Dear Referee1,

In addition to our clarifications that were sent in the previous reply, and in order to specify our answers to the two main criticisms, that are the perceived disconnection of the manuscript from the subject of agro-ecosystem carbon budgets as well as its length.

First, concerning the relevance of the study regarding carbon budgets, we provide the following elements:

The annual carbon budget for croplands that represents the amount of organic C gain or loss depends on the annual CO_2 fluxes (with GPP-Rauto conditioning the biomass production) and the lateral fluxes of carbon as organic amendments (C imports) and exported at harvest (C exports) as in the equation 1 (Ceshia et al. 2010, Woodwell and Whittaker et al., 1968, Chapin et al., 2006). Except for carbon imports, those variables are estimated by the SAFYE-CO2 model in Agricarbon-EO. We agree that this link is not presented clearly enough in the paper. In order to clarify the relation between soil organic carbon stock changes, CO_2 fluxes and biomass, we will add the equation 1 , that connects the different components, into the introduction section of the manuscript with an associated explanation:

$$NECB = \overbrace{\overbrace{GPP - Rauto}^{NPP} - Rh}^{NEE} + C_{imports} - C_{exports} \qquad \text{(eq.1)}$$

$$Reco$$

ΔNECB is the Net Ecosystem Carbon Budget. It can be divided into two components. First the carbon fluxes as CO_2 induced by the biological processes represented by the Gross primary production (GPP) resulting from photosynthesis, autotrophic respiration (Rauto i.e. plant respiration) and heterotrophic respiration (Rh, i.e. soil respiration). The add-up of those fluxes is the Net Ecosystem Exchange (NEE). When the NEE is integrated over a cropping year, it is referred to as the Net Ecosystem Productivity (NEP) . The net flux for the plant (GPP-Rauto) is referred to as the Net Primary production (NPP) which represents the amount of biomass produced. The sum of respiration fluxes (Rauto + Rh) is the ecosystem respiration (Reco) . The Net Ecosystem Carbon Budget also depends carbon fluxes resulting from farming practices, namely the Cimports representing the amount of C brought as organic amendments (e.g. manure, compost) and the Cexports that represent how much C has been exported at harvest (e.g. grain, grain+straw, tubers).

When the crop is harvested, the unharvested plant biomass (litter and roots) are incorporated into the soil, which means ΔNECB = ΔSOCat the end of the cropping year. In the revised version of the manuscript, we will present a ΔSOC variation map to complement the NEP maps over the wheat growing period by considering the following imports and exports conditions:

- In the region of interest, carbon imports are negligible as the fraction of farms practicing animal husbandry is very low. Furthermore the mass of seed carbon for wheat is about 6 to 10 g/m^2.
- Cexports are the parts of the plant that are harvested or removed. For wheat, grains are usually the only part of the plant that is exported in the region of interest.

$$C_{exports} = \overbrace{DAM \times HI}^{\text{dry Yield}} \times Cfrac \qquad \text{(eq.2)}$$

HI is the harvest index and Cfrac is the fraction of carbon per unit biomass.

As NEE and NEP (annually cumulated NEE) are computed by Agricarbon-EO, by relying on eq1 and eq2, ΔSOC maps can be computed and added after figure 9 in the manuscript considering the rules mentioned above (no organic amendments, only grain is harvested):

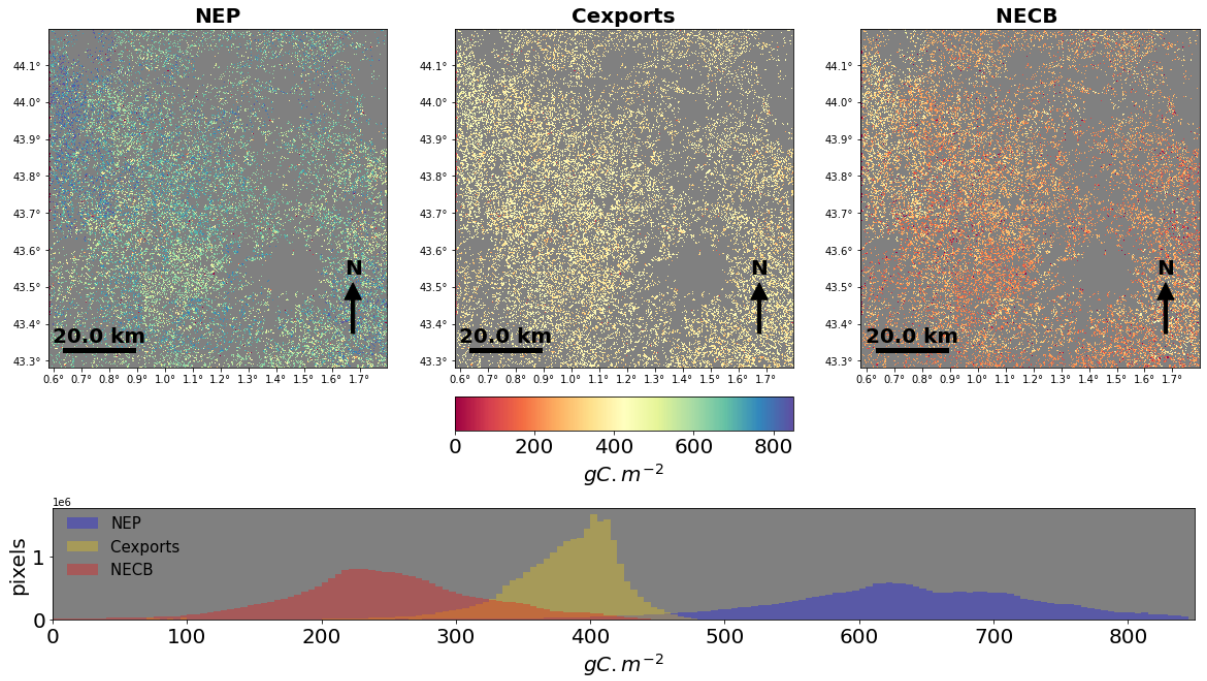

Figure R1: Net Ecosystem Productivity, Carbon exports based on yield and Net Ecosystem Carbon Budget maps between 20161001 and 20171001 over the T31TCJ SENTINEL2 tile and the distribution of those variables.

By highlighting and adding those elements, we hope that the utility of this processing chain for studies regarding soil carbon is now clarified. In the discussion section the limitations related to the soil module are already mentioned but will be also amended. More precisely, alternative solutions include adding more environmental constraints to the Rh terms in SAFYE-CO2, or estimating at high-resolution root and aboveground biomass inputs to the

soil with AgriCarbon-EO that will be used as inputs in soil models such as AMG,Daycent or RothC.

Second, concerning the length of the paper. The additions of eq.1 to the introduction and the carbon budget maps will not lengthen the paper as we suggest below to remove and reduce parts of the manuscript. While some analysis is needed to justify driving elements of the method like scalability, accuracy, and high-resolution (figures 11 and 12), we reckon that reducing some elements would enhance the manuscript.

In summary, we suggest the following major modifications to the paper to enhance the readability and focus on the main research questions:

I. **Clarifying the link between soil carbon, carbon fluxes and biomass:**
   A. We will add the change of soil carbon and net ecosystem carbon budget in the introduction with the NECB equation presented in **comment I**.
   B. We will add the Figure R1 here above that presents the SOC stock change map using this same equation and the hypothesis explained here above.

II. **Reducing and simplifying parts of the paper:**
   A. Section 2.4 **"Bayesian normalized importance SAmpling using Look out Table - BASALT"** will be fused with section 2.4.2 **"Log-likelihood computations"**.
   B. Section 2.4.1 **"Normalised Importance Sampling and Look-up table"** will be moved to supplementary material.
   C. **Figure 6** and **figure 5** will be fused together as they treat the same years and field.
   D. **Figure10** regarding posterior parameter distributions and the analysis related to this figure will be moved to supplementary material.
   E. **section 5.3 "Regional scale analysis"** containing **Figure14** and **Figure15** will be removed.

III. **Enhancements:**
   A. The "Discussion" section will be amended based on feedback from the discussion process.
   B. Time series corresponding to the pixel wise validations over the ESU biomass dataset will be added to the supplemental material.
   C. We leave it to the editor to decide whether or not part of or all of the equations of the Agronomic model should be put in the supplemental.

IV. **Grammatical and typo:**

   The paper will be spell checked by an external service and several native speakers with knowledge in the domain.

We will also integrate the eventual comments provided by the Scientific Editor.

Bibliography:

E. Ceschia, P. B eziat, J. F. Dejoux, M. Aubinet, C. Bernhofer, B. Bodson, N. Buchmann, A. Carrara, P. Cellier, P. Di Tommasi, J. A. Elbers, W. Eugster, T. Gr¨unwald, C. M. J. Jacobs, W. W. P. Jans, M. Jones, W. Kutsch, G. Lanigan, E. Magliulo, O. Marloie, E. J. Moors, C. Moureaux, A. Olioso, B. Osborne, M. J. Sanz, M. Saunders, P. Smith, H. Soegaard, M. Wattenbach, Management effects on net ecosystem carbon and GHG budgets at European crop sites, Agriculture, Ecosystems & Environment 139 (3) (2010) 363–383. doi:10.1016/j.agee.2010.09.020. URL https://www.sciencedirect.com/science/article/pii/S0167880910002537

F. S. Chapin, G. M. Woodwell, J. T. Randerson, E. B. Rastetter, G. M. Lovett, D. D. Baldocchi, D. A. Clark, M. E. Harmon, D. S. Schimel, R. Valentini, C. Wirth, J. D. Aber, J. J. Cole, M. L. Goulden, J. W. Harden, M. Heimann, R. W. Howarth, P. A. Matson, A. D. McGuire, J. M. Melillo, H. A. Mooney, J. C. Neff, R. A. Houghton, M. L. Pace, M. G. Ryan, S. W. Running, O. E. Sala, W. H. Schlesinger, E.-D. Schulze, Reconciling Carbon-cycle Concepts, Terminology, and Methods, Ecosystems 9 (7) (2006) 1041–1050. doi:10.1007/s10021-005-0105-URL https://doi.org/10.1007/s10021-005-0105-7

G. M. Woodwell, R. H. Whittaker, Primary Production in Ter-restrial Ecosystems, American Zoologist 8 (1) (1968) 19–30.24 doi:10.1093/icb/8.1.19. URL https://academic.oup.com/icb/article-lookup/doi/10.1093/icb/8.1.19