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Comment on gi-2021-21

Anonymous Referee #2

Referee comment on "Towards agricultural soil carbon monitoring, reporting, and verification through the Field Observatory Network (FiON)" by Olli Nevalainen et al., Geosci. Instrum. Method. Data Syst. Discuss., https://doi.org/10.5194/gi-2021-21-RC2, 2021

The paper "Towards agricultural soil carbon monitoring, reporting and verification through Field Observatory Network (FiON)" presents the Field Observatory Network (FiON) that aims at establishing a unified methodology towards monitoring and forecasting of agricultural carbon sequestration by combining offline and near real-time field measurements, weather data, satellite imagery, modeling and computing networks.

General comments:

The paper is overall well written and some components of the observatory such as the multi-actor approach and the online service for near real-time model-data synthesis and decision support for the farmers are very valuable. However, several aspects of the methodology needs to be clarified and I didn't really see the added value of the forecasting system for improving carbon storage as the forecasting methodology is limited to 15 days. More problematic, I consider that the approach suffers from critical flaws concerning both the modeling approach and the in-situ monitoring. Therefore, I do not recommend this article for publication.

Specific comments:

My main concern is that the modelling approach doesn't seem to be mature and it has not proved its ability to simulate the carbon budget components (biomass, biomass restitution to the soil, CO_2 fluxes, carbon budget) in the context of this observatory. More generally, I

have strong doubts concerning the scalability of this modelling approach. First, the modelling approach should be described more in details. For instance, are simulations done at 10m resolution by assimilating LAI time series to account for spatial variability in vegetation development which can be quite significant even within a field? How is remote sensing used to calibrate the model exactly? Which parameters are calibrated? Is the calibration procedure parcimonious? Also it is obvious that the model will perform better for simulating LAI and CO_2 fluxes when those variables are used for calibration! But what will be the capacity of the model to simulate not only the net CO_2 fluxes but also the other components of the C budget when CO_2 is not used for calibration (i.e. at all the ACA sites or even at larger scale)? More generally, what is the plan for applying this approach to sites not equipped with EC? What would be the accuracy of the model then to simulate the C budget components? What is the plan for validating the other C budget components (e.g. biomass) or the C budget itself when upsacling or applying the model at the ACA sites? Indeed I really doubt that soil sampling strategy will allow to validate the C budget estimates from the model at the ACA sites and it won't be feasible at the flux sites. Indeed:

- Given the soil sampling methodology described p7 I have strong doubts concerning the ability to detect SOC stock changes at the ACA sites which is the main objective of the FiON observatory. Indeed, many studies showed that between hundreds and thousands of samples are needed to detect changes in SOC stocks at a few years of intervals. See for instance the soil sampling protocols at the ICOS flux tower sites.
- The eddycovariance (EC) setups do not allow to quantify annual CO2 fluxes nor annual C budgets at the Qvidja and Ruukki sites. Indeed, it is written p8 line 45 that the height of eddycovariance (EC) setup at the Qvidja was installed at 2.3 m height, (in Figure 1 this measurement height seems even lower). However, when a distance of 2m between the EC setup and the canopy is not respected, there is a strong risk of underestimation of the CO_2 Figure 1 shows that this minimum distance is clearly not respected. Also, from what is written lines 45-46, I understand that measurements are not performed over a whole cropping year at the Ruukki site (they start on June 13 2019 and end on November 4th 2019) meaning that 1) it is not possible to evaluate the plot annual C budget and 2) it is not possible to evaluate the model's ability to simulate soil respiration outside the cropping period.

Another concern is that the method (SEN2CORE, see P 10 line 102) for detecting clouds and could shadows for the L2A S2 data on the GEE is based on a monodate approach meaning that the performance for cloud detection is not optimal compared to methods based on multitemporal approaches (e.g. MAJA processing chain): the consequence is that NDVI and LAI time series may be quite noisy reducing the accuracy of the modelling approach relying on the use of remote sensing products times series. Also, why considering NDVI which is known for saturating when the vegetation is well developed (meaning that the vegetation development may be underestimated)?

Then the following points need clarifications:

- P7 lines 10-12: it is written "At ACA sites, the measurements are done at three, static measurement points per field. The points have c.a. 30-100 m distance from each other and are located on a transect line. They were located to cover the variability of the field and cover similar soil conditions in both the test and control plots". Which variability are the authors referring to? Soil properties I assume but which soil properties where considered? SOC content ? Depth ? Texture…? Also what does "similar soil conditions" means exactly? A quantitative analysis should be provided.
- P7 line 12: Please describe the sampling procedure (depth, method for sampling, i.e. core or other…)? An appropriate soil sampling methodology is critical for estimating SOC stock changes
- P8 section 3.2: it is not clear how those measurements will be used to monitor changes in SOC stocks (especially O_2 and CO_2 concentrations in the soil). Also please provide information on the model of the O_2 and CO_2 instruments and information on the depth of measurements?
- P9 line 69: I don't understand this sentence. Does it mean that different gapfilling methods are used depending on the size of the gap in the observations?
- P9 line 75: I don't understand the sentence "For gap-filling, the data are divided into blocks based on the harvest dates…". Please be more explicit.
- P10 line 88: where does this "Emod" comes from? No mention of a modelled NEE before
- P10-11, Section 3.5: Why standardizing cumulative NDVI sums? Also does it really make sense to consider fixed starting/ending dates for growing seasons because of inter-annual variability and North/South gradients for the sites which means that the growing seasons are probably not synchronous. Last, why computing both LAI and NDVI? This point should be clarified.
- P11 line 113: what is the justification for multiplying the associated uncertainties by 1.645?
- P11 line 118: what do you mean by observational uncertainty?

Technical corrections:

P2 line 35: the authors state that "Carbon farming practices include methods, such as reduced soil disturbance (reduced or zero tillage)…" while recent meta-analysis showed that soil work mostly act on the SOC

P4 in Table 1: change "Crops planted to lengthen photosynthetically active period and to increase carbon assimilation, carbon and root inputs and to reduce leaching of carbon and

nutrients.” by “Crops planted to lengthen photosynthetically active period and to increase carbon assimilation, carbon inputs through aboveground and belowground biomass and to reduce leaching of carbon and nutrients. ». Also, the statement relative to soil amendment “Exogenous carbon input. In addition may stimulate plant growth throughincreased water holding capacity, nutrients, etc.” is also true for cover crops or any practices allowing SOC stock increases.

P4 line 92: replace “fluxes and weather(see Sect. 3).” by “fluxes and weather (see Sect. 3).”