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The magnitude of interannual variability of ecosystem photosynthetic capacity is controled by stand age and biodiversity

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Gross primary productivity, GPP, the total uptake of carbon dioxide (CO_2) by ecosystems via photosynthesis, is the largest flux in the global carbon cycle. The photosynthetic capacity at light saturation (GPPsat) is a fundamental ecosystem functional property and its interannual variability (IAV) is propagated to the net ecosystem exchange of CO_2.

In this contribution we made use of a variety of data streams consisting of ecosystem-atmosphere CO_2 fluxes measured at eddy covariance flux sites with more than 4 years of data, the GPPsat derived at the different sites, information about climate (temperature, precipitation, and water availability index - WAI), biodiversity information and species richness, stand age, and plant traits, nutrient availability indexes derived from field campaigns, ancillary databases, and the literature. We also used data about forest structure derived from satellite products. Sites were selected according to the availability of eddy covariance flux measurements for at least 4 years, information about stand age, canopy cover, canopy height, and species abundance. The resulting global database consisted of 50 sites with different vegetation types across different climatic regions.

Considering the importance of the understanding of IAV in CO_2 fluxes to improve the predictive capacity of the global carbon cycle we analyzed a range of alternative hypotheses and potential drivers of the magnitude of IAV in GPPsat in forest ecosystems. The results show that the IAV in GPPsat within sites is driven by climate (i.e. fluctuations in air temperature and soil water availability), but the magnitude of IAV in GPPsat is related to ecosystem structure, and more in details to stand age and biodiversity ($R2=0.55$, $p<0.0001$). We conclude that irrespective of forest type the IAV of GPPsat in older and more diverse forests is dampened, and is higher in younger forests with few dominant species.