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Assessing plant traits of mechanistic relevance for optical remote sensing and their relationship to plant functioning

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A wide array of plant traits have been studied in order to understand and predict plant functioning of species and communities. Earth observation (EO) offers capabilities to continuously map various plant traits in time and space and therefore attracted increasing attention towards ecological research (Kattenborn 2017). From a remote sensing perspective, the mechanistic response of various optically relevant plant traits is already quite well understood and formulated in process-based models, i.e. radiative transfer models (RTMs). However, the variables implemented in radiative transfer models have not been linked in an exhaustive way to ecological gradients or plant functioning. This study addresses this gap by comparing plant functioning with traits implemented in PROSAIL, the most established radiative transfer model of plant canopies. PROSAIL takes into account traits describing the canopy structure (e.g. through LAI or leaf angles) as well as the optical leaf properties (e.g. in terms of chlorophyll or water content). To cover a wide functional range we cultivated 49 species covering the full range of the CSR spectrum. The considered traits were measured on a weekly basis for an entire season. As reference for plant functioning we used the competitor, stress tolerator and ruderal plant strategy scheme (CSR, Grime 1997) as well as the leaf economic spectrum (LES, Wright et al. 2004). The acquired trait data was subsequently analyzed towards two principle research questions: 1) How do optically relevant plant traits relate to the functional spectrum of traditional schemes, i.e. CSR and LES. 2) To what degree can the set of optically relevant plant traits explain or replace traditional schemes of plant functioning? The results show that optically relevant plant traits indeed explain an extensive proportion of the CSR and LES space. As such, the traits inherited in radiative transfer models might not only enrich the suite of potential indicators to characterize plant functional gradients; it might also allow us to establish physical and therefore explicit relationships between reflectance and plant traits which advance our theoretical understanding as well as the transferability and operationalization of such knowledge.

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