# Fusion of full waveform Laserscanning and airborne hyperspectral remote sensing data for the characterization of forest stands

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Hyperspectral data offer the maximum spectral reflectance information available from remote sensing. A continuous spectrum of narrow bands with near-laboratory quality is recorded for each pixel. This data can be used for difficult classification tasks or detailed quantitative analyses, e.g. determination of chlorophyll or water content in leaves. But in forested areas, discerning between different age classes of the same tree species is still error-prone.

Airborne Laserscanning measures the three-dimensional position of every reflecting object and can be used to map tree heights and crown volumes. These are highly correlated with tree age and timber volume. In addition, Laserscanner data can be used to differentiate between coniferous and deciduous trees either by analysing crown shapes that lead to different surface roughness or by exploiting the intensity information of laser echoes from the crowns. But a more detailed determination of tree species is not possible using Laserscanning alone.

The combination of hyperspectral and Laserscanning data promises the possibility to map both tree species and age classes. We used a HyMap data set with 122 bands recorded in 2003 and a full waveform Laserscanning recorded in 2005 in the same area, Idarwald Forest in South-western Germany.

To combine both datasets, we defined voxels above the HyMap pixels, containing the mean laser intensity in slices of 50 cm height. These voxels form a second hyperspectral dataset of 76 bands with the same geometry as the HyMap image, so that they could be fused into a 198 band image.

The joined image performed better in a classification of tree species and age classes than each of the single images and also better than a dataset consisting of the hyperspectral image and a tree height map. Apart from classification, it can also be used to derive tree heights and crown base heights and to estimate biomass, leaf area index and timber volume and to characterize the vertical forest structure.