

## Memo: Vertical Elevation Error from the CopernicusDEM and 3 Other Global DEM's

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### Introduction

Many of us still rely on the Shuttle Radar Topography Mission (SRTM) as a preferred digital elevation model (DEM).

Is it time to move on and use CopernicusDEM?

A more recent and accurate DEM with full global coverage.

### Approach

The vertical accuracy of the CopernicusDEM, NASADEM, SRTM and AW3D30 have been evaluated using 'ground truth' data from 9 national high-resolution elevation models and a runway dataset. The approach is as follows:

- Evaluate vertical elevation error of the DEM's as the model value minus the ground truth value.
- Use ground truth elevations from:
  - National digital terrain models (DTM's) in 5m resolution for: Germany, Spain, Belgium, France, Great-Britain, Estonia, Slovenia, Netherlands and Luxembourg
  - Runways from airports around the world – see "Global Elevation Data Testing Facility (GEDTF)" by Bęcek et al.
- Compare different datasets - here we use 4 global elevation models at different spatial resolutions:
  - CopernicusDEM (30m, 90m), SRTM (30m, 90m), NASADEM (30m) & AW3D30 (30m)
- Evaluate vertical accuracy at the following locations:
  - 3600 wind turbines within the European countries (where ground truth data is available, see list above)
  - 12000 runways from the "Global Elevation Data Testing Facility (GEDTF)"

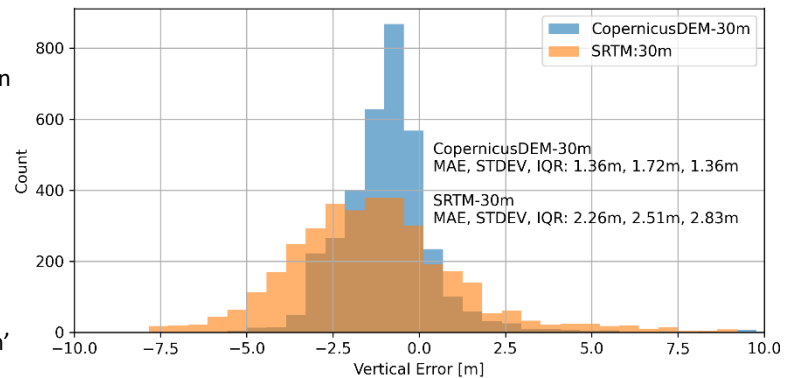


Figure: Distribution of vertical elevation error at 3600 turbine locations. Two datasets are shown: CopernicusDEM-30m (blue) and SRTM-30m (orange).

### Analysis

The table below reports different metrics of the distribution of the vertical elevation error. The following abbreviations are used: MAE = Mean Absolute Error, RMSE = Root Mean Square Error, STDEV = Standard Deviation and IQR = Inter Quantile Range. All metrics are in meters. Green colour = Best dataset. Red colour = Worst dataset.

DEM DATASET	METRIC	WIND TURBINE LOCATIONS				RUNWAY LOCATIONS			
		MAE	RMSE	STDEV	IQR	MAE	RMSE	STDEV	IQR
Copernicus DEM – 30m		1.36	1.91	1.72	1.36	1.78	2.67	2.42	1.99
Copernicus DEM – 90m		2.01	2.84	2.48	2.12	1.90	2.78	2.47	2.00
NASADEM – 30m		1.84	2.42	2.28	2.45	2.81	3.68	3.38	4.10
SRTM – 30m		2.26	2.82	2.51	2.83	2.88	3.63	3.53	4.54
SRTM – 90m		2.50	3.13	2.63	2.93	2.65	3.37	3.25	4.31
AW3D30 – 30m		2.63	5.06	5.03	3.19	2.19	2.92	2.92	3.50

### Findings and Recommendations

- The CopernicusDEM–30m dataset has the lowest overall vertical elevation error of the 4 global datasets. This is the case for all metrics considered – and for both cases with wind-turbine locations and the airport runway locations.
- The metrics for vertical error for the CopernicusDEM-30m dataset is roughly half of that of the STRM-30m (varies between 44% and 74% for the metrics considered).
- For wind-energy applications - it is our recommendation to prioritize use of the CopernicusDEM-30m over the other global elevation models analysed here: NASADEM, SRTM, AW3D30 and EUEM.
- For the highest accuracy: Use a national DTM model (like one of the DTM's used here, if available)

## Data Acknowledgements and References

*WindPRO Elevation Models*: Read more: <https://tinyurl.com/emd-dems>

*CopernicusDEM*: Copernicus DEM GLO-90 (Copernicus WorldDEM™-90) or Copernicus DEM GLO-30 (Copernicus WorldDEM™-30) - unmodified data: - © DLR e.V. 2010-2014 and © Airbus Defence and Space GmbH 2014-2018 provided under COPERNICUS by the European Union and ESA; all rights reserved. Read more: <https://tinyurl.com/emd-copernicusdem>

*Global Elevation Data Testing Facility (GEDTF)*: Kazimierz Bęcsek, Monika Stepnowska, Jakub Łuczak. Global Elevation Data Testing Facility (GEDTF). [dataset, database] Available in Atlas of Open Science Resources, <https://www.zasobynauki.pl/zasoby/global-elevation-data-testing-facility-gedtf,49859/>. License: CC BY-SA 4.0, <https://creativecommons.org/licenses/by-sa/4.0/legalcode.pl>. Date of access: 20.09.2021.

*NASADEM*: Contains NASADEM elevation data. Courtesy NASA/JPL-Caltech. Read more: <https://tinyurl.com/emd-nasadem>

*SRTM*: NASA, team around STS-99 and the US public are thanked for making this great digital elevation dataset available in the public domain and thus for aiding the development of renewable energy. Read more: <https://tinyurl.com/emd-srtm>

*AW3D30*: Contains AW3D30 elevation data from the JAXA - Japan Aerospace Exploration Agency (©JAXA). Read more: <https://tinyurl.com/emd-aw3d30>

*Germany Berlin DGM*: Based on data from Geoportal Berlin / ATKIS® DGM1 / Datenlizenz Deutschland – Namensnennung – Version 2.0. Read more: <https://tinyurl.com/emd-berlindgm>

*Germany Brandenburg DGM*: Based on data from Geobroker Brandenburg / © GeoBasis-DE/LGB, dl-de/by-2-0, 2020 Datenlizenz Deutschland - Namensnennung - Version 2.0. Read more: <https://tinyurl.com/emd-brandenburgdgm>

*German Hamburg DGM*: Based on data from Freie und Hansestadt Hamburg, Landesbetrieb Geoinformation und Vermessung (LGV), DGM1. Datenlizenz Deutschland – Namensnennung – Version 2.0. Read more: <https://tinyurl.com/dgm-hamburg>

*German Nordrhein-Westfalen DGM*: Contains modified elevation data from Geobasis NRW (geobasis.nrw.de). dl-de/by-2-0. Read more: <https://tinyurl.com/dgm-de-nrw>

*Germany Saxony DGM*: Based on elevation data from GeoSN, Data license Germany – attribution – version 2.0. Read more: <https://tinyurl.com/dgm-saxony>

*Germany Saxony-Anhalt DGM*: Elevation model based on data from © GeoBasis-DE / LVermGeo LSA. Read more: <https://tinyurl.com/dgm-saxonyanhalt>

*Germany Thuringia DGM*: Elevation model based on data from © GDI-Th / Datenlizenz Deutschland – Namensnennung – Version 2.0. Read more: <https://tinyurl.com/dgm-thuringia>

*UK Scotland DTM*: Contains public sector information licensed under the Open Government Licence v3.0: <http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/>. Read more: <https://tinyurl.com/dtm-scotland>

*UK Wales DTM*: Contains Natural Resources Wales Information ©. Natural Resources Wales and database right. CC-BY-4.0. Read more: <https://tinyurl.com/dtm-wales>

*Spain MNT*: Elevation data from the Spanish Instituto Geográfico Nacional (IGN). MNT05/MTD25 2008-2019 CC-BY 4.0 ign.es. Read more: <https://tinyurl.com/emd-spainmnt>

*Belgium-Flemish DTM*: Contains elevation data from the Agency of Geographical Information Flanders (Agentschap voor Geografische Informatie Vlaanderen). Digital Height Model Flanders 2013-2015. Read more: <https://tinyurl.com/belgium-flemish>

*Belgium-Walloon MNT*: Based on data from "Service public de Wallonie (SPW)" - <http://geoportail.wallonie.be>. Modèle Numérique de Terrain (MNT) 2013-2014. Read more: <https://tinyurl.com/emd-belgium-walloon>

*France MNT*: Contains elevation data from the Institut National de l'Information Géographique et Forestière (IGN) – 05/2019 & 03/2021. Read more: <https://tinyurl.com/emd-francemnt>

*Estonia DTM*: Elevation data: Estonian Land Board 2012-2017. Read more: <https://tinyurl.com/dtm-estonia>

*Slovenia DTM*: Modified elevation data from Agencija RS za okolje. Read more: <https://tinyurl.com/dtm-slovenia>

*Netherlands AHN*: Data from the Actueel Hoogtebestand Nederland (AHN). Read more: <https://tinyurl.com/ahn-netherlands>

*Luxembourg MNT*: Data from the administration of cadastre and topography in Luxembourg (ACT). More: <https://tinyurl.com/mnt-luxembourg>