Referee #1

General comments:

This paper presents a European inventory of CH4 and N2O fluxes, which is an update from a recently-published inventory by the same lead author (released in 2021). The paper thoroughly documents reported emissions, as well as emissions inferred from top-down inversions. I think the authors could have done a stronger job explaining the differences between this current manuscript and the data synthesis they published just last year in 2021. This justification was distributed throughout the text, but I think the paper would really benefit from the authors laying out a strong case in the introduction for why this 2022 manuscript is necessary over the 2021 paper. This being said, I do agree that updating datasets often is valuable for the community, whether or not this includes a thorough re-analysis of trends. Given the importance of CH4 and N2O to climate change, the keeping emissions inventories current is clearly valuable.

We thank Referee #1 for his review comments and we acknowledge that the manuscript would indeed beneficiate from a stronger explanation regarding the updates. Therefore, we made some changes the final paragraph in the Introduction (L192-201) as following:

"As Petrescu et al. (2021a) is the most comprehensive comparison of the NGHGI and research datasets (including both TD and BU approaches) for the EU27+UK to date, the focus of the current paper is on improvement of estimates in the most recent version in comparison with the previous one, including changes in the uncertainty estimates and identification of the knowledge gaps and added value for policy making. Such exercises of yearly updates are needed to improve the different respective approaches and furthermore can inform the development of formal verification systems. Official NGHGI emissions are compared with research datasets, including necessary harmonization of the latter on total emissions to ensure consistency. Differences and inconsistencies between emission estimates were analyzed, and recommendations were made towards future evaluation of NGHGI data. While NGHGIs include uncertainty estimates, the "uncertainty analysis should be seen, first and foremost, as a means to help prioritize national efforts to reduce the uncertainty of inventories in the future, and guide decisions on methodological choice" (Volume 1, Chapter 3, IPCC, 2006) and were therefore not developed to enable comparisons between countries or other datasets. In addition, individual spatially disaggregated research emission datasets often lack quantification of uncertainty. Here, the focus is on the median and minimum/maximum (min/max) range of different research products of the same type to get a first estimate of uncertainty (see Sect. 2). For those datasets providing uncertainties, new uncertainty reduction maps are presented (see Section 3.1.5). For those models/inventories who did not provided an update for this study, the previously published timeseries are shown."

Specific comments:

Line 216: Please define LULUCF

Yes, thank you for noticing it. We added the definition.

Table 1 – since this table is meant to highlight data sources, please include references to the data sources. I also suggest reformatting the table structure. You could have 3 columns (Emissions sector, data source, data source reference), and then vertically stack the sections for the Anthropogenic BU, Natural BU, and TD

Thank you for your suggestion, the references to the data sources are all included in Table 2. Table 1 was meant to highlight the sectors covered by the current study, while data sources are of secondary importance here.

Line 298 – Here you say "to a small extent" is this extend calculation in national inventories? If so, I suggest including the value here instead of a vague description. If this contribution isn't calculated and you are assuming its relevance, can you provide a reference that eutrophication only contributes a small amount to total inland water CH4 emissions? If not, please rephrase this sentence.

Thank you for your comment. The natural CH_4 emissions are not included in the countries' NGHGIs. The leaching/run-off are reported under Agriculture (3.D.2.2) only for indirect N_2O emissions and not for CH_4, therefore we can't add the inventory value. For clarity, we included the following paragraph and provided references for this statement, related to eutrophication.

"Globally, the contribution of eutrophication is estimated to lead to a further increase in lake and reservoir emission by 30 to 90% over the 21st century, which would be the result of a ~3 times higher nutrient loading to lakes and reservoirs (Beaulieu et al., 2019), similar to the review by Li et al. 2021 who gathered a lot of prove that eutrophication significantly increase CH_4 emissions. In temperate Europe, eutrophication contributes significantly to the overall increase natural emissions and Rinta et al., 2017 found that eutrophic, central European lakes show CH_4 emission rates which are about one order of magnitude higher than those of oligotrophic boreal lakes and this study's model results are consistent with it."

Li et al. 2021 (https://www.sciencedirect.com/science/article/pii/S0048969720381134?via%3Dihub)

Beaulieu et al., 2019, https://www.nature.com/articles/s41467-019-09100-5)

Rinta et al., 2017 (https://doi.org/10.4081/jlimnol.2016.1475)

Line 328 – When you say "While many different inversions have been used…" do you mean "While many different inversions exist…"

Thank you, we will rephrase this sentence as suggested.

Line 372 – 373 – It is not clear why you highlight that the first GST will include 2021, given that the GST will be in 2023. Do you mean that the first GST will include data up until 2021? If so, why don't your 5-year means align with a 2017 – 2021 window?

Thank you for your comment. Indeed, the GST connection here is a bit out of its scope, however what we were trying to say is that our 5yr mean results are of importance to the five-yearly GSTs, to give an overview of emission trends, even if, for the 2023 1st GST, we won't be able to provide an estimate, as this should be provided by the NGHGI compilers. At this point we are not able to include 2017-2021 mean because no dataset used has provided us with results up until 2021 and most importantly we would need the UNFCCC data will only be available in 2023 for 2021. We rephrased as following:

"Figure 1 shows the total CH_4 fluxes from the NGHGIs for base year 1990, as well as five-year mean values for the 2011-2015 and 2015-2019 periods. ~~We use~~ The five-year periods are informing on emission trends and what could be achieved by the GST process. ~~2023, the year of the first GST, when for most parties to the Convention the reported inventories will include 2021.~~ Given that the GST is only repeated every five years, a five-year average is clearly of interest even if, in this current study 2021 estimates are not available."

Line 383 – What contributes to the decrease in methane emissions? It would be helpful to comment at least briefly on what is driving the trend, or point the reader to where in the text you discuss this.

Thank you for your question. The decrease in CH_4 emissions observed everywhere in Europe is mainly due to the EU's legislation, policies and strategies aimed at reducing emissions in Europe. The EU's methane emissions dropped by a third between 1990 and 2019. Since 1990s and up to 2005, the decreasing trend was triggered by the implementation in the early 90s of European and country-specific emission reduction policies on agriculture and the environment, as well as socioeconomic changes in the sector resulting in overall lower agricultural livestock and lower emissions from managed waste disposal on land and from agricultural soils. For the consequent periods (2005-2019), the relative agricultural CH_4 (sector which dominates the CH_4 emissions) reduction is smaller but still consistent between all data sources. For the Central and Eastern Europe, reductions were abrupt just after the dissolution of the Soviet Union (1989–1991) and the consequent structural changes in their economy of the former eastern European communist centralized economy block and in 1990 CH_4 emissions registered very high CH_4 reductions which afterwards showed a constant decreasing trend. (Petrescu et al., 2020).

We will add the following paragraph:

"*The decrease in CH_4 emissions is mainly due to the EU legislation policies and strategies starting with the implementation in the early 90s of European and country-specific emission reduction policies on agriculture and the environment, as well as socioeconomic changes in the sector resulting in overall lower agricultural livestock and lower emissions from managed waste disposal on land and from agricultural soils. After 2005, these trends maintain their decreasing trajectory, even if, at a lower intensity. For the Central and Eastern Europe, reductions were abrupt and mainly due to the dissolution of the Soviet Union (1989–1991) and the consequent structural changes in the economy of the former eastern European communist centralized economy block (Petrescu et al., 2020).*"