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Estimation of yield and water requirements of maize crops combining high spatial and temporal resolution images with a simple crop model, in the perspective of the Sentinel-2 mission

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Water resources are under increasing pressure as a result of global change and of a raising competition among the different users (agriculture, industry, urban). It is therefore important to develop tools able to estimate accurately crop water requirements in order to optimize irrigation while maintaining acceptable production. In this context, remote sensing is a valuable tool to monitor vegetation development and water demand. This work aims at developing a robust and generic methodology mainly based on high resolution remote sensing data to provide accurate estimates of maize yield and water needs at the watershed scale.
Evapotranspiration (ETR) and dry aboveground biomass (DAM) of maize crops were modeled using time series of GAI images used to drive a simple agro-meteorological crop model (SAFYE, Duchemin et al., 2005). This model is based on a leaf partitioning function (Maas, 1993) for the simulation of crop biomass and on the FAO-56 methodology for the ETR simulation. The model also contains a module to simulate irrigation.
This study takes advantage of the SPOT4 and SPOT5 Take5 experiments initiated by CNES (http://www.cesbio.ups-tlse.fr/multitemp/). They provide optical images over the watershed from February to May 2013 and from April to August 2015 respectively, with a temporal and spatial resolution similar to future images from the Sentinel-2 and VENμS missions. This dataset was completed with LandSat8 and Deimos1 images in order to cover the whole growing season while reducing the gaps in remote sensing time series. Radiometric, geometric and atmospheric corrections were achieved by the THEIA land data center, and the KALIDEOS processing chain. The temporal dynamics of the green area index (GAI) plays a key role in soil-plant-atmosphere interactions and in biomass accumulation process. Consistent seasonal dynamics of the remotely sensed GAI was estimated by applying a radiative transfer model based on artificial neural networks (BVNET, Baret,Weiss et al.). This tool allows using multiple sensors at different view angles while removing sensor and acquisition artifacts.
Simultaneously, in situ data such as GAI, DAM, final grain yield, soil humidity and irrigation rates were collected over a set of plots allowing to sample the heterogeneity of the entire watershed. ETR fluxes were also measured continuously over maize crops in the Lamasquère (CESBIO) experimental site (http://fluxnet.ornl.gov/site/477).
Preliminary results show that the model reproduced correctly the final yield at both local and regional scale and for different years. It was also tested in a predictive mode with quite good results. The model is also able to provide good estimates of ETR. The results highlighted the capacity to take into account the effect of water stress and irrigation on DAM. This approach combined with Sentinel-2 mission can offer a great opportunity for operational applications such as optimization of crop water management over large areas.