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Characterisation of reflectance and chlorophyll fluorescence anisotropy – defining requirements for an experimental setup.

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Over the last two decades, sun-induced fluorescence (SIF), a part of energy absorbed by chlorophyll and reemitted at longer wavelengths (red and far-red) than for excitation, has been studied by many researchers, considered a proxy for light-use efficiency (LUE) and functioning of photosynthesis machinery. Although many studies support the use of SIF as a tool for monitoring of photosynthetic activity, SIF measurements are still a challenging task. The anisotropy of SIF emission was not yet fully characterised, which could potentially help to relate SIF to photosynthetic processes and refine the influence of plant traits (e.g. leaf structure) on SIF signal, therefore, we focused on defining experimental design requirements for characterisation of SIF bidirectional behaviour.

We conducted two sets of experiments measuring reflectance and SIF of two small homogeneous canopies (a coniferous and herbaceous one) under varying view zenith angles (0°, 20°, 45°) using a Fluorescence box (FloX, JB Hyperspectral Devices UG). The sensor has been placed at approximately 20 cm from the canopy, enabling to measure the same area within the FOV of the instrument for all view zenith angles. Moreover, we examined the effect of using two different incoming radiation measurements strategies on SIF estimations in O_2B (687 nm) and O_2A (760 nm) bands under varying view zenith angles – using downward bare fiber optics looking at a spectralon white panel at the same view zenith angles as at the vegetation target, and fiber optics with cosine diffuser looking upward.

The preliminary results showed that in a conifer canopy, usually characterised by relatively low SIF signal, apparent reflectance, calculated using cosine diffuser for incoming radiation measurements, exhibit a peculiar "dip" instead of a peak around 760 nm wavelength when observing the target under high (45°) view zenith angle. This behaviour affected SIF estimates since it results in the direct radiation negative in-filling effect, caused by the nonlinear contribution of direct and diffuse radiation at the absorption bands - lower reflectance of direct than diffuse radiation. On the contrary, in an herbaceous canopy, this effect was masked by the higher SIF emission of the grassland. In addition to the observed directional variation in the reflectance and SIF, there was a significant difference in SIF estimation when using the spectralon white panel and the cosine diffuser for incoming radiance measurements, reaching up to 30% variation in O_2A SIF retrieved under 45° viewing zenith angle.

We can conclude that there is a need for a full characterisation of SIF anisotropy with the use of a specifically designed goniometer, and that the experimental setup with respect to incoming radiance measurements should be defined considering the results obtained.