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Exploration of space-borne LiDAR data for forest parameter retrieval for Alpine regions

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The existing forest inventories have difficulties in providing data with sufficient spatial and temporal resolution to quantify dynamic properties of forests, which are mainly caused by short-term events such as drought, storm, snow damages, or pest infestations.
This study aims to explore in a first step the potential of space-borne LiDAR for forest parameters extraction over Alpine forests in Austria. The space-borne LiDAR data investigated in this study is ICESat2 (Ice, Cloud and Land Elevation Satellite-2) and GEDI (Global Ecosystem Dynamics Investigation).
GEDI is a full-waveform, multibeam laser altimeter on the International Space Station, with a footprint diameter of about 25m (Dubayah, 2020). As for ICESat-2, it carries a micropulse, multi-beam photon-counting laser altimeter, with a footprint diameter of about 17m (Neuenschwander and Magruder, 2019). Two footprint-level products are used in this study: GEDI L2A and ICESat-2 ATL03. The GEDI L2A product provides footprint-level elevation and height metrics that extract terrain height, canopy height, and relative height metrics from the received waveform. ICESat-2 ATL03 records horizontal coordinates and ellipsoidal heights of all photon data, and the classification labels are extracted from its higher product, ATL08. The DTM with a resolution of 1m and the DSM derived from ALS (Airborne Laser Scanning) point clouds acts as “ground truth” to assess the accuracy of the terrain and canopy height of the two space-borne LiDAR products, respectively. For ICESat-2 ATL03, only photons with a signal confidence flag ranging from medium confidence (sigal_confidence=3) or high confidence (sigal_confidence=4) are included for evaluation. For GEDI L2A, only waveforms with a valid quality flag (quality_flag=1) are included for evaluation. To evaluate the performance of ICESat2 and GEDI for different forest types and topographic conditions, two study sites in Austria are selected: western part of Tyrol and the Vienna Woods.
A preliminary results of terrain and canopy height accuracies shows that the terrain height of the two space-borne LiDAR products fits well with the DTM. Compared to GEDI L2A, ICESat2 ATL03 has a better correlation with DTM values.
The canopy height accuracy is not as good as the terrain height accuracy. It has been shown that ICESat-2 tend to underestimate the canopy top height as derived from airborne LiDAR. Overall, GEDI has a better canopy height accuracy than ICESat-2.
Furthermore, we have investigated the influence of different beam power, data acquisition time and season. In general, the accuracy of both ICESat-2 and GEDI data acquired in nighttime is higher than that of the daytime data. The statistic also shows that for the ICESat-2 data, the terrain

height accuracy of weak beam footprints only slightly worse than that of strong beam footprints. For GEDI, footprints of strong beams always perform better than that of weak beams in terms of terrain and canopy height. Regarding the impact of season, for both ICESat-2 and GEDI, the canopy height is more accurate in summer than the collection in winter. For GEDI, the terrain height can be better measured in winter than in summer.