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Proposition for a methodological framework and prototype MRV tool for cropland C stock change assessment at high resolution over large regions

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Abstract:
Increasing soil organic carbon (SOC) stocks is a well-identified climate change mitigation solution. However, accurate and extensive estimation of cropland SOC stock changes for National Inventories, for the Common Agricultural Policy or for the voluntary carbon market with in-situ measurements exclusively would be too costly. For this reason, soil or coupled plant/soil models are often used to quantify SOC stock changes but these models make many simplifying assumptions and lack accuracy when assessing the effect of the spatial variability in biomass production on SOC stock changes. This effect can be substantial when considering for instance cover crops. Therefore, Paustian et al. (2019, DOI:10.1080/17583004.2019.1633231) and Smith et al. (2020, DOI: 10.1111/gcb.14815) have proposed theoretical frameworks for the Monitoring, Reporting and Verification (MRV) of agricultural SOC stock changes relying on the combination of high-resolution remote sensing data, field information, and physical models. However, there is still no clear methodological framework nor set of tools that would allow to consistently monitor SOC stock changes in those different contexts following those theoretical frameworks.

For this reason, the ORCaSa project has proposed a methodological framework for MRV and a prototype of Operational Processing Chain (OPC) for cropland. We present here both the methodological framework and the AgriCarbon-EO OPC that provides the yield, biomass, water and carbon budget components of agricultural fields at 10m resolution and at regional scale. The OPC has been optimized to assimilate high resolution optical remote sensing data (Sentinel-2 and Landsat-8) into a radiative transfer model and a coupled crop/soil 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 for each date of satellite acquisition in clear conditions. Second, LAI is assimilated into the SAFYE-CO2 crop model using a temporal Bayesian retrieval that enables the calculation of the yield, biomass, CO_2 and water fluxes components with their associated uncertainties. Next the biomass that returns to the soil simulated by SAFYE-CO2 is used as an input in the AMG soil model. AgriCarbon-EO was applied over the South-West of France covering three Sentinel-2 tiles for major crops (wheat, maize, sunflower) and cover crops. The outputs were validated for several cropping years with independent in-situ biomass, yield and CO_2/water fluxes data measured at several flux towers in Europe. We show the added value of assimilating high-resolution satellite data in driving the crop/soil models to account for the impact of complex processes that are embedded in the LAI signal (e.g. vegetation water stress, disease, and agricultural practices) on the yield, biomass and carbon/water budgets components estimates.