

Reply to comments of Anonymous Referee #1

RESPONSE: We thank anonymous referee #1 for evaluating and reviewing our manuscript. We are especially grateful for the many constructive comments and suggestions and we have to the best of our abilities responded to them. We address the referee's comments in the following point by point response.

GENERAL COMMENTS

The authors present an extensive and comprehensive study on soil N₂O fluxes and nitrogen dynamics in tropical wetland soils of the Pantanal region, including influences of precipitation and soil moisture dynamics. The study will make an important contribution to our still scarce knowledge about soil N dynamics and N₂O fluxes from tropical landscapes, and wetlands in particular. The topic of the study is well within the scope of Biogeosciences.

The introduction is largely well written, only the structure could be slightly improved. In general, the methodology appears well considered and sound, but needs to be more specific in some aspects. The results section needs major revisions. Currently, many values or ranges, which can often be read from Figures or Tables, are just laid out instead of summarizing and presenting main patterns. Unfortunately, hardly any statistical analyses have been conducted, which currently weakens this paper considerably. The findings need to be assessed statistically before publication. Also, the discussion should be critically revised and some parts of it should be transferred to the results section.

RESPONSE: We thank the referee for commenting on the value of our manuscript. We have restructured the Introduction according to the comments and suggestions offered by the referee in the specific comments (see details below). In addition, the Materials and Methods section has been revised, also according to the referee's comments (see details below). Most importantly, we have improved on the Results section by incorporating a statistical analysis of our data (see details below).

Finally, we have revised the Discussion section by restructuring paragraphs or omitting them entirely according to the referee's suggestions (see details below).

For all these suggested revisions I am giving more specific suggestions below. Finally, the paper would gain by being edited by a native English speaker. Once the paper has been carefully revised it will be a highly valuable contribution to the field of tropical biogeochemistry, which I am looking forward to see published.

SPECIFIC COMMENTS

Abstract

General: You use both the terms 'dry' and 'drained' when you talk of the conditions during the drying cycles. I think it would be easier if you just stick to one expression (e.g. dry).

RESPONSE: We use the terms "dry" and "wet" to describe the general precipitation pattern (dry/wet season) and the terms "drained" and "flooded" to describe the general soil moisture pattern (drained/flooded season). During the dry season the soil is mostly flooded, while during the wet season the soil is mostly drained. This is admittedly a bit confusing and any entry of 'drying'

has been replaced with 'draining' in the revised manuscript. Hopefully this has lead to clarification.

P5992/L6: Please specify what 'long term' means here, i.e. duration of the study.

RESPONSE: Specified as requested

P5992/L7: Suggest to spell out ammonium, nitrate and oxygen since you hardly use the acronyms/chemical formulas afterwards in the abstract.

RESPONSE: Changed as requested

P5992/L8: CO₂ has not yet been defined as acronym. The abstract does not include any information so far about the carbon dioxide fluxes.

RESPONSE: Removed as requested

Was there a consistent pattern in the changes in inorganic N concentrations with moisture conditions? If so, I suggest to specify how the inorganic N pools changed, i.e. how high were concentrations during dry periods and flooding periods, respectively.

RESPONSE: We have changed the wording to: '...with higher concentrations of NH₄⁺ found in flooded soil than drained soil and higher concentrations of NO₃⁻ found in dry drained soil than wetted drained soil...'

P5992/L11: Suggest to be more specific, e.g. how high were O₂ concentrations at 60 cm depth. According to your Fig. 5a, oxygen was not always similarly high down to 60 cm. Instead of writing that O₂ was depleted by rain events (was not captured as pronouncedly, Fig. 5a) maybe rather state that the system was mostly anaerobic in the waterlogged-site throughout all soil depths. (note: (a) and (b) are missing in Fig. 5).

RESPONSE: Changed to: 'O₂ penetrated (37-97% air sat.) the upper 60 cm of drained soil, but O₂ was depleted (6-96 % air sat.) in response to precipitation, while the waterlogged soil remained mostly anoxic throughout all depths.'

P5992/L14: Please include duration of these measurements (i.e. what is 'rapid').

RESPONSE: Changed to: 'Microsensor measurements in soil slurries showed relatively rapid N₂O accumulation reaching >500-1000 Pa after 13-20 hours...'

P5992/L15: Consider to tone down 'dominating' (e.g. 'important').

RESPONSE: Changed to: 'An important parameter...'

P5992/L17ff: Please give error estimates for the N₂O fluxes, e.g. standard errors.

RESPONSE: Standard errors have been added.

P5992/L20: It may not be clear from only reading the abstract that this R^2 is from a multiple regression. The relationship with pH is not significant and should not be reported as a main finding in the abstract, please delete.

RESPONSE: Entry deleted.

Introduction

P5993/L23: Is this a typo? (Low O₂ availability at high soil moisture contents stimulates denitrification, not nitrification). Suggest to also give the range of soil moisture content you are talking about (i.e. what is 'high'?).

RESPONSE: As requested we have now specified the soil moisture content and the O₂ partial pressure at which N₂O release is stimulated.

Poth and Focht (1985) found that nitrifiers reduced nitrite to N₂O under O₂-limiting conditions and release of N₂O from soil nitrifiers has been shown to be highest at O₂ levels of ~5% air sat. (Bollmann and Conrad, 1998).

P5993/L5: 'Higher N₂O release rates often occur...'

RESPONSE: Changed as requested

P5993/L10: Please insert a reference for the statement that denitrification is often considered to be the main N₂O producing process.

RESPONSE: Two references inserted as requested

P5993/L21-P5994/L21: I think that this section can be much improved by restructuring. Currently, you jump a bit between the topics. You start with factors affecting nitrification and denitrification, then you state that N₂O release rates may be especially high in systems with rapid changes in soil moisture, afterwards again some statements of when (de)nitrification is likely important, next again aspects on changing soil moisture. I suggest to reconsider and improve the structure of these 3 paragraphs.

RESPONSE: Section restructured as requested by 1. introducing the topic of nitrogen cycling in tropical terrestrial ecosystems, 2. introducing the microbial nitrogen cycling processes that produce nitrous oxide, 3. introducing the 'Hole-in-the-pipe' model and 4. introducing the mechanisms present in the Pantanal that might affect nitrification-denitrification.

P5994/L23: In which aspect did the three sites differ? Please specify. The current expression sounds as if you have three seasons in the ecosystem, please improve the wording here.

RESPONSE: Thank you for pointing this out. We have changed the description to 'Three sites were sampled repeatedly over a period of 23-42 days in the beginning of the low water season in 2008 and 2009.'

Materials and methods

P5996/L1ff: From first reading it is not understandable which ones are the campaign sites, and why you have only 11 sites marked in Fig. 1b. Please make this clearer.

RESPONSE: Description changed to ‘In 2008 and 2009 a main site (site A: 19°01.16’S; 57°32.99’W) was chosen for repeated sampling. An additional site was chosen for repeated sampling in 2008 only (site B: 19°0.61’S; 57°33.51’W) and in 2009 only (site C: 18°59.28’S; 57°25.17’W). In 2010, ten sites (A-K) representing different soil and habitat types were screened (Fig.1b and Table 1). All sampling was conducted during the drained season: In 2008 and 2009 sampling was conducted during the period of retreating water, while the screening in 2010 was conducted during the period of rising water level (Fig.2a). A weather station was installed at site A in 2009 (Fig. 2a) and measured the local precipitation and soil water content for 170 days of the drained season 2009-2010 (Fig.2b).’

P5996/L11: I think that it may be a bit difficult to remember what the word ‘level’ means, please consider to give it a more meaningful name, e.g. ‘landscape level’ or ‘moisture level’.

RESPONSE: Your suggestion to use ‘moisture level’ or ‘landscape level’ to make it easier for the reader to grasp is quite reasonable. However, the moisture level was not constant at each Level and therefore not the best term to describe a fixed location. We also feel that ‘landscape’ gives associations to larger scales than the 10-25m transects we studied. Lacking a better term we settled on “Level” because it is often used by physical geographers to describe stations along an inclining transect. Alternatively, we could exchange ‘Level’ with ‘Plot’ although we feel that ‘Plot’ doesn’t give the same association to a difference in elevation.

Fig. 2: Suggest to refer to Fig. 1b, i.e. ‘...indicates the period of local weather station monitoring at site A (Fig. 1b)’.

RESPONSE: Changed as requested.

P5996/L27: At which depth was the pressure transducer installed?

RESPONSE: Since there was a technical problem with the pressure transducer we decided not to use the data and have deleted it from the M&M section.

P5997/L6: It has been shown that storage of tropical soil samples prior to inorganic nutrient extraction can significantly change the measurement results (Arnold *et al.*, 2008; Turner & Tania, 2009). E.g., for tropical lowland forest soils from Panama, samples which had been frozen at -35 °C for four weeks contained significantly higher concentrations of ammonium compared to samples which were immediately extracted. Please consider these studies, and expand on this issue. How long did you store the soil samples before extraction and, based on the above publications, (how) can this have biased your results?

RESPONSE: Thank you for bringing this to our attention! Our samples were stored at -20°C and according to the mentioned studies this may indeed have biased our results towards higher-than-in-situ NH₄⁺ concentrations. Unfortunately the conditions in the field did not allow us to perform the analysis on fresh soil. Nevertheless, it is an issue we will have to deal with in following studies. We have elaborated on the storage time of the frozen soil samples until extraction of ammonium and included the mentioned studies in the discussion of the ammonium results and the significance of the potential bias.

P5997/L12: I don't find drying of the samples mentioned (but in the results you present values per gram dry weight of soil, e.g. for nitrate in Table 3)?

RESPONSE: A description of the soil drying procedure is now added.

P5997/L13-15: Please insert the town for the reference to Rhizosphere Research Products. From the current description I am not quite sure about the setup. Did you take soil cores, insert the filters and re-inserted the cores in the original position?

RESPONSE: We have elaborated on the description of the sampling setup in the revised manuscript.

P5997/L19: Please insert the town for the reference to Sartorius (and same below for RL Instruments and for several other references).

RESPONSE: Cities were added in the revised manuscript as requested.

P5998/L7: How high were the calibration concentrations? Please specify. How many and at which depths were soil samples taken?

RESPONSE This information has been added in the revised manuscript as requested.

P5998/L9-12: Is this the same pH method as above for porewater? If so, please shorten/combine.

RESPONSE: The 2008 and 2009 pH values were determined in the filtered/extracted porewater, while pH measurements were done in soil slurries during the 2010 screening. This has been clarified in the revised manuscript

P5998/L13 and L16: How many samples did you take per plot, at which depth?

RESPONSE: We collected 9 samples per plot (Level) i.e. 27 per site. The samples were collected at 1.5 cm, 3.5 cm and 6.5cm depth. This information has been included in the revised manuscript.

P5998/L17: Suggest to use 'landscape level', 'moisture level' or something similar (please see comment above).

RESPONSE: Your suggestion to use 'moisture level' or 'landscape level' to make it easier for the reader to grasp is quite reasonable. However, the moisture level was not constant at each Level and therefore not the best term to describe a fixed location. We also feel that 'landscape' gives associations to larger scales than the 10-25m transects we studied. Lacking a better term we settled on "Level" because it is often used by physical geographers to describe stations along an inclining transect. Alternatively, we could exchange 'Level' with 'Plot' although we feel that 'Plot' doesn't give the same association to a difference in elevation.

P5998/L17: Dried for only 2 hours? This is quite short and shorter than usual to get oven-dry samples.

RESPONSE: For soil samples of 2 g we found that 2 hours at 105°C were sufficient.

P5998/L20ff: Since the optodes were permanently installed, could they still be calibrated prior to measurements? If not, how could you assure that they remained measuring accurately? Please include a sentence on this issue.

RESPONSE: From our previous experience these optodes are quite stable and keep their calibration over long time periods. Frequent calibration over several months of similarly constructed optodes used for soil and sediment have had signal drift of <2% of the measured value (i.e. at 100% air saturation a reading will not be outside the 98%-102% range and at 10% air saturation a reading will not be outside the 9.8%-10.2% range).

P5999/L2: When were these samples taken?

RESPONSE: The information has been added in the revised manuscript as requested

P5999/L17: Why were gas fluxes not measured in level 3? Please make a note on this.

RESPONSE: For logistical reasons we were limited to 10 flux chambers per site. At the first measurements made in 2008, we divided the 10 chambers between all three levels with three chambers at each level. However, the fluxes measured at Level 2 and 3 were very similar at both site A and B while the measured fluxes at Level 1 at both site A and B were significantly lower. Furthermore, we expected Level 1 to undergo larger changes in soil moisture during the field campaign (it had been recently flooded and was still completely water-logged when we arrived) and so decided to rearrange the chambers to better cover the heterogeneity of Level 1 and 2.

P5999/L19: Please comment on why you chose this insertion depth. I am wondering if inserting so (to my mind relatively) deep may have affected the soil respiration measurements due to e.g. excluding horizontal fine root ingrowth over a considerable depth?

RESPONSE: This is a good point. When placing a flux chamber on the ground a compromise must always be made between preventing the cutting of roots/exclusion of root ingrowth and preventing the lateral loss of gas from the soil under the chamber due to the decreasing concentration gradient between the soil and the closed chamber. In our case the recently flooded soil flats were covered with patches of Eichhornia crassipes mats that decayed on the draining soil, but at the same time prevented (or at least delayed) the growth of plants like Panicum maximum. Correspondingly only few roots could be seen in the soil. At the same time we were unsure of how the soil would react when draining, so in order to prevent the chambers from detaching from the soil matrix we decided to insert them at 15cm depth.

P5999/L25: There is quite some discussion in the literature about how to calculate gas fluxes from time series of concentrations over time. Please insert the literature reference for the exponential calculation method you chose, and comment on why you used this calculation method. Please also include the units for the equation you used.

RESPONSE: This important information has been added in the revised manuscript as requested.

P6000/L4: In the result section, you are reporting differences, e.g. on P6000/L19-20, but in

the Statistical methods section you do not mention how you tested for differences between sites or over time. Please make sure that results which you report in the Results section have been statistically verified, include the tests which you applied in the Statistics methods, and the respective statistical parameters (e.g. *P*-values) in the results section.

RESPONSE: A statistical analysis of the data, and further details of the analysis, have now been included in the revised manuscript. Thank you for suggesting this.

Results

P6000/L12: Please give the soil depth you are talking about for ‘near the soil surface’.

RESPONSE: This information has been included in the revised manuscript

P6000/L14: This would not only be evaporation but drainage as well.

RESPONSE: Changed as requested.

P6000/L15: Please here, and throughout the manuscript, include error estimates for your mean values (e.g. standard errors). For example for temperature, mean values were very similar but, according to your Fig. S1, variability was more pronounced in the top soil than in deeper soil layers.

RESPONSE: Standard errors were added in the revised manuscript as requested.

Fig. 3: It is not mentioned in the figure or legend in which years the measurements were taken but you frequently refer to sampling years in the results. Please include this information in the Figure. How about presenting Site A in just one panel, which includes all measurements over the two sampling years? It would reduce the figure to just 3 panels. I am also thinking about the choice of this presentation more in general – did you try to plot the data, instead of as barplots, as time series, with three different symbols for the three different landscape levels? I can imagine that this might make it easier for the reader to grasp the patterns, especially for sites with more frequent data like for nitrate at site A. This would be a graph similar to Fig. 7 where fluxes are presented as time series.

RESPONSE: We have revised this figure. Figure 3 has been split into two separate figures: one for ammonium and one for nitrate. We have also rearranged each figure to show first site A, followed by site B and site C, as requested.

Furthermore, the data has been plotted as time series, but we had to stick with the bar plots because the data points overlap. We hope that this way of presenting the data is more intuitive and clear.

Are the units for ammonium and nitrate here $\mu\text{mol cm}^{-3}$, as opposed to $\mu\text{mol N cm}^{-3}$ as for TN in Table 1? Please use the same units throughout consistently.

RESPONSE: Error estimates have been included as requested.

The unit for ammonium and nitrate ($\mu\text{mol cm}^{-3}$) is the same as $\mu\text{mol N cm}^{-3}$, as there is 1 nitrogen atom per molecule. However, we agree that for the sake of clarity and easier comparison the units should be unambiguously consistent. This has now been done in the revised manuscript

P6000/L19-P6002/L4: Please verify all the statements about differences statistically, and give the respective statistical information. I think that this section (and also the results further below) may be a bit clumsy to read because so many values and ranges are mentioned. Please consider if all these are really necessary (since they can be read from Fig. 3a), or if you would focus on just some important ones. Also for pH I don't think it is necessary to mention all the values – just summarize...e.g. that porewater was generally acidic, varying between x and y across sites and sampling years. I also suggest to present the results from site A together for both years instead of splitting it up as it is currently done.

RESPONSE: A statistical analysis of ammonium, nitrate and pH data has been included as requested. The section has been revised accordingly in the revised manuscript.

Fig. 4: I think that also this Figure might become more intuitive by presenting the patterns over time (on the x-axis) since this is the more common form, and readers are more used to it. I also suggest to have just one panel for site A. From the current legend it is not clear from which year the measurements are (can be guessed but not unambiguously).

RESPONSE: Fig. 4 has been changed as requested (now Fig. 5).

P6001/L23: Fig. 4c?

RESPONSE: Fig. 4 changed as requested (now Fig. 5).

Figs. S2-S4: It is not clear what the symbols mean, i.e. from which measurement dates/months they are.

RESPONSE: We have removed several figures according to the suggestion from referee #2 to decrease the number of figures. Figs. S2-S4 have accordingly been removed.

Table 3: Please note why error estimates are not available for phosphate and for some other values. Unit for phosphate is missing.

RESPONSE: During the 2010 screening some of the soil samples were unfortunately lost along with our vehicle due to a hold up. The units have been included in the revised manuscript.

Fig. 5: Please include in the legend at which landscape level the oxygen concentrations were measured.

RESPONSE: Information included as requested.

P6002/L5-12: It is not necessary to give these values in the text since they can be found in Table 1. Please revise and shorten this section.

RESPONSE: Revised as requested.

P6003/L11: How were flux rates integrated? Please include this in the Methods Section.

RESPONSE: This important information has been included as requested. ‘Integrated emissions of N₂O and CO₂ were calculated for each level at each site, assuming linearity between subsequent measurements.’

P6003/L4-25: Please revise this results section. Since the flux rates can be seen in Figs.7 and S9 please summarize the main patterns instead of repeating all ranges, limit yourself to mention a few central values if necessary (e.g. means and SE).

RESPONSE: Revised as requested.

P6004/L5: N₂O fluxes are not at all related to pH, with a P-value of 0.138. Please exclude.

RESPONSE: Correlation analysis excluded.

Discussion

P6004/L16: Please replace ‘such a large’ with another, more neutral expression.

RESPONSE: Revised as requested. Phrase changed to ‘Finally we speculate on how the loss of nitrogen could be supported in a natural system like the Pantanal.’

P6004/L22: What type of ecosystems where these (e.g. forests?), and where in the tropics was this?

RESPONSE: This section has been revised and accordingly the above comment is no longer relevant.

P6005/L3-15: In my opinion, this would be good as a results but not discussion section.

RESPONSE: This section has been revised and accordingly the above comment is no longer relevant.

P6005/L15: During which period (water-logged, drained?) did Kern (1996) measure?

RESPONSE: Information added as requested. Kern et al. (1996) measured during the period of declining water level and the low water period in both water-logged and exposed sediments. We have elaborated on this in the text.

P6005/L18-22: And how do you interpret/judge about this comparison?

RESPONSE: The reference to Cenciani et al. has been removed. Following phrase added: ‘As the Pantanal soil contained less P and more nitrogen (Table 1) than the tropical soil from Hawaii (Hedin et al., 2003), we suggest that the Pantanal wetland soil is similarly phosphorus-limited.’

P6006/L12: Please include a reference for the last statement.

RESPONSE: References added as requested ‘...acidification of the draining wetland soil was dominated by the oxidation of dissolved ferrous iron as described by Shen et al. (1998)’

P6006/L17: You did not measure NO₃ and NO₂ concentrations in the slurries. Therefore I suggest not to state this as an unambiguous finding but rather tone it down as a possible explanation.

RESPONSE: We have revised the wording as requested.

P6007/L11-14: Please avoid to repeat results unless it is necessary for the interpretation – here, you could just immediately refer to Table 3 instead of giving measured values once again.

RESPONSE: Changed as requested.

P6007/L18-19: Even higher? E.g. $0.39 \text{ mmol N}_2\text{O m}^{-2} \text{ d}^{-1} / 0.001 \text{ mmol N}_2\text{O m}^{-2} \text{ d}^{-1} = 390$.

RESPONSE: Correct! Changed as requested.

P6007/L22: Transitory emissions were increased 5-fold in the montane and 7-fold in the lowland forest in the study from Panama (Koehler *et al.*, 2009).

RESPONSE: This has been included in the revised manuscript.

P6007/L26: N₂O fluxes were also stimulated by N-addition to the N-limited forest site, but the effect was much less pronounced than for the P-limited site (Hall & Matson, 1999).

RESPONSE: This has been included in the revised manuscript.

P6008/L6-7: Suggest to rather include the comparison with the N₂O fluxes in the first paragraph.

RESPONSE: Restructured as requested.

P6008/L19: Can you verify this statement statistically, e.g. were VWC and N₂O fluxes correlated?

RESPONSE: The data set is too limited to verify the observation statistically. The statement is based on observations of increased N₂O fluxes 6-12 h after precipitation.

P6008/L28: N₂O fluxes were not significantly correlated to pH.

RESPONSE: This has been included in the revised manuscript.

P6009/L5: Why is this a conservative calculation? I don't really understand that.

RESPONSE: This was meant to be conservative because we did calculations assuming linear changes between the drained soil fluxes (lower than the peak event fluxes) and assume that peak events last only 1 day. Had we considered all flux 'events' to be equal, e.g. a 3 day interval between a drained soil flux measurement and a peak event flux measurement would mean that the peak event flux would be allowed to bias the cumulated emission, as it would be implicitly assumed to last

more than a day. However, we completely understand the confusion and have tried to clarify this in the revised manuscript.

P6010/L6-17: This calculation is really interesting, but I think a bit difficult to follow right now. I needed to read through several times in order to understand what you calculated and what you argue. Please try to improve the presentation of this.

RESPONSE: We have revised this section thoroughly to improve the presentation: 'For calculation purposes, we considered each flux measurement to be either a drained soil flux or a precipitation-triggered peak event flux. The wetted mixed soil experiment (Fig. 7) and the in situ N₂O flux measurements (Fig. 8a-b) suggest that a typical peak event lasted ~1 day. Therefore, cumulative emissions were calculated assuming linear changes between subsequent measurements of drained soil fluxes, while precipitation-triggered peak event fluxes were assumed to last 1 day. In total, 116 in situ flux measurements (each representing a mean of 5 chambers) were performed from 2008 to 2010, of which we attributed 94 measurements to drained soil fluxes, while 22 measurements were considered precipitation-triggered peak events. The mean flux of the drained soil flux measurements (n = 94) was $0.43 \pm 0.03 \text{ mmol N}_2\text{O m}^{-2} \text{ d}^{-1}$, while the mean precipitation-triggered peak event (n = 22) lasted 1 day with a flux of $1.54 \pm 0.24 \text{ mmol N}_2\text{O m}^{-2} \text{ d}^{-1}$.

In lines 14-16 [P6010] this is an estimate, right, based on an extrapolation. Please make sure that this is made clear.

RESPONSE: We have added 'suggest' to make it clear that this is an estimate.

For the contribution of the dried soil do you calculate 164 days * 0.43 mmol N₂O m⁻² day⁻¹? That would give 70.5 mmol N₂O m⁻² day⁻¹. Please check and update (also in the abstract) if necessary.

RESPONSE: The daily flux from non-wetted drained soil was actually 0.4268 mmol N₂O m⁻² day⁻¹ and the 0.43 written in the text is merely short for that.

P6009/L21-23: I think that this sentence does not tie very well with the rest of the paragraph, suggest to revise.

RESPONSE: Section revised and this sentence deleted in the process

P6010/L18-20: Please specify the assumptions underlying this up-scaling, i.e. how many days of dry and wet conditions did you assume, based on which information? And please include a reference for the areal estimate of the Pantanal, and for the global emission budget.

RESPONSE: Upscaling calculation revised accordingly. We measured precipitation etc. during 170 days of the drained season and base our calculation on this. We have not included the flooded season into the estimate and have made this clear in the revised manuscript. References for the areal estimate of flooded areas in the Pantanal and for the global emission budget included in the revised manuscript as well.

P6011/L1-2: Well, obviously it does...

RESPONSE: Expression revised...

P6011/L2: Please avoid ‘such a large’ and choose a more neutral expression.

RESPONSE: Phrase deleted due to the previous comment. Accordingly this comment is no longer relevant.

P6011/L4: N₂O is a stable trace gas and production can continue much deeper into the soil. For example tone down, that you assume ‘most of the N₂O production occurred’ in that soil layer, and give a reference of why such assumption might be adequate.

RESPONSE: Good point! We tried to revise the text accordingly.

P6011/L11-12: Review also included N-oxide fluxes measured in Brazil and Costa Rica (Koehler *et al.*, 2009).

RESPONSE: Corrected as requested.

P6011/L16-19: This rather belongs into the Results Section.

RESPONSE: Excluded from revised manuscript.

P6011/L21: ‘a conservative estimate would be’

RESPONSE: Changed as requested.

P6011/L23-24: I get different calculation results, please check. If I got it right (please excuse if I am wrong) it would be $0.1 * 158.5 / 0.9 = 20.6$ for NO, and $0.2 * 158.5 / 0.8 = 39.6$ for N₂?

*RESPONSE: So do we! Thank you for pointing this out. However, we get $0.1 * 158.5 / 0.9 = 17.6$ for NO. The results have been corrected in the revised manuscript.*

P6011/L25-28: There are other nitrogen transformation and loss vectors, and the system is not necessarily in steady state. The total N-oxide fluxes (which are already based on a calculation including several assumptions) need not be exactly balanced by input. Please rephrase to make this more specific.

RESPONSE: We agree and have rephrased the text as requested.

P6012/L10-11: 6- to 8-fold lower

RESPONSE: Changed as requested.

P6012/L13: ‘of the estimated input by N₂ fixation’

RESPONSE: Changed as requested.

P6012/L15ff: Atmospheric N deposition is also not included in the considerations.

RESPONSE: We have added this in the revised text as requested.

P6012/L22: Please avoid expressions like ‘extremely large’ or ‘such large’.

RESPONSE: Changed as requested.

P6013/L5: Please include a reference for the statement that the fluxes have so far been considered negligible.

RESPONSE: Paragraph revised to: ‘In comparison with the number of studies of nitrogen dynamics and N₂O emissions from tropical forest soils, research on nitrogen dynamics and N₂O emissions from tropical freshwater wetlands are noticeably scarce. Furthermore, the contribution of N₂O from tropical freshwater wetlands has largely been considered negligible (Matson and Vitousek, 1990).’

P6013/L8: Please put your measured fluxes into perspective here again, i.e. what means ‘very high’, compared to what?

RESPONSE: We have revised the text as requested: ‘...comparable to heavily fertilized agricultural soils.’

P6013/L11: ‘natural and pristine tropical systems’?

RESPONSE: Changed as requested.

TECHNICAL CORRECTIONS

P5992/L7: ‘in laboratory soil slurries’

RESPONSE: Changed as requested.

P5992/L8: ‘in situ surface fluxes’

RESPONSE: Changed as requested.

P5992/L16: insert comma after ‘was precipitation’?

RESPONSE: Changed as requested.

P5992/L18: Suggest to write ‘fluxes’ instead of ‘activity’, and spell out ‘10’

RESPONSE: Changed as requested.

P5992/L24: rain-induced (insert dash)

RESPONSE: Changed as requested.

P5993/L22: Nitrification and denitrification are responsible for the production of N₂O, not for the release.

RESPONSE: Changed as requested.

P5994/L1: It is called ‘Hole-in-the-pipe’ model

RESPONSE: Changed as requested.

P5995/L8: typo: Fig. 1a

RESPONSE: Changed as requested.

P5995/L26: typo: Fig. 1b

RESPONSE: Changed as requested.

P5995/L21/22: ‘This explains why the Pantanal receives...’

RESPONSE: Changed as requested.

P5997/L4: ‘KCl-extracted’ (insert dash)

RESPONSE: Changed as requested.

P5997/L11: ‘by the fluorometric method’

RESPONSE: Changed as requested.

P5997/L20 and P5998/L5: ‘laboratory’ instead of ‘lab’

RESPONSE: Changed as requested.

P5998/L22: ‘custom-built’ (please insert dash)

RESPONSE: Changed as requested.

P5998/L24: ‘intervals’

RESPONSE: Changed as requested.

P5999/L5: Please insert a comma: ‘slurry, measuring...’

RESPONSE: Changed as requested.

P6000/L12: ‘...near the soil surface, and progressively less so’?

RESPONSE: Changed as requested.

Fig. 4: ‘water-logged’

RESPONSE: Changed as requested.

Legend to Fig. S6: 'near sites a, B and C'

RESPONSE: Changed as requested.

Legend to Fig. S7: 'from the screening field campaign'

RESPONSE: Changed as requested.

P6005/L5: 'After 1-2 weeks of draining, the soil...'

RESPONSE: Changed as requested.

P6005/L11: You did not measure throughout the drained season. Therefore rather tone down from 'indicating' to e.g. 'suggesting'.

RESPONSE: Changed as requested.

P6007/L5: delete 'be'

RESPONSE: Changed as requested.

P6007/L20-21: Koehler et al. 2009; ',nitrogen addition to'; ',N₂O emission peaks'

RESPONSE: Changed as requested.

P6007/L23: 'phosphorus-limited'

RESPONSE: Changed as requested.

P6007/L25 and P6009/L23: 'long-term'

RESPONSE: Changed as requested.

Changed as requested.

P6008/L24: Fullstop missing after the sentence.

RESPONSE: Changed as requested.

P6009/L6: 'rain-wetted' (and throughout the MS)

RESPONSE: Changed as requested.

P6010/L10: 'precipitation-triggered'

RESPONSE: Changed as requested.

References

Arnold J, Corre MD, Veldkamp E (2008) Cold storage and laboratory incubation of intact soil cores do not reflect in-situ nitrogen cycling rates of tropical forest soils. *Soil Biology and Biochemistry*, **40**, 2480-2483.

Hall SJ, Matson PA (1999) Nitrogen oxide emissions after nitrogen additions in tropical forests. *Nature*, **400**, 152-155.

Koehler B, Corre MD, Veldkamp E, Wullaert H, Wright SJ (2009) Immediate and long-term nitrogen oxide emissions from tropical forest soils exposed to elevated nitrogen input. *Global Change Biology*, **15**, 2049-2066.

Turner BLR, Tania E (2009) Short-term changes in extractable inorganic nutrients during storage of tropical rain forest soils. *Soil Science Society of America Journal*, **73**, 1972.