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Crop biomass and evapotranspiration estimation using SPOT and Formosat-2 Data

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The use of crop models allows simulating plant development, growth and yield under different environmental and management conditions. When combined with high spatial and temporal resolution remote sensing data, these models provide new perspectives for crop monitoring at regional scale.

We propose here an approach to estimate time courses of dry aboveground biomass, yield and evapotranspiration (ETR) for summer (maize, sunflower) and winter crops (wheat) by assimilating Green Area Index (GAI) data, obtained from satellite observations, into a simple crop model.

Only high spatial resolution and gap-free satellite time series can provide enough information for efficient crop monitoring applications. The potential of remote sensing data is often limited by cloud cover and/or gaps in observation. Data from different sensor systems need then to be combined. For this work, we employed a unique set of Formosat-2 and SPOT images (164 images) and in-situ measurements, acquired from 2006 to 2010 in southwest France.

Among the several land surface biophysical variables accessible from satellite observations, the GAI is the one that has a key role in soil-plant-atmosphere interactions and in biomass accumulation process. Many methods have been developed to relate GAI to optical remote sensing signal. Here, seasonal dynamics of remotely sensed GAI were estimated by applying a method based on the inversion of a radiative transfer model using artificial neural networks.

The modelling approach is based on the Simple Algorithm for Yield and Evapotranspiration estimate (SAFYE) model, which couples the FAO-56 model with an agro-meteorological model, based on Monteith's light-use efficiency theory. The SAFYE model is a daily time step crop model that simulates time series of GAI, dry aboveground biomass, grain yield and ETR.

Crop and soil model parameters were determined using both in-situ measurements and values found in the literature. Phenological parameters were calibrated by the assimilation of the remotely sensed GAI time series. The calibration process led to accurate spatial estimates of GAI, ETR as well as of biomass and yield over the study area (24 km x 24 km window).

The results highlight the interest of using a combined approach (crop model coupled with high spatial and temporal resolution remote sensing data) for the estimation of agronomical variables. At local scale, the model reproduced correctly the biomass production and ETR for summer crops (with relative RMSE of 29% and 35%, respectively). At regional scale, estimated yield and water requirement for irrigation were compared to regional statistics of yield and irrigation inventories provided by the local water agency. Results showed good agreements for inter-annual dynamics of yield estimates. Differences between water requirement for irrigation and actual supply were lower than 10% and inter-annual variability was well represented as well. The work, initially focused on summer crops, is being adapted to winter crops.