Assimilation of remotely sensed fluorescence data into the landsurface model CLM4

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1. Motivation

Up to 90 **%** of land-atmosphere CO_2 exchange is related to **photo-synthesis** (Ozanne et al. 2003), which depends on dynamic plant-specific adaptation strategies to environmental conditions.

Land surface models, such as **Community Land Model** 4 (CLM4) predict carbon and water fluxes at various temporal and spatial scales.

State-of-the-art models often rely on **plant specific constants** and therefore **poorly simulate the dynamic adaptation** of the physiological status.

The overall objective of this study is to implement **sun-induced chlorophyll fluorescence** (SIFC) observations as a proxy for the dynamics of plant physiological adaptation in CLM4.

2. Study Area

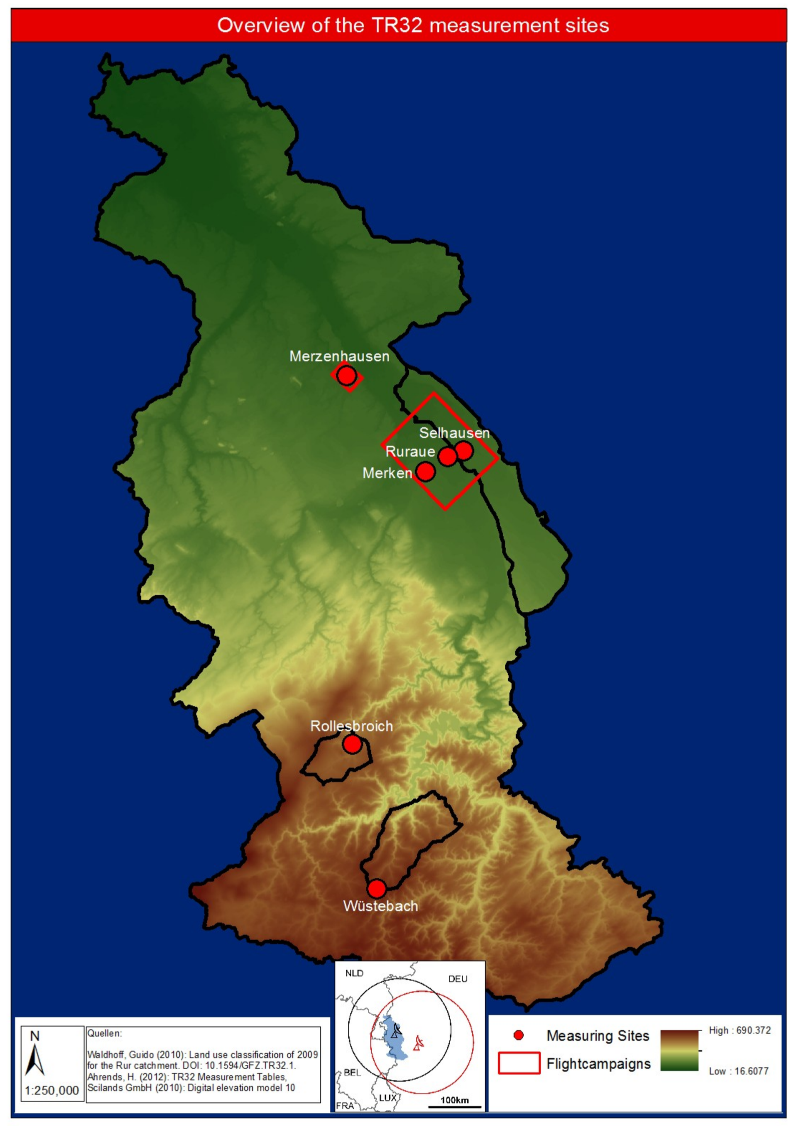


Figure 1: Measurement sites in the Rur catchment, Germany

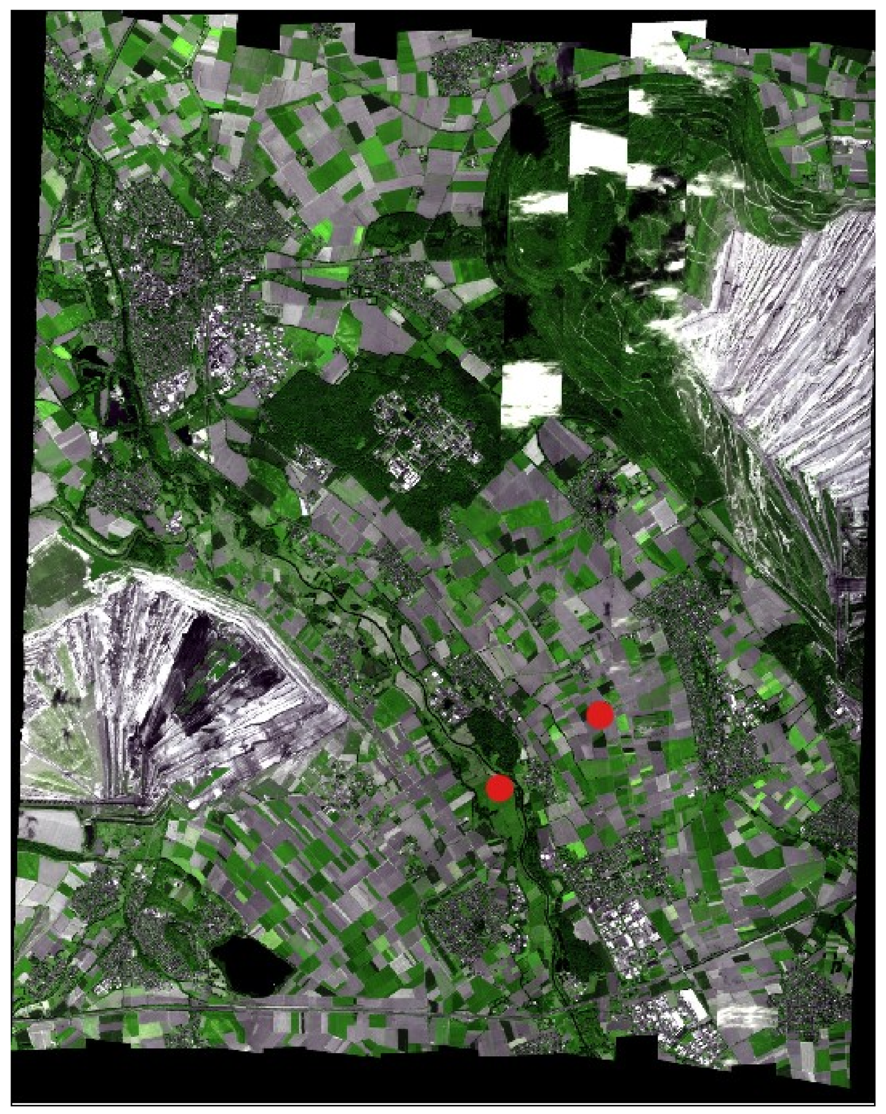


Figure 2: Aerial Image of the study area (10 x 10 km) with 3 m resolution. The Image was taken during an aircraft campaign in end of August 2012. The red dots show the locations of ground measurement sites

Study area is the Rur Catchment in western Germany (Fig. 1). Five established **TR32** research sites are equipped with **eddy covariance (EC) stations**, which provide continous measurements of carbon dioxide and water vapour exchange.

Main landuse types are **sugar beet**, **winter wheat** and **temperate grassland**.

3. Material & Methods

SICF is physically connected to photosynthesis (Fig. 3) and can be used to **estimate Gross Primary Productivity (GPP)** (Schickling et al. 2012) (Fig. 6).

SICF data is obtained from **aircraft campaigns** (2012, 2013) with a novel fluorescence imager application (**HYPLANT**) (see Fig. 2 for a sample aerial image) and from ground-based continous measurements of SICF.

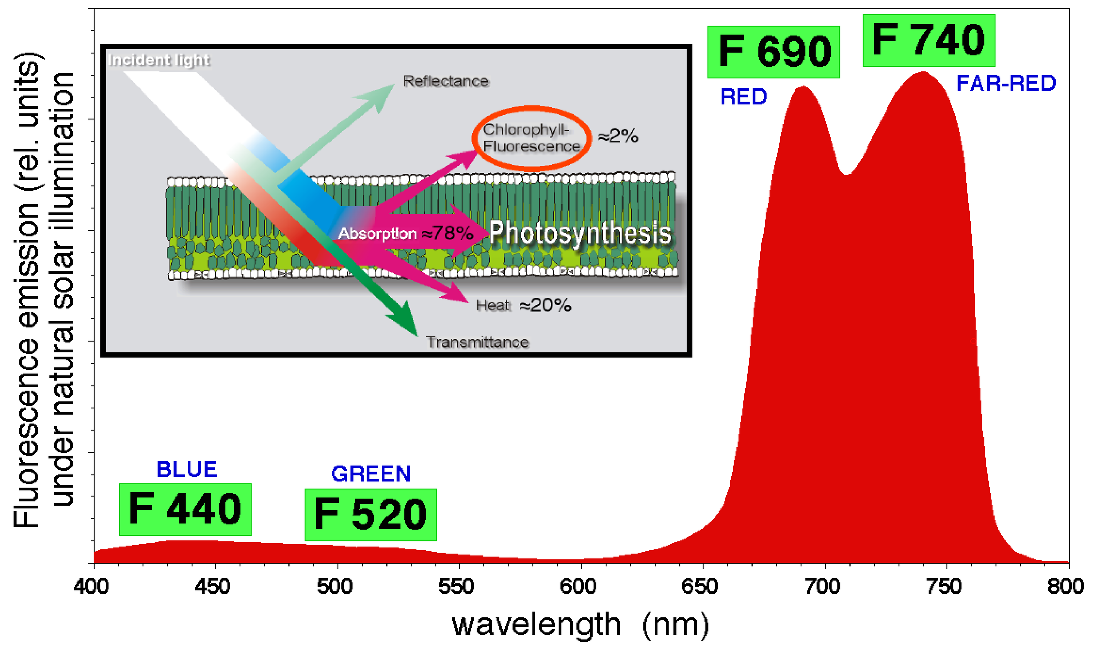
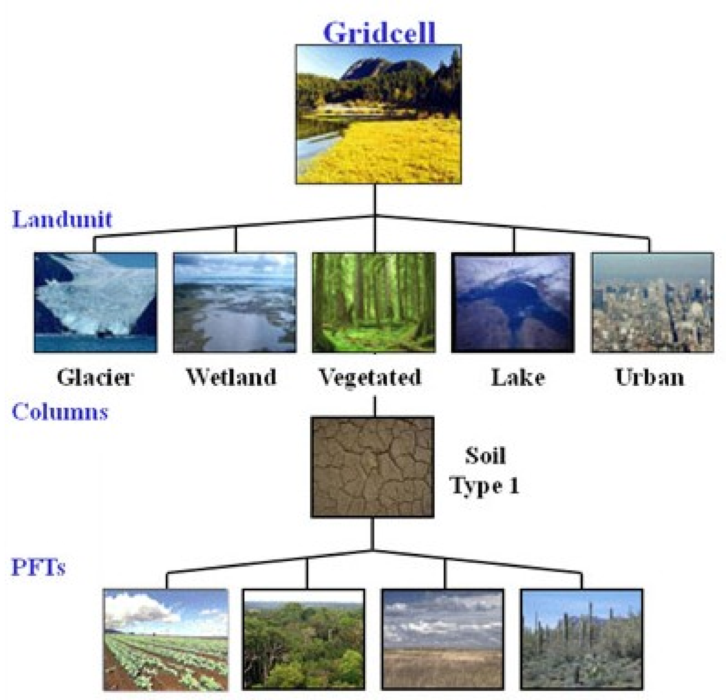


Figure 3: Fractionation of incident light on a plant leaf and fluorescence emissionspectra
Source: changed after C. Buschmann (oral presentation)

SICF will be used to adapt plant-specific constant model parameters. Suitable parameters:

1. **maximum rate of carboxylation** (V_{cmax})
2. **Quantum use efficiency** (α)



The novel spatial datasets of these parameters will be implemented in the CLM4 photosynthesis model (based on **Farquhar** et al., 1980).

Model runs will be performed on a spatial resolution of 30 m for a 10km x 10km area (111,556 gridcells).

This high resolution will **prevent upscaling errors** which could occure due to CLM4 surface representation (Fig. 4).

Figure 4: Surface representation of the CLM (CLM4; http://www.cgd.ucar.edu/tss/clm)

6. Preliminary results and outlook

SICF measurements allow the estimation of GPP with high accuracy (diurnal cycle dynamics) (Fig. 5&6).

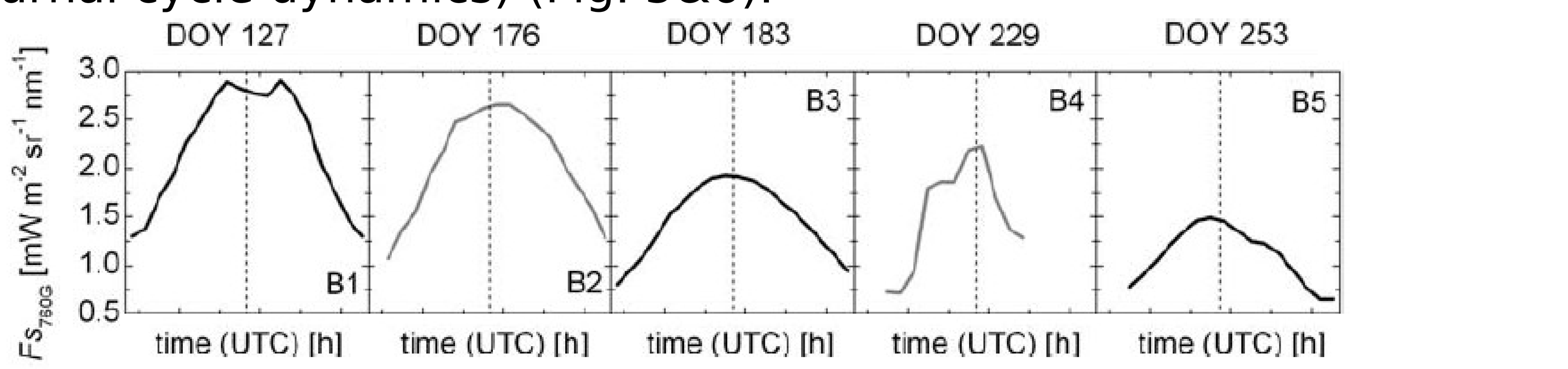


Figure 5: Diurnal behaviour of fluorescence for winter wheat (DOY 127, 176) and for sugar beet (DOY 183, 229, 253) in 2009 (Schickling, 2012)

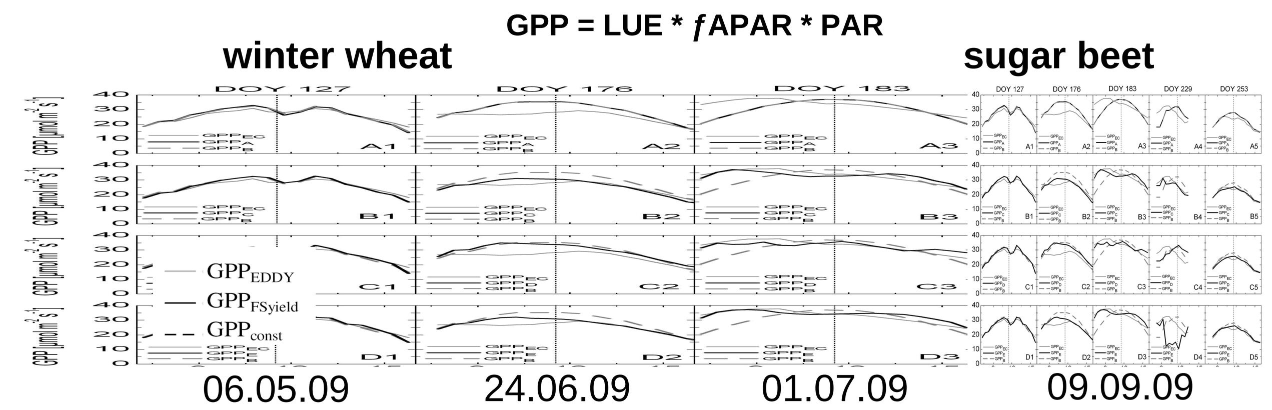


Figure 6: modeling of GPP based on SICF measurements (Schickling, 2012)

The **diurnal pattern** of the observed net ecosystem exchange was satisfactorily predicted by CLM4 (Fig. 7&8).

However, uptake of carbon dioxide is strongly underestimated (Fig. 7&8).

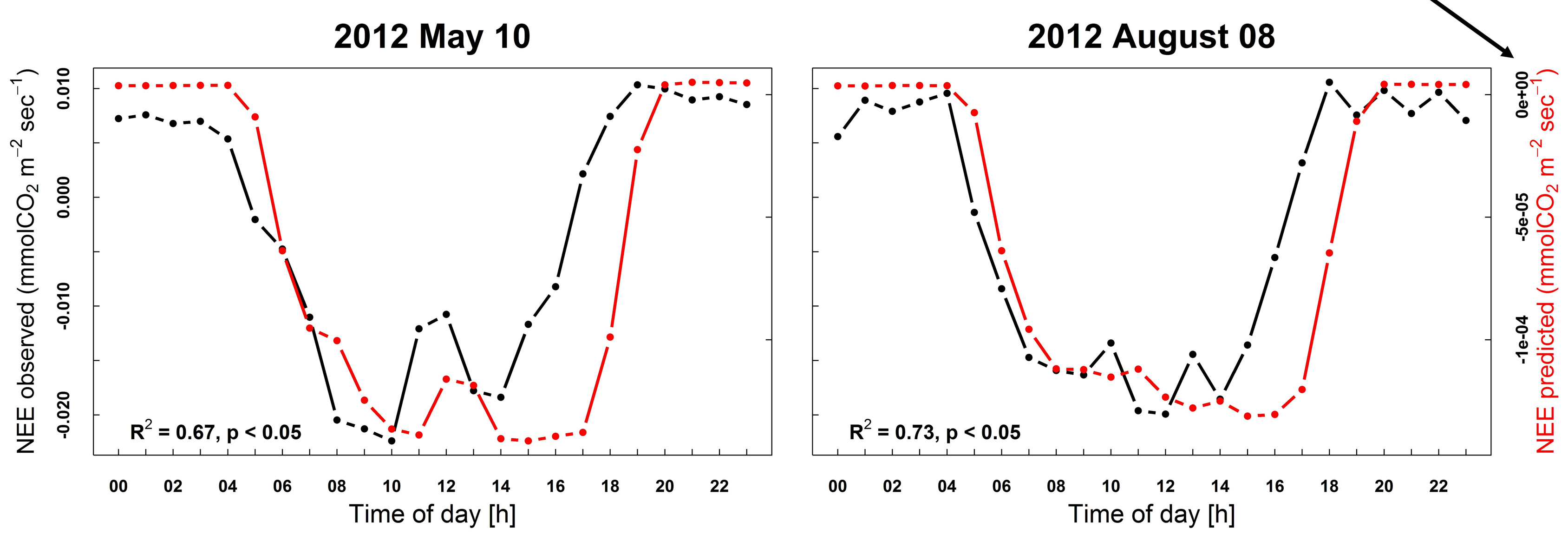


Figure 7 and 8: first comparison of modeled (red line) and measured (black line) net ecosystem exchange (NEE) with the unmodified CLM4

In the next steps CLM4 will be **validated** and **evaluated** on the basis of **EC measurements,** and the SICF data will be assimilated for an **improved simulation of CO_2 fluxes**.

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Schickling, A. et al. (2012): Remote sensing of sun-induced fluorescence for improved modeling of of gross primary productivity in a heterogeneous agricultural area, Ph.D. dissertation, University of Cologne.

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