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# Analysing global ecosystem $CO_2$ uptake capacity with plant trait data

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Given the modulating role of vegetation in the global carbon cycle, there is a demand for simple and general scaling relationships of vegetation characteristics and ecosystem $CO_2$-uptake and emissions. On a leaf level, is it well established that plant trait foliar nitrogen (N) relates strongly with leaf level $CO_2$. Furthermore, ecosystem productivity or $CO_2$ uptake capacity have been related directly with whole-canopy N concentrations for a variety of ecosystems such as grasslands, and boreal, temporal and tropical forests. However, studies on the global validity of these leaf and ecosystem level relationships have been lacking up to date. The arrival of the large plant trait database TRY database offers the opportunity to link plant trait and ecosystem functioning on a global scale.

In this study, we used $CO_2$ flux data from the FLUXNET database, with plant trait ($N_{area}$) data from TRY and $N_{area}$ measurements from a selection of FLUXNET sites as well. For 83 global FLUXNET sites, which had information available on species composition, we derived the light saturated gross primary productivity ($GPP_{1000}$). We used MODIS LAI and fPAR, together with the species' relative height and abundance data, to up-scale the TRY derived $N_{area}$ values to a canopy value per site ($N_{canopy}$). For this calculation we assumed that top canopy leaves contribute more to $CO_2$ uptake, and used a Lambert-Beer canopy light extinction principle to weigh the relative contribution per species to the final $N_{canopy}$ value. For our analyses, we divided the sites in five different vegetation classes: broad leaved forests, needle leaved forests, grasslands, crops and (sub)arctic non-forest vegetation.

Site-measured $N_{area}$data corroborated well with TRY derived $N_{area}$ data, giving confidence in using a database such as TRY for global analyses like ours. $N_{canopy}$ alone explained 18 % of the observed variation in maximum ($90^{th}$ percentile) $GPP_{1000}$ with a linear model. When adding the different vegetation types as a covariate, however, this increased to explaining 72% of the observed variation. Furthermore, the $N_{canopy}$ - LAI patterns suggest a global ecosystem level strategy of relatively high N-investment per leaf area when little N is available and additional investment in leaf area only when more N is present.

Overall, our study shows that including $N_{area}$ and vegetation type information can be very informative when analyzing the global GPP patterns in addition to using LAI alone, underlining the potential of including traits in modeling global $CO_2$ uptake. Our results furthermore point out the importance of putting our focus beyond leaf level and consider whole canopy strategies for explaining ecosystem level $CO_2$ exchange.