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Corner Reflectors for Direct Measurement of Forest Vegetation Optical Depth

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Plant water content is the primary contributor to the Vegetation Optical Depth (VOD), a remote sensing parameter that describes signal attenuation by vegetation in the microwave domain. Short-term variations in VOD contain information about changes in canopy water content, while long-term changes reflect phenological dynamics and overall vegetation development. VOD is also used in several models to estimate biomass and vegetation water content.

Unfortunately, the validation of VOD remains challenging due to the lack of direct ground-truth data, making it common practice to evaluate its performance through spatiotemporal comparisons with relevant vegetation proxy variables. Corner reflectors are passive reflective surfaces that allow accurate characterisation of reflected microwave radiation. By placing them within forest vegetation, we can directly measure the attenuation of their signal caused by the canopy. This makes them a potentially practical tool for direct VOD measurements as well as water balance.

In our project, we developed an innovative corner reflector design specifically for forest microwave satellite observations. We verified the geometry using theoretical reflection simulations at several frequencies for future applications with the Sentinel-1 (5.405 GHz), TanDEM-X (9.65 GHz), and NISAR (L-band: 1.257 GHz / 3.2 GHz) missions. Based on these theoretical assumptions, we subsequently constructed four prototypes and deployed them in mature forest stands in Germany and the Czech Republic. To evaluate the maximum forest canopy density that can still be measured using our corner reflectors, we also conducted an artificial shading experiment. The results demonstrate the capability of corner reflectors to measure VOD, as well as the limitations of current prototypes and recommendations for future applications.