Response to interactive comments of reviewer 1 (bg-2018-205-RC1)

We provide the reviewer's comments and critique in blue and provide our response in black. All pages and lines are from the revised manuscript unless otherwise stated.

The manuscript describes the long-term C budget of a Swiss cropland field over thirteen years. CO2 fluxes were measured by eddy covariance and import or export through harvest, organic amendments and seeds were registered by the farmer (and the C content analysed). There are to my knowledge only very few comparable studies in croplands and therefore this study is timely. In particular because there is political interest in the potential of C sequestration of croplands (launched at the COP in Paris; 4 per mille initiative). The C budget approach in croplands is rather sensitive to errors, and the authors estimate these errors based on literature references. The results of the study are compared to a more traditional approach of changes in soil C stocks be- fore and after the thirteen years. These results compare rather well with the C budget. The paper is well-written and the experiments and data analysis is sound.

Thank you very much for this positive assessment.

My main remarks are on the context and on the implications of the study. The losses (in soil C) are rather large at 1.2 Mg C ha-1 y-1. It should be noted that such high losses are to a large extent a result of the initial conditions. The authors mention an 8 year rotation with 3 years of temporary grassland. This rotation is likely to reach a much higher soil C stock than the cropland rotation that followed. I would appreciate if this could be mentioned in the discussion. After all, a continuous loss of 1.2 mg C ha-1 y-1 seems unlikely, given that most croplands contain round 50 Mg C ha-1 in the top 30 cm.

We added a sentence to the discussion that the preconditions of the field likely enhanced the C losses:
"The loss strength, however, was likely influenced by the arable-ley rotation, which was used at the field until the late 1990s and which is expected to reach a higher soil C stock than the crop rotation that was used afterwards." (P.11, l. 10-11)

Also for the context, there is a recent literature review on the potential of C sequestration by conservation agriculture (Chenu et al in press). Some of the measures (e.g. cover crops) are also discussed in this review and are reported to sequester C. I would appreciate your views on this paradox.

Chenu, C., Angers, D.A., Barré, P., Derrien, D., Arrouays, D., Balesdent, J. (in press) Increasing organic stocks in agricultural soils: Knowledge gaps and potential innovations. Soil and Tillage Research

Powlson, D.S., Whitmore, A.P., Goulding, K.W.T. 2011.Soil carbon sequestration to mitigate climate change: A critical re-examination to identify the true and the false. European Journal of Soil Science, 62 (1), pp. 42-55.

We added the following sentences to the text:
“In contrast to tropical regions (Powlson et al., 2016), where climate during cover crop seasons is not a limiting factor, the field experienced a net loss of C during the cover crop seasons due to the less favorable climate (colder and less light) on the Swiss Plateau in autumn” (P. 15, l. 11-13)

“In a recent review by (Chenu et al., 2018) the use of cover crops was discussed. Similar to our findings they conclude based on a number of different studies that the use of cover crops is beneficial for soils because it results in higher soil organic C stocks compared to their absence.” (P.15, 18-20)

Finally, you mention the application of manure as a measure to compensate C losses in the framework of the GHG reporting (page 17, lines 5-10 and Conclusion lines 18-19. There is some discussion on the role of organic amendments for the sequestration of atmospheric CO2. Powlson et al (2011) argue that amendments transfer C from one location to another, but do not sequester CO2 from the atmosphere. I believe Chenu et al (in press) also address this issue.

In general, we would like to focus on the relevance of C for soil fertility. We rearranged the text to focus more on this aspect. However the potential to compensate C losses to the atmosphere is of course also interesting. We agree that importing manure does not necessarily result in an overall CO_2 sequestration because it might be missing somewhere else. This is a very interesting point, however, it would require a complete life cycle assessment which goes beyond the scope of this study.

We made the following changes:
We changed the first sentence in the section to:
“The more frequent use of solid manure could compensate at least partly the C losses of the crop field and decrease or prevent the loss of soil fertility.“ (P. 15, l. 23-24)

We deleted the sentence:
“However, Switzerlands nationally determined contribution (NDC) to the reduction in greenhouse gas emissions assumes zero emissions from non-forest lands like croplands (NDC, 2017) ” (in first submission version P. 15, 31-32)

We added the following paragraph:
“Switzerland’s nationally determined contribution (NDC) to the reduction in greenhouse gas emissions lists zero emissions from non-forest lands like croplands (NDC, 2017). Therefore, the C losses should be reduced from a climate change point of view. The use of organic fertilisers could help get closer to the set goal. In the case of CH-Oe2, the grains, peas and potatoes were not used to feed animals on the same farm. However, straw produced on the field at a rate of 78 g C m^{-2} $year^{-1}$ (1013 gC m^{-2} in total during the 13 years of measurements) is used on the farm. If this straw would have been added back to the field (either directly or included in solid manure), it could have compensated a fraction of the C losses over the 13 years. Ammann et al. (2007) studied the C exchange of the neighboring grassland managed by the same farm. Intensive management of the grassland fertilised with a mixture of solid and liquid manure from the same farm resulted in a significant

uptake of C. Because the grassland was a C sink it could have been considered to apply the manure to CH-Oe2 instead to counteract the higher C loss of the arable field. Therefore, we assume that there is a potential to decrease the field´s C losses substantially by increasing the application of the farm's own solid manure. In order to determine if the application of manure would improve the greenhouse gas budget of the cropland as listed by Switzerland's NDC, it would require a complete life cycle assessment which goes beyond the scope of this study" (P. 17, l. 9-21)