

Interactive comment on “Definitions and methods to estimate regional land carbon fluxes for the second phase of the REgional Carbon Cycle Assessment and Processes Project (RECCAP-2)” by Philippe Ciais et al.

Anonymous Referee #2

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This manuscript presents a conceptual and methodological framework for the computation of land-atmosphere fluxes in the context of the RECCAP-2 project. It describes in detail the main fluxes to be consider for obtaining the net exchange of carbon between land and atmosphere, with special emphasis in the homogenization of top-down versus bottom-up estimates. The manuscript is well written, and it is a meaningful contribution to the literature. Given that the definitions and conceptual framework described here has applications mostly for the RECAP project, the manuscript could be publish in its current form after minor revisions. However, if this work is intended to transcend

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RECAP, and provide a useful conceptual framework for global carbon cycle science, then a major revision is required. I have three main concerns that I will detail below, followed by a list of small minor issues.

1 Major concerns

- From my point of view, the definition of the main component fluxes of the budget presented in this manuscript, and summarized in Figure 2, mixes two different aspects of a carbon budget. On the one hand, many of the fluxes are defined by the specific process that generate a transfer of carbon from one pool to another (lateral transfers), or from a pool to the atmosphere. This definition of fluxes is intuitive and is a good approximation to our scientific understanding of the main processes in the Earth system that produce transfers of carbon among reservoirs. On the other hand, some of the fluxes, and in particular those related to the land use component, are defined based on the proximate cause of anthropogenic emissions. I think this mix on the way the fluxes are defined is confusing and prone to double counting or confusing accounting. For example, a process that generates emissions of carbon to the atmosphere from the land is the respiration of heterotrophic organisms, which includes wild and domesticated animals as well as humans. Heterotrophic respiration is the main biological process that produces the emission, but one could attribute these emissions based on the type of heterotrophic organisms that produce them. In other words, one can define the flux based on the process (heterotrophic respiration) or based on the proximate cause, e.g. 'carbon emissions from crop biomass consumed by animals and humans' as defined in section 2.5.1. However, it is confusing to define fluxes based on processes and based on proximate causes as part of the same budget. It can also lead to double counting. The same problem appears in the definition of fluxes due to fires and those due to land use change or deforesta-

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tion. The process that defines the flux is fire, but the proximate cause may be due to crop management, deforestation, or annual natural disturbances. The fluxes considered in this manuscript is a mix of both, fluxes defined by processes and fluxes defined by the proximate cause. I do not think this can help us to get some clarity in constraining the global carbon budget and to understand its change. A better approach would be to define all fluxes based on the processes that lead to the flux, or to define them based on all the different proximate causes. The idea is to be consistent. I personally would prefer definitions of fluxes based on processes, and in a posteriori analysis, attribute the fluxes to specific proximate causes. I think such an approach would help to get separate two main aims in current C cycle research, to understand processes, and to attribute causes of change.

- Although the aim of this project is on the fluxes of carbon between the atmosphere and land, it is surprising that no effort is placed in quantifying and reporting carbon stocks of the main source pools from the land. Knowledge on the carbon stocks is important for two main reasons: 1) to know the relative proportion of carbon emitted from source pools and how they differ among main regions, and 2) to identify potential mass balance problems when fluxes are much larger than the size of the source pool. For reporting based on Delta methods, reporting the size of the pools is easy and should be recommended.
- The recommendation of reporting NPP instead of GPP is troubling, and does not reflect well our current physiological understanding of carbon assimilation in terrestrial ecosystems. The authors define NPP as 'the flux of carbon transformed into biomass tissues after fixation by GPP', probably assuming that autotrophic respiration is already removed in NPP; i.e. $NPP = GPP - \text{autotrophic respiration}$. The problem with this definition is that we know that autotrophic respiration can only occur from living tissues produced after biomass formation, not before as the definition implies. Only living cells can respire carbon, and experiments and

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isotopic analyses have shown that carbon respired from roots and stems can be years to decades old. While GPP quantifies the instantaneous removal of CO₂ from the atmosphere, autotrophic respiration is the lagged release of CO₂ back to the atmosphere. These fluxes are not necessarily in sync, and therefore NPP is a poor approximation of the instantaneous net flux. This is important for the planned comparison of fluxes from the inversions, because they are computed at much higher temporal resolutions than the NPP estimates from forest inventories. In addition, there are now a range of techniques that aim at quantifying GPP in ecosystems using measurements of fluorescence and COS both from satellites and at flux tower sites. Therefore, there is an opportunity to include independent estimates of carbon assimilation (GPP) as part of the regional carbon balances.

2 Minor comments

- Line 62. Add 'of' after 'estimates'
- Ln 190. Add ',' or ';' after 'regions'
- Ln 224. Add 'be' in 'needs to paid'
- Section 2.2.3. The quantification of carbon fluxes due to trade is interesting. Would it be useful to include also carbon fluxes due to trade of unburned fossil fuels?
- Line 371. This sentence is similar to line 360 in previous paragraph. Consider removing it.
- Line 614. NEE at the ecosystem level only considers CO₂, at least as it is commonly done in eddy-covariance studies. However, you define regional NEE as the net carbon balance of carbon, not just CO₂. I see a mismatch here between

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the more traditional definition of NEE at the ecosystem level and your new definition at the regional level. Wouldn't be better to call your new quantity net regional carbon balance?

- Figure 2. I don't see the benefit of repeating the same figure twice to only add the names of the fluxes. I would make only one diagram with the abbreviations and define the flux names in a table.

Interactive comment on Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2020-259>, 2020.