FABDEM Updates - FABDEM V1-2

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Abstract—**FABDEM (FABDEM (Forest And Building removed copernicus Digital Elevation Model) is a global 1 arc second grid spacing Digital Terrain Model. Trees and buildings are removed from Copernicus GLO30 DEM using a novel machine learning approach. Since FABDEM's release it has been widely used by the community in a variety of geoscience applications.**

In this paper, we outline the latest updates to FABDEM (V1-2). Improvements to FABDEM include updating the baseline Digital Surface Model and methodological tweaks to fix discontinuities at some tile edges and artifacts caused by resampling at higher latitudes.

I. Introduction

FABDEM (Forest And Building removed copernicus Digital Elevation Model) is a global 1 arc second grid spacing Digital Terrain Model that removes buildings and trees from the Copernicus GLO30 DEM using a random forest based machine learning technique [1]. Since FABDEM V1.0 was released in December 2021, there have been numerous applications of FABDEM ranging from flooding [2,3] to road network extraction [4]. Users have provided invaluable feedback, and based on this, we introduce an update of FABDEM called FABDEM V1-2. FABDEM V1-2 is available from data.bris.ac.uk [5]. Note that FABDEM V1-1 was created but never publicly released and is not discussed in this article.

There are five changes in FABDEM V1-2 compared to FABDEM V1-0, with the changes outlined below:

- Discontinuities fixed at the edge of tiles covering large homogeneous forests
- The underlying Copernicus DEM has been updated to Copernicus 2021_1. Details on the updates to the Copernicus GLO30 DEM can be found on the Copernicus website [6].
- Copernicus GLO30 DEM has variable grid spacing in high latitudes (50°N/S). This results in grids not being aligned across the interface where different resolutions are used, resulting in some artifacts being introduced. For FABDEM, Copernicus DEM was first resampled to a 1 arcsecond grid, however for V1.0, the alignment of high latitude tiles was not matched to the low latitude tiles. The pre-processing of the Copernicus DEM was updated for FABDEM V1.2 to align all tiles consistently.
- File format: changed to Cloud Optimized Geotiff, with updated compression options (DEFLATE with PREDICTOR=2). This reduces file size by ~40%
- File metadata: AREA_OR_POINT label changed to Point. Previously incorrectly labelled as Area.

Further details on some of the fixes are given in the following subsections, as well as comments on accuracy metrics to compare FABDEM V1-2 to FABDEM V1-0.

II. Improvements

A. Discontinuities

Discontinuities were first reported in the Amazon rainforest. In FABDEM V1-0 post-processing, a 5 pixel buffer was added to the corrected DEM for each 1 degree tile, before the post-processing stage. This buffer was taken from the Copernicus GLO30 DEM, without forests removed. The inconsistency between the corrected DEM and buffer resulted in incorrect depression filling during the post-processing step for densely forested areas (Fig. 1). The uncorrected buffer would typically be the height of the forest, usually ~20m, resulting in depression filling from the edge of the tile. This happened in large forests as these are areas where corrections are applied over wide areas.

The discontinuities were fixed by extending the buffer to 0.1 degrees and using a corrected buffer (FABDEM). This avoids using the uncorrected elevations which falsely filled in the depressions. The result of the fix can be seen in Fig. 2.

B. Artifacts in high latitude tiles

Copernicus DEM has variable grid spacing in high latitudes (50°N/S), which FABDEM resampled to 1 arc second to create a consistent grid that is more compatible to models typically used in the geosciences. However, the alignment of the lower latitude tiles did not match the higher latitude tiles, creating a slight offset. A result of this were artifacts being introduced in some tiles due to resampling and processing errors, such as an extreme example in Fig. 3. Note most of the changes are minimal (e.g. Fig. 4).

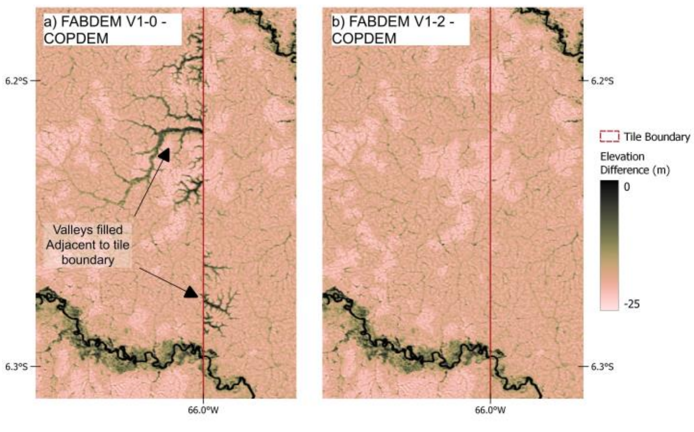

Figure 1. FABDEM V1-0 with valleys incorrectly filled (a), compared to FABDEM V1-2 (b). Difference to Copernicus DEM. Note the valleys incorrectly filled on FABDEM V1-0. Colour Maps for Figures are the Scientific color maps [7]

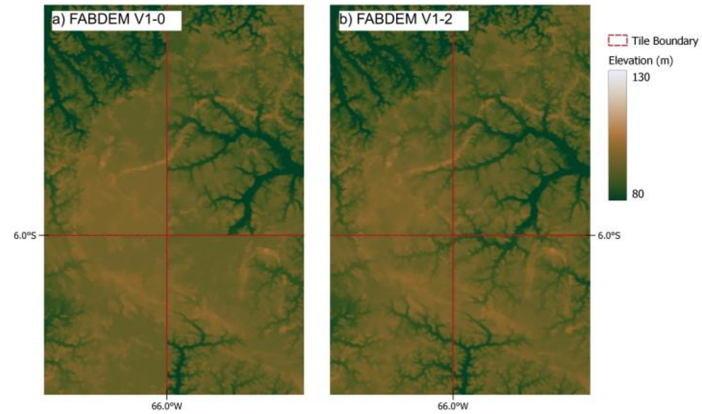

Figure 2. FABDEM V1-0 (a) compared to FABDEM V1-2 (b). Note the lack of discontinuities at tile boundaries in FABDEM V1-2.

C. Error Metrics

Reprocessing error metrics for FABDEM V1-2 yields mild improvements over FABDEM V1-0, with improvements in the order of 1-10cm (e.g. tiles in Germany and Poland not shown). However, for some applications, particularly hydrological applications, the improvements in FABDEM V1-2 can be significant, especially where discontinuities and artifacts have been removed.

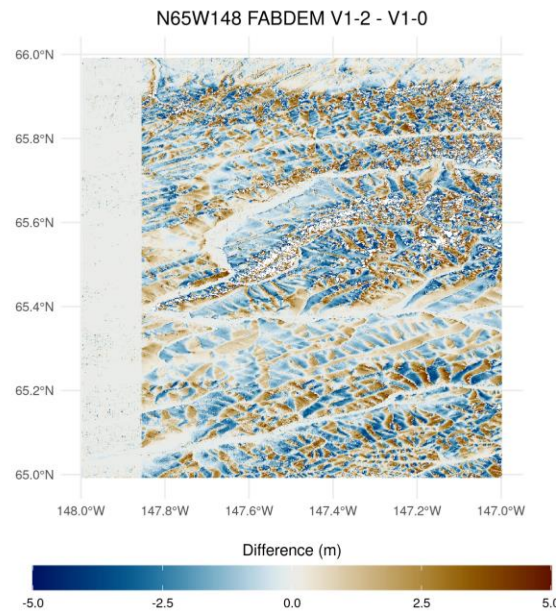

Figure 3. Difference between FABDEM V1-2 and FABDEM V1-0 for a high latitude tile.

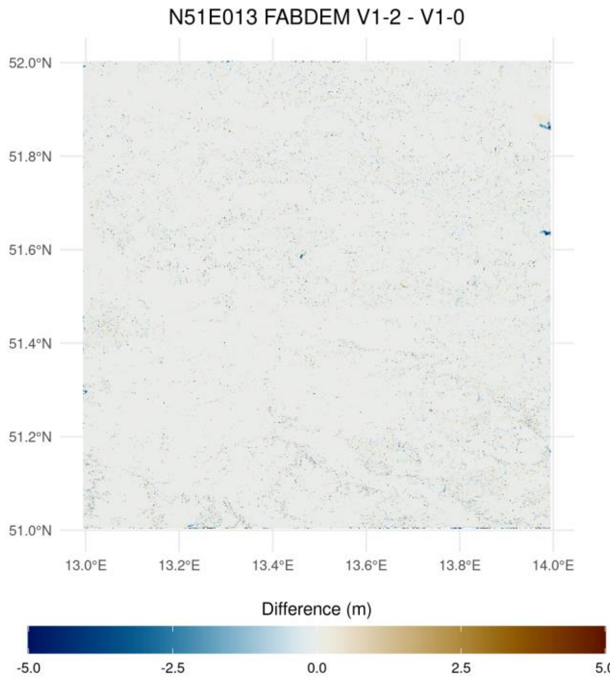

Figure 4. Difference between FABDEM V1-2 and FABDEM V1-0 for a high latitude tile (less extreme example)

D. Other changes

The file format of FABDEM V1-2 has been changed to Cloud Optimized Geotiff, with updated compression options (DEFLATE with PREDICTOR=2). This has helped reduce the size of the entire dataset to less than 300Gb, from ~450Gb of FABDEM V1-0. The new data record also includes a geoJSON of the tile extents (i.e. FABDEM in 1x1 degree tiles) to add useability. Finally, the file metadata AREA_OR_POINT label has been changed to Point. Previously this was incorrectly labelled as Area.

E. Future Outlook

FABDEM will be continuously improved with the addition of improved covariates, more (in both quantity and diversity) training reference elevation data and the refinement of the machine learning method. As a result, the development team will cease incremental updates to the FABDEM V1.X family of DEMs and focus on a more major development. Besides improving the quality of the corrections, other noteworthy developments that need to be addressed include filling in the missing tiles covering Armenia and Azerbaijan (not available in Copernicus GLO-30 DEM), making FABDEM easier to download, and working with groups to develop datasets that commensurate FABDEM such as a hydrography.

III. ACKNOWLEDGMENTS

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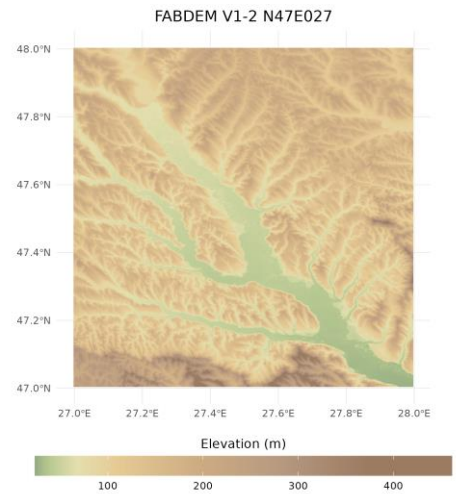

Figure 5. Terrain containing Iasi, Romania

REFERENCES

[1] Hawker, L., Uhe, P., Paulo, L., Sosa, J., Savage, J., Sampson, C. and Neal, J., 2022. A 30 m global map of elevation with forests and buildings removed. Environmental Research Letters, 17(2), p.024016. https://dx.doi.org/10.1088/1748-9326/ac4d4f

[2] Loli, M., Kefalas, G., Dafis, S., Mitoulis, S.A. and Schmidt, F., 2022. Bridge-specific flood risk assessment of transport networks using GIS and remotely sensed data. Science of the Total Environment, 850, p.157976 https://doi.org/10.1016/j.scitotenv.2022.157976

[3] Teng, J., Penton, D.J., Ticehurst, C., Sengupta, A., Freebairn, A., Marvanek, S., Vaze, J., Gibbs, M., Streeton, N., Karim, F. and Morton, S., 2022. A Comprehensive Assessment of Floodwater Depth Estimation Models in Semiarid Regions. Water Resources Research, 58(11), p.e2022WR032031. https://doi.org/10.1029/2022WR032031

[4] Chen, Y., Yang, X., Yang, L. and Feng, J., 2022. An Automatic Approach to Extracting Large-Scale Three-Dimensional Road Networks Using Open-Source Data. Remote Sensing, 14(22), p.5746. https://doi.org/10.3390/rs14225746

[5] Hawker, L., Uhe, P., Paulo, L., Sosa, J., Savage, J., Sampson, C. and Neal, J., 2022. FABDEM V1-2 https://doi.org/10.5523/bris.s5hqmjcdj8yo2ibzi9b4ew3sn

[6] Copernicus DEM, ESA 2022. https://doi.org/10.5270/ESA-c5d3d65

[7] Crameri, Fabio. (2021). Scientific colour maps (7.0.1). Zenodo. https://doi.org/10.5281/zenodo.5501399