RC1: 'Comment on essd-2021-235', Anonymous Referee #1, 20 Sep 2021

This is important and long-time awaited paper, describing the methodology and results of making inversion modeling comparable with GHG inventories in the UNFCCC national reporting. The paper provides multidimensional assessment, which considers three major gases: CO2 (managed and unmanaged land), CH4 (anthropogenic emissions, fossil, agriculture & waste) and N2O (anthropogenic), separately for large counties.

The paper provides motivation to different communities and countries to advance the modeling and reporting: Inverse modeling community – to check the reasons for inconsistency between the models and with other estimations; independent validation of country UNFCCC reporting; upscaling in situ measurements; etc.

The advantage of inversions is that they provide insights on seasonal and interannual greenhouse gas fluxes anomalies, e.g. during extreme events such as drought or wildfire, while national inventories tend to average and delay with recording emissions.

The paper is well written, all data processing steps are described, the results are discussed extensively. I have just a few comments.

Line 143: “we chose countries with an area that contains at least 13 grid boxes of the highest resolution grid-scale inversions”? Any reason for such a decision? Was it a pre-condition or did you find out minimum number of pixels (13) after country selection process?

We thank the Reviewer for the comment. The inversion models usually have coarse spatial resolution. The CAMS CO2 and N2O inversions, for instance, solve for fluxes on the grid of their transport model, with cells of 1.875° in latitude by 3.75° in longitude; the Jena-Carboscope CO2 inversion has a resolution of 4° by 5° which is about two times coarser. Some other inversions solve for fluxes at a coarser scale than their transport model, over small or large regions. Given this discretization of fluxes in global inversions, small countries (e.g. below the size of a middle-sized EU country like France) cannot be resolved well. Therefore, we focused the comparison on large countries or grouped countries that are large emitters (for each gas) and cover an ad hoc area of ≈ 13 CAMS pixels, roughly 1.25 M km^2. An exception is Venezuela for CH4 that is just below this limit (916,400 km^2).

Line 229: “intact forest areas (that are unmanaged, by definition)”. Definitions of managed forest are different in different thematic areas and vary in different countries for UNFCCC reporting.

IPCC Guidelines (2006) defines "Managed land is land where human interventions and practices have been applied to perform production, ecological or social functions". For example, intact forest in a national park is managed to support ecological functions (i.e. the forest is under fire protection). This intact forest is considered as “managed” for UNFCCC reporting. Based IBFRA analysis (unpublished IBFRA report, 2021), 49% of forest area in the IFL - Intact Forest Landscapes (Potapov et al., 2017) polygons belongs to “managed land” according to UNFCCC national reporting in Boreal biome. At the same time substantial amount of “unmanaged forest” are outside of IFL polygons, e.g. northern open

woodlands. I understand that in absence of global dataset of managed land the IFL is a logical compromise. However, the readers should be warned about this limitation.

We thank the Reviewer for the comment and the information about the unpublished IBFRA report. We have added and addressed this limitation in Line 1149-1154: "However, it should be noted that there are discrepancies between the Intact Forest Landscapes maps of Potapov et al. (2017) that we use and the unmanaged land defined in NGHGIs. For instance, an intact forest protected in a national park will be classified as managed in the corresponding NIR. Conversely, some areas of "unmanaged forest" are outside of the Intact Forests defined by Potapov et al. (2017), e.g. northern open woodlands"

Before that, we have also discussed the limitations of the approach we used to extract flux from unmanaged land in Line 232-235:
"This approach assumes that non-intact forest represents a reasonably good proxy of managed forest reported in the NIRs (Grassi et al., 2021). In the absence of a machine-readable definition of the areas considered to be managed in many NIR, this choice remains somewhat arbitrary and other unmanaged land datasets could have been used (Ogle et al., 2018; Chevallier 2021)."

And we also discussed the mismatch of CO2 fluxes from NIRs and inversions in Brazil and Canada in Line 877-887:

"Brazil is a specific case because although large fractions of the Amazon Forest are slightly disturbed by management activities, it contains a significant fraction of protected areas and Indigenous territories (23% of the total forest area in BRA) (Alejo et al., 2021; IWGIA, 2021) which are counted as managed land, by a political decision on land use. Thus, there is a mismatch between nationally reported areas of unmanaged land (316 Mha in 2010 according to Table 3.109 from MCTI (2016)) and the intact forest mask we used (166 Mha in 2010, ~33% of the national forest cover). According to Supp. Table 3 of Grassi et al. (2021), the share of intact forest over total forest was around 40% in CAN and BRA, and 20% in RUS. This share depends on the threshold used to define forest, but in BRA, our intact forest area (16%) used to exclude the inversion fluxes from unmanaged land may be too small, which means that BRA has non-managed land in non forest biomes. In comparison, the national communication reports of Brazil report that about half of the forest area is unmanaged."