Intercontinental Geoinformation Days

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Vertical accuracy assessment of DEMs around Jabal al-Shayeb area, Egypt

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Keywords
DEMs
ALOS PALSAR
NASADEM
geomorphological
ASTER GDEM

ABSTRACT

As a quantitative and numerical representation of earth surface topography, Digital Elevation Models (DEMs) are widely used in several applications including geological, hydrological, and geographical Aspects. With the availability of several types of DEMs, various intrinsic errors may be incorporated due to sensor acquisition inconveniences, or processing techniques compared to the actual land surface measurements. Consequently, this study aims to analysis and test the vertical accuracy of NASADEM, Advanced Spaceborne Thermal Emission and Reflection Radiometer–Global Digital Elevation Model (ASTER GDEM) and Advanced Land Observing Satellite (ALOS) Phased Array L-type band Synthetic Aperture Radar (PALSAR) DEM compared to the actual ground control points (GCPs) derived from topographic maps through calculating Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE). Our results revealed the sublimity of ALOS PALSAR DEM over NASADEM and ASTER GDEM. Thus, ALOS PALSAR DEM is recommended for further geomorphological studies.

1. Introduction

Over the last three decades, prolonged efforts are dedicated to enhancing the capability of obtaining accurate and enhanced global DEMS (Hirano et al., 2003; Welch and Marko, 1981). Several environmental studies mostly include a 3D representation of the investigated locations utilizing DEMs. Thus, it becomes a fundamental element in comprehensive environmental and geomorphological studies. Dems significantly contribute to solving geomorphological, agricultural, hydrological, geological, pedological, and ecological problems (Pulighe and Fava, 2017) and their modeling (Marzolff and Poesen, 2009; Schumann et al., 2008; Siart et al., 2009). DEMs could also be extracted from digital stereo imagery (Pieczonka et al., 2011; Pulighe and Fava, 2017). Whatever the source of utilized DEMs, assessing the accuracy is an indispensable issue as errors could directly cause unwise decisions that could finally negatively affect the environment or human life. DEMs are utilized in calculating Aspect and slope maps(Ashmawy et al., 2018; Ibrahim-Bathis and Ahmed, 2016; Panahi et al., 2017; Shebl and Csámer, 2021; Webster et al., 2006) that largely control the strength and direction of several flash floods, which could cause several geohazards. Consequently, this study aims to assess the vertical accuracy of three widely utilized DEMs to recommend the best for usage in further investigations.

2. Study area

The study area (Jabal al-Shayeb area) is a mountainous region, about 45 km southwest of Hurghada city, Egypt. Jabal al-Shayeb area is located between latitudes 26° 54′, 27° N and longitudes33° 23′,33° 29′E. It covers an area of 13 km x 11 km (143 km^2). Elevations range from 710 m up to over 2140 m a.s.l., the average slope is 20° and most of the reliefs are facing southeast-west southwest. This region is mostly covered by granitic rocks with some occurences of Phanerozoic sedimentary rocks. Figure 1 depicts the study area and Figure 2 depicts the locations of the GCPs collected from a 1:100,000 scale topographic map (Military Survey Authority, 1992). The surface of the study area is the result of combined influence of internal and external processes, and the developed drainage network in it was formed as a result of heavy rainfall, during pluvial phases particularly in Pleistocene.

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Cite this study

Shebl A, Atalla M A & Csámer Á (2021). Vertical accuracy assessment of DEMs around Jabal al-Shayeb area, Egypt. 3rd Intercontinental Geoinformation Days (IGD), 42-45, Mersin, Turkey

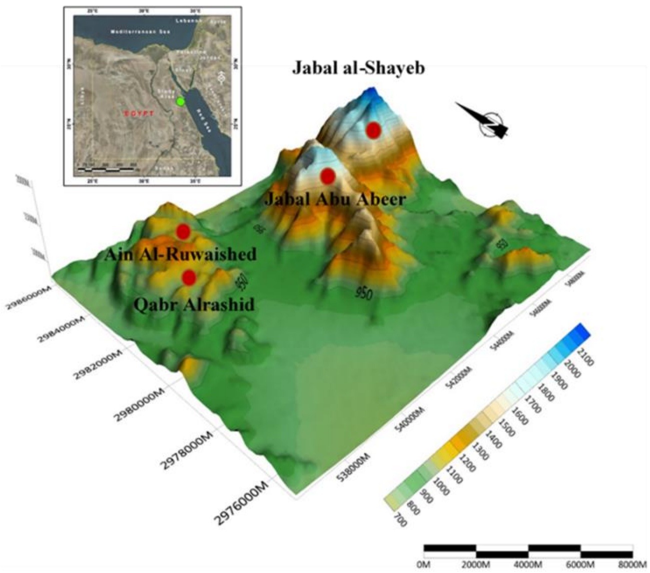

Figure 1. Location of the study site (Source: https://lpdaac.usgs.gov)

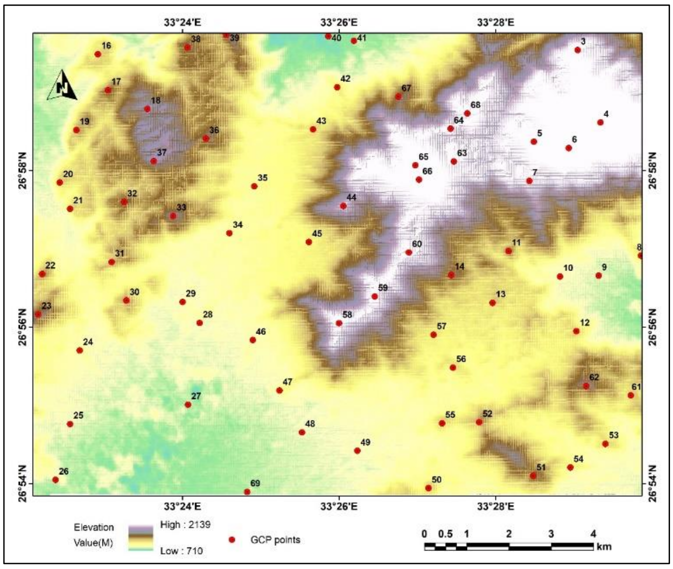

Figure 2. Depicts the locations of the GCPs collected from a 1:100,000 scale topographic map (Source: Topographic map scale 1:100,000)

3. Materials and methods

In the current study, three DEMs are analysed regarding their vertical accuracy and compared to topographic maps. NASADEM product (30m) is a state-of-the-art global digital elevation model derived from a combination of SRTM processing improvements, elevation control, void-filling, and merging with data unavailable at the time of the original SRTM production. NASA DEM is distributed in 1◦ by 1◦ tile and consist of all land between 60◦ N and 56◦ S latitudes. For this study, National Aeronautics and Space Administration (NASA) DEM was obtained from the USGS web-based data (https://lpdaac.usgs.gov/).

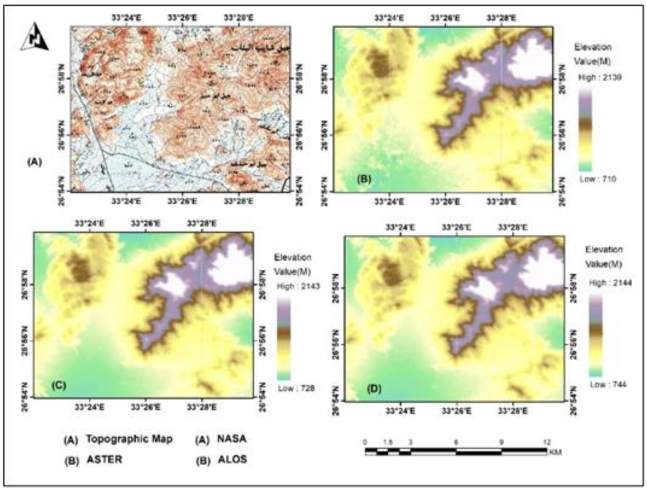

Figure 3. The colour levels represent the DSM dataset and the reference DSM data (Source: https://lpdaac.usgs.gov; topographic map (modified after Military Survey Authority, 1996).)

Advanced Spaceborne Thermal Emission and Reflection Radiometer–Global Digital Elevation Model (ASTER GDEM) has 1 arc-second (30 m) spatial resolution, and this project is done by the Ministry of Trade, Economy and Industry (METI) of Japan and the United States NASA to provide high-resolution DEM to the public. The Advanced Land Observing Satellite (ALOS) was launched on January 24, 2005. ALOS is provided with the Phased Array L-type band Synthetic Aperture Radar (PALSAR) for day-and-night and all-weather land observation. PALSAR sensor is an active microwave sensor (help to avoid weather barrier conditions and day or night effect), L-band (1.27 GHz) synthetic aperture radar aid at achieving high-resolution DEM products (Shebl and Csámer, 2021). In the current study, we applied Mean Absolute Percentage Error (MAPE) which represents the average of absolute errors divided by actual observation values. To ensure a wise comparison, we resampled the ALOS PALSAR DEM data (12.5m) to 30m (the same resolution for NASA and ASTER DEMs). Then, the four DEMs including ALOS PALSAR (12.5m), resampled ALOS PALSAR (30 m), NASA (30 m) and ASTER (30 m) DEMs are used in the mathematical calculations using 69 GCPs (which represents the actual values in the current studies). As shown in figures (2; 3). Using Extract Multi Values to Points function in ArcMap, the points are compared then evaluated according to equation 1.

$$\mathrm{MAPE} = \frac{\sum_{t=1}^{n} \left| \frac{A_t - F_t}{A_t} \right|}{n} \times 100$$

Where At –Ft represents the error value, | At -Ft| is the absolute error value, n accounts for number of points which is 69 points in the current study (Fig. 2).

Additionally, the Root Mean Square Error (RMSE) (Hirano et al., 2003; Rawat et al., 2019; Santillan et al., 2016; Zhao et al., 2011) +was calculated according to the following equation.

$$\text{RMSE} = \sqrt{\frac{\sum_{t=1}^{n}(A_t - F_t)^2}{n}}$$

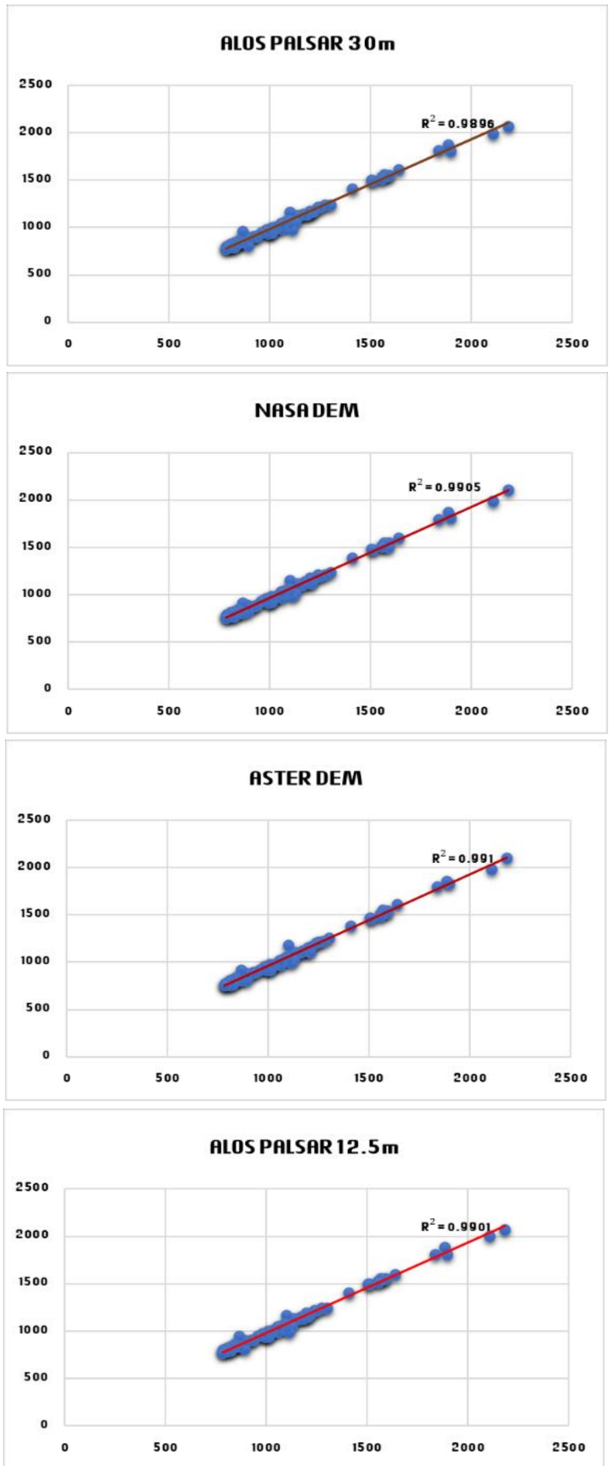

Figure 4. Determination coefficient of the actual and tested values for the four utilized DEMs

4. Results

Our results reported the effectiveness of ALOS PALSAR DEM over NASA and ASTER DEMs. MAPE values were 2.71, 2.78, 3.68, and 4.01 for ALOS PALSAR (12.5m), resampled ALOS PALSAR (30 m), NASA (30 m) and ASTER (30 m) respectively. However, the data are linearly correlated as shown in figure (4), the RMSE is a significant value indicating the higher error value between the measured (topographic) and DEM values. RMSE values were 42.8, 41.4, 51.4, and 52.5 for ALOS PALSAR (12.5m), resampled ALOS PALSAR (30 m), NASA (30 m) and ASTER (30 m) respectively. This could be attributed to the time gab between topographic map measurements and DEMs data acquisition, however the study strongly recommends DEMS evaluation in terms of their accuracy whenever possible. ALOS PALSAR DEMs (radar data) superiority was attributed to the absence of weather conditions effect (Adiri et al., 2017; Shebl and Csámer, 2021). It should be emphasized that the data utilized for validation should be acquired at an acquisition time closely related to that of the models to be away from any inconveniences (e.g., anthropogenic or natural changes that could affect the accuracy assessment process).

5. Conclusion

In the current study, ALOS PALSAR DEM, NASA and ASTER DEMs were evaluated regarding their vertical accuracy to recommend the best for usage in future geomorphological applications. Our results disclosed That the three sensors delivered a reliable data for further investigations however it is recommended to implement PALSAR data as their Mean Absolute Percentage Error is smaller than the others. Its higher accuracy was attributed to independence of radar data from any weather conditions.

References

Adiri, Z., El Harti, A., Jellouli, A., Lhissou, R., Maacha, L., Azmi, M., Zouhair, M., Bachaoui, E.M., 2017. Comparison of Landsat-8, ASTER and Sentinel 1 satellite remote sensing data in automatic lineaments extraction: A case study of Sidi Flah-Bouskour inlier, Moroccan Anti Atlas. Adv. Sp. Res. 60, 2355–2367.

Ashmawy, M.H., Abd El-Wahed, M.A., Kamh, S.Z., Shebl, A., 2018. Scientific Journal of Basic and Applied Sciences Comparative study of the drainage basin morphometry extracted from topographic maps and SRTM DEMs: an example from Ghadir watershed, Eastern Desert, Egypt. Sci JBAS 39, 52–64.

Hirano, A., Welch, R., Lang, H., 2003. Mapping from ASTER stereo image data: DEM validation and accuracy assessment. ISPRS J. Photogramm. Remote Sens. 57, 356–370. https://doi.org/10.1016/S0924-2716(02)00164-8

Hirano, A., Welch, R., Lang, H., 2003. Mapping from ASTER stereo image data: DEM validation and accuracy assessment. ISPRS J. Photogramm. Remote Sens. 57, 356–370. https://doi.org/10.1016/S0924-2716(02)00164-8

Ibrahim-Bathis, K., Ahmed, S.A., 2016. Geospatial technology for delineating groundwater potential zones in Doddahalla watershed of Chitradurga district, India. Egypt. J. Remote Sens. Sp. Sci. 19, 223–234. https://doi.org/10.1016/J.EJRS.2016.06.002

Marzolff, I., Poesen, J., 2009. The potential of 3D gully monitoring with GIS using high-resolution aerial photography and a digital photogrammetry system. Geomorphology 111, 48–60. https://doi.org/10.1016/J.GEOMORPH.2008.05.047

Military Survey Authority, topographic maps, scale 1: 1,000,000 plates, Jabal al-Shayeb Al_banat, 1996

Panahi, M.R., Mousavi, S.M., Rahimzadegan, M., 2017. Delineation of groundwater potential zones using remote sensing, GIS, and AHP technique in Tehran–Karaj plain, Iran. Environ. Earth Sci. 2017 7623 76, 1–15. https://doi.org/10.1007/S12665-017-7126-3

Pieczonka, T., Bolch, T., Buchroithner, M., 2011. Generation and evaluation of multitemporal digital terrain models of the Mt. Everest area from different optical sensors.

Pieczonka, T; Bolch, T; Buchroithner, M (2011). Gener. Eval. multitemporal Digit. terrain Model. Mt. Everest area from Differ. Opt. sensors. ISPRS J. Photogramm. Remote Sensing, 66(6)927-940. 66, 927–940. https://doi.org/10.1016/J.ISPRSJPRS.2011.07.003

Pulighe, G., Fava, F., 2017. DEM extraction from archive aerial photos: accuracy assessment in areas of complex topography. https://doi.org/10.5721/EuJRS20134621 46, 363–378. https://doi.org/10.5721/EUJRS20134621

Rawat, K.S., Singh, S.K., Singh, M.I., Garg, B.L., 2019. Comparative evaluation of vertical accuracy of elevated points with ground control points from ASTERDEM and SRTMDEM with respect to CARTOSAT-1DEM. Remote Sens. Appl. Soc. Environ. 13, 289–297. https://doi.org/10.1016/J.RSASE.2018.11.005

Santillan, J.R., Makinano-Santillan, M., Makinano, R.M., 2016. Vertical accuracy assessment of ALOS World 3D - 30M Digital Elevation Model over northeastern Mindanao, Philippines. Int. Geosci. Remote Sens. Symp. 2016-November, 5374–5377. https://doi.org/10.1109/IGARSS.2016.7730400

Schumann, G., Matgen, P., Cutler, M.E.J., Black, A., Hoffmann, L., Pfister, L., 2008. Comparison of remotely sensed water stages from LiDAR, topographic contours and SRTM. ISPRS J. Photogramm. Remote Sens. 63, 283–296. https://doi.org/10.1016/J.ISPRSJPRS.2007.09.004

Shebl, A., Csámer, Á., 2021. Reappraisal of DEMs, Radar and optical datasets in lineaments extraction with emphasis on the spatial context. Remote Sens. Appl. Soc. Environ. 24, 100617. https://doi.org/10.1016/J.RSASE.2021.100617

Shebl, A., Csámer, Á., 2021. Stacked vector multi-source lithologic classification utilizing Machine Learning Algorithms: Data potentiality and dimensionality monitoring. Remote Sens. Appl. Soc. Environ. 100643. https://doi.org/10.1016/J.RSASE.2021.100643

Siart, C., Bubenzer, O., Eitel, B., 2009. Combining digital elevation data (SRTM/ASTER), high resolution satellite imagery (Quick bird) and GIS for geomorphological mapping: A multi-component case study on Mediterranean karst in Central Crete. Geomorphology 112, 106–121. https://doi.org/10.1016/J.GEOMORPH.2009.05.010

Webster, T.L., Murphy, J.B., Gosse, J.C., Spooner, I., 2006. The application of lidar-derived digital elevation model analysis to geological mapping: An example from the Fundy Basin, Nova Scotia, Canada. Can. J. Remote Sens. 32, 173–193. https://doi.org/10.5589/m06-017

Welch, R., Marko, W., 1981. Cartographic potential of a spacecraft line-array camera system - Stereosat. PgERS 47, 1173–1185.

Zhao, S., Cheng, W., Zhou, C., Chen, X., Zhang, S., Zhou, Z., Liu, H., Chai, H., 2011. Accuracy assessment of the ASTER GDEM and SRTM3 DEM: an example in the Loess Plateau and North China Plain of China. https://doi.org/10.1080/01431161.2010.532176 32, 8081–8093. https://doi.org/10.1080/01431161.2010.532176