Geophysical Research Abstracts
Vol. 16, EGU2014-5336, 2014
EGU General Assembly 2014

Utility of Landsat-based leaf chlorophyll and leaf area index estimates for constraining model simulations of CO_2 exchange in a heterogeneous agricultural landscape

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Leaf area index (LAI) and leaf chlorophyll content (C_{ab}) are key biophysical and biochemical variables in controlling energy, water and carbon exchange in the soil-vegetation-atmosphere continuum. LAI is an indicator of vegetation density and phenology. Chlorophyll is an important photosynthesizing pigment in living leaf tissue, and C_{ab} may serve as a useful proxy for photosynthetic capacity, which is typically parameterized in terms of the maximum rate of caboxylation (V_{cmax}) in process-based land surface models. Hence, it is essential to obtain accurate estimates of the two variables when modeling carbon fluxes in terrestrial ecosystems. Both exhibit great temporal and spatial variation in response to climate, phenology, species type, and agricultural management. As a leaf-scale parameter, V_{cmax} is very difficult to prescribe in space and time and land surface models (LSM) commonly assume constant broad plant functional type specific values, only set to vary as a function of temperature. However, this does not reflect the real nature of this property. Candidate techniques utilizing remotely sensed data in the visible to near-infrared spectrum may be employed to retrieve this information in order to better represent the spatio-temporal variability in key photosynthetic model controls.

The present study applies the REGularized canopy reFLECtance (REGFLEC) model for retrieving C_{ab} and LAI from time-series Landsat-7 and 8 data over a highly heterogeneous agricultural landscape in Denmark. During the 2013 growing season, C_{ab} (SPAD) and LAI measurements were conducted at a barley field, which represent the most common crop in the region. A SPAD-C_{ab} relation was established by destructive leaf sampling and estimation of C_{ab} in the laboratory, and the in-situ C_{ab} was related to V_{cmax} inferred from the literature. REGFLEC vegetation retrievals were evaluated against the field measurements, and the generated maps of LAI and C_{ab} (translated into V_{cmax}) were used as input to the Community Atmosphere Biosphere Land Surface Model (CABLE) for simulations of carbon exchange between the land surface and the atmosphere at sub-field scale resolution. The model simulations were validated against eddy covariance CO_2 flux data measured at the barley field site. A key objective of this research is to utilize the functional links between leaf chlorophyll and photosynthetic capacity, and to evaluate the benefit of remote sensing techniques for model parameterization and reducing uncertainties of model predicted carbon fluxes.