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Field and satellite-estimated seasonal ground vegetation patterns in boreal ecosystems

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Boreal ecosystems, in particular peatlands, are one of the most essential terrestrial carbon pools. Aboveground biomass (AGB) and leaf area index (LAI) are key plant traits widely used to characterise their ecosystem processes. However, it has remained poorly understood how these variables develop over seasons among different vegetation types (VTs) and plant functional types (PFTs), and how well their seasonal spatiotemporal patterns can be detected by satellite images.

To address these gaps, we carried out field measurements between May and September during one growing season to investigate the seasonal development of ground vegetation AGB and LAI in seven VTs and PFTs within three peatland and forest study areas in northern Finland. We linked field-based AGB and LAI estimations to Sentinel-2 (S2) multi-temporal images via Random Forest (RF) regressions, yielding seasonal AGB and LAI maps.

Although AGB and LAI followed a clear unimodal curve in most VTs, their seasonal trajectories were more stable in forests and fen lawns than in fen strings and flarks. AGB peaked around the first week of August in about 900 DD5 (the sum of degree days above 5 °C), and, in most cases, one to two week(s) later than LAI. Besides evergreen shrubs, other three vascular PFTs presented clear unimodal seasonal patterns in AGB and LAI, while the AGB of mosses remained steady over the season. When upscaling to the landscape-level, the R^2 of regressions was 24.2-50.2% (RMSE: 78.8-198.7 $\text{g}\cdot\text{m}^{-2}$) for AGB and 48.5-56.1% (RMSE: 0.207-0.497 $\text{m}^2\cdot\text{m}^{-2}$) for LAI. The S2-estimated AGB and LAI had unimodal seasonal patterns, though peaking dates were one to three week(s) earlier than in the corresponding field-based estimates.

Our findings suggest that S2 data which has relatively high spatial and temporal resolution has potential to monitor ground vegetation seasonality in boreal landscapes, especially in areas with sparse or no tree cover.