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# Modelling the phenology and carbon budget of major crops at the field scale, supported by remote sensing data

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Reducing uncertainties involved in estimating the carbon balance of croplands, which are most directly, intensively and continuously affected by human intervention (i.e. land-use), is an important step towards more precisely evaluating the overall terrestrial carbon balance. Human appropriation of the land surface and its production has direct consequences on issues such as the sustainability of ecosystem services and biogeophysical as well as biogeochemical parameters of affected areas. Moreover, cropland management and phenology explains a major component of the seasonality of carbon fluxes between the terrestrial biosphere and the atmosphere of agricultural regions. To address key research questions, crop functional types (CFTs) along with land management issues, need to be considered within state-of-the-art land surface models.

In this study, we embedded a crop modelling approach within the Soil-Plant-Atmosphere model (SPA) in order to build a true cropland carbon mass balance model with an explicit carbon allocation and storage pattern. SPA is a process-based model that simulates ecosystem photosynthesis and water balance at fine temporal and spatial scales and has been intensively applied to and tested against natural ecosystems and their observed carbon fluxes. Here, new carbon pools (root, leaf, stem, storage organ) have been introduced into SPA and linked with a new dynamic carbon allocation pattern, which further allows for the remobilization of carbohydrates. The crop modelling philosophy in terms of assimilates partitioning and crop development is based on Penning de Vries et al., with the simulation of crop developmental rate further having been refined using a modified Wang and Engel model. SPA now realistically simulates the carbon fluxes and stocks, evolution of LAI, phenology and evapotranspiration for three major crop types (winter/spring wheat and barley, maize).

We compared modelled values of carbon fluxes against observations measured at the CarboEurope site at Auradé, France for winter wheat sown in autumn 2005 (DOY 300). We show a significant correlation between predicted and observed rates of daily carbon exchange ($R^2$ = 0.76) using the eddy covariance measurement technique and evapotranspiration ($R^2$ = 0.73) for the entire growing period from sowing until harvest in 2006 (DOY 180). These results further show that SPA is able to represent the seasonal cycle of NEE with high accuracy, whose onset is mainly a function of temperature (winter crops) and/or sowing date (predominantly spring crops). Moreover, time series of remotely sensed data (MODIS 250m) will be used to further constrain and upscale the model in terms of land management and crop phenology by 1) extraction of land management signals and 2) assimilation using the Ensemble Kalman Filter (EnKF).