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Interactive comment on "The consolidated European synthesis of CH_4 and N_2O emissions for EU27 and UK: 1990–2018" *by* Ana Maria Roxana Petrescu et al.

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Dear Topical Editor Nellie Elguindi, Dear Referees and Editorial Board of ESSD,

As requested, we are submitting responses to the referees' comments. We will provide as well a track-change version of the manuscript. We will not refer here to grammar or language corrections, but they will appear in the marked-up manuscript. The lines in the following answers refer to the track-change version of the manuscript.

Interactive comment on: "The consolidated European synthesis of CH4 and N2O emissions for EU27 and UK: 1990–2018" by A.M.R. Petrescu et al.

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REPLY TO THE REFEREE #2 The authors thank Referee #2 for acknowledging this study as being the most comprehensive assessment of CH4 and N2O emissions for EU27+UK, as well as being very useful for the modelers and the whole scientific community. We indeed agree that such a comparison was not easy and straight forward and we thank Referee #2 for the comments to which we answer below. 1. The results are presented as individual CH4 and N2O fluxes (figures 1-9). It would be great to have these figures together particularly for both gases as it will increase the readability especially when comparing the CH4 and N2O fluxes for each region. Currently, its hard to look at these figures of CH4 and N2O fluxes separately and derive any conclusion or recommendation on the dominant control of CH4 on N2O fluxes for different regions.

We thank the Referee for this comment. We mainly chose this structure of the paper (section 3.1 to address CH4 and section 3.2 to address N2O) to better focus on differences we've found between BU and TD estimates for each gas. If we would have presented in parallel both CH4 and N2O, would have been difficult to individualize and discuss specific findings and the overall discussion would have been confusing (we tried this before in an early version of the manuscript and most of co-authors suggested and agreed on keeping separate the two gases, each with its own section).

2. I am left wondering about why only CH4 and N2O emissions are included in this study. Since the study uses ground based observation, ecosystem modeling and inverse modeling, there should also be availability of data related to CO2 fluxes and that would provide a big picture of the net GHG for EU27 and UK. Adding CO2 into the current CH4 and N2O fluxes would be valuable not only to identify regions that are GHG sources/sinks but also to carry out large scale mitigation effort depending on the dominant control of individual GHG at the given location. In the same time with this study, the companion paper dedicated to CO2 was/is as well in review in ESSD (we mention it on Line 185). Please find below the link to access the manuscript. https://essd.copernicus.org/preprints/essd-2020-376/

3. Datasets: Since this is a data paper, I only see the aggregated data provided in Fig

1-9. I strongly suggest the authors to provide these data at pixel level so that it can be meaningful and useful to other colleagues working on CH4 and N2O fluxes for the UK and EU27 region. I am also wondering whether appropriate approach has been made to use data from all the papers that the authors have cited and whether there has been an agreement on making the data open source through this paper. Similar to the comment received from Referee #1, we believe that the data behind figures is sufficient for a correct replicability of the figures and represents the complete country/regional information. More detailed data at pixel level (if available, e.g., some models only provide country totals) should be asked from co-authors in accordance with their individual data policy (Appendix B2, Table B1). On the VERIFY web portal we present as well figures at the country level, which can be used by interested parties to check accuracy of the regional totals. This information is freely accessible with only a simple registration needed to keep track with whom is using the data, which sometimes is updated on the website but not yet published. http://webportals.ipsl.jussieu.fr/VERIFY/FactSheets/ Regarding the agreement and the open source data, the data policy of the VERIFY project (consortium governing document), which supported most of the research presented here, restricts the free use of raw data (gridded products) for the first 12 months after its publication, as it may not be entirely published by the data providers. Therefore, we agreed to only make public aggregated data. We intend to submit to ESSD yearly updates for the European GHG budget and once the new update will be published the old version of previous synthesis will be released as publicly available.

4. I have also seen unexpected citation approach (for example: line 160-165). The authors cite Yuanzhi Yao as personal communication for 66% of the N2O emitted from rivers are considered anthropogenic. This needs an appropriate citation with 66% of what, and how what is the contribution of the rivers toward total N2O fluxes (I do believe it should be relatively small compared to fluxes from agricultural lands). The 66 % was calculated for this study by our co-author, Yuanzhi Yao. It is not published in a peer-reviewed study and we wanted to acknowledge his work. We changed accordingly throughout the text “pers. comm.” with “in this study”. (L166, L245, L282, L687).

On L281 we also completed the sentence as following (in bold): "Note that the estimates of Maavara et al. (2019) and Lauerwald et al. (2019) include anthropogenic emissions from N-fertilizer leaching accounting for 66% of the inland water emissions in EU27+UK. In 2016, emissions from rivers represent 2.2 % of the total UNFCCC NGHGI (2019) N2O emissions."

5. Uncertainty: I am still not convinced about how the uncertainty was assessed since the data came from different sources. For example, if the authors are using ecosystem models, is it appropriate to use the standard deviation to determine uncertainty in N2O and CH4 fluxes. I do believe that model uncertainty comes from parameter use, the model structure and uncertainty in input datasets. However, the authors have not tried to address this issue in the manuscript. We agree that BU and TD approaches differ as well as the way uncertainties are quantified. Therefore, for TD results we agreed to use a neutral approach and define as uncertainty the variability we've seen for the model ensembles, calculating the mean, and set the uncertainty range as the min/max values. For BU models and inventories, only EDGAR v5.0 provided us for 2015 with an uncertainty estimate which, for comparability purposes, was calculated with the same method (the error propagation method (95% confidence interval) according to IPCC (2006, chap. 3, Eq. 3.7).) as the UNFCCC NGHGIs. We refer to Petrescu et al., 2020 for the EDGAR uncertainty methodology calculation https://essd.copernicus.org/articles/12/961/2020/#section8

6. Tables: While there are many details on the datasets used to estimate N2O and CH4, there is no any tables that shows the emissions from different sector when these datasets are compiled together. I strongly suggest the authors to provide the top-down and bottom up N2O and CH4 fluxes in one table with different sources (agriculture, natural vegetation, wetlands etc). Yes, we added the two tables below to the Appendix B1 Overview tables: Table B1a, B1b. Table B1a: Comparison of CH4 results from the BU and TD methods for common periods: BU Anthropogenic 1990-2015, BU and TD natural 2005-2011 and TD total 2006-2012 representing the com-

mon period between all data sets and the last year available. All values are in kton CH4 per year. The UNFCCC NGHGI uncertainties represent the 95% confidence interval; uncertainty for EDGAR v5.0 was calculated for 2015 and the min/max values for all sectors are as following: Energy: 33/37, IPPU: 39/34, Agriculture: 18/18, Waste: 32/38; the uncertainty represents the 95 % confidence interval of a lognormal distribution. The other uncertainties represent the variability of the model ensembles (TD) and are the min and max of the averaged result over the time period. All values are rounded to the nearest 0.1 kton CH4 and therefore columns do not necessarily add up. Bottom-up EU27+UK CH4 emissions Sector Data source Mean flux CH4 (kton)* BU Anthropogenic 1990-2013 2005-2011 2006-2012 2010-2016 Last available year** Energy UNFCCC NGHGI 5262.6 ± 1205.1 4022.6 ± 920.2 3938.7 ± 902 3641.2 ± 833.8 3398.5 ± 778.2 GAINS 4661.5 3336.5 3237.6 n.a. 2460.2 EDGAR v5.0 5438.4 (+2012.2; -1794.7) 4464.6 (+1651.9; -1473.3) 4401.7 (+1628.6; -1452.6) n.a. 4276.9 (+1582.4; -1411.4) IPPU UNFCCC NGHGI 69.6 ± 18.3 70.3 ± 19 68.1 ± 18.4 63.2 ± 17.1 63.4 GAINS n.a. n.a. n.a. n.a. n.a. EDGAR v5.0 26.2 (+10.2; -8.9) 26.7 (+10.4; -9.1) 26.2 (+10.2; -8.9) n.a. 25.0 (+9.8; -8.5) Agriculture UNFCCC NGHGI 10284.3 ± 998.8 9682.9 ± 992 9622.1 ± 985.3 9512.3 ± 974.1 9671.9 ± 17.1 GAINS 10791.3 9730.9 9632.6 n.a. 9441.3 EDGAR v5.0 10816.4 (± 1947) 10165.7 (± 1829.8) 10125.9 (± 1822.6) n.a. 10178.5 (± 1832.1) CAPRI 9915.3 9049.2 8975.9 n.a. 8834 FAOSTAT 10864.8 10067.5 9990.7 9814.4 9870.6 LULUCF UNFCCC NGHGI 278.5 ± 136.5 245.1 ± 118.3 244.7 ± 120.0 227.1 ± 111.3 320.6 ± 157.1 Waste UNFCCC NGHGI 8010.7 ± 1629.4 6735.9 ± 1549.3 6483.5 ± 1491.2 5564.1 ± 1279.7 5018.7 ± 1154.3 GAINS 8364.8 7691.1 7562.91 n.a. 6546.3 EDGAR v5.0 8792.9 (+3341.3; -2813.7) 7717.7 (+2932.7; -2469.6) 7501.7 (+2850.6; -2400.5) n.a. 6103.6 (+2319.4; -1953.2) Total anthropogenic BU - UNFCCC NGHGI 23905.7 ± 2220.8 20756.8 ± 1928.3 20357.2 ± 1891.2 19007.9 ± 1765.8 18473.1 ± 1716.1 BU natural CH4 emissions JSBACH-HIMMELI peatlands n.a. 1446.4 1423.0 1442.0 1345.9 Lakes_reservoires n.a. 2531.6 2531.6 n.a. 2531.6 Geological flux n.a. 1275.0 1275.0 1275.0 1275.0 TOTAL natural BU n.a. 5253 5229.6 2717 TD natu-

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ral CH4 emissions GCP-CH4 wetlands from inversions n.a. 1519 (+4649.1; -462) 1486.5 (+4825.4; -464.3) 1355.9 (+5188.2; -431.5) 1248.1 (+2608.5; -272) Top-down EU27+UK total CH4 emissions TD regional total FLEXPART - FLExKF-TM5-4DVAR n.a. 30486.8 30047.3 27062.3 24594.83 TM5-4DVAR n.a. 28770.7 29308.9 29431.5 29144.0 FLEXINVERT_NILU n.a. 33190.6 32714.9 32434.1 31343.8 CTE-CH4 n.a. 32836.8 32213.3 30246.7 33483.5 InGOS inversions n.a. n.a. 29496 (+6115.4; -1305.1) n.a. 27467.5 (+1913; -4857.4) TD global total Total SURF n.a. 24702.1 (+ 10174.7; -5083.2) 24308.5 (+9593.2; -4529.1) 23719.0 (+9195.4; -4605.7) 26175.7 (+4798.9; -6474)) Total GOSAT n.a. n.a. n.a. 22689.3 (+8190.9; -3240.3) 22651.4 (+8511.5; -10759.0) *The three periods were chosen based on the availability of data. The common period between all data sets is 2006-2012. **Last available year as following: UNFCCC NGHGI 2017, EDGAR v5.0 2015, GAINS 2015, CAPRI 2013, FAOSTAT 2017, JSBACH-HIMMELI 2017, Lakes_reservoires 2011, geological (one value for 2005-2017), GCP-CH4 natural wetlands partition from TD 2015, FLEXPART - FLExKF-TM5-4DVAR 2017, FLEXINVERT_NILU 2017, CTE-CH4 2017, InGOS 2012, GCP ensemble total 2017, total SURF 2017, total GOSAT 2017. For details on model estimates and yearly values please download the data behind the figures on Zenodo https://doi.org/10.5281/zenodo.4590875

Table B1b: Comparison of N2O results from the BU and TD methods for different periods: BU Anthropogenic 1990-2015, TS total 2005-2014 and the common period between all data sets 2010-2014 and the last year available. All values are in kton N2O per year. The UNFCCC NGHGI uncertainties represent the 95% confidence interval; uncertainty for EDGAR v5.0 was calculated for 2015 and the min/max values for all sectors are as following: Energy: 12/250, IPPU: 13/19, Agriculture: 74/191, Waste: 63/166; the uncertainty represents the 95 % confidence interval of a lognormal distribution. The other uncertainties represent the variability of the model ensembles (TD) and are the min and max of the averaged result over the time period. All values are rounded to the nearest 0.1 kton N2O and therefore columns do not necessarily add up. Bottom-up EU27+UK N2O emissions Sector Data source Mean flux

N2O (kton)* BU Anthropogenic 1990-2013 2005-2014 Last year available** Energy UNFCCC NGHGI 102.6 ± 24.1 99.0 ± 23.2 97.9 ± 23.0 GAINS*** 85.3 100.1 97.7 EDGAR v5.0 90.3 (+225.75; -10.8) 86.1 (+215.3; -10.3) 77.9 (+194.8; -9.3) IPPU UNFCCC NGHGI 231.5 ± 37.1 103.1 ±16.5 37.1 ± 5.9 GAINS 259.9 147.8 69.5 EDGAR v5.0 234.5 (+44.5; -30.5) 155.7 (+29.6 ; -20.2) 141.7 (+26.9; -18.4) Agriculture**** UNFCCC NGHGI 636.4 ± 636.4 603.7 ± 603.7 627.7 ± 627.7 GAINS 704.7 665.7 669.8 EDGAR v5.0 612.3 (+1169.5; -453.1) 578.0 (+1104; -427.7) 587.7 (+1122.5; -434.9) CAPRI 637.9 n.a. 639.1 FAOSTAT 689.7 653.8 670.1 ECOSSE 429.0 425.6 386.0 DayCent^ n.a. 643.9 ± 60.0 643.9 ± 60.0 LULUCF UNFCCC NGHGI 60.7 ± 29.7 64.9 ± 31.8 61.2 ± 30.0 Waste**** UNFCCC NGHGI 32.1 ± 32.1 34.0 ± 34.0 35.2 ± 35.2 GAINS 61.6 63.3 68.4 EDGAR v5.0 49.0 (+81.3; -30.9) 58.1 (+96.4; -36.6) 59.7 (+99.1; -37.6) Total BU anthropogenic UNFCCC NGHGI 1063.3 ± 853.6 904.7 ± 726.2 859.2 ± 689.7 BU natural N2O emissions Lakes, rivers, reservoirs n.a. 2.7 2.7 Top-down EU27+UK total N2O emissions TD total (2005-2014) MACTM-JAMSTEC (global) n.a. 1535.7 1577.3 PYVAR_NILU (global) n.a. 1024.2 1401.6 TOMCAT_LEEDS (global) n.a. 1369.7 1411.0 FLEXINVERT_NILU (regional) n.a. 1541.7 1228.5 Total TD min and max n.a. 1362.9 (+181.2; -340.3) n.a. *The three periods were chosen based on the availability of data. The common period between all data sets is 2010-2014. **Last available year as following: UNFCCC NGHGI (2019) 2017, EDGAR v5.0 2015, GAINS 2015, CAPRI 2013, FAOSTAT 2017, ECOSSE 2018, DayCent average 2011-2015, Lakes_rivers_reservoires (one value 2010-2014), FLEXINVERT_NILU 2017, TOMCAT_LEEDS 2014, PYVAR_NILU 2017, MACTM-JAMSTEC 2016. For details on model estimates and yearly values please download the data behind the figures on Zenodo https://doi.org/10.5281/zenodo.4590875 ***GAINS reports one value for every five years ****UNFCCC uncertainties for Agriculture and Waste were capped at 100%, but the actual reported values are much higher: 626% for Waste and 107 % for Agriculture. ^DayCent 2011-2015

7. Table 1,2 and 3 all can go in supplementary material. These tables are just taking too much space in the manuscript and given that Table 3 is adopted from some other

paper, I do not think it should be in the main content. Thank you for your comment. We would like to keep these tables in the text as there are many data sets and we believe these tables offer from the beginning of the paper a good overview on data availability, periods covered and references. Table 3 indeed is an updated version from Petrescu et al 2020 AFOLU paper, and relates to the discussion on N2O; we moved it into Appendix B1, Table B1c.

8. Seasonal flux estimates: Currently, the manuscript estimates CH4 and N2O fluxes at annual time scale and completely ignore the fact that understanding seasonal dynamics of these fluxes are important and useful for climate mitigation efforts. At least, there should be an acknowledgement on why seasonal fluxes were not estimated.

The seasonality discussion is a very important point in estimating correctly the CH4 and N2O emissions, both anthropogenic and natural. This paper in its core is a comparison of scientific data with UNFCCC national submissions. Unfortunately, the latter does not take into account any seasonality from emissions, and we agree that in climate mitigation efforts these should be indeed taken up and sent as a message to the national inventory agencies for further improvement of their reporting. As NGHGIs follows the IPCC guidelines and apply consistently low-tier methods to estimating emissions and uncertainties for all countries, there is a long journey needed for such a change to happen, but we hope that this sort of synthesis will increase awareness in both scientific and political communities. Inventories like EDGAR or FAOSTAT do not account for seasonal changes. We will take on board this comment and aim to include in the next synthesis the seasonality simulated by some process models. We included in the conclusion (L769) a statement on acknowledging the importance of estimating seasonal fluxes, as follows. “Additionally, we advocate the need of analyzing the seasonality of emissions, which are of great importance for CH4 (wetland emission estimates have large uncertainties and show large variability in the spatial (seasonal) distribution) and N2O (agriculture fertilizer application). This information is largely included in the prior flux estimates for TD approaches but not included in the reported IPCC guidelines. In the climate mitigation process these seasonal variations may play an important role for a better quantification of sector specific uncertainties”

References: Etiope, G., Ciotoli, G., Schwietzke, S., and Schoell, M.: Gridded maps of geological methane emissions and their isotopic signature, Earth Syst. Sci. Data, 11, 1–22, https://doi.org/10.5194/essd-11-1-2019, 2019.

Hmiel, B., V. V. Petrenko, M. N. Dyonisius, C. Buizert, A. M. Smith, P. F. Place, C. Harth, R. Beaudette, Q. Hua, B. Yang, I. Vimont, S. E. Michel, J. P. Severinghaus, D. Etheridge, T. Bromley, J. Schmitt, X. Faïn, R. F. Weiss & E. Dlugokencky: Preindustrial 14CH4 indicates greater anthropogenic fossil CH4 emissions, Nature 578, 409–412, 2020.

Janssens-Maenhout, G., Pinty, B., Dowell, M., Zunker, H., Andersson, E., Balsamo, G., Bézy, J.-L., Brunhes, T., Bösch, H., Bojkov, B., Brunner, D., Buchwitz, M., Crisp, D., Ciais, P., Counet, P., Dee, D., Denier van der Gon, H., Dolman, H., Drinkwater, M., Dubovik, O., Engelen, R., Fehr, T., Fernandez, V., Heimann, M., Holmlund, K., Houweling, S., Husband, R., Juvyns, O., Kentarchos, A., Landgraf, J., Lang, R., Löscher, A., Marshall, J., Meijer, Y., Nakajima, M., Palmer, P., Peylin, P., Rayner, P., Scholze, M., Sierk, B., and Veefkind, P.: Towards an operational anthropogenic CO2 emissions monitoring and verification support capacity, B. Am. Meteorol. Soc., https://doi.org/10.1175/BAMS-D-19-0017.1, online first, 2020.âĂĆ

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