searching algorithm was designed to search the optimal indices and the respective optimal channels. Three indices were found to meet the requirements: R761/R763, R689/R648 and R759/R761.

S6.2 Assessing canopy fluorescence yield indexes reliability by the mean of canopy fluorescence simulation

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Vegetation plays a fundamental role in the functioning of land surfaces. A better understanding of the interactions between vegetation and atmosphere that would allow predicting the response of vegetation to future climate change is mandatory to design mitigation strategies. In this framework, remote sensing of vegetation mainly focused on the analysis of reflected sunlight in the optical domain to derive canopy biophysical variables. Besides reflectance, chlorophyll fluorescence is very promising since it is widely used to characterize the functioning of photosynthesis at leaf level.
It is well known that the fluorescence yield (i.e. the ratio of the fluorescence flux emitted by a leaf to the absorbed light) is the physical parameter that can be linked to the photosynthetical activity. Although this parameter can be easily determined at leaf level, it is much more complex at canopy level because of the difficulty to accurately estimate the absorbed energy. In fact, the sunlight canopy absorption depends on several factors including three-dimensional structure of the vegetation, sun direction, direct to diffuse ratio and light spectrum. Furthermore, depending on the emitted wavelength, the fluorescence generated at leaf level can be partially reabsorbed by surrounding leaves.
In the frame of passive fluorescence measurements using the filling-in of the O_2-Band and O_2-A bands, we used two fluorescence yield indexes:

– ASFY (apparent spectral fluorescence yield = fluorescence flux / PAR);
– FF (fluorescence fraction = fluorescence flux / reflected flux at a reference wavelength).

The most useful ASFY indexes are the ASFY687 and ASFY760. Similarly the most used FF indexes are FF687 and FF760, where the reference wavelength is 685 nm for both.
In this study we simulate the daily variations of these indexes at canopy level using the FluorSAIL model. We defined a canopy fluorescence yield as the sum of the emitted fluorescence by all leaves divided by the total absorbed sunlight. When the individual leaf fluorescence yield is set constant in time for all leaves, the simulated daily variation of the canopy fluorescence yield is also constant during diurnal cycle within 3 ‰.
Because the canopy fluorescence yield is constant during the diurnal cycle,T to compare the indexes to the canopy fluorescence yield, we just look at their diurnal variability. We simulate different canopy structures, three main FluorSAIL parameters were varied: leaf inclination distribution (χ), leaf area index (LAI) and viewing angle. It was found that, in most cases, fluorescence indexes exhibit significant daily variations, of the order of magnitude of fluorescence yield variations obtained either at leaf or canopy level by active fluorescence measurements (< 20 %). Although this study should encompass more canopy structures fluorescence models, it points out the need of using fluorescence ASFY and FF indexes in a comparative manner (stress situation versus control) rather than as true yield values. However, it is possible that for planophile canopies ($\chi > 2$), with great LAI (> 4) and observing conditions avoiding the hotspot, ASFY and FF show a diurnal variability inferior to 1 %.

S6.3 Analysing the Relation between Solar Induced Fluorescence and Photosynthesis with the SCOPE Model

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We simulated solar induced fluorescence (SIF) in the Oxygen A and B bands for a range of plant functional types (PFTs) with the Soil-Canopy Observations of Photosynthesis and Energy balance

(SCOPE) model. The purpose of the simulations was to understand how SIF and gross primary production (GPP) relate to each other in different biomes.

In the first part of the study, we use measured light and CO_2 response curves of electron transport rate, photosynthesis and fluorescence yields to parameterize and calibrate a leaf photosynthesis and fluorescence yields model. The leaf model uses rate coefficients for the photochemical (Kp) and non-photochemical (Kn) dissipation pathways. Fluorescence yield has a peak at intermediate light saturation and declines both in low light (high Kp) and in conditions where photosynthesis strongly limited by the dark reactions (high Kn), Although variations in the yields were relatively small, the effects of the variations on SIF were not muted when scaling from leaf to canopy with the model SCOPE.

In the second part of the study, the leaf model was embedded in SCOPE, which was then used to simulate the radiative transfer of the emitted fluorescence. We show how the leaf physiology is coupled with the optical properties of leaves in SCOPE.

Monte-Carlo analyses of the model were conducted in parts of the parameter space that correspond to plant functional types of temperate and evergreen deciduous forest, C_3 and C_4 crops and grassland. The model was forced with typical, seasonally varying midday values for weather conditions (ERA-Interim date from ECMWF) in the climatic zones where the PFTs occur. The sensitivity to SIF (in the O_2-A and O_2-B band) and a number of state variables and parameters were evaluated, including GPP, leaf inclination, Leaf Area Index (LAI), Chlorophyll content (Cab), several greenness indices, carboxylation capacity (Vcmax), and stomatal conductance. SIF is most sensitive to irradiance, LAI and Cab. However, with a priori information about these factors, the physiological parameter Vcmax, and hence the light use efficiency of photosynthesis, could be estimated from SIF as well.

S6.4 Steady-State Fluorescence as a Probe of Photosystem II Processes: Observations and Model

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We present a novel functional model of the interactions between PSII fluorescence and photochemistry, and of the resulting link with electron transport and photosynthetic rates.

A lake model of fully interconnected units is assumed for the representation of reaction centres organization. Moving from a standard representation of energy dissipation, an analytical solution is found for the relationship between fluorescence yield, irradiance and photochemistry.

Energy-dependent heat dissipation is the result of pH build-up in the thylakoid lumen and xanthophyll de-epoxidation, arising from electron transport back-regulation by dark photosynthetic processes under CO_2-limited conditions. Under light-limited conditions, the rate constant for energy-dependent heat dissipation (kd) is found to be proportional to electron transport rates.

According to the model, the relationship between fluorescence yield and PSII photochemical yield shows a segmented pattern, with a positive association under CO_2-limited conditions and a negative linear relationship under light-limited conditions. A strong and consistent correlation is predicted between PSII electron transport and fluorescence radiance, which is largely unaffected by nutrition and photosynthetic potentials.

The model has been thoroughly tested against leaf-level measurements under controlled conditions, in response to changes in [CO_2] and light in two contrasting species (Arbutus unedo, Populus x euroamericana).

Finally, the model is discussed in the context of a critical review of alternative leaf-level models of steady-state fluorescence and photochemistry.

S6.5 Angular and Canopy Structure Dependency of Canopy Scale Chlorophyll Fluorescence Simulated by the Newly Developed Three Dimensional Plant Canopy Fluorescence Model

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