Abstract

Gross primary productivity (GPP) is an important parameter to quantify carbon fixation by plant ecosystems. To determine GPP at different spatial scales, remote sensing (RS) offers the unique possibility to provide information from local to global scales. Attempts to estimate GPP from RS data focus on the light-use efficiency (LUE) concept of Monteith that relates GPP to the absorbed photosynthetically active radiation and the efficiency of plant canopies to utilize the absorbed radiation for photosynthesis. To reliably predict GPP at different spatio-temporal scales, LUE has to be linked to optical remote sensing parameters that detect variations in photosynthetic efficiency as a result of changes in environmental conditions.

In this study two optical remote sensing parameters were investigated for their potential to serve as a proxy for LUE: the sun-induced fluorescence yield derived from the oxygen absorption O_2-A band at 760 nm (Fs_{760}-yield) and the photochemical reflectance index (PRI). Both parameters were derived from two ASD FieldSpec spectrometers that were operated in parallel, one above the vegetation canopy of either a winter wheat or a sugar beet field and one from a small research aircraft. Based on the LUE concept of Monteith GPP was calculated on a diurnal basis including optical parameters derived from ground observations and compared to simultaneously acquired GPP data from the eddy covariance method. The results showed that the diurnal response of physiological regulation of photosynthesis to changing environmental conditions could be tracked reliably with the Fs_{760}-yield or a combination of the Fs_{760}-yield and the PRI.

Moreover, the airborne observations were used to characterize the spatial variations of Fs_{760}-yield, PRI and GPP of different fields at a regional observation site over the course of a day. Results of this spatio-temporal investigation revealed a significant variability of GPP between different winter wheat fields compared to the within-field variability. For sugar beet the results also showed an increase of the within-field variability in the afternoon in addition to the significant between-field variability. It could be shown that optical RS parameters are sufficiently sensitive to detect a reduction of photosynthetic CO_2 uptake due to stomatal closure. In the sugar beet canopy this regulation of photosynthesis caused a reduction of GPP in the afternoon ranging from 25 % to 33 % in comparison to maximum GPP values in the morning.