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Estimation of crops biomass and evapotranspiration from high spatial and temporal resolutions remote sensing data

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Carbon and water cycles are closely related to agricultural activities. Agriculture has been indeed identified by IPCC 2007 report as one of the options to sequester carbon in soil. Concerning the water resources, their consumptions by irrigated crops are called into question in view of demographic pressure. In the prospect of an assessment of carbon production and water consumption, the use of crop models at a regional scale is a challenging issue. The recent availability of high spatial resolution (10 m) optical sensors associated to high temporal resolution (1 day) such as FORMOSAT-2 and, in the future, Venμs and SENTINEL-2 will offer new perspectives for agricultural monitoring. In this context, the objective of this work is to show how multi-temporal satellite observations acquired at high spatial resolution are useful for a regional monitoring of following crops biophysical variables: leaf area index (LAI), aboveground biomass (AGB) and evapotranspiration (ET).

This study focuses on three summer crops dominant in South-West of France: maize, sunflower and soybean. A unique images data set (82 FORMOSAT-2 images over four consecutive years, 2006-2009) was acquired for this project. The experimental data set includes LAI and AGB measurements over eight agricultural fields. Two fields were intensively monitored where ET flux were measured with a 30 minutes time step using eddy correlation methods.

The modelisation approach is based on FAO-56 method coupled with a vegetation functioning model based on Monteith theory: the SAFY model [5]. The model operates at a daily time step model to provide estimates of plant characteristics (LAI, AGB), soil conditions (soil water content) and water use (ET). As a key linking variable, LAI is deduced from FORMOSAT-2 reflectances images, and then introduced into the SAFY model to provide spatial and temporal estimates of these biophysical variables. Most of the SAFY parameters are crop related and have been fixed according to literature investigation. The remaining parameters are affected by crop management practices and describe the biomass-to-leaf partitioning and the leaf senescence phase, the day of emergence and the Effective light-use efficiency. These parameters have been calibrated through optimisation method on the basis of remotely sensed LAI time series. Soil related parameters are deduced from soil texture analyses. The model is evaluated and validated at both local scale (including in-situ measurements on eight agricultural fields) and regional scale (over a 24 x 24 km^2 area where more than 2,000 are analysed).

The SAFY model is well designed to reproduce the time-course of LAI. Mean residual error of calibration step obtained on the whole FORMOSAT-2 scene is 0.2 m2.m-2. A good agreement was also found between estimated and measured biomass (RRMSE = 30 %). Preliminary analyses show that the ET is reproduced for two experimental fields equipped with flux towers. Dynamic of bare soil period and vegetation period are decently reproduced. However, simulation are underestimated (bias = -0.29) and presents important scattering (R^2 = 0.65). Additional calibration analyses will be performed, especially on soil physical characteristics. On irrigated crops (maize and soybean), the model uses an automatic irrigation mode which simulated amount of irrigated water supply. At a regional scale, estimated amount of irrigation will be compared to water use decelerated by the farmers and regional statistics on water pumping over a watershed located inside the study area.