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Exploring plant functional traits variability with a terrestrial biosphere model

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Mechanisms of plant trait adaptation and acclimation are still poorly understood and consequently lack a consistent representation in terrestrial biosphere models (TBMs) where global vegetation is most often grouped in plant functional types (PFTs) with fixed parameters calibrated on few discrete observations. Despite the increasing availability of geo-referenced trait observations, current databases are still insufficient to cover all vegetation types and environmental conditions. In parallel, the growing number of continuous eddy-covariance observations of energy and CO_2 fluxes has engaged modelers to calibrate TBMs upon these data. Past attempts to optimize TBMs parameters based on eddy flux data mostly focused on model performance overlooking the ecological properties of ecosystems. Here we invert the parameters of the ORCHIDEE model against 371 site-years of gross primary productivity (GPP) measured within the FLUXNET network, spanning a large environmental gradient and seven vegetation types. The aim of this study is to assess the ecological consistency of optimized trait-related parameters while improving the model performances for GPP at sites. The calibrated parameters values are shown to be consistent with leaf-scale traits, in particular well known trade-offs observed at the leaf level like the negative relationship between specific leaf area and leaf age from the leaf economic spectrum theory. Results further show a marked sensitivity of trait-related parameters to local bio-climatic variables, and here again, reproduce observed relationships between traits and climate. Our approach validates biological processes implemented in the model and allows us to study ecological properties of vegetation at the canopy level, as well as traits difficult to observe experimentally (e.g., allocation-related and belowground traits). This study stress the need for implementing explicit trade-offs and acclimation processes in TBMs to improve simulations, as well as the need for performing systematic traits measurements at FLUXNET sites in order to gather information on micro-meteorology, plant ecophysiology and plant diversity at single locations.