

Interactive comment on “Towards a more complete quantification of the global carbon cycle” by Miko U. F. Kirschbaum et al.

Anonymous Referee #1

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This is a novel and interesting paper that should stimulate discussion around this important topic. It brings together a quantification of many relatively small elements of the global carbon cycle that when combined could make a substantial reduction in the “residual sink” that has typically been assigned to the terrestrial biosphere. The paper further makes explicit some aspects which had previously been implicit in the budget – as the authors state, this improves clarity. Overall, the implications for vegetation modelling could indeed be substantial as there is an implication that current global vegetation models (which simulate an imbalance within the uncertainty of the residual sink; Le Quéré et al., 2018) may be overestimating the carbon sink provided by the biosphere (but see comment below about how this discussion is presented).

Many of the estimates included have been published elsewhere or are novel contri-

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butions but very provisional. This paper will certainly not be the last word on those numbers, however the important thing that this paper does is to bring them all together in a consistent format and set them in the context of the global carbon budget. Careful attention has been paid to whether the fluxes considered are omitted or considered implicitly in the Global Carbon Budget as presented by Le Quéré et al. (2018). I recommend publication subject to addressing the concerns below.

Major comment

My only substantial concern relates to Section 12. The results presented by Kirschbaum et al. potentially tie in with very active discussion over the extent to which CO₂ fertilisation of leaf photosynthesis is propagated through to ecosystem-level increases in carbon storage (e.g. Körner, 2017, 2006; Luo et al., 2004; Medlyn et al., 2015). It is relevant to mention this however I find Section 12 generally a step too far. For instance, in section 12.1 it is stated “any carbon uptake by forests is likely to be largely due to their disturbance history”. This is a valid and highly-relevant hypothesis, but it is only a hypothesis. We currently do not know the relative contributions of CO₂ fertilisation versus forest demography with any certainty. This should be reflected in the discussion.

Similarly, Arneth et al. (2017) is cited relating to the importance of biophysical drivers (pg. 12, line 19), but a key conclusion of Arneth et al. is that because the land-use and management change emissions may be systematically underestimated in the budget, this implies that the terrestrial “residual” sink may have previously been underestimated. Thus, it may be that the calculations presented by Kirschbaum et al. do not imply an overestimation of the carbon sink in global vegetation models, but instead account for a missing portion of the budget that balances previously underestimated land-use and management change emissions. This possibility should be explicitly laid out. Finally, the soil organic carbon section (12.4) is extremely speculative and doesn't really fit in the framework of the manuscript. Yes, a change of 0.4

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Overall, in my opinion this section needs to be much more balanced, laying out the various competing hypotheses, so as to reflect a review, rather than an opinion piece.

Minor comments

Pg. 1, line 38. “net additions”? “the oceans overall are”?

Pg. 2, line 5. The budget is based on terrestrial biosphere models (TBMs) run offline, not Earth System Models.

Pg. 4, line 11. Ro or Rd?

Pg. 5, para 2. Wood product pools are included in many, if not all, of the TBMs used in Le Quéré et al. (2018). Stocks have rarely been published, which unfortunately does not facilitate a comparison, but this flux has not entirely been neglected. This should be recognised in the text.

Pg. 7, line 8. “some extra inputs mineral weathering” – does not seem to make sense. Please rephrase.

Pg. 7, line 10. Cole et al. 2009 or 2007 (cf. Table 2)?

Pg. 7, line 18/19. Repetition of material from two paragraph previously.

Table 2 is not the easiest to follow. Use of vertical lines for grouping into sections and bold text to highlight the values being carried forward would help readability.

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