Assimilation of remotely sensed fluorescence data into the land-surface model CLM4

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ABSTRACT

The most important exchange process of CO_2 between the atmosphere and the land-surface is photosynthesis. Therefore, the prediction of vegetation response to increasing atmospheric CO_2 concentrations is crucial for a reliable prediction of climate change. Photosynthesis is a complex physiological process that consists of numerous bio-physical sub-processes and chemical reactions. Spatial and temporal patterns of photosynthesis depend on dynamic plant-specific adaptation strategies to highly variable environmental conditions.

Photosynthesis can be estimated using land-surface models, but, while state-of-the-art models often rely on plant specific constants, they poorly simulate the dynamic adaptation of the physiological status of plant canopies. Another way to estimate photosynthesis is the measurement of sun-induced chlorophyll fluorescence (SICF). Several studies over the last decade have demonstrated that SICF is a promising proxy to estimate the diurnal dynamic vitality of the photosynthetic apparatus at both the leaf and canopy levels. Recent studies have shown, that the weak SICF signal is also detectable from air- and space-borne sensors. Time series of SICF can already be derived from ground based measurements and first spatial maps from air- and space-borne sensors are available. It is expected that in the preparation of the European satellite mission FLEX further spatial and temporal data sets will become available. Although, it is not possible to derive data sets that have a diurnal and spatial resolution at the same time, spatial data sets could be used to update certain model

parameters that are normally set as constants. This will result in a better simulation of plant-specific adaptation strategies.

In this study we focus on the retrieval of the maximum rate of carboxylation (V_{cmax}), by implementing the SICF signal into the photosynthesis module of the Community Land Model 4 (CLM4; http://www.cgd.ucar.edu/tss/clm), which is based on the Farquhar model. V_{cmax} varies strongly between and within Plant Functional Types (PFTs) and even within a species. Furthermore, V_{cmax} is one of the most sensitive parameters in CLM4. Therefore, a reliable mapping of different V_{cmax} parameter would result in a more realistic simulation of photosynthesis.

Within the framework of the Transregio32 project (www.tr32.de) we installed automated hyperspectral fluorescence sensors at an agricultural site (winter wheat) in the Rur catchment area in west Germany at the end of July 2012. Later, at end of August, measurements on a nearby temperate grassland site (riparian meadow) and on a sugar beet field followed. The sensors recorded diurnal time series of SICF in the footprint of eddy covariance towers. Spatial SICF data of the region will be available from measurement by the air-borne hyperspectral FLEX sensor in August 2012. Based on these diurnal and spatial data we validate and discuss different approaches to derive V_{cmax} and its implementation into the photosynthesis module of CLM4.