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Functional traits and structural controls on the relationship between photosynthetic CO_2 uptake and sun-induced fluorescence in a Mediterranean grassland under different nutrient availability

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Recent studies have shown how human induced nitrogen (N) and phosphorous (P) imbalances affect essential ecosystem processes, and might be particularly important in water-limited ecosystems. Hyperspectral information can be used to directly infer nutrient-induced variation in structural and functional changes of vegetation under different nutrient availability. However, several uncertainties still hamper the direct link between photosynthetic CO_2 uptake (gross primary productivity, GPP) and hyperspectral reflectance. Sun-induced fluorescence (SIF) provides a new non-invasive measurement approach that has the potential to quantify dynamic changes in light use efficiency and photosynthetic CO_2 uptake.

In this contribution we will present an experiment conducted in a Mediterranean grassland, where 16 plots of 8x8 meters were manipulated by adding nutrient (N, P, and NP). Almost simultaneous estimates of canopy scale GPP and SIF were conducted with transparent transient-state canopy chambers and high resolution spectrometers, respectively. We investigated the response of GPP and SIF to different nutrient availability and plant stoichiometry. The second objective was to identify how structural (LAI, leaf angle distribution, and biodiversity) and canopy biochemical properties (e.g. N and chlorophyll content - Chl) control the functional relationship between GPP and SIF. To test the different hypotheses the SCOPE radiative transfer model was used. We ran a factorial experiment with SCOPE to disentangle the main drivers (structure vs biochemistry) of the relationship GPP-SIF.

The results showed significant differences in GPP values between N and without N addition plots. We also found that vegetation indices sensitive to pigment variations and physiology (such as photochemical reflectance index PRI) and SIF showed differences between different treatments. SCOPE showed very good agreement with the observed data (R^2=0.71). The observed variability in SIF was mainly related to changes in functional traits of the vegetation (changes in N and P content and Chl). However, beside changes in functional traits, changes in canopy structure (and in particular variation in plant forms abundance after fertilization) controlled the GPP-SIF relationship. According to these results, plant N/P stoichiometry and structure should be considered when modelling GPP assuming a linear relationship with SIF at grasslands sites.