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Shining light on the structural and functional properties of plant canopies –current status and potential to quantify photosynthesis using optical remote sensing and fluorescence approaches

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Abstract: Imaging spectroscopy is greatly driven by the rapid development in sensor technologies. While a few years ago imaging techniques relied on the use of a few spectral bands, nowadays it became technically feasible to measure a continuous spectrum of light using imaging sensors.

In this presentation we will give an overview on the principles of imaging spectroscopy and highlight basic and advance approaches that are currently used to quantify functional and structural plant and canopy properties in space and time. Special emphasis will be given on the retrieval of the sun-induced chlorophyll fluorescence signal by active and passive methods. Especially passive detection of sun-induced fluorescence was recently emphasized by the selection of a novel satellite mission (FLEX) of the European Space Agency (ESA) that proposed to launch a satellite for the global monitoring of steady-state chlorophyll fluorescence in terrestrial vegetation. This method aims for mapping photosynthetic efficiency by quantifying steady state fluorescence in the so called Fraunhofer lines. In preparation for this satellite mission extensive field campaigns were conducted, providing simultaneous airborne measurements of solar induced fluorescence and CO_2 fluxes. It was combined with extensive ground-based quantification of leaf- and canopy-level processes. The aim was to test if fluorescence signal detected from an airborne platform can be used to improve estimates of plant mediated exchange on the mesoscale. Canopy fluorescence was quantified from airborne platforms using a high resolution spectrometer to quantify fluorescence in the oxygen A band. The multi-scale design of the airborne radiometric measurements along with extensive ground activities fosters a nested approach to quantify photosynthetic efficiency and gross primary productivity (GPP) from passive fluorescence. Linking these results with ecosystem flux measurements and regional carbon modeling shows the way how direct quantification of photosynthesis may reduce uncertainties to predict plant mediated exchange processes.

Keywords: photosynthetic efficiency; sun-induced fluorescence; imaging spectroscopy; high resolution spectroscopy; plant mediated exchange processes; plant stress