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Quantification of Yield, Water, and Carbon budget at intra-field scale using the AgriCarbon-EO tool

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Achieving the United Nations Sustainable Development Goal 2 that addresses food security and sustainable agriculture requires the promotion of readily transferable and scalable agronomical solutions. The combination of high-resolution remote sensing data, field information, and physical models is identified as a robust way of answering this requirement. Here, we present the AgriCarbon-EO tool, a decision support system that provides the yield, biomass, water and carbon budget components of agricultural fields at a 10m resolution and at a regional scale. The tool assimilates high resolution optical remote sensing data from Copernicus Sentinel-2 satellites into a radiative transfer model and a crop model. First, the application of a spatial Bayesian retrieval approach to the PROSAIL radiative transfer model provides Leaf Area Index (LAI) with its associated uncertainty. Second, LAI is assimilated into the SAFYE-CO2 crop model using a temporal Bayesian retrieval that enables the calculation of the yield, biomass, carbon and water budgets components with their associated uncertainties. In addition to remote sensing data, input datasets of crop types, weather and soil data are used to constrain the system. The concise weather data is provided from local weather stations or weather forecasts and is used to force the crop model (SAFYE-CO2) dynamics. The soil data are used in two folds. First to better parametrize the soil emissions in the radiative model retrievals and second to parametrise the water infiltration in the soil module of the crop model. The AgriCarbon-EO tool has been optimized to enable the computation of the yield, carbon, and water budget at high spatial resolution (10m) and large scale (100km2). The model is applied over the South-West of France covered by 3 Sentinel-2 tiles for major crops (wheat, maize, sunflower). The outputs are validated over experimental plots for biomass, yield, soil moisture, and CO2 fluxes located all in the South-West of France. The experimental sites include the FR-AUR and FR-LAM ICOS sites and 22 cropland fields (biomass sampling). The validation exercise is done for the 2017-2018 and 2019-2020 cultural years. We show the added value of the use of high resolution in driving the crop model to take into account the impact of complex processes that are embedded in the LAI signal like vegetation water stress, disease, and agricultural practices. We show that the system is capable of providing the yield, carbon, and water budget of major crops accurately. At the regional scale, we give global estimates of the carbon budget, water needs, and yields per crop type. We present the impact of intra-plot heterogeneity in the estimation of yield and the annual carbon and water budget showing the added value for high-resolution intra-plot modeling.