

We thank the reviewers for their comments on our manuscript, which has greatly helped to clarify the information presented. Please see the point-by-point response below.

The reviewer's comments are **in blue**, our reply **in black**, and the new text integrated in the manuscript **in red**.

Corinne Le Quéré, on behalf of the author team.

#### Comments by A. J. Dolman (Referee)

This is an excellent paper that deserved to be published. I have a few general remarks and some minor suggestions.

There is no doubt that this is an important publication that is used by both policy makers and scientists. As such proper referencing and transparency of method is crucial. The authors do a great job in this. The authors appear to have trimmed the actual text a bit to last year that makes the paper overall now more readable. The authors now use two bookkeeping methods, which diverge. This is a useful step. The authors have taken the brave and courageous step to base the land sink and land use emissions on models, resulting in a closed budget with the residual reflecting (0.6 GtCyr-1) the errors in all terms. Previous budgets put the residual in the land sink. This is in my view a much needed step, as it identifies issues in the land surface models and the overall budget.

That being said, I would appreciate if there is a little more discussion about the error attribution to both the land sink and LUCCF emissions. We know the models may provide the right answers for the wrong reasons as they were invariably tuned and in the paper further constrained by observations of the historical period. 5. The change in cumulative emission due to these changes is substantial (20 Gton excluding the ). I would suggest that the authors make a little more of this the final discussion and conclusion. In particular the latter reads like a rather lacklustre introduction in a Research proposal. The change and uncertainty in the land have important implications for policy- how much is still left to reach the 1.5 target and has implications for a monitoring effort of reductions in general. The latter is now discussed in a separate paper (Peters et al., 2017), but I feel that it is appropriate to mention and discuss it here, as this is the ultimate source on which it is based.

We have added the following paragraph in the discussion on the uncertainty in the land sink and LUCCF emissions: “**Although we have presented six components of the Global Carbon Budget individually, different aggregation of terms are possible. In particular  $S_{LAND}$ ,  $E_{LUC}$  and  $B_{IM}$  could be aggregated into land fluxes and total uncertainty, as traditionally done, which would result in generally lower uncertainty compared to each term individually (see Table 6).** This information is limited in usefulness however, as it mixes direct and indirect processes and bring in errors from other components and hence the signal becomes difficult to interpret. However providing a realistic assessment of uncertainties for  $S_{LAND}$  and  $E_{LUC}$  is also difficult. Here we have used the model spread as a measure of uncertainty, which may be on the one hand underestimated because it includes only partly uncertainty in the underlying observations, and on the other hand overestimated as it includes artificial spread from different boundary limits in among models. Therefore further work is needed not only to better quantify the fluxes but also to better describe and quantify the uncertainty and reduce it where possible.”

#### Minor comments

P 4, l 14. It suggest here that the budget is only referring to the atmosphere. Suggestion to change wording to include land and ocean and emissions.

We changed the text to: The global carbon budget presented here refers to the mean, variations, and trends in the perturbation of CO<sub>2</sub> in the environment”

P 4, l 28. I would use the word bulk emissions to emphasise what it is you determine. There may still be hidden other sources or sinks that we do not take into account, other than the ones you mention here.

We are sorry but we do not understand specifically where this text should be integrated. We have included further detail of the emissions that are not included in our budget in Section 2.7.

P 1, l 3 change comparing to normalising

replaced as suggested

P 17, l 15. What is meant by the difference in approach and processes. Is approach not obsolete in this sense?

here we mean the different methodologies (so bookkeeping or DGVM approaches). We have changed the text accordingly.

P 29 l 1-3. The suggestion here is that only the known factors explain the variability in the residual. I would like to leave open the possibility that there is an unknown factor. The for example is a bit weak in this context.

Indeed. We have added “or other yet unknown factor”

P 32 l 9-16. Given the wide uncertainty ranges, the use of wording such as „very close to“ is a bit presumptuous. Better also use terms like within the uncertainty.

replaced as suggested

P 37 and Table 10. I like Table 10, as it is almost a roadmap for further research. However, it would help the reader if there is some indication of the sign of the components possible flux. If all would work (I know they do not: : :) in the same direction they could make a difference of almost 4 GtC yr<sup>-1</sup>. That surely is not the case, so an additional column indicating the possible sign if known would help.

The suggestion to add the sign in Table 10 is good but also quite tricky because we do not know the sign for most of the processes. However we have added in the discussion the paragraph below and will reflect on the Table suggestion ahead of the next budget: “Although multiple processes have been identified here, some will increase variability (e.g. land management processes, ocean circulation) while others might decrease it (e.g. better energy statistics, response to rainfall variability), and processes would not be all acting simultaneously. It is also possible that further yet unknown processes are not taken into account. Better understanding the source of the carbon imbalance and how to resolve it is critical to progress further in the understanding of the contemporary carbon budget.”