Evaluation of Copernicus DEM 30 and the geometric quality of Sentinel-2 Collection-1 with different repeat orbits over Norwegian mountainous terrain

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Introduction

The Norwegian Mapping Authority (NMA) earlier evaluated the performance of different versions of the Copernicus DEM (COP-DEM) and their impacts on the geometric performance of Sentinel-2. This poster presents the quality assessment of the latest Copernicus DEM and Sentinel-2 Collection-1, which has improved geometric calibration and uses Copernicus DEM at a higher resolution (30 m).

Specifically, we conducted two analyses in Norway: 1) to assess the quality of the latest version of the COP-DEM, "2022_1"; and 2) to test the use of the COP-DEM 30 in the ortho-rectification of Sentinel-2 Collection-1 satellite imagery versus older scenes using the COP-DEM 90 in the ortho-rectification. The quality of COP-DEM was assessed by the CNES tool DEMcompare (CNES, 2023), and the geometric performance was derived by the standardized normalized cross-correlation (NCC) tool CIAS (Kääb & Vollmer 2000; Heid & Kääb 2012; Kääb 2015) to track the offsets between two scenes.

Copernicus DEM

The COP-DEM utilize external infill data in areas whereas acquisition geometry and radar characteristics and relief-dependent effects such as layover, foreshortening or shadow may appear, particularly in dense urban and mountainous areas as well as at forest edges (AIRBUS, 2019). In 2019, the NMA delivered AIRBUS with a high-resolution digital surface model (DSM) for external infill data to replace data such as SRTM, AW3D30, and GMTED2010. Due to the ongoing LiDAR/image matching collection, the delivered DSM did not cover the entire Norway. However, the collection was completed in 2022, and in the same year, NMA provided AIRBUS with an updated high-resolution DSM with complete coverage (referred to as the Norway DEM).

When we compare the different versions of the 30 m COP-DEM with the Norway DEM, we find that the latest version of the COP-DEM shows significantly better results. This is mainly due to the latest filling of the Norwegian DEM, which now covers Norway completely. Table 1 shows the associated comparison statistics. Figure 1 visualizes the difference DSM (DoD) between the Norwegian DEM and COP-DEM for each version.

Table 1: Overview of calculated statistics for the different COP-DEM 30 m versions when compared to the Norway DEM. The statistics exclude pixels on all water surfaces to remove anomalies in water on the Norway DEM and the different COP-DEM 30 m versions.

COP-DEM Version	Standard deviation	Mean error	Median	NMAD	95th Percentile
2019_1	5.722	0.042	-0.003	0.614	3.402
2020_1	3.635	0.061	-0.004	0.608	2.930
2021_1	3.122	0.011	-0.005	0.605	2.848
2022_1	1.613	0.019	-0.006	0.600	2.689

Geometric performance of Sentinel-2 Collection-1

From the Copernicus Sentinel-2 Collection-1, we obtained consistent Sentinel-2A and Sentinel-2B time series with a uniform processing baseline. From pixel-to-pixel comparisons, the use of Global Reference Imagery (GRI) in the archive will improve multi-temporal co-registration. In mountainous areas, the use of a COP-DEM with a resolution of 30 meters would improve geolocation performance compared to the currently used COP-DEM with a resolution of 90 meters.

We used the NCC tool CIAS to compare scenes from the old processed baseline with the new Sentinel-2 Collection-1 product and found offsets of up to 40 meters (see Figure 2). The offsets are particularly high for mountainous scenes and for scenes that were not refined with GRI in the old data but were refined with GRI in the new data. When comparing data on different repeat orbits, we also see an improvement in mountainous areas.

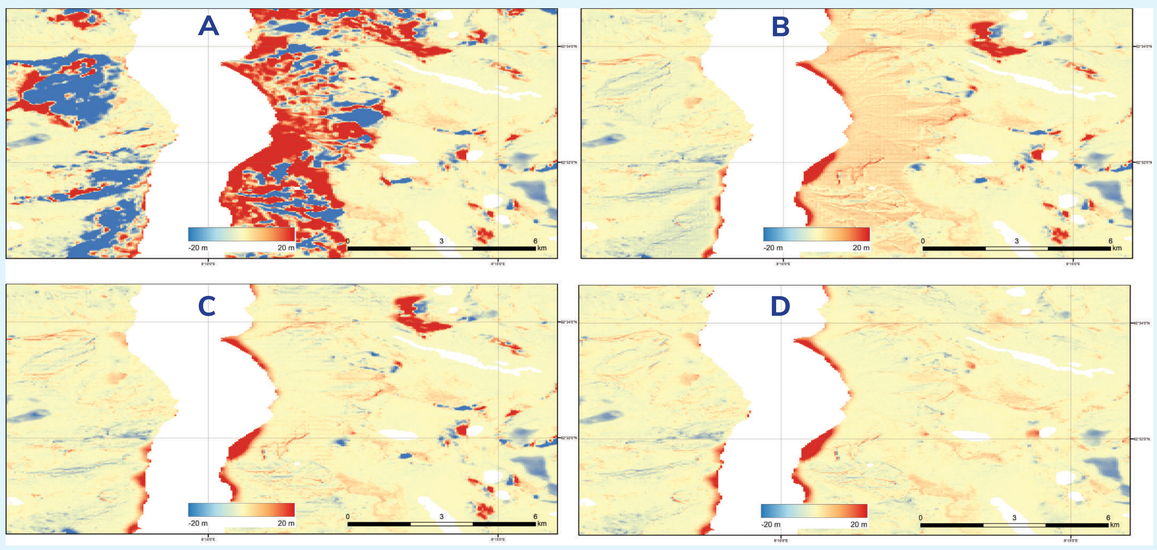

Figure 1: The DoD between Norway DEM and COP-DEM. Letters A-D indicate the different COP-DEM version used: (A) 2019_1, (B) 2020_1, (C) 2021_1 and (D) 2022_1. Produced using Copernicus WorldDEM-30 © DLR e.V. 2010-2014 and © Airbus Defence and Space GmbH 2014-2018 provided under COPERNICUS by the European Union and ESA; all rights reserved.

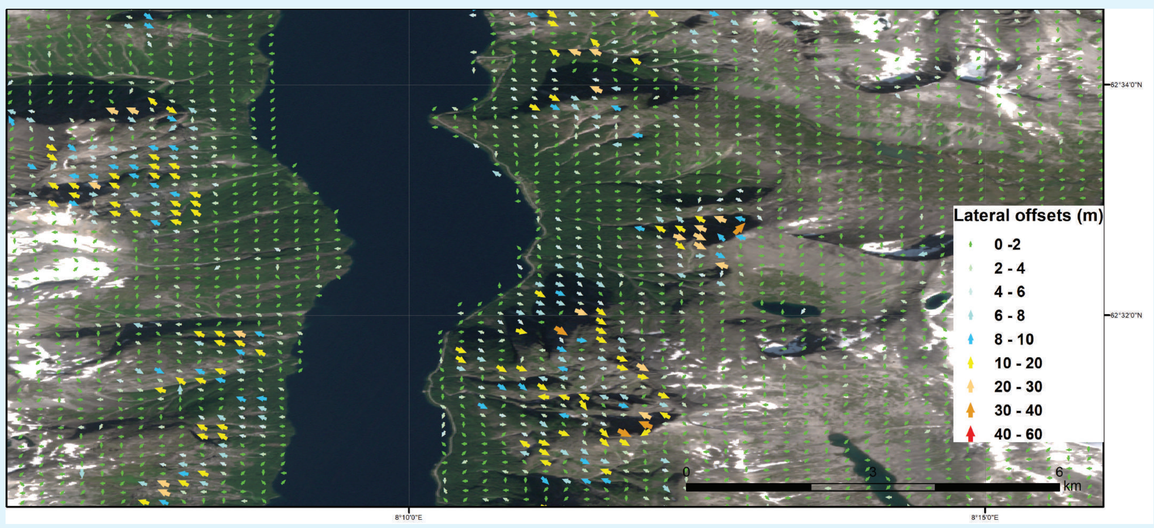

Figure 2: Observed displacement between the old baseline 03.01 and Collection-1 05.00 on a Sentinel-2 scene from 24-07-2021 over steep mountainous terrain. Contains Copernicus Sentinel-2 data (2021).

Results and suggestions

The evaluation of the COP-DEM shows that it has evolved and improved over time with the updates of the infill data and infill algorithm by AIRBUS. Similarly, we note that geometric quality has improved with the uniform processing baseline for the Sentinel-2 historical data introduced by Collection-1. For future improvements, we recommend that COP-DEM improve its infill mask to include more erroneous COP-DEM data in the mask. An example of this is Figure 1, where the COP-DEM has incorrectly classified lakes and shorelines. For future Collection-2 processing, we recommend using the latest COP-DEM version, as the current processing uses the 2021_1 COP-DEM.

References

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