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Interactive comment on "Global and regional emissions estimates for N2O" *by* E. Saikawa et al.

Anonymous Referee #2

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General comments

This manuscript presents new estimates for N2O emissions at the global and continental scale using observations of N2O mole fractions and a global transport model in an inversion framework. The emissions are estimated annually from 1995 to 2008 and are analysed for regional trends and inter-annual variations. This study represents a large effort in terms of compiling and analysing the observational data, and determining the calibration offsets between each of the networks included. The authors have also made considerable effort in compiling different prior estimates for the natural soil emissions.

While one novel aspect of this study is the optimization of the emissions by source type (natural soils, agricultural soils, industry, biomass burning and oceans), this also presents one major concern: that there is no observational constraint for the allocation of the emissions on land to agricultural soil, natural soil, industrial or biomass burning sources. There is not even a geographic separation of the sources, as the emissions are solved at continental or sub-continental scale.

The emissions from the inversion also seem to be strongly dependent of the prior estimate (in Fig. 3). In Fig 3a there is only error reduction in Europe, North America and South Asia and for the other regions the posterior emissions are almost undistinguishable from the prior. In Fig 3b, again the a priori and a posteriori industrial emissions are almost the same with very little to no error reduction. In Fig 3c, for natural soil emissions there is error reduction only for Northern Asia, Southern Asia, North America, and Central & South America. It is surprising, however, that there is error reduction for e.g. Northern Asia and Central & South America where there is only a very weak observational constraint but in Europe, where there are many more observations, there is very little error reduction.

For these reasons, the authors should consider including one figure showing the total emissions (all sectors) for each region and the uncertainty and extend section 4.1 explaining why they think it is justified to try to solve the emissions by sector. Also, to help the author's case (i.e. that it is justified to try to solve the emissions by sector) a figure or table showing the correlation of the posterior errors for each sector and region should be included. Furthermore, although this paper focuses on the optimization of emissions by sector (natural versus agricultural etc) there is no mention of delta-15N isotope measurements, which could help provide a constraint on this. Admittedly, these measurements are rare but may still provide a weak constraint on the different source types at continental scales.

Lastly, although this study is generally well presented English language editing is recommended.

Specific comments

p19473, l21-24: Actually, this statement is not correct, there are examples of at least 2

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previous studies using multiple network data, i.e. Corazza et al., 2011 and Thompson et al. 2013.

p19476, l9-11: Again, this is actually not the first time that these data have been combined in an inversion (refs. given above).

p19477, l10-12: Was only one error estimate used throughout the whole time period? It is known for example that the NOAA CCGG data prior to circa 1998 is much less certain than the data collected after this. Therefore, it would be important to account for this change in measurement accuracy in the observation uncertainties.

p19479, l4: The authors should say in the text that this ratio is between the calibration scale of a given network to that of AGAGE, i.e. calibration scales are referenced to that of AGAGE. Also, it should be made clear at the beginning that this is the ratio of the N2O data (this only becomes apparent later in this same paragraph).

p19479: Should mention the impact of chosing AGAGE as the reference scale as opposed to e.g. NOAA. Since the scales are diverging, chosing one rather than another will have a small impact on the global and regional trends.

Section 2: The authors do not discuss the changing precision and accuracy of the measurements at all in this section, which is an important consideration when looking at trends and inter-annual variations.

p19481, l24: The reference(s) to these previous studies should be given here.

p19482, l14: Again, the authors should state which studies they are referring to.

p19483, l1-2: The estimated lifetimes of N2O should be stated here.

p19483, l28: The temporal resolution of the emission sensitivities (i.e. in the Jacobian matrix H) should be stated, is this 1 year?

p19484, l16-19: This belongs in the results section.

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p19487, l5: The winter soil emissions in northern Eurasia are expected to be very low as the ground is frozen in most places during this time. Perhaps the authors are referring to the uncertainty in N2O emissions from thawing permafrost, which could potentially be an important source of N2O in the high northern latitudes? (see Elbering et al., 2010)

p19487, l20-22: From Fig. 1, Northern Asia does not appear to be as well covered by observations as e.g. North America or Europe.

p19488, l5: Please state the confidence level and which statistical test of significance was used.

p19488, l1-3: Fig. 3b shows a decreasing trend in the prior and posterior industrial emissions for Europe and North America, which is based on EDGAR-4.1. How well determined is this decreasing trend? Could it be that the increase in agricultural emissions found in the inversion may be compensating for the decreasing industrial emissions?

p19488, l27-28: There only appears to be an obvious convergence of natural soil emission estimates for the regions Northern Asia, North America and Southern Asia (in fact it is difficult to tell because the subpanels in Fig. 3 are very small).

p19491, l5: The AR4 estimate referred to here is actually Bouwman et al. 2002 and the original reference should be given. Presumably the authors have calculated the totals for North America and Europe from Bouwman's data themselves as this is not given in the IPCC AR4 report.

p19492, l11-13: Are these percentages the percentage of the total N2O emission from each region? This should be made clear.

p19492, l14: Should be specified that this is the natural soil and ocean emissions.

p19493, l11-13: The authors should mention the work of Corazza et al. (2011), who incorporated the optimization of the calibration scale offsets into their inversion. While

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it is indeed true that more work is needed to harmonize the calibration scales and measurement networks, considerable effort has been made to account for these offsets in inversions.

p19494, l1-5: Again, the authors should recognize the work of Corazza et al. (2011) who have performed a high-resolution inversion of N2O globally with a zoom over Europe.

Technical corrections

p19474, l11: grammatically correct: "Since N2O is inert within the troposphere, it has a long atmospheric lifetime. . ."

p19474, l13: no comma after "emissions"

p19474, l17: not "has" but "have"

p19474, l18: need to add "sources" after "anthropogenic" to be grammatically correct

p19476, l4: "sectorial" (and elsewhere e.g. section 4 heading, Table 3)

p19477, l27: "as well as at the seven following sites:. . ."

p19478, l25: it would be more accurate to say that the Tohoku University data cover a wide latitude range from north of Japan to Australasia.

p19479, l7: ". . .the calibration scales appear to be close to one another."

p19481, l12: "reproduces" suggests that the seasonal and inter-annual emissions have been validated and are correct, which means that there would be no need to perform an atmospheric inversion (at least for this source type), therefore, "estimates" or "simulates" would be more appropriate here.

Generally: attention should be paid to the use of articles and commas.

References

Corazza et al.: Inverse modelling of European N2O emissions: assimilating observations from different networks, Atmos. Chem. Phys., 11 (5), 2381-2398, 2011.

Thompson et al.: Nitrous oxide emissions 1999 - 2009 from a global atmospheric inversion, Atmos. Chem. Phys. Discuss., 13 (6), 15697-15747, 2013.

Elbering et al.: High nitrous oxide production from thawing permafrost, Nature Geoscience, doi:10.1038/NGEO803, 2010

Bouwman et al.: Modeling global annual N2O and NO emissions from fertilized fields. Global Biogeochem. Cy., 16, (4), 10.1029/2001GB001812

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 19471, 2013.