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Variations in spatiotemporal averaging and canopy illumination and its impact on the interpretation of SIF and vegetation index observations

Katja Grossmann (1), Jochen Stutz (2), Christian Frankenberg (3), Troy S. Magney (3), Philipp Köhler (3), Fedele S. Colosimo (2), Ulrike Seibt (2), Diego Dierick (4), and André Butz (1)

(1) University of Heidelberg, Institute of Environmental Physics, Heidelberg, Germany (katja.grossmann@iup.uni-heidelberg.de), (2) University of California Los Angeles, Department of Atmospheric and Oceanic Sciences, Los Angeles, California, United States , (3) California Institute of Technology, Pasadena, California, United States, (4) Center for Conservation Biology Riverside, University of California Riverside, California, United States

Solar-Induced Chlorophyll Fluorescence (SIF) is a powerful proxy for photosynthetic activity and spatially and temporally averaged SIF observations are increasingly used to study the carbon cycle in various ecosystems. Leaf-level chlorophyll fluorescence measurements have shown the dependence of photosynthesis on the radiative environment at the leaf-scale. Consequently, canopy SIF measurements are highly sensitive to canopy structure and illumination geometry.

To bridge the gap between leaf-level and canopy averaged SIF observations we deployed our new state-of-the-art tower-based PhotoSpec instrument at different field sites to perform simultaneous co-centered measurements of red and far-red SIF, canopy reflectance, and vegetation indices (VI). A two-dimensional telescope/scanning unit with a narrow field-of-view (0.7°) allows the observation of the long-term spatial distribution of SIF and various VIs in complex canopies. PhotoSpec also includes an additional PAR sensor operated at a one-second time resolution to quantify the variation of solar radiation during the canopy observations.

We present different spatial scanning strategies and the resulting statistical distributions of SIF and various VIs (NDVI, EVI, PRI) for different ecosystems, such as the tropical rain forest of Costa Rica, soybean and corn fields in Iowa, U.S., and the alpine forest at Niwot Ridge, Colorado, U.S. We show strategies to classify the radiative environment in the canopy via direct vs. diffuse solar irradiance or sunlit vs. shaded canopy components. The classification by the radiative transfer conditions gives insight into the variability of photosynthesis in complex canopies under different light conditions. The statistical analysis of this data and its relation to SIF and VIs provides information on the contribution of different canopy locations to the spatiotemporal average of SIF and VI in a canopy.