, 2000, to November 30, 2013. The image has a spatial resolution of 30 meters and has been automatically set to the Universal Transverse Mercator (UTM) 10N zone cartographic projection. The downloaded image covers a much larger area than the research area or the area covered by LiDAR data. The area covered by the LiDAR data is taken as the reference for the research area. Specifically, a portion of approximately 10,000 square meters has been extracted and aligns with the area covered by the LiDAR data. The area of interest is depicted as a rectangle in Figure 7.

A raster image of the desired area was obtained from the ASTER image, and using the same tool as in the case of LiDAR data, "Raster to TIN," a new Digital Elevation Model (DEM) in TIN (Triangulated Irregular Network) structure was created (Figure 8).

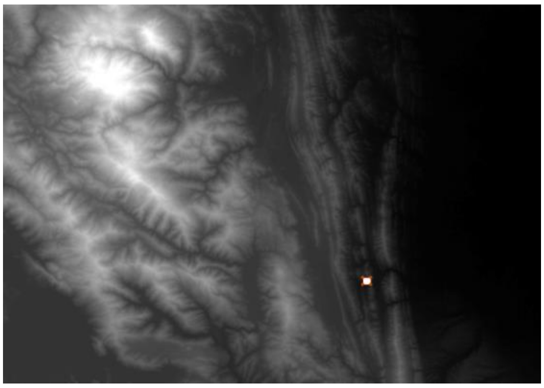

Fig. 7 The area of interest on the ASTER image

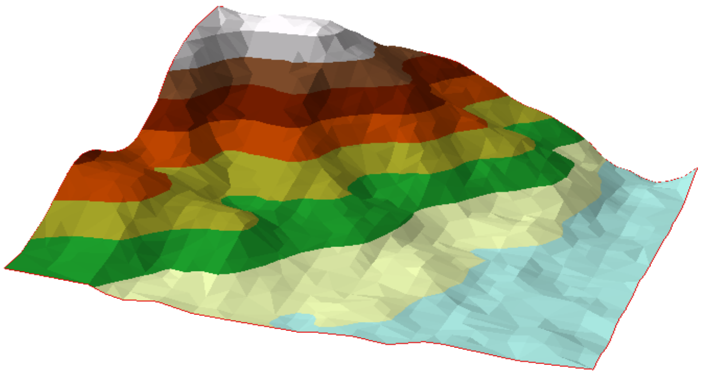

Fig. 8 The generated DEM based on ASTER data in TIN (Triangulated Irregular Network) structure

3.4. Creating a Digital Elevation Model (DEM) through the digitization of a topographic map

The topographic map for the area of interest was downloaded from the website ngmdb.usgs.gov [8]. The key characteristics of the topographic map are (Figure 9):
Publication date: 1958
Map scale: 1:24,000
Cartographic projection: UTM, Zone 10
Measurement unit: feet
Contour interval: 40 feet, equivalent to 12.19 meters.

The downloaded topographic map has been georeferenced into a projected coordinate system. Subsequently, the contours representing the terrain's elevation were vectorized.

In the next step, the Shapefile with contours was loaded into ArcMap, and by using the "Create TIN" option within "3D Analyst Tools" under "Data Management," a Digital Elevation Model (DEM) in TIN (Triangulated Irregular Network) structure was generated (Figure 10).

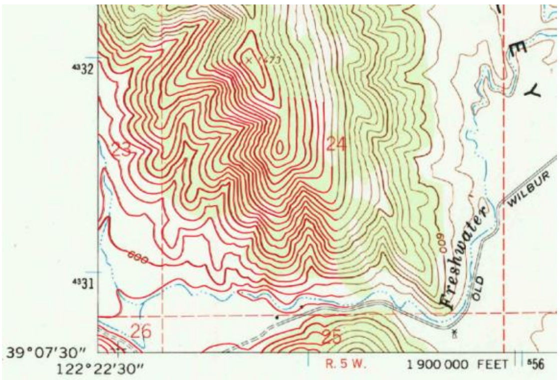

Fig. 9 Quasi-static tests of Model M1: a) Shot during the quasi-static testing of column Model M1; b) Damage from quasi static testing of column Model M1

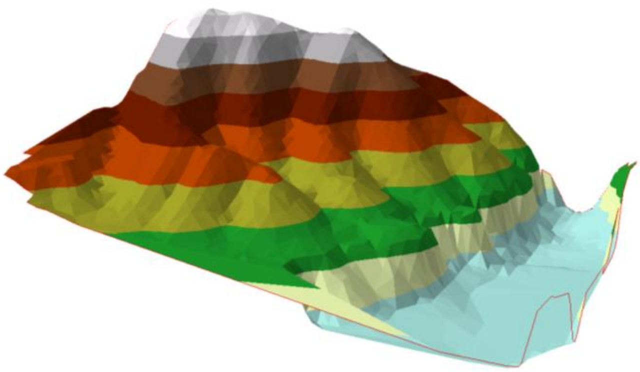

Fig. 10 The generated DEM based on the topographic map in TIN (Triangulated Irregular Network) structure

4. Analysis and Discussion of Results

After creating a Digital Elevation Model (DEM) based on various data sources for the same research area, the analysis and comparison of the obtained elevation models were conducted. The comparison and analysis of the DEMs were carried out as follows:

- Creating and performing a comparative analysis of cross-sectional profiles.
- Generating and visualizing elevation differences between models.
- Creating and displaying viewpoints.

Comparisons and analyses were conducted within the ArcGIS software environment.

4.1. Analysis of cross-sectional profiles on Formed Elevation Models

Creating cross-sectional profiles can be done at various locations on the generated elevation models from different data sources. The analysis of cross-sectional profiles was performed at characteristic points and directions within the model. Two characteristic profiles were created. The first profile was created at the summit of a mountain, where significant elevation changes occur (Figure 11).

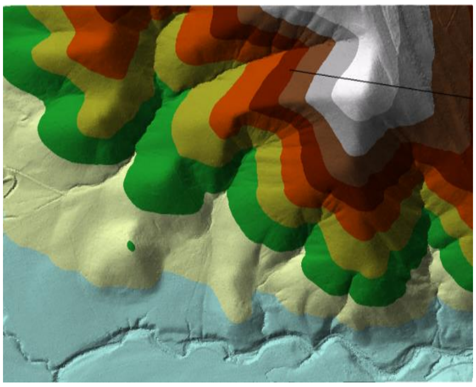

Fig. 11 Location of the first profile

By plotting profiles along the generated elevation models, specific cross-sections are obtained, along with graphical representations and numerical information about them. In Figure 12, individual profile views are provided. In these views, certain discrepancies or differences between the DEMs obtained from different data sources can be observed.

The green line represents the DEM obtained from topographic maps. For instance, it shows a certain flattening at the location of the mountain summit. In this case, the contour interval is not always well chosen to accurately represent certain geomorphological features, especially the terrain peaks. Some parts of the terrain are not suitable for displaying and using new contour intervals, which is why the summit appears "flattened," which is not the case in nature.

The red line represents the elevation model obtained through LiDAR technology. In areas with a constant slope, there are no significant deviations, especially when compared to the green line (vectorized topographic maps).

This primarily applies to the left side of the graph since the geomorphology of the terrain on the left slope is quite uniform. However, there are more significant deviations on the right side. The terrain is slightly "undulating," and this could not be accurately represented by contour lines, unlike LiDAR data, which have high density. The most significant differences are observed at the mountain's summit, for the previously mentioned reasons and explanations.

The blue line represents the elevation model created based on ASTER data. In terms of intensity, it is very similar to the DEM obtained from LiDAR data. It closely follows the terrain, with no major deviations compared to the previous two models. However, it is important to note that in this case, the DEM represents ellipsoidal heights, not orthometric heights, leading to relative differences in elevations. Such systematic differences can be removed by calibrating the model to known control points using first or second order polynomials [13]. Besides this difference, there is a somewhat better match between ASTER and LiDAR data on the right side of the slope, as there is a convergence of ellipsoid and geoid heights in that area (Figure 13).

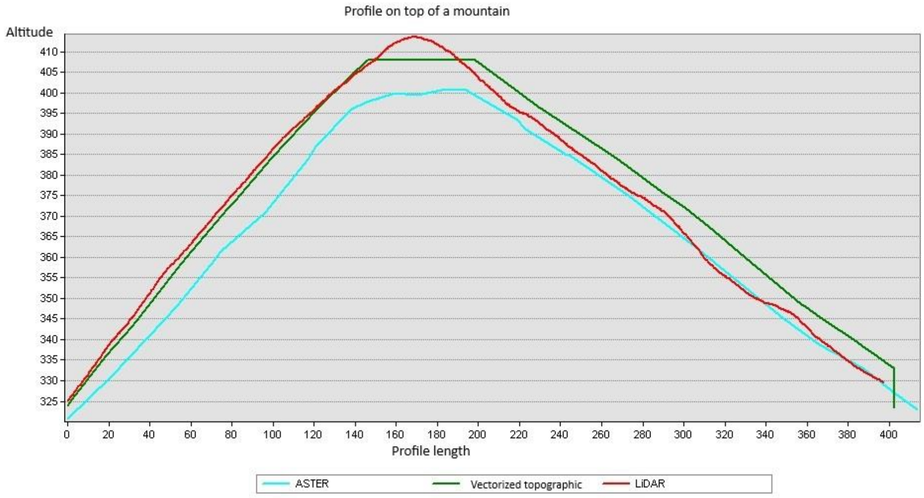

Fig. 12 Graphs of the first profile

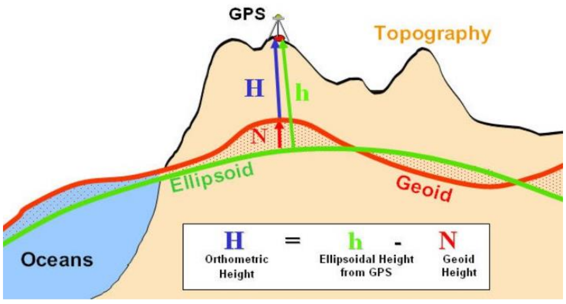

Fig. 13 Difference between ellipsoidal and orthometric height [9]

The second characteristic cross-sectional profile was projected and drawn across the middle of the mountain, crossing several mountain passes (Figure 14).

The second profile graph yielded more complex results compared to the first profile. The DEM created from LiDAR data provides a more detailed representation of the terrain, especially in the areas of local minima (valleys) and maxima (peaks). It also offers a truer approximation of the terrain compared to the DEM formed by vectorizing contour lines from topographic maps (Figure 15). When it comes to the DEM obtained from ASTER data, it presents the terrain quite faithfully and offers a good approximation of geomorphological features unless systemic deviations due to ellipsoidal and orthometric heights are ignored. However, the issue with the DEM created from ASTER data is that due to the image resolution, it cannot detect minor geomorphological changes, which can be observed on the second (right) local minimum (Figure 15). Therefore, the DEM created from LiDAR data reveals many details compared to DEMs formed by vectorizing topographic maps or using ASTER data.

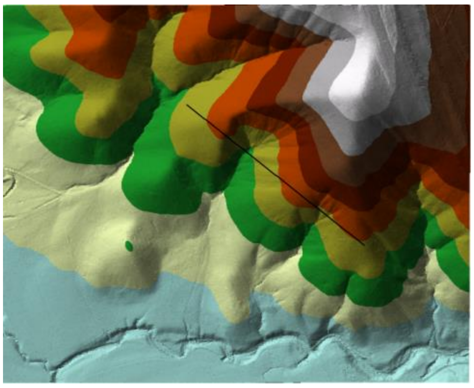

Fig. 14 Location of the second profile

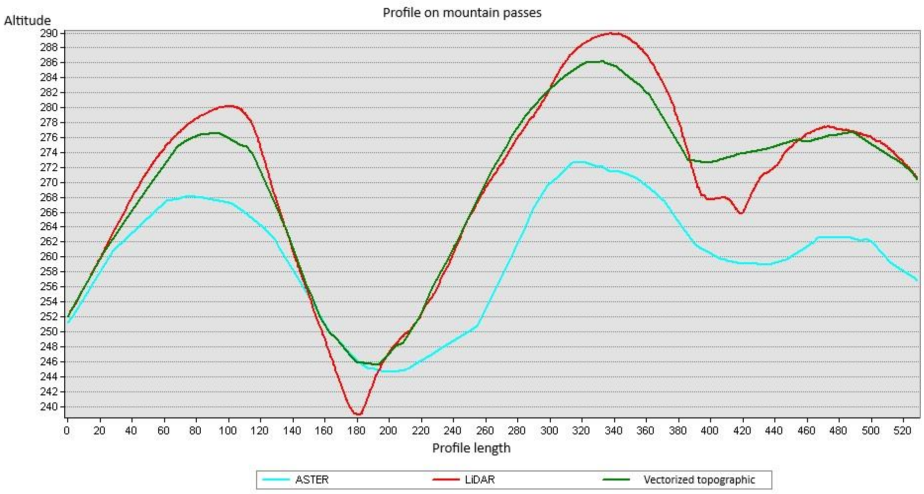

Fig. 15 DEM Profiles Graphs

4.2. Difference in elevation between obtained DEMs

After generating DEMs for the same area from various data sources, a geometric comparison of the elevation models was performed, specifically the triangles of the input surfaces of the DEMs. To clarify, the DEM triangles based on LiDAR data should be classified if their entire surface is below or above the DEM obtained from vectorized topographic maps. In cases where intersections occur between certain triangles of the

LiDAR-based DEM and the triangles of the DEM based on vectorized topographic maps, the existing triangles are divided into smaller ones. In this manner, the new triangles are entirely either above or below the surface of the other model and are classified accordingly. Adjacent triangles, if classified in the same way, are merged into corresponding polygons. The volumes of the triangles (the volume above or below the reference surface) and their surface areas are summed up, providing a better overview of the areas that are above and below the reference model. As a result, the output presents the content with previously defined and classified polygons along with their volume and surface area values. The difference surface is constructed using Delaunay triangulation criteria [10].

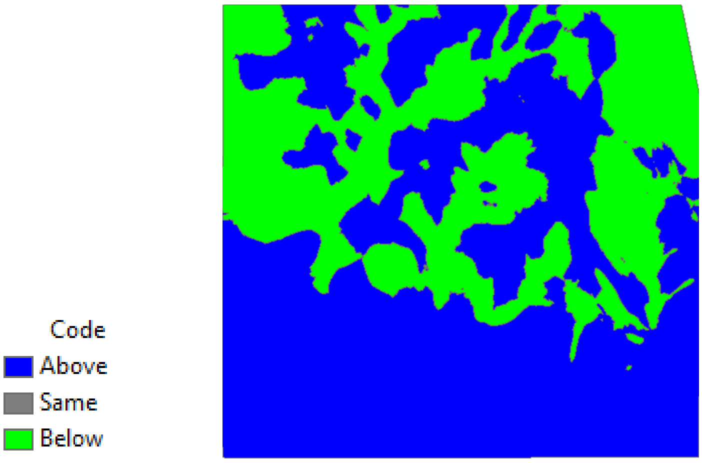

Fig. 16 Elevation difference between LiDAR-Based DEM and vectorized topographic map

In Figure 16, it is evident that the LiDAR-based model is consistently above at locations of local maxima and below at locations of local minima because it provides a more detailed representation of valleys and peaks compared to contour lines. This aligns with the previous analysis in Figure 15. In the lower part of Figure 16, there is a slight difference in elevations, and the terrain is predominantly flat. The DEM created based on contour lines could not accurately represent this area, resulting in the entire model consistently being below the LiDAR-based DEM. The elevation comparison is limited to the LiDAR model and the topographic map model, as the ASTER model was excluded due to constant differences in elevations.

4.3. Calculation and line of sight analysis on elevation models

Comparative analysis that can be conducted when DEMs are available pertains to line of sight calculations. The initial step involves placing a point on the DEM, from which line of sight calculations are performed to obtain the corresponding line of sight area. Specifically, using the "Viewshed 2<Visibility<3D Analyst Tools" option yields a raster image of the visible portion of the model from the designated point. Combining the resulting rasters with the model provides the results depicted in Figure 17.

The point from which the line of sight was calculated is in the same position on all three models (Figure 17). The line of sight position is set on the top of a hill, slightly shifted to the west. It can be said that visibility on the models is similar, with the clearest definition on the LiDAR-based DEM (Figure 17, a). On the right are the DEMs obtained from the topographic map and satellite image, yielding similar results but with less precision. The primary reason for this difference lies in the quality and accuracy of data collection methods.

a) b) c)

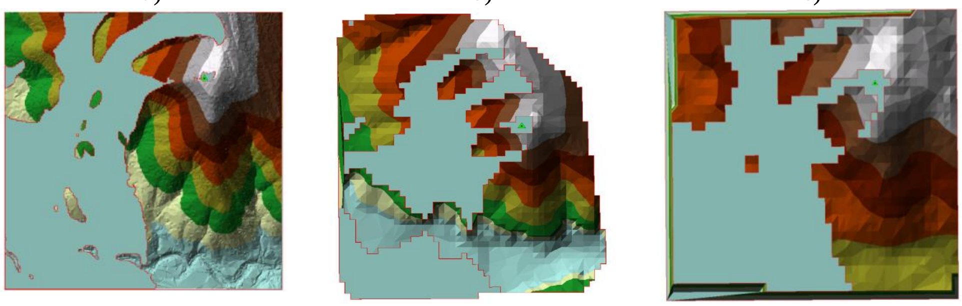

Fig. 17 Line of Sight Calculation with DEMs: a) LiDAR data; b) topographic map; c) ASTER image

The calculation and analysis of the line of sight have significant relevance and applications in the design of geodetic point networks, road design, power lines, and similar infrastructure projects. This capability enables visibility determination without the need for on-site visits, providing a substantial advantage and efficiency when working in such inaccessible terrains.

5. CONCLUSIONS

Once all three elevation models have been obtained, loaded into the software, and spatially aligned, analyses and comparisons were conducted using the following methods: creating profiles at characteristic locations, analyzing the elevation differences between models through their spatial overlay, and performing a line of sight analysis from the same point on all three models. Whether a particular area's surveying was conducted using older, conventional methods or more modern techniques, there is always an effort to produce a more faithful digital representation of the terrain. From topographic maps that only offered a 2D representation, advancements in data acquisition instruments and computational data processing are apparent, showing significant differences in accuracy and visual representation. Modern surveying methods and existing GIS software allow the creation of 3D models of mountains, roads, tunnels, buildings, and even their interiors, producing precise, accurate, and credible representations that anyone can easily understand and review.

By analyzing the three DEMs created using different methods in this study, it can be observed that it is possible to create quality elevation models both with conventional and newer surveying methods. Depending on resources, purposes, and required accuracy, elevation models can be created even from topographic maps that were made 50 or even 100 years ago. The quality of these models primarily depends on scale, contour intervals, local and global deformations that occurred before and during the digitization process. New surveying methods now dominate due to the pursuit of a more precise and faithful terrain representation, offering numerous advantages over traditional topographic maps.

The main drawback of newer methods lies in their cost, which is higher than digitizing and processing existing topographic maps.

From the analysis of the obtained results, it can be concluded that LiDAR surveying provides the best and most accurate surveying results. It is apparent in the lower part of the topographic map that a river is depicted, but only in the LiDAR elevation model is this river observable. Its width, depth, or the volume of the riverbed can be accurately calculated. In contrast, the other two models do not allow for the identification of the riverbed. Creating a model from vectorized topographic maps is suitable for areas where a high level of model accuracy is not required. Its advantage, unlike the other two methods, is that it does not require additional time for surveys and investment in data acquisition. Accurate topographic maps for that area are needed. The advantage of digital models obtained from satellite images is that they do not require on-site surveys or additional time for topographic map digitization. For an artificial satellite, every part of the Earth is visible, and surveying data can be obtained independently of the region's inaccessibility, unlike other surveying methods. One satellite image covers a much larger area than a map and is ideal for mapping vast regions. The drawback compared to other surveying methods is the spatial resolution, but with the ongoing trend of increasing satellite image resolution, their more frequent application is expected.

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REFERENCES

1. Mesa-Mingorance, J.L.; Chicaiza-Mora, E.G.Bueaño, X.; Cai, J.; Rodríguez-Pascual, A.F.; Ariza-López, F.J. Analysis of Users and Uses of DEMs in Spain. Int. J. Geo-Inf. 2017, 6, 406. [CrossRef]
2. José L. Mesa-Mingorance and Francisco J. Ariza-López: Accuracy Assessment of Digital Elevation Models (DEMs): A Critical Review of Practices of the Past Three Decades, Remote Sens. 2020, 12, 2630; doi:10.3390/rs12162630
3. Retrieved from: https://sr.wikipedia.org/sr-ec/Kalifornija
4. Retrieved from: https://en.wikipedia.org/wiki/MicroStation
5. Retrieved from: https://www.terrasolid.com/products
6. TerraModeler User's Guide (1995-2016)
7. Retrieved from: https://www.esri.com/content/dam/esrisites/sr-rs/media/pdf/implementation-guides/implement-arcgis-online.pdf
8. Retrieved from: https://www.nasa.gov/mission_pages/terra/spacecraft/index.html.
9. Retrieved from: https://ngmdb.usgs.gov
10. Retrieved from: https://www.esri.com/content/dam/esrisites/sr-rs/media/pdf/implementation-guides/implement-arcgis-online.pdf
11. Retrieved from: https://www.researchgate.net/figure/Orthometric-geoid-and-ellipsoid-heights-Ellipsoidal-Orthometric-N-h-H-1_fig1_329686559
12. Retrieved from: https://desktop.arcgis.com/en/arcmap/10.3/tools/3d-analyst-toolbox/how-surface-difference-3d-analyst-works.htm
13. Bulatović, V., Sušić, Z., Ninkov, T. (2012): Estimate of the ASTER-GDEM regional systematic errors and their removal, International Journal of Remote Sensing, Volume 33, Issue 18, pp. 5915-5926, https://doi.org/10.1080/01431161.2012.676744
14. Borrough, P.A.; McDonnenell, R.A.; „Principles of Geographical Information Sistems“ 2e, Principi Geografskih informacionih Sistema, drugo izdanje, prevod objavljen 2006. Građevinski fakultet Univerziteta Beograd; ISBN 86-7518-070-5; COBISS.SR-ID 131291916.

POREĐENJE DIGITALNIH ELEVACIONIH MODELA PLANINSKOG TERENA KREIRANIH KORIŠĆENJEM RAZLIČITIH IZVORA PODATAKA

U radu se analiziraju digitalni elevacioni modeli (DEM) istog područja na osnovu različitih izvora i metoda prikupljanja geoprostornih podataka. DEM otvorenog koda kreiran je u planinskom području okruga Kolus, koji je severni deo američke države Kalifornije. Istovremeno, podaci o nadmorskoj visini terena odnose se na LiDAR snimanja i sadržaj topografskih karata, dok se ASTER podaci zasnivaju na elipsoidnim visinama. Takođe, izvorni podaci sadrže izvesnu grešku izabranog načina prikupljanja i samog procesa obrade, kao i greške koje se odnose na međusobna odstupanja visinskih referentnih sistema. Zanemarujući visinski sistem, primećuje se da greška izvora podataka značajno utiče na kvalitet prikaza modela kao i na detalje terena. Prikaz DEM-a na osnovu LiDAR podataka je veoma blizak DEM-u na osnovu podataka sa topografskih karata, za razliku od modela nadmorske visine dobijenog na osnovu ASTER slika

Ključne reči: *Poređenje kvaliteta, DEM, različiti izvori podataka, ista oblast*.