Annual vegetation height maps based on Sentinel-2 data – Potential applications for the Swiss National Forest Inventory

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Area-wide information on Vegetation Height (VH) has been recognized of great value for many applications such as large-scale analysis and evaluation of various forest functions (carbon stock, timber production, biodiversity, or protection against natural hazards). This is why the Swiss National Forest Inventory (NFI) generates and provides countrywide vegetation height maps using aerial image-based point clouds (Ginzler and Hobi 2015). The high spatial map resolution of 0.5 m and their regular update (every six years) enable fine-scale structural analyses in the forest. However, the updating period of six years limits certain applications in which the time factor plays an important role such as disturbance and change analyses. Lang et al. (2019) showed that it is possible to map vegetation height annually with Sentinel-2 (S2) data. They modelled the mean VH on a spatial resolution of 10 m with a deep Convolutional Neural Network (CNN) from S2 data acquired within a single year. Becker et al. (2021) has extended this approach to predict multiple forest structure variables at the same time. This approach has been applied to estimate the mean and maximum VH within 10 m × 10 m from Sentinel-2 using the latest high-resolution Swiss NFI-VH map as reference training data. Annual countrywide VH maps were computed for the years 2017-2020, which are evaluated as a valuable complementary product to the spatial high resolution NFI data.

The potential of the S2-based VH maps for the application within the framework of the Swiss NFI was evaluated based on an accuracy assessment with two independent reference datasets. The two reference datasets comprised VH measured by 1) visual aerial stereo-image height measurements of NFI plots and 2) derived from a countrywide Aerial Laser Scanning (ALS) campaign. Moreover, interannual differences from expected annual variation in the S2 input data were analysed between 2017-2020.

The evaluation revealed that for the S2-based VH maps similar values were obtained as for the reference data. While on large scale in particular, the vegetation height patterns correspond well to the ALS based VH map, fine structural details are missing due to an observed smoothing of the height values. This spatial blurring was explained by the use of a CNN, that models texture context over pixel neighbourhoods (Lang et al., 2019). Overall, the interannual differences were neglectable and enable change analyses between two years such as the detection of disturbed forest areas after a storm event. Difficulties in analysing changes were found in areas with more complex terrain such as the Alps due to the influence of shadows in the S2 data. Preliminary results confirm that annual countrywide VH maps based on S2 data have a great potential to serve as a valuable and complimentary source of vegetation information to the already existing spatial high resolution VH maps of the Swiss NFI.

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