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Comment on bg-2020-489

Anonymous Referee #4

Referee comment on "Additional carbon inputs to reach a 4 per 1000 objective in Europe: feasibility and projected impacts of climate change based on Century simulations of long-term arable experiments" by Elisa Bruni et al., Biogeosciences Discuss.,
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Review of Additional carbon inputs to reach a 4 per 1000 objective in Europe: feasibility and projected impacts of climate change based on Century simulations of long-term arable experiments

This study used the Century model (well established mathematical model of plant-soil cycling to simulate soil carbon dynamic in different pools) to assessed the required level of carbon inputs increase to reach the 4 per 1000 target in 14 European long-term agricultural experiments. Originated on Minasny et al. (2017) paper, the 4p1000 initiative aims to promote better agricultural practices to maintain and increase soil organic carbon stocks with the principle that a 4‰ per year on average soil carbon increase for 30 years would partially mitigate anthropogenic greenhouse gas emission (in addition to improve soil fertility and food security). Using these 14 European long-term agricultural experiments, the authors compared Century computed carbon inputs to the actual carbon input from the different treatments used on the individual experimental sites. From the 14 sites, 13 had exogenous organic matter addition and only one had had different crop rotations as way of increasing carbon input. The exogenous input were: pig manure, cow manure, poultry manure, farmyard manure, green manure, sawdust, biowaste, sewage sludge, household waste. The Century model was calibrated to fit the control plot of the study sites. These control plots, which did not receive additional carbon inputs, were considered as conventional management (business as usual).

The analyses detected that Century model for the studied systems might be overestimating the effect of additional C inputs on the variation of SOC stocks in some sites. Overall, the authors found that (based on Century modelling), on average among the selected experimental sites, annual carbon inputs would have to increase on average by $43.15 \pm 5.05 \%$, ($0.66 \pm 0.23 \text{ MgC ha}^{-1}$) per year, with respect to the control situation to reach the 4p1000 target. One very interesting feature of the study is that the authors

analyzed how this would change under future scenarios of global warming (with modelling performed at simulated +1C° and +5C°). Accordingly, it was estimated that annual carbon inputs would have to increase further due to temperature increase effect on decomposition rates, that is 54% and 120% for a 1°C and 5C° warming, respectively.

In my opinion, the study is original and has a high potential impact scientifically and for policy makers because it is a broad analysis about the very important issue of global warming mitigation. The study is in line with EGU Biosciences journal topics and the manuscript is well organized. The different sections are interesting to read and well written.

However, I consider that the paper in its current form has some important shortcomings not properly handled or discussed that could potentially produce misinterpretation for policy makers. In the introduction it is acknowledged that to use soil carbon stock to offset net annual CO₂ anthropogenic emissions to the atmosphere it is an all-encompassing increase that is needed. Specifically, line 60 states: "the [4p100] initiative ... that increasing global SOC stocks up to 0.4 m depth by 4p1000 (0.4%) per year ...". Conversely, the large majority of sites and treatments used in the analyses were with animal manures as source of extra added carbon to reach the 4p1000. This brings two fundamental issues. First, the use of animal manures is generally not considered an improved agri-management practice but a business as usual scenario that unlikely could significantly be expanded. Thus, arguably, these animal manure treatments would be a type of standard practice and in these farms using customary animal manure another additional carbon input would be needed to reach the 4per1000. Second, the exogenous organic matter likely created a leakage carbon stock effect. That is, the soil carbon balance of the farmlands where the animal feeds were cultivated, harvested and exported need to be taken into account. Specifically, these lands could be carbon negative which would counterbalance the carbon gain where the manure is applied. Also, to really offset net annual CO₂ anthropogenic emissions the complete life cycle to the carbon is needed which include emissions by the animals, in the processing, transport and application of the manure. It is likely impossible to incorporate all these aspects into a single scientific paper but this manuscript should clearly discuss these limitations and mention in the conclusion that the results does not represent the full carbon balance. Finally, the discussion section should recognize that other potential beneficial management practices were not included in the study (e.g. cover crops, reduced tillage, biochar application, increased irrigated areas, improved pH, landscape diversification, mineral amendments, etc.) and that further studies should try to find medium to long-term experiments with these managements to determine if they follow Century modelling predictions to increase soil carbon storage enough to achieve 4per1000.

Overall, I consider that the necessary addition to the manuscript is considerable. I suggest major revision.

I have no specific comments, as stated above, the manuscript is well written.