

Hyperspectral vs. multispectral data for tree species classification – first experiences with EnMAP data

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Abstract

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Challenge

Tree species classification using Earth observation (EO) data is crucial for biodiversity conservation and it supports sustainable forest management. Overall, accurate classification helps maintain ecosystem health and resilience, ensuring forests' ecological, economic, and social benefits are preserved. Large-scale tree species maps are feasible only through the use of EO data, as they offer comprehensive, consistent, and repeatable coverage over extensive and often inaccessible regions. Furthermore, remote sensing technologies provide detailed spectral information crucial for distinguishing between different species across large landscapes, making them indispensable for accurate and efficient mapping. However, different tree species often have similar spectral signatures, making it difficult to distinguish between them. This is especially true for species that have similar leaf structures and pigments. Next to the spectral information also the spatial resolution and the temporal availability are crucial. Optimal EO data would be fine enough to capture individual trees or small groups of trees and would have a high revisit rate to detect changes in the spectral properties over time due to seasonal variations, phenological stages, and environmental stressors. However, tree species can be even more robustly identified if we classify/identify them in the biophysical feature space and not in the spectral-temporal feature space.

Materials & Methods

The study aims to obtain preliminary results on the suitability of EnMAP data for the differentiation of tree species in Central European forests. Therefore, a comprehensive reference dataset (1200 samples) from the well-studied Wienerwald Biosphere Reserve was chosen. To investigate the suitability of mono-temporal EnMAP for distinguishing 12 Central European tree species in Austria, a classical approach was chosen, using random forest classification with recursive feature selection. For comparison, Sentinel-2 data (with higher spatial resolution) and Landsat-9 data (same spatial resolution) from the same period were also classified, and the resulting accuracies were compared. Three usable (low cloud cover) scenes were available for the analyses: two from June 2024 and one from August 2024. For all sensors data after standard atmospheric correction (L2) were used and for the modeling only the spectral data without additional pre-processing was used for model training.

Results

The accuracies achieved at the individual available points in time did not show any major differences. The same was also true for the comparison between the sensors. For example, using the data from June 05 (best result): an overall accuracy of 65.6% was achieved with EnMap. Sentinel-2 achieved a slightly higher accuracy of 67.9%, while the result achieved with Landsat-9 was slightly lower than that of EnMAP at 62.2%. This shows that the significantly higher spectral information content of EnMAP at the same spatial resolution only leads to a slight improvement in classification accuracy, while the better spatial resolution of Sentinel-2 compensates for the lower spectral resolution for the distinguishing of tree species. The low separability of the individual tree species is also reflected in the spectral signatures from all reference data shown in Figure 1. Some tree species show very similar mean curves, whereby the variance within the classes must also be taken into account and there is a large overlap between individual tree species classes.

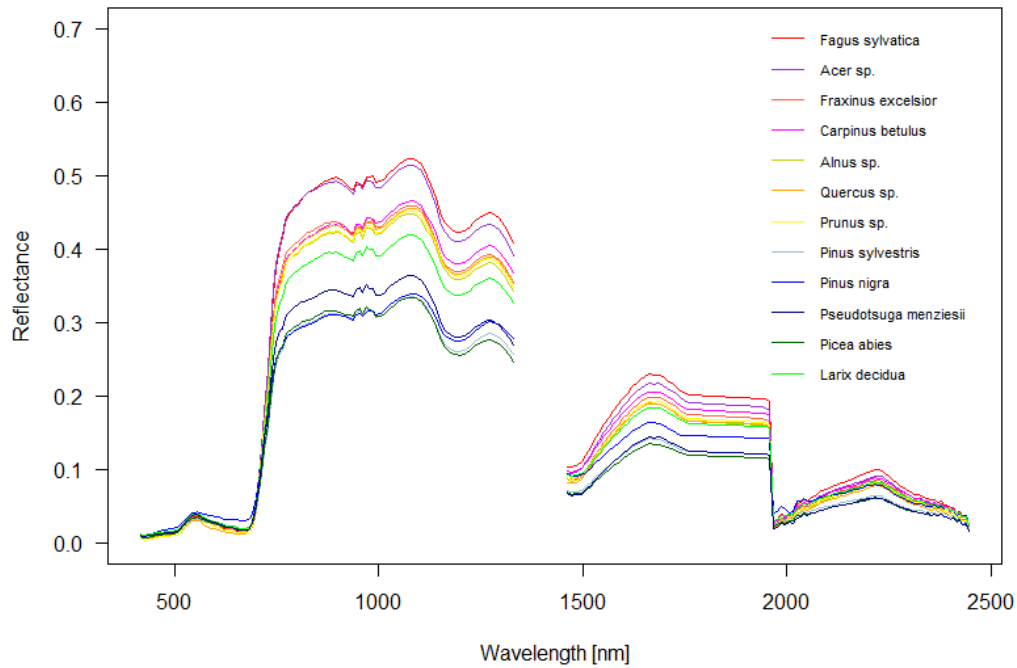


Figure 1 Mean spectral signature of 12 tree species based on the EnMAP acquisition from June, 5th 2024

Outlook

Likewise, the potential of hyperspectral data was not fully exploited in this preliminary study so that in the future such data can be used to derive large-scale biophysical variables such as chlorophyll content and LAI etc. Specifically for tree species classification the potential of multitemporal EnMAP data will be examined. There is also great potential in combining this data with higher spatial and temporal resolution data (e.g., Sentinel-2, Planet) to leverage the advantages of different datasets and enable more precise descriptions of forests.