A comparative accuracy of Google Earth height with MyGeoid, EGM96 and MSL

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Abstract. This study aims to provide understanding on the accuracy of height derived from Google Earth ($H_{GoogleEarth}$) as compared to height obtained from Malaysian Geoid Model ($H_{MyGeoid}$), Mean Sea Level (H_{MSL}) and Earth Geoid Model 96 (H_{EGM96}). Total of 50 established points with height acquired from $H_{MyGeoid}$ and H_{MSL} were measured within UiTM (Universiti Teknologi MARA) Arau Campus. These points were also used to extract height from Google Earth and EGM96. Statistical results showed a good range of R^2 between $H_{GoogleEarth}$-$H_{MyGeoid}$, $H_{GoogleEarth}$-H_{MSL} and $H_{GoogleEarth}$-H_{EGM96} i.e. 0.823, 0.843 and 0.824 respectively. It shows $H_{GoogleEarth}$ strongly correlated with H_{MSL}.

1. Introduction

A study conducted by [1] has proved the usage of digital elevation model (DEM), obtained from Google Earth. They were able to delineate a watershed boundary with appropriate accuracy. The same researcher also proved that DEM from Google Earth correlate significantly with other free source height data which are SRTM90 and ASTER30 [2]. However, the accuracy of Google Earth height data as compared to real-site measurement height data remains unknown. The accuracy of DEM depends on the location that can be estimated using Ground Control Point (GCP) measured with the help of Global Navigation Satellite System (GNSS) on the ground survey. Among various methods of accuracy assessment, GPS (Global Positioning System) survey provides the best way to map features on terrain with high accuracy.

Therefore, the main objective of this study is to evaluate the accuracy of height extracted from the Google Earth by comparing the height with 50 GNSS Ground Control Point (GCP) and local Mean Sea Level derived from ground survey levelling in UiTM Arau, Perlis.

2. Method and data

The method and data acquisitions will be explains more in this section.

2.1. Study area

UiTM (Universiti Teknologi MARA) Arau branch located between 6°27'19.41"N, 100°16'19.06"E (upper left) and 6°26'47.21"N, 100°17'10.24"E (lower right) (Figure 1). Total 50 height points were marked within the campus known as cadastral reference marks (CRM). These points were measured on site using GPS instrument which later in this paper will be referred as $H_{MyGeoid}$. By using the same points (50 points) heights were extracted from Google Earth ($H_{GoogleEarth}$) and EGM96 (H_{EGM96}). In addition, height from mean sea level (H_{MSL}) was also measured at the same points which are taken as the datum height for this study.

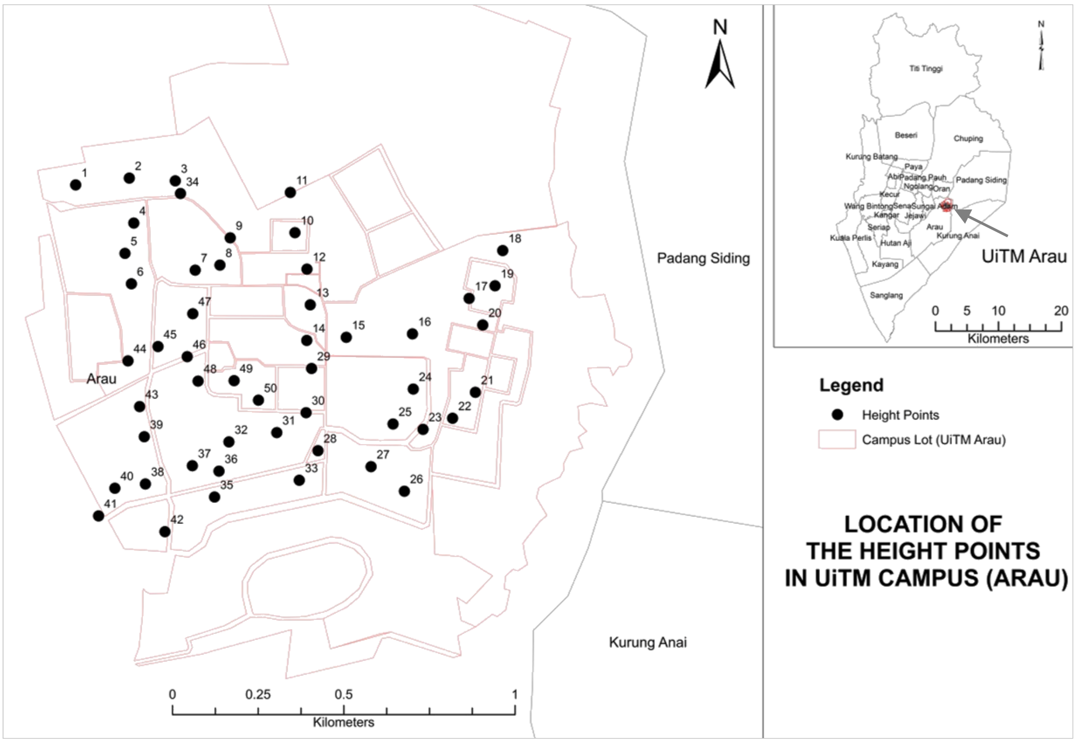

Figure 1. Study area and points location of elevation/height in UiTM Arau.

2.2. Source of data and processing

There are four (4) types of heights obtained in this study which are the heights from Google Earth, EGM96, MyGeoid and MSL. Both $H_{MyGeoid}$ and H_{MSL} were measured on site using GPS and levelling instruments respectively.

2.2.1. Height from Google Earth. The $H_{GoogleEarth}$ was derived from Google Earth using Terrain tool provided at http://www.zonums.com/gmaps/terrain.php. As declared by Zonum, the source of $H_{GoogleEarth}$ height was SRTM90 (Shuttle Radar Topographic Mission 90) produced by NASA (National Aeronautics and Space Administration). Subsequently, all of the 50 points from different heights ($H_{MyGeoid}$, $H_{GoogleEarth}$, H_{MSL} and H_{EGM96}) were analyzed to identify its correlation.

2.2.2. GPS surveys and processing. The 50 GPS GCP in this study has been observed using static GPS with two (2) hours observation to obtain accurate three-dimensional coordinates. GPS observations were carried out using Topcon GR5 field observation and the observation procedure was conducted in accordance with the regulation prescribed by the Department of Survey and Mapping Malaysia (DSMM). For the determination of GCP coordinates, all measurements were connected to the Arau and UUM Continuously Operating Reference Station (CORS) from MyRTKnet and the coordinates were established in the Geocentric Datum Malaysia 2000 (GDM 2000). In GPS data processing, all the raw GPS observations were processed using commercial software named Topcon Tool Software. Table 1 show the processing parameters used in this study.

Table 1. Processing Parameters. [3]

Items	Parameters
General procedure	Procedure provided in manufacturer manual must be followed
Datum	GDM2000
Elevation mask	15^0
Ephemerides	Short baseline of less than 30 km: Broadcast Long baseline: Precise
Baseline processing	RMSE less than two (2) cm
Quality	Maximum data rejection: less than 10% Ambiguity fixed solution
Adjustment	Least square adjustment should be used
Minimally constrained adjustment	One control station fixed in GDM2000 coordinate
Quality indicator	Pass chi-square test at 95% confidence region All baseline must pass local test
Over-constrained adjustment	At least two (2) control stations must be fixed in the final adjustment

2.2.3. Determination of orthometric height. Before height comparisons, the GPS GCP with height values of the DEM extracted from the Google Earth, the coordinate of GCP should be converted from GDM2000 to World Geodetic System (WGS84). Meanwhile, the ellipsoidal height with referenced to the WGS84 ellipsoid also should be converted to orthometric height with the EGM96 geopotential model using a well-known formula in Equation 1:

$$H = h - N \qquad \text{(Equation 1)}$$

where N is the geoid height from EGM96 (NEGM96), *h* is the ellipsoidal height regarding World Geodetic System (WGS84) and *H* is the orthometric height.

The geoid height from NEGM96 at each point can be computed online using the following link: http://earthinfo.nga.mil/GandG/wgs84/gravitymod/egm96/intpt.html. Besides that, the height from Google Earth has also been compared with orthometric height computed using ellipsoid height as referenced to GDM2000 and precise local geoid model, Malaysia Geoid Model MyGEOID provided by Department of Survey and Mapping Malaysia (DSMM).

2.2.4. Precise levelling survey. The accuracy of Google DEM was analyzed by comparing it with the height above local mean sea level. The height was based on the mean sea level (MSL) value from the tide gauge in Port Klang. In this study, Leica NA3003 digital level has been used for the execution of leveling works to determine local mean sea level value at 50 GPS GCP. A collimation test for levelling or two (2) -peg test has been performed to determine the level's collimation error. The minimally constrained adjustment was carried out by fixing Standard Benchmark (SBM) located at

UiTM Arau. The height of SBM 0121 is 45.022 metres above the mean sea level (MSL). The permissible discrepancy for this study is 3mm$\sqrt{km}$ for first order two (2)-way levelling.

3. Results and analysis

To analyze the accuracy of height obtained from Google Earth ($H_{GoogleEarth}$) with another source of height data ($H_{MyGeoid,}$ H_{EGM96} and H_{MSL}), fifty points of height were overlapped with $H_{MyGeoid}$ and H_{MSL} at the same coordinates. The correlation results are plotted in Figure 2. $H_{GoogleEarth}$ was placed on Y-axis in each graph.

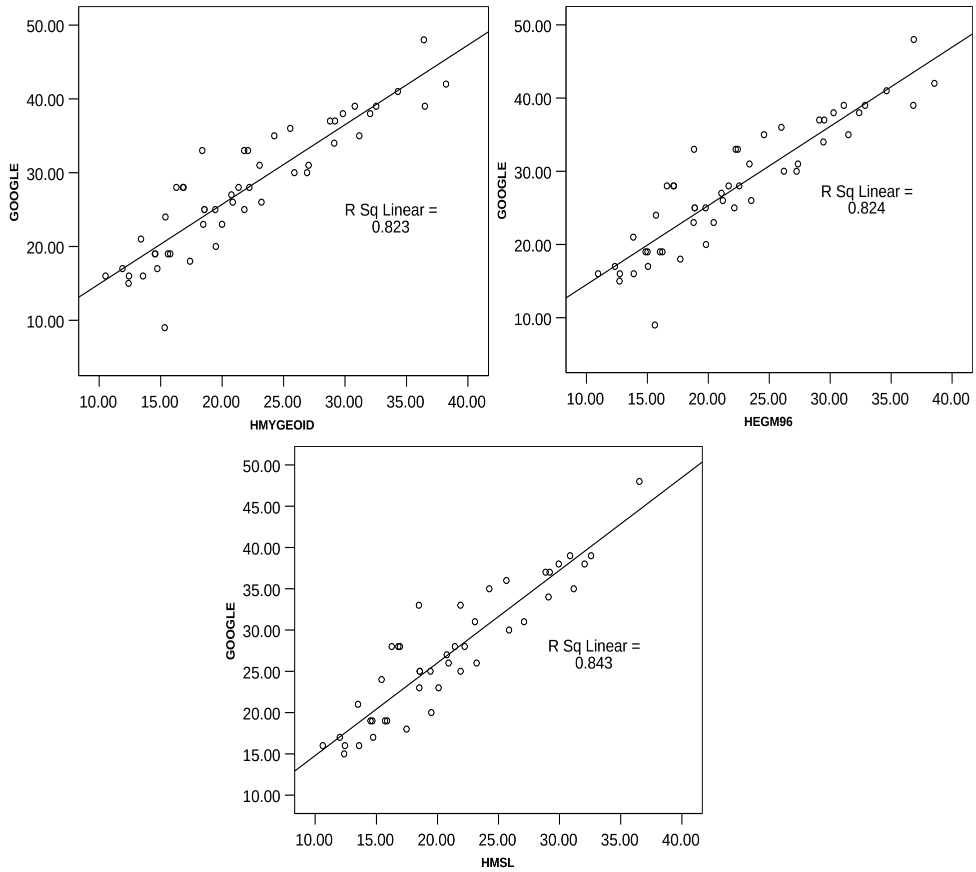

Figure 2. Results of R^2 for each comparison.

Statistically, $H_{GoogleEarth}$ was highly correlated with H_{MSL} data (0.843), H_{EGM96} (0.824) and $H_{MyGeoid}$ (0.823) accordingly. The results indicated that the $H_{GoogleEarth}$ accuracy is much closer to $H_{MSL.}$ Figure 3 illustrates the location of $H_{GoogleEarth}$ among three (3) sources of height.

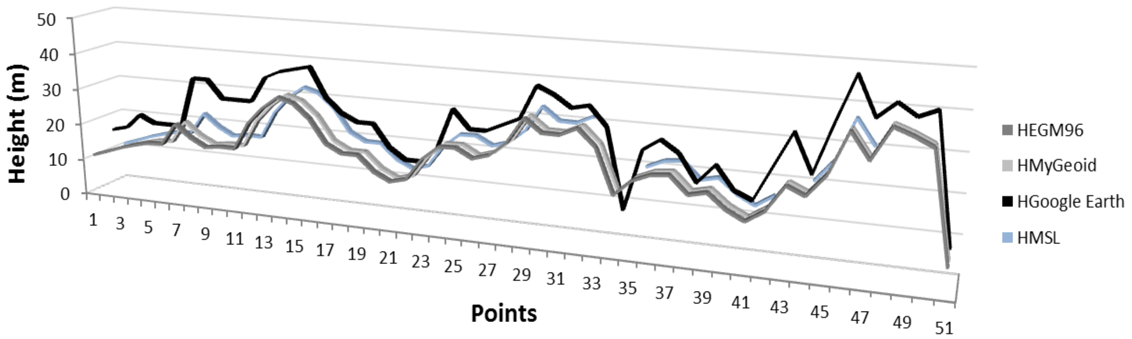

Figure 3. Location of $H_{GoogleEarth}$, $H_{MyGeoid}$, $H_{EGM96\ and}$ H_{MSL} based on results.

Then, $H_{Google\ Earth}$ was further analyzed to see a range of differences with the three (3) sources of height data. $H_{Google\ Earth}$ was substracted from $H_{MyGeoid}$, H_{MSL} and H_{EGM96} to obtain the differences (Figure 4). The range of differences between $H_{Google\ Earth}$ and $H_{MyGeoid}$ is from 0.5 m (minimum) to 14.6 m (maximum), $H_{Google\ Earth}$ and H_{EGM96} is from 0.18 m (minimum) to 14.1 m (maximum) and $H_{Google\ Earth}$ and H_{MSL} is from 0.5 m (minimum) to 14.5 m (maximum).

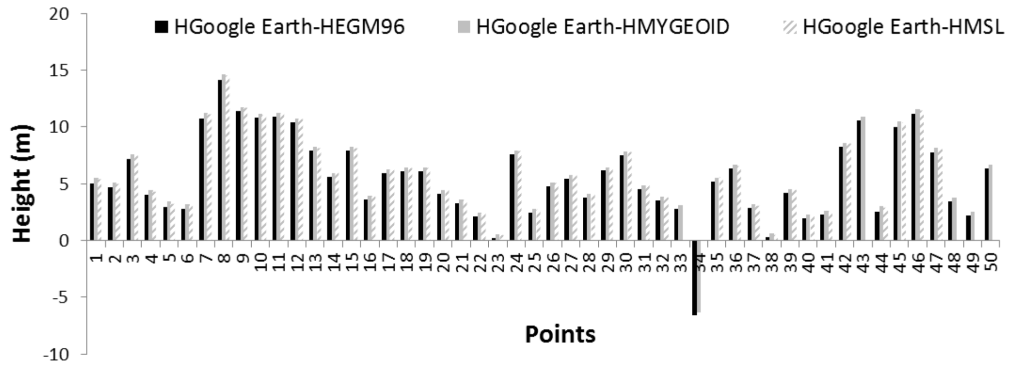

Figure 4. $H_{Google\ Earth}$ differences with $H_{MyGeoid}$, $H_{EGM96\ and}$ H_{MSL}.

4. Conclusion

The results from the analysis of data indicate that the height from Google Earth ($H_{GoogleEarth}$) proves to be highly correlated with on ground levelling height data which are $H_{MyGeoid}$, and H_{MSL}. Therefore, these findings will hopefully assist researchers to obtain a free source of height data with appropriate accuracy without spending more money and facing tedious data collection and processing.

References

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