ANSWER to Referee #2

(answers by the authors are in red)

The paper provides an interesting advancement of the previous analysis of the same authors on the mismatch between national inventories and global models used for estimating the emissions of the land sector. The paper is well structured and accurate in the analysis and clarifies many of the possible reasons of mismatch between statistics and estimations, providing also perspectives for the reconciliation of these differences. Although the comparison is very detailed and accurate, there is no information on the different pools that are considered in the different sources considered (NGHGI, BM and DGVM) and whether this can be a source of mismatch between estimations. This should be clarified in the method section as it is a potential source of discrepancy (potentially also adding this information in Table 1).

Thank you for the positive and very constructive comments.

On carbon pools, we agree that more information was needed.

In the Methods, we added new information for models (both BMs and DGVMs) and NGHGIs.

For models we simply added that "Estimates from both BMs and DGVMs include all carbon pools."

For NGHGIs, we added: "In terms of reported carbon pools, the situation varies depending on the country and the land category. The IPCC guidelines (2006, 2019) distinguish living biomass (above- and below-ground), dead organic matter (dead wood and litter), soils (mineral and organic) and harvested wood products (sometimes referred to as a separate category rather than a carbon pool). The vast majority of AI countries report the CO_2 fluxes from the carbon pools in case of land-use changes (e.g. forest converted to settlements, cropland converted to forest, grassland converted to cropland), and from the most important carbon pools in case of land uses that remain unchanged (e.g., biomass in forest land remaining forest land, soil in cropland remaining cropland). The NAI countries typically report the CO_2 fluxes from living biomass on deforestation and, in the vast majority of cases, on forest land. For the other pools the situation is less clear. Dead organic matter, mineral soils and harvested wood products are reported by the largest NAI countries (including Brazil, China, India, Indonesia, Mexico) but are often not considered by other NAI countries. CO_2 fluxes from organic soils are reported only by a few NAI countries (e.g., Indonesia)"

Furthemore, we extracted the available data and made a preliminary comparison, in the Result and Discussion, we added:

"With regard to the allocation of fluxes to the various carbon pools, the comparison between global models and NGHGIs is hampered by different definitions of carbon pools and by incomplete estimations by NGHGIs (especially for NAI countries). Nevertheless, based on the available data, mineral soils do not seem to represent a major source of difference in land use CO_2 fluxes between global models and NGHGIs, at least in forest land. According to NGHGI data from AI countries for the category forest land, the vast majority of the forest sink is reported in the living biomass, with mineral soil and dead organic matter representing, respectively, 7% and 11% of the total net sink for the period 2000-2020 (excluding organic soils). This information is broadly in line with the results from global models. Data from the

TRENDY v11 dataset (for nine DGVMs only), for example, show that the sink in forest soils represents about 10% of the overall forest sink in AI countries during the same period. For all land uses, the BMs' results indicate a net source from mineral soils (about 1.5 $GtCO_2$ yr^{-1} from BLUE and 0.6 $GtCO_2$ yr^{-1} from H&N for 2000-2020), with emissions associated with land-use changes (mostly deforestation) and a small sink in forest land. Overall, we argue that a more comprehensive analysis of fluxes in different carbon pools should be prioritized in future studies comparing global models and NGHGIs, along with analyses of possible lateral fluxes that might be overlooked by both BM and NGHGIs."

In the Conclusions:

"Furthermore, our study highlights priority areas for future comparisons between globals models and NGHGIs, such as indentifying in the NGHGIs the fluxes associated with shifting agriculture and - in both global models and NGHGIs - disaggerating further the fluxes to the level of carbon pools (at least biomass and non- biomass)."

Overall the assessment is very positive, I therefore recommend the publication with minor revisions.

Specific comments:

-Lines 94- 95 Missing quotation to the sentence "BMs estimate that land use is a net source of CO2 globally, mainly due to deforestation, equal to around 12% of total global 95 anthropogenic CO2 emissions."

Thanks, now added (Friedlingstein et al. 2022)

Line 108 Suggest to add the reference to Figure 1 at the end of the para

Since that para also include natural effects (sensu IPCC 2006), which are not represented in the figure, we prefer keeping the reference to figure 1 few lines below.

Line 112 "The main conceptual difference is that global models consider those forests as managed that were subject to recent harvest and have not yet regrown to pre-harvest stock level…." With global models are you referring to both DGVM and BM? Otherwise please specify.

Thanks, we clarified that here we refer to Bookkeeping models.

Lines 322-25: The sentence is not clear, I suggest to reformulate it.

In response to this and the other reviewers' comments we have consolidated the explanation of the loss of additional sink capacity at the end of the method section and clarified this statement there.

Line 374-377: This paragraph refers to an "adjustment" but I think it is more correct to refer to a "difference" or "gap" as the number represent a difference between estimations, while the adjustment is done when you want to make one of the two comparable to the other (e.g. line 378)

Thanks. We modified as "The sink in non-intact forest estimated by Grassi et al. (2021), using one DGVM only, was equal to -5.0 $GtCO_2$ yr^{-1} for the period 2005-2020 (Supplementary Table 8, Grassi et al. 2021). In this study, for the period 2000-2020, 16 DGVMs estimate a sink in non-intact forest of -6.4 $GtCO_2$ yr^{-1}. In both cases, the adjustments based on these sink estimates reconcile most of the gaps identified between the anthropogenic land-use CO_2 flux estimated by NGHGIs and by global models (either IAMs or BMs)"

468 – missing space between “thatBMs”

Thanks, corrected

595 – not clear why a the inclusions to natural terrestrial sink would lead to a “double-counting” perhaps to a wrong attribution of the natural fluxes to anthropogenic causes?

We deleted that sentence.

Table 1: add a reference to the pools included in the different sources. On Organic soils: Oscar uses the same dataset as BLUE, I guess it is not the case of H&N. I suggest to include the source of the datasets for the three BMs.

Thanks, done.

In the row LULUCF net, last three cells (related to BMs): instead of repeating the same information, the information could be included once, merging the three cells (also in other cases above where the same approach is used by different models)

Thanks, done.

Finally, it should be noted that we updated the results to make it consistent with the Global Carbon Budget 2022 (at the time of the original submission, only GCB 2021 data were available). While results changed a bit (i.e., now we have a better match between BMs and NGHGIs at the level of LULUCF, but a less good match for forest land and deforestation), the message of the paper does not change.