We would like to thank the editor for helping us to improve this manuscript (MS). We apologize for failing to see that the tracked changes .pdf in our last submission had its last pages missing. Our MS copy is produced using LaTex. A conflict between *latexdiff* (needed to track changes) and the official supplementary files of the Copernicus LaTex package led to an incomplete .pdf being produced. Now our tracked changes document has been produced in a different way. Below we refer to each of the reviewer and editors comments, point to the MS location where revisions were made and provide a written response. We use the page (P) and line (L) number in the revised MS when pointing to revisions made.

1. Please clarify the seemingly interchangeable use of the terms GB and UK

Response : We have clarified this in the revised MS and now use GB throughout.

2. Comment #4 of reviewer #1 (for the second review of the MS)

The NBE can not be obtained from the values presented in the table. It would be helpful to give values for all the components of NBE and ΔSOC. In addition, it is not clear what is the meaning of C flux into soil. Does it include litter and manure?

Editor comment : *But this is not what the table caption says, please revise caption*

Authors response : We understand that this table has been the source of confusion regarding what is and what is not included in the presented variables. We replaced the table with a clearer schematic of estimated C pools, fluxes and balance (Figure 6, P18). The new figure shows the simulated area-mean (and standard deviation across all fields) of C pools and fluxes for the two simulated years (2017 and 2018); as well as the GB-mean annual NEE and NBE. The figure clarifies what was simulated and compares the size of pools and fluxes during the two simulated years.

3. Comment #5 of reviewer #1 (for the second review of the MS)

It is not clear what are included in the "high inputs of C to soils", litter + manure? Does manure from refinement included in this study? If not, it should be mentioned and discussed. Because it will cause an underestimation of C input for grassland.

Editor comment : *The fact that manure cannot be inferred from EO-data or inferred from land-use statistics, but is an important component of the C-balance is one of the important reasons why there needs to be more care when going from the implications of your study from effects on LAI and GPP to the whole ecosystem carbon balance. I don't see this properly explained in the tracked-changed version of the manuscript.*

Authors response : Unfortunately some of the text that was added in response to this comment (after the 2nd review) was in the limitations section of the revised MS; which was the part that was missing from the last submitted tracked changes pdf. Reference to the fact

that external manure additions are not considered in this study, and the likely implications, can be found in 4 different parts of the revised MS :

(1) abstract (L14)

(2) materials and methods section 2.1.2 (L177)

(3) materials and methods section 2.1.5 (L225)

(4) Discussion of limitations (L616).

The addition of manure to the soil is an important component of the C balance of any grassland. In this study, we assume that the amount of manure added to a field's soil equals that produced by the livestock that graze it and that it is applied weekly and directly after each grazing even (i.e. biomass-C is grazed and part of it returns as manure-C to the soil). This application mode is a simplification. In reality livestock spend time indoors (mostly in winter, autumn). During these "housing" periods, livestock excrements are collected and stored to be either applied later on a farm's fields or sold to other grassland and/or arable farms. It is not possible to know how much manure is applied to each field but it is credible to assume that manure production and application is closely related to and driven by farm livestock density. This is particularly important when looking at things at GB scale. We refer to this in section 4.5 (L616-627) of the revised MS and added a citation to the relevant literature.

4. Comment #1 of reviewer #2 (for the second review of the MS)

My main concern is that the manuscript does nothing to convince the reader that the net carbon fluxes (NEE and NBP) can be inferred by assimilating only leaf area index (LAI) data. This outcome seems counter-intuitive. I can accept that assimilating LAI can provide better estimates of GPP and possibly Ra. However, it is far from clear that this will give the correct results for Rh and hence NEE or NBP

Editor comment : *I take all your points, but I fail to see how this discussion has entered the discussion section of the manuscript (the tracked changed version ends prematurely at page 22). I also disagree that a random error on the SOC initialization will result in an appropriate quantification of the SOC related error, since soil grids does not (to my knowledge) use grazing versus cutting as a factor in the upscaling. Given that you find notable GPP differences between these types of management, one might also expect differences in soil C, which isn't/cannot be captured by your approach. I also agree that there are limited C balance data for UK and other grasslands, but again, this is a caveat that needs to be clearly stated. I agree with your statement that your study is an important improvement over earlier studies not taking account EO data, but, as reviewer #2 pointed out - it is far from yielding a comprehensive C balance for UK-grasslands. This limitation is also not appropriately reflected in the abstract, where the reader is not informed that the EO-informed grassland growth model is then used to prognostically simulate the carbon balance of UK-grasslands, with a range of important yet unconstrained terms in the calculation.*

Authors response : We clarify that our diagnostics are based on probabilistically implementing a model that has been calibrated and validated against what we believe are the most detailed and extensive set of relevant ground measured data available in GB [1]. We do not infer exact C pools, fluxes and net C balance (ecosystem/biome) simply by assimilating LAI time-series. Instead we use EO-based LAI time series to constrain model estimates of aboveground biomass dynamics and use the modelling of underlying biogeochemical processes to generate probabilistic estimates of NEE. The modelling is supported by the setting of realistic priors on parameters through the detailed calibration undertaken in earlier studies using appropriate relevant ground data [1,2]. We discuss this it in the introduction (L121) of the revised MS. Also we added a reminder/note of/to the approach in the discussion section (L490).

In relation to the soil C model input data, we failed to make it clear that, over decadal periods relevant to soil C dynamics, the majority of GB grasslands undergo alternations between cutting and grazing and so their management varies from year to year (relevant comment was added to L525). Therefore, there is no fixed spatial pattern in defoliation practices across GB and no certainty over which practices are applied each year. This is why we rely on EO to infer defoliation methods at field scale. Our study quantifies how grazing/cutting management affects biomass productivity (GPP) and litter inputs. The initial model soil C stocks are constrained with SoilGrids data and then soil C dynamics depend on simulated inputs and outputs. We note that spatial information on vegetation type (land cover maps) and biomass productivity (satellite data) are among the factors used to go from national-domain ground-measured point-based datasets to the global-scale gridded data that are provided by SoilGrids.

[1] Myrgiotis et al. A model-data fusion approach to analyse carbon dynamics in managed grasslands. Agricultural Systems 184, 102907 (2020). https://doi.org/10.1016/j.agsy.2020.102907

[2] 1.Myrgiotis, V., Harris, P., Revill, A., Sint, H. & Williams, M. Inferring management and predicting sub-field scale C dynamics in UK grasslands using biogeochemical modelling and satellite-derived leaf area data. *Agricultural and Forest Meteorol* **307**, 108466 (2021). https://doi.org/10.1016/j.agrformet.2021.108466

5. Comment #2 of reviewer #2 (for the second review of the MS)

... The argument seems to be that it is too spatially coarse to represent a field, but have sufficient spatial resolution to detect grazing or cutting. I personally do not understand this. The choice is apparently driven by a better temporal resolution (10-days) than Sentinel-2, but the combined Sentinel-2 instruments actually have a shorter revisit time than this, so the only advantage appears to be that the GCLS data are gap-filled. But (a) won't the gap filling itself reduce the ability of the data to represent grazing/cutting? and (b) why not gap fill the Sentinel-2 LAI data? Can the authors provide a better justification for using both data sets?

Editor comment : *the response to this comment seems to be absent from the revised manuscript. I recommend to include a distilled from of the justification for using CGLS into*

Section 2.1.4. It would probably help to move the last paragraph of Section 2.1.4 it the beginning of that section and add a few more sentences to that paragraph. I agree with reviewer #2 that Section 2.2.2 is unclear as to how the Sentinel 2 data are used. Maybe it would be helpful to state more clearly which parameters were calibrated based on Sentinel vs CGLS?

Authors response : Along the lines of the editor's suggestions we rearranged sections 2.1.4 (P8) and 2.2.2 (P10). We now describe the EO data used in the study in section 2.1.4. At that point the reader will have all the necessary information about the two EO based LAI time-series that we use i.e. their source, spatial/temporal resolution and processing details. We believe that having the justification for using two EO datasets at the materials section can be confusing as this is mostly a methodological aspect of the study. The revised section 2.2.2 now (1) clarifies *why* we need two EO datasets and (2) describes *how* the two EO datasets are used. We use text and the schematic of Figure 3 (P13) to describe the two EO-based time-series are used in our model-data fusion framework.