

Biogeosciences Discuss., referee comment RC3  
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## Comment on bg-2020-489

Anonymous Referee #3

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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., <https://doi.org/10.5194/bg-2020-489-RC3>, 2021

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### Summary

Bruni and co-authors synthesize a wealth of observational data from cropping experiments and explore in changes in C inputs that would be needed to meet 4 per mil goals across European agricultural sites with the CENTURY model. The paper is well written and appropriate for the journal. Before final publication, however, greater attention needs to be given to model validation to contextualize the projections being made.

### Major concerns

I assume these papers follow a rather prescriptive formulation that involves model calibration, validation, and implementation / implication sections.

- The model calibration is presented (Table 3, Fig 4), where the authors calibrate the litter quality, Q10 and reference temperature for control plots at the 14 sites. The findings raise some concerns, described below, but the discussion generally handles this well.
- I would assume that model validation would involve projecting trends in soil C stocks from the modified C input experiments. I appreciate that the observations of trends from these experimental treatments are highly variable (line 155 and Table 1). But there is seemingly no effort to validate the ability of the model to capture the correct magnitude of soil C change (relative to controls) in the additional carbon experiments that are listed. Revisions to the manuscript should more clearly illustrate how well the calibrated CENTURY model captures observed soil C changes across these experimental plots in response to experimental manipulations.

- Model implications are well documented and described.

I don't completely understand the details of the model calibration and optimization that were taken, but it's surprising to me that the metabolic:structural partitioning varies to such a great extent among experimental sites (Table 3). Notably, the aboveground M:S calibration largely flips between the upper and lower limit of the range allowed by the model (85:15 or 15:85). Does this seem realistic? I would assume there are general estimates for lignin:N ratios of different plant parts for different crops that could be used to help constrain this parameter?

Similarly, why is there such a large range in the Q10 values for each site (range 2-5!). I understand this was done to help calibrate the model, but I wonder if the propensity for the calibration to settle on the extreme values for parameter ranges for litter quality and temperature sensitivity points to either: (a) structural deficiencies in the model or (b) equifinality issues from trying to fit a complicated model with sparse data. This is briefly discussed at the beginning of the discussion, but I wonder if it's a finding that should be noted in the abstract & conclusion as well?

To this point, the last sentence of section 4.1 is alarming, and suggest that CENTURY projects 2x the amount of SOC accumulation with 0.5x of the additional inputs, compared to observations. This raises two issues:

- Lack of validation for the additional carbon experiments.
- If agricultural management practices or negative emissions strategies are supposed to be informed by studies this like (as implied in the introduction) it seems like the model projections may be overly optimistic by a factor of four! This raises some serious concerns that are somewhat glossed over by reading the abstract (and conclusion).

**Minor and technical concerns:**

Line 48, maybe this sentence can be clarified to address some of the concerns above?

Line 77: I don't know what it means to 'promote a virtuous C cycle' and suggest this phrase be removed

Section 2.2 I understand that CENTURY also has functions where soil pH determines turnover times and soil texture (specifically sand content) modifies the partitioning of C fluxes between pools (and to CO<sub>2</sub>). It doesn't look these were used here, which is fine, but it should be clarified in the text.

Figure 4 is fine, but I guess I expected to see some kind of predicted vs. observed soil C stock plot as part of the model calibration?

The word 'virtual' is used heavily throughout the text and especially in the results and discussion. We know that the simulated results are from a model. As such, I wonder the use of 'virtual' is potentially redundant (I e.g. "virtual simulations"; "virtual C inputs") and can be removed?

Line 564 should there be a +/- symbol here?

