Biogeosciences Discuss.,
doi:10.5194/bg-2016-357-AC1, 2017

Biogeosciences Discussions

Interactive comment on "Soil nitrogen oxide fluxes from lowland forests converted smallholder rubber and oil palm plantations in Sumatra, Indonesia" *by* Evelyn Hassler et al.

Evelyn Hassler et al.

evelyn.hassler@forst.uni-goettingen.de

Received and published: 1 February 2017

We would like to thank Referee #1 for the time he/she invested to give his/her thoughtful and constructive comments. For clarity, we have copied his/her comments and placed our answers below each comment.

GENERAL COMMENTS

Referee: A general problem I have with this manuscript is the length of many sections and the wordiness of many paragraphs. The abstract alone comes in at ∼430 words and could be substantially shortened (no need to describe site replication for instance). The "Materials and Methods" section for instance is extremely long (9.5 pages) and

should be streamlined.

Answer: In order to address the referee's concerns, we shortened the abstract. As suggested we took out the replication and the timing of sampling (page 2, lines 10-15 of the original manuscript and removed the sentences about N-oxide losses of the applied N in the abstract (page 3, lines 1-3 of the original manuscript). We also streamlined section 2.1 "Study area, experimental design and management practices". We took out details regarding the management practices, which have been reported in our earlier paper (Hassler et al., 2015) and which have been not directly relevant in the present manuscript (page 8, lines 6-15 of the original manuscript). Lastly, we shortened section 2.3 "Statistical analysis" (see answer to detailed comment #13 below) and put the detailed statistical description to Appendix A.

Referee: In contrast, the discussion in particular would beneïňĄt from greater detail (and discussion with results from other regions of the world).

Answer: We indeed compared our results on soil N-oxide fluxes with measurements from other parts of the world (page 19, lines 7-8; pages 19-20, lines 22-2; page 21-22, lines 22-2; page 22, lines 13-16). This we elaborated also in our answer to comment #27 below).

Referee: Also to me, a clear site/ replicate nomenclature would better guide the reader through the text as the full measurement setup is rather complex (two soil landscapes, 4 land uses, 3 chamber positions at each site, 4 replicates). For instance, if the authors could deïňĄne some site abbreviations (e.g., reference land uses: F (forest), JR (jungle rubber); converted uses: RP (rubber plantation), PP (oil palm plantation), they could simple use to those instead to repeat the site attributes or be overly descriptive. This is also true for the naming of the three within-site chamber positions (currently: a, b, c). While their properties are described in the text, and also in the caption of table 4 it makes the digestion of the data presented unnecessary hard for the reader (maybe: F1 (fertilised area position 1 / 0.3m from stem), F2 (fertilised area position 1 (0.8m from

stem), NF (non fertilised: 4.5m from stem). In lengthy paragraphs it is easy to get lost and scramble to read up what i.e. position b represents (same for the reference to the proposed hypothesis').

Answer: We agree with the suggestion to use more descriptive abbreviations for chamber positions a, b and c. To address this concern, we introduced the abbreviations: F1 = chamber at 0.3 m from the tree base with incidental fertilization, F2 = fertilized chamber at 0.8 m from the tree base, NF = non-fertilized chamber location at 4-4.5 m from the tree base (page 10, lines 2-6 and Tables 2 & 4). We also, as suggested, included abbreviations for the hypotheses (H1 and H2) (page 5, lines 19-24) and pointed to these abbreviated hypotheses in the discussion to remind the reader how we linked our findings with the hypotheses (e.g., page 13, lines 15-18). On the other hand, we did not use abbreviations for the land uses in order to avoid confusions with all the abbreviations.

Referee: Furthermore, I feel that reorganising and cleaning the tables would help the better digest the main results presented. Table A1 & A2 should be combined and added to the main text. The ïňĄgures are appropriate, but could also be improved, too (see detailed comments).

Answer: Please find our answers regarding this comment below (detailed response).

DETAILED RESPONSE:

Referee: In the following I'd like to suggest some changes to the tables (often admittedly personal preference)

Table 1.

- Referee: Shorten the caption (16 lines of description).

Answer: The reason why the table titles are long is because in Biogeosciences, the table format must not have a footnote. This table title would have been short if the parts on statistical tests and identifiers can be placed as a footnote. We shortened the

table titles (Tables 1-4) by taking out details on the measurement period, which are now put in Appendix Table A1 (as suggested by reviewer 2). The table title, however, has to be succinctly correct without too much reference to the text, as one of the criteria of a Table is that it has to be completely understandable without referencing too much to the main manuscript.

- Referee: Also a column with number of samples (n) would help the reader to assess the robustness of the given average emission.

- Answer: We included this information directly after the SE on the first line of the table title in order to minimize columns with anyway the same entry for n = number of 'real' replicate sites or plots per land use.

- Referee: I would suggest to round to the first decimal to reduce visual clutter (esp. with the group identifiers presented in the table)

- Answer: We agree with the suggestion and reduced the decimal place to one.

Table 2

- Referee: The chamber location identifiers a, b and c do not help the reader. Either also identify the distance to the tree in the table or use descriptive abbreviations

- Answer: As the reviewer suggests in the general comments #3 above, we introduced the abbreviations: F1 = chamber at 0.3 m from the tree base with incidental fertilization, F2 = fertilized chamber at 0.8 m from the tree base, NF = non-fertilized chamber location at 4-4.5 m from the tree base.

- Referee: Again, indicate the number of measurements considered

Answer: The number of measurements is already indicated in the table title (line 3), and also the number of replicates is given in table title (line 1).

- Referee: Given the lack of NO data for 4 of the 6 sampled sites, maybe another organization would be better. For instance: Table 2a (N2O) – columns: Oil palm site /

ch pos / N2O (clay Acrisol) / N2O (loam Acrisol)

Table 2b (NO)- columns (with oil palm sites given as NO column identifier (?): CH pos / NO (clay Acrisol) / NO loam Acrisol

- Answer: Although this is generally a very good suggestion, we are convinced that the given structure of the table is also reasonable because of the following reasons: At a glance it is possible to see the differences in NO and N2O fluxes for the sites where both gases were measured. The structure follows that of Table 1, to which the reader can easily cross-reference. To reduce clutter and improve ease in reading, the values are rounded off to one decimal place.

Table 3./4.

- Referee: They could go into the appendix

- Answer: We put all supplementary information now in Appendix A and Appendix Tables A1-A3. We decided to keep Tables 3 and 4 in the main manuscript because one of our objectives is to determine the controlling factors of soil N-oxide fluxes. These tables show the important controlling factors in the different land uses and also following fertilization.

- Referee: Table 4 should be split into N2O and NO data (see Table 2)

- Answer: Splitting Table 4 into two for these two gases will increase unnecessarily the number of tables, when in fact N2O and NO can simply be put in the same table and it is easy to read this table for these two gases. This Table has similar structure as Table 3 in our earlier study (Hassler et al. 2015), published in Biogeosciences, where the two gases, CO2 and CH4, are put in the same table with their soil controlling factors.

Table A1/A2.

- Referee: Shorten caption

- Answer: In case of Table A1 (now Table A2 in the revised manuscript), we addressed

this concern by taking out the information on the statistical analysis because the significant differences among land uses and between landscapes do not play a role on how we discussed the influence of these parameters on soil N-oxide fluxes. - In case of Table A2 (now Table A3 in the revised manuscript), we addressed this concern by taking out the information about their measurement period, since this was also described in the methods (page 12, lines 10-13). We kept the statistics in this case because we refer to differences in soil mineral N content in our discussion (page 22, lines 17-21).

- Referee: Combine A1 and A2 into one table and add it into main document as a site description/ reference for the reader.

- Answer: We are convinced that these tables should stay separated for clarity reasons: First, the data in Table A1 (now Table A2) are used for the determination of spatial controls on annual soil N2O fluxes and are only determined once, while the data in Table A2 (now Table A3) were determined concurrently with the soil N-oxide flux measurement (page 12, lines 10-13) and are used for determination of temporal controls on monthly measured soil N2O fluxes (section 3.3). Second, a general site description is given in section 2.1, and Table A2 not aimed to describe the site but to give supporting data, which show correlations with annual soil N2O fluxes.

- Referee: Round WFPS, NH4 and NO3 to one digit to reduce clutter

- Answer: We rounded the values to one decimal place.

- Referee: This might be personal preference, but maybe remove the significance letters, too (they make the table really hard to read, also almost all entries in A1 have a lowercase ‘a’, maybe only label when they differ?; and important differences can be discussed in the manuscript).

- Answer: We agree with this suggestion and removed the statistical analysis from Table A1 (now Table A2).

Figures.

Referee: Some scale modification and additional labels would make the figures easier to read.

Fig. 2. - Referee: Matching scales would help the reader (at least 4 groups; a) & c) and b) & d)

- Answer: We tried this suggestion but it did not improve clarity. Instead, it diminished temporal pattern of the fluxes following fertilization. The reason is because soil N2O fluxes at F1 (0.3 m from the tree base with incidental fertilization; Figs. 2a and 2b) would be so minimized because of its much lower fluxes than those at F2 (fertilized location; Fig. 2c and 2d). Thus, we kept the original figure.

- Referee: Add Tree-base distance in the plots to guide the reader

- Answer: We included these now on the figure panels, in addition to the fact that they were actually included in the figure caption.

- Referee: Add fertilizer amounts to plot or captions (instead of referring section 2.2)

- Answer: We included the amount of added N to the caption.

Fig. 3

- Referee: See comments for figure 2 (y-axis break for a) and b) required)

- Answer: Please see author's answers for Figure 2 above.

DETAILED COMMENTS

1) Referee: p5, l19: Introduce site abbreviations that you can refer to in the text

Answer: We believe that introducing site abbreviations for the four land uses will not improve clarity but could confuse the reader, since we also used abbreviations for the different chamber locations within the smallholder oil palm plantations (see answer to general comment #3 above).

2) Referee: p5, l22: Introduce H1 and H2 for your hypothesis so you can refer to them

in your discussion

Answer: We included this suggestion (see answer to general comment #3).

3) Referee: p6: I would give a site property table here (basically combine A1&A2) and add soil properties – I feel a reference to Allen et 2015 and Hassler 2015 for such fundamental information for the manuscript is not sufficient.

Answer: We gave all the necessary site characteristics, including soil characteristics (page 6, lines 19-24), in section 2.1. Therefore, an additional table for site general characteristics is not necessary (see also our detailed response to comment on Table A1/A2 above).

4) Referee: p6, l16: is the precip data given as SD?

Answer: The precipitation data are the mean of the years 1991-2011 with the standard error among these measurement years.

5) Referee: p6, l20: that is actually substantially higher

Answer: That is true and therefore we highlighted this fact.

6) Referee: p7-8: site & design description could be shortened substantially

Answer: We streamlined section 2.1 by taking out details, mainly regarding the management practices (see answer to general comment #1 above).

7) Referee: p8: Please work on the language in this section: I counted 'was done', 5 times in this paragraph

Answer: After removing lines 6-15, we hope this language shortcomings are also remedied.

8) Referee: p9, l20: give a reference for N fertilizer induced pulse emissions

Answer: We cited Veldkamp and Keller (1997) and Veldkamp et al. (1998) who reported fertilizer-induced pulse emissions (page 9, lines 10-13).

9) Referee: p11: trapezoidal rule should be explained briefly here (esp. since it is not explained in the given reference Hassler at al., 2015, either.; in there is an other reference to Koehler at./ Veldkamp 2013).

Answer: For clarity reasons, we rephrased this sentence. Basically, trapezoidal rule is the simple interpolation between measured fluxes and the interval between sampling days (page 11, line 14-17).

10) Referee: p12, l4-l10: this is hard to read; just give the equation

Answer: We rewrote these lines into an equation form, aligned to the left margin for ease in reading (page 12, lines 1-4).

11) Referee: p13, l10: "when necessary" – explain

Answer: We improved the sentence; we meant, when assumptions for normal distribution and homogeneity of variance were not met (page 13, lines 13-15).

12) Referee: p13, l13: briefly remember your reader about your hypothesis H1 & H2 here

Answer: We added the hypotheses into the brackets of the sentence (page 13, lines 15-18).

13) Referee: p13, l22- p14, l15: this is very detailed... maybe move this into the appendix/ a supplement?

Answer: We agree with the referee's suggestion and put the detailed statistical description regarding the use of LME models to Appendix A. We revised section 2.3 "Statistical analysis" to describe which comparisons these LME models were applied (page 13, lines 15-24).

14) Referee: p15, l11: mention the reference land uses again

Answer: We included them in brackets (page 15, lines 1 and 7).

15) Referee: p15, l11: "...from soils. In the clay..."

Answer: We take this suggestion (page 15, line 1-2).

16) Referee: p15, l15: Was this systematic? I.e., was there always one measurement (position) an outlier?

Answer: This was not systematic. This occurred in all land uses, where one or two plots in some sampling days displayed higher emissions than the other plots of the same land use within the same landscape.

17) Referee: p16, l3-4: give the fertilizer rates here, too.

Answer: We included them into the brackets (page 15, line 23).

18) Referee: p16, l6: "in the chamber location closest to the tree, soil N2O emissions..."

Answer: We included this suggestion to make clearer which location we are talking about (pages 15-16, lines 25-2).

19) Referee: p16, l9: There is also a peak for site 1 (but smaller)

Answer: That is true! Nevertheless, mean fluxes were statistically not different between chamber location F1 and NF in this site, and hence we only highlighted site 2.

20) Referee: p16, l18: Due to which assumptions? Trees per ha? Avg. basal area of those trees?

Answer: The area-coverage calculation of fertilizer-induced N-oxide emissions was based on the number of trees/hectare. We made this clearer by including this information into the brackets (page 16, lines 13-14).

21) Referee: p18, l3: NH4 (only weak?)

Answer: For NH4+, only a weak correlation was found. We stated in section 2.3 (page 14, lines 19-20) that correlations with marginal significant will be included, and this is

also clearly identified in Table 3.

22) Referee: p18, l5: What is the temperature amplitude between the measurements? Relatively minor I suppose due to the tropical climate.

Answer: The soil temperatures of the sampling days during 1 yr of measurement in the converted land uses ranged between 24.4 °C and 30.6 °C. This correlation with soil temperature was definitely because of fertilizer-induced high N2O emissions on one sampling day with relatively high soil temperatures (28.8° C).

23) Referee: p18, l5-9: Remove this single sampling period outright since it clearly seems fertilizer-induced

Answer: We removed these lines and revised Table 3, according to this suggestion, since we also believe that this information is unnecessary.

24) Referee: p18, l13-14: How is this possible?

Answer: NO fluxes following fertilization in chamber location F2 (formerly, chamber b) of the clay Acrisol did not correlate with mineral N contents but instead correlated negatively with WFPS. The clay soil had high water retention capacity and WFPS overshadowed the influenced of mineral N on soil NO fluxes (in a condition with sufficient mineral N availability from fertilization) – soil NO fluxes were favored under conditions of low WFPS. Conversely, in the loam Acrisol, where WFPS were lower than those in the clay Acrisol, and favored for soil NO fluxes, NO was more influenced by mineral N than by WFPS. This is exactly what we discussed in pages 25-26, lines 20-2.

25) Referee: p19, l17: Give the range of your fluxes here for comparison

Answer: The reason why we don't write in the text the fluxes reported clearly in Table 1 is to avoid redundancy. One clear requirement is that values reported in Tables should never be repeated in the text; instead, we referred to the Table where these values are reflected.

26) Referee: p19, l19-25: This is very wordy, could be shortened substantially

Answer: We need to provide in these sentences the frequency of sampling and spatial replications of the studies to which we compared our values. These are very much needed in order to understand why fluxes from other studies are higher or lower compared to our measured fluxes. Still, we understand the referee's concern and therefore we removed the information on elevation (since we state anyway if we are talking about lowland forests or montane forests) and removed the decimal places but retain the sampling frequency and spatial replication (page 19, lines 8-18).

27) Referee: p20, l8: What about the other literature? You only compare to reports from your specific region

Answer: The reviewer is referring here only the summary statement of our comparisons with other values. We indeed relate our measured fluxes not only with previous studies within Indonesia but also with those studies in other tropical regions. In the first part of this paragraph, we indeed compared our soil N2O fluxes with values reported in literature (page 19, lines 7-8) and we also put these findings in a broader context (page 20, lines 7-10).

28) Referee: p21, l24: I do not get the reasoning here. Were the fires going on in the region during the measurements?

Answer: Fires are regularly occurring in Jambi region and in the whole of Sumatra Island. During fires, NO levels are generally elevated (Levine, 1999). To highlight this, we included Gaveau et al. (2014), who reported Sumatran fires 2013 (page 21, line 13-14).

29) Referee: p22, l8: Give the observed flux range here for better comparison, also the N application rates would help to judge the observations.

Answer: We did not repeat putting in our measured fluxes in the text as these are clearly stated in Table 1 to which we referred. To minimize the wordiness of our com-

parison with other reported studies, we removed the information on elevation, but retained the information on replication and sampling frequency. We agree that stating N fertilization rates is important, and we included them if they were provided by the cited studies (pages 21-22, lines 22-16).

30) Referee: p22, l9: Why do you give the elevation here? This is not really a factor (110m, 580,. . .)

Answer: We took out this aspect (see answer to detailed comment #26).

31) Referee: p22, l12: However the sampling there was very detailed and covered the transition period

Answer: We provided uniformly for all cited studies the frequency of measurement or the duration of measurement, whichever is given by the cited studies, and the replications so that the readers have the full background on how to judge the differences in flux values reported by these studies (see answer to detailed comment #26).

32) Referee: p22, l15: "nine monthly" is a bit deceptive, it's 9 single measurements, right?

Answer: Nine sampling days at monthly interval.

33) Referee: p22: Maybe a literature review table with relevant citations for the investigated land uses combined with your results would be appropriate here? This would also help the better interpret your results in context.

Answer: Yet another table will not shorten this manuscript. Besides there are only few studies that measured soil N2O fluxes (nothing for soil NO fluxes) from the same land uses to warrant another table. We are convinced that by having incorporated the above mentioned changes (removing information on elevation and rounding off values to have no decimal place) improve this section.

34) Referee: p23, l4-l6: Also true, this seems unnecessary to mention here. Maybe

give a half-sentence in the abstract highlighting the novelty of your NO measurements.

Answer: We agree with this comment and have removed this sentence, since we also mention this aspect in the conclusion (page 26, lines 12-14).

35) Referee: p23, l7: remind the reader about the hypothesis again

Answer: We referred back to the hypothesis number, but not rewriting it again in order to avoid redundancy. The reader can easily get back to the hypotheses now that these are referred to in numbers (page 22, lines 17).

36) Referee: p24, l21: Isn't it expected that fertilizer-induced emissions occur at the site where fertilizer is applied?!?

Answer: Yes, of course. But we want to point out here that for banded (meaning around a small area from the tree base) fertilizer application, as was claimed to be practiced by our smallholders, fertilizer-induced N-oxide emissions are limited within the fertilized area and only lasted within a short time. This may be different for large-scale plantations where fertilizers are broadcasted in much larger amounts.

37) Referee: p25, l8: mention your fertilizer rates again for comparison

Answer: We included the rates, as suggested (page 24, line 24).

38) Referee: p25, l9: these seem high; please give the references

Answer: We included the references again: Veldkamp and Keller, 1997; Veldkamp et al., 1998 (pages 24-25, lines 25-1).

39) Referee: p25, l25: pulse application? Maybe: "the event-based application of high N rates" or something similar?

Answer: We agree that this is an awkward wording, and deleted the word "pulse" (page 25, line 17).

40) Referee: p26, l10-12: This is most likely not true for low – medium moisture levels.

Answer: The referee points out that soil NO fluxes do not decrease and soil N2O fluxes do not increase under low to medium moisture levels. According to Davidson et al. (2000) soil N2O fluxes start to increase at around 30 % WFPS and soil NO fluxes start to decrease at around 60 % WFPS. WFPS in site 1 of the loam Acrisol soil (chamber locations F1 and F2, which showed a positive correlation between soil N2O fluxes and WFPS) ranged between 25 and 45 %. WFPS in in site 3 of the clay Acrisol (chamber location F2, which showed a negative correlation between soil NO fluxes and WFPS) ranged between 46 and 68 %. The correlation between N-oxide fluxes and WFPS follows the expected pattern based on the HIP model. Therefore, we are convinced that this sentence is correct.

41) Referee: p26, l12-16: This sentence actually highlights a key problem with such extensive sampling routine and should be discussed further.

Answer: We believed we have indeed discussed this extensively by pointing out the temporal patterns following fertilization at each smallholder site. Besides, an extensive sampling is not a problem but indeed a solution to include the short-term effect of fertilization. It is clear from our results that soil N-oxide measurements should be accompanied with concurrent measurements of known controlling factors; otherwise, investigators will not be able to explain their results. We are indeed able to explain this temporal pattern because we have recognized the simultaneously decreasing WFPS and increasing mineral N content over time in this site 3 of the loam Acrisol soil.

42) Referee: p26, l20: true, although the “full year” is based on few measurements

Answer: We also do not want to overrate our study and therefore clearly stated again, that our measurements were conducted on a monthly basis (page 26, lines 12-13).

43) Referee: p26, l22: Name the hypothesis, the reader might have forgotten which hypothesis was which

Answer: We referred to the hypothesis number (also see answers above for the same

comments).

44) Referee: p27, l7: ditto

Answer: Please see answer above.

45) Referee: p27, l12: change unit ‘kg’ to ‘t’

Answer: We changed “kg” to “tons” (page 27, line 4).

REFERENCES

Allen, K., Corre, M. D., Tjoa, A., and Veldkamp, E.: Soil nitrogen-cycling responses to conversion of lowland forests to oil palm and rubber plantations in Sumatra, Indonesia, PloS one, 10, e0133325, 2015.

Davidson, E. A., Keller, M., Erickson, H. E., Verchot, L. V., and Veldkamp, E.: Testing a conceptual model of soil emissions of nitrous and nitric oxides, Bioscience, 50(8), 667–680, 2000.

Gaveau, D. L. A, Salim, M. A, Hergoualc’h, K., Locatelli, B., Sloan, S., Wooster, M., Marlier, M. E., Molidena, E., Yaen, H., DeFries, R., Verchot, L., Murdiyarso, D., Nasi, R., Holmgren, P. and Sheil, D.: Major atmospheric emissions from peat fires in Southeast Asia during non-drought years: evidence from the 2013 Sumatran fires, Sci. Rep., 4, 1–7, 2014.

Hassler, E., Corre, M. D., Tjoa, A., Damris, M., Utami, S. R., and Veldkamp, E.: Soil fertility controls soil–atmosphere carbon dioxide and methane fluxes in a tropical landscape converted from lowland forest to rubber and oil palm plantations, Biogeosciences, 12, 5831–5852, 2015.

Levine, J. S.: The 1997 fires in Kalimantan and Sumatra, Indonesia: Gaseous and particulate emissions, Geophys. Res. Lett., 26(7), 815–818, doi:10.1029/1999GL900067, 1999.

Veldkamp, E. and Keller, M.: Nitrogen oxide emissions from a banana plantation in the humid tropics, J. Geophys. Res., 102(D13), 15889–15898, 1997.

Veldkamp, E., Keller, M., and Nuñez, M.: Effects of pasture management on N2O and NO emissions from soils in the humid tropics of Costa Rica, Global Biogeochem. Cy., 12(1), 71– 21, 1998.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/bg-2016-357/bg-2016-357-AC1-supplement.pdf

---

Interactive comment on Biogeosciences Discuss., doi:10.5194/bg-2016-357, 2016.