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New opportunities for high-resolution countrywide tree type mapping

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Precise and regularly updated information on the state, change and distribution of tree types is essential for the forestry sector and beyond. Wall-to-wall tree type maps are fundamental inputs for the changing requirements of regional and national forest inventories (NFIs). While repeated and routinely acquired digital aerial images have been incorporated into operational NFIs, limitations of optical data remain due to weather and illumination conditions - particularly in areas with complex terrain, such as the European Alps. In their first high-resolution countrywide tree type mapping approach, Waser et al. (2017) showed that such limitations resulted in an overestimation of coniferous trees in these areas.

In the present study, a novel approach is introduced that minimizes these limitations and allows to generate repeatable and objective tree type maps (broadleaved, coniferous) with a spatial resolution of 10 m for the whole of Switzerland (41,285 km²). It incorporates a Random Forest (RF) classifier, explanatory variables from Sentinel-1 SAR and Sentinel-2 multispectral data and a Digital Terrain Model (DTM) from Airborne Laser Scanning (ALS) data, digitized training polygons and independent validation data from the NFI.

The usage of combined winter and summer imagery from multispectral Sentinel-2 partly reduced the previous overestimation of conifers but results were still unsatisfactory in complex topography with shadows. Only a further adaption of the approach, by combining Sentinel-1 and -2 data (summer and winter) and by training the classification models of these problem areas with backscatter data (VV, VH) from Sentinel-1 SAR enabled a substantial reduction in overestimations of conifers. Additionally, the identification of larch (*Larix decidua*) also became feasible.

10-fold-cross-validation revealed high overall model accuracies (95-98%) with small variations between different regions. A comparison with independent NFI plot data revealed differences in the range of 5-8%. Validation was refined to incorporate different NFI height levels, species dominance and productions regions.

This tree type map of Switzerland is superior to existing products due to its national coverage, high level of detail and the free availability of the basis remote sensing data which thus enables regular updating. The tree type map is potentially useful for optimizing forest management and planning activities and is an important information source for applications outside the forestry sector.

The presented approach is currently being optimized by calculating additional remote sensing indices, collecting more training data from different tree species, and testing ensemble modelling and deep learning algorithms.

Reference: Waser, L.T.; Ginzler, C.; Rehush, N. Wall-to-Wall Tree Type Mapping from Countrywide Airborne Remote Sensing Surveys. *Remote Sensing* 2017, 9, 766.