In the following, we have numbered our answers as AACC1-n, where n is the answer number (Author Answers to CC1). This allows referring to our answers in this document as well as in the answers to the other reviewers and vice versa.

CC1: 'Comment on egusphere-2025-592', Fabien FERCHAUD, 28 Apr 2025

This is an interesting paper that aims to compare SOC stock measurements, flux balance approach and modelling.

However, it seems quite surprising to use fixed depth (FD) calculations in your results and comparison of measured (carbon stocks, flux balance) vs simulated data (AMG), while it is stated in the introduction that "comparing SOC stocks on the same soil mass per unit area was recognised as a better practice than the fixed depth approach" (line 96). It is shown that the Equivalent Soil Mass (ESM) gave similar results than FD for the whole soil profile (~0-60 cm), but this is not true for the upper layers, as the bulk density strongly decreased in 0-5 and 5-10 cm (and increased in 30-60 cm). Furthermore, AMG simulations should not be compared to SOC stock calculated at fixed depth when bulk density changes with time. Indeed, such a simple SOC model does not take into account the change in bulk density, but consider a constant soil mass.

It would be therefore recommended to keep the FD calculations as supplementary results and mainly focus on ESM results. It would also help for the comparison with the literature (published results are often at ESM).

AACC1-1. We fully agree with Fabien Ferchaud's comment that ESM is the reference method, as he noticed we wrote this textually in the manuscript. We think we were rather clumsy in the way we presented the comparison between the FD and the ESM method. We however think it is a valuable result to show that FD may be a robust estimation as long as the sampling depth is large enough, and we propose to keep a figure in the main manuscript to show this and also show that the FD does not work for shallower depth (30 cm). This would promote sampling to > 60 cm depth.

The initial choice of keeping the fixed depth method for comparison with the simulations could maybe be due to the fact that a lower decrease of SOC stocks (0-30 cm) was obtained from the ESM method calculation (decrease from 7.60 to 7.16 with ESM vs 8.25 to 7.28 with FD) and did not align completely well with flux balance and simulations with AMG model.

AACC1-2. This choice was made by a different reasoning: we observed that the soil stock changes were equal in the 30 cm and 60 cm layer as estimated with the FD (all changes were attributed to the 0-30 cm layer. Moreover, the FD and ESM methods in the 0-60 cm layer were equal. Hence the 30 cm FD stock evolution was representative of carbon the whole stock change over the entire soil profile. We further considered that the AMG model should be representative of the SOC stock change in soil explored by the crop and not only of the arbitrary 30 cm depth. This was the reason of our choice, which was not explicated.

However, for the ~0-30 cm calculation, it could maybe be tested if a slightly higher reference soil mass could be used to calculate the stocks at ESM or maybe consider a slightly deeper upper soil horizon (e.g. ~0-35 cm) to capture the main decrease in SOC stocks and for comparisons and modelling.

For example, the reference soil mass for the ~0-30 cm layer could be obtained from the mean soil mass measured in 2005: this would be more representative of the initial situation.

AACC2-3. We fully agree with this analysis, which is the one that led to our choice of the 30 cm FD ~ 60 cm FD ~ 60 cm ESM. To give more ground to the comparison between AMG and the soil stock difference between 2005 and 2009 we propose to represent both ESM @ 30 cm and ESM @60 cm. This comparison shows indeed that the AMG model represents rather the change of the whole soil stock profile than the 0-30 cm (Figure R4).

We further propose to add some sensitivity tests of the AMG model to organic imports and residue return effect as well as meteorological conditions similar to the 30 previous years: (1) the residues return to the soil were increased to 100% of the agronomically sound possibility, (2) the organic amendments were cut to zero or (3) were multiplied by two, and (4) the meteorology was set to a repeated 1987-2004 meteorology for the 2005-2050 period. Additionally, a sensitivity to the ratio of the active to stable C pool (Cs = 0.65) was made to illustrate the sensitivity of the model to this crucial parameter. For that values of 0.63 and 0.68 as independent estimate on a soil nearby were taken from Kanari et al. (2022).

This leads to the Figure R4 below which shows that (1) AMG in its standard setup overestimate the ESM soil sock change by a factor 1.5, (2) the incorporation of 100% of the crop residues would lead to 20% less decrease, while doubling the organic amendments would lead to 40% less decrease. It is also clear that the meteorology cannot explain the observed soil-stock difference between, 2005 and 2019, while the model is highly sensitive (as expected) to the Cs parameter. When changing this parameter to the range of evaluated values for this soil (0.63-0.68, from Kanari et al. (2022), we find a change of SOC stock 0.3 kg C m^{-2} in 2019. The Cs ~0.68 would lead to a better agreement with the observed stock evolution from 0 to 30 cm.

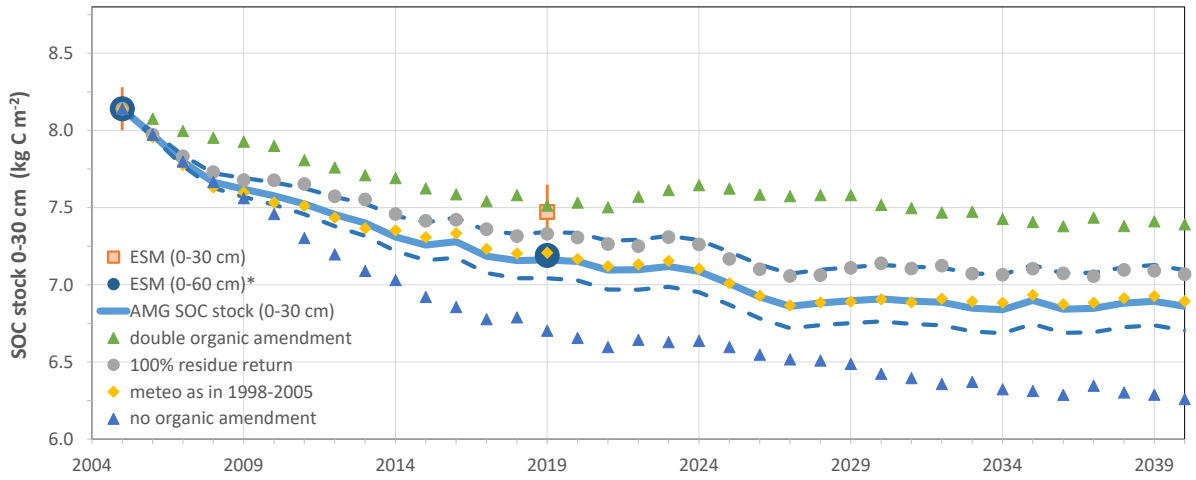

Figure R4. Comparison of the AMG simulations with the ESM stock evolution over the 2005-2019 period in the 0-30 cm and in the 0-60 cm. The blue line is the reference simulation (Cs = 0.65), and blue dashed lines correspond to a range of plausible values for Cs (Cs = 0.63 and Cs = 0.68). The dots correspond to 100% residue return, a doubling of organic amendment or no organic amendment, and a meteorology identical to the 30 years period before 2005. * To allow comparison of the 0-60 cm layer with the 0-30 cm layer the 2005 0-60 cm soil stock was shifted to that of the 0-30 cm layer.

Concerning the comparison of SOC stocks dynamics, their simulations and the flux balance, it appears really frustrating to only have 2006 to 2010 data for the flux balance (data that are now 15 years old and published in 2011). Indeed, the comparison appears relatively limited because only restricted to the 5 first years. Data from recent years or at least until 2019 could be added to strengthen the comparison and improve the significance of this study.

AACC1-4. This comment was also provided by the reviewer 2. We did not include a full carbon balance because this would imply computing the net ecosystem exchange (NEE) over the whole period 2005-2019. While in principle we have all the data to do such a carbon balance, we should stress that during that period the instrumentation have changed from pre-ICOS to ICOS standard, and in particular the InfraRed Gas Analyser (IRGA) has changed from open path (Licor 7500) to close path (Licor 7200). The flux computation has also changed from using EDIRE to using EDDYPRO. As a consequence, there might be changes over the whole period that could be due to instrumental or computational changes and lead to erroneous conclusions. This is the reason why we would like to first recompute the historical data with a homogenised processing, and the latest standards prior to using these data. We acknowledge that this would bring more information to that paper but this process is also slow and we consider this should come with a later publication.

The rationale on the reduced area should be further developed to better justify the choices made (notably by being more explicit on “only the strata having soil characteristics similar to the 2005 sampling area” line 185). As it stands, it is not easy to understand well while some 2019 sampling points close to the footprint from the Eddy covariance mat and to the 2005 campaigns were not integrated in

the reduced area (e.g. sampling point in the grey area #9) while others that are quite far were considered.

AACC1-4. This comment was also given by Reviewers 1 and 2. See detailed answers **AARC1-4** and **AARC2-2**.