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Interactive comment on "Indications of nitrogen-limited methane uptake in tropical forest soils" *by* E. Veldkamp et al.

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Answers to referee Dr. Mo:

'General comments: The authors explored the impact of chronic N addition on soil CH4 fluxes from two old-growth forests in Panama. There so far is little information available in the scientific literature dealing with response of soil CH4 fluxes to N addition in tropical forests. The results from this study will improve our knowledge on the response of CH4 to elevated N deposition in various tropical ecosystems and will be interested by the readers of this journal. Generally, this work is well written and presented. I don't have major concerns, but several issues need to be well addressed before it is published.'

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Answer: We thank Dr. Mo for his comments and suggestions. Below we would like to address the specific comments.

1 'There are some inconsistencies in this manuscript. The authors found that there was a nagative correlation between soil CH4 fluxes and soil mineral N (NH+4, NO3- or total available N) in these two forests, which suggest that soil CH4 uptake was limited by N availability in both forests. However, results from this study showed that nine to twelve years of N addition to this lowland forest and one to four years of N addition to this montane forest did not affect soil CH4 fluxes, although N addition significantly increased soil N availability (Fig. 2).'

Answer: These points raised by this referee are exactly what we discuss in detail in section 4.2: we presented other supporting evidence (lines 472-479); and we discuss why we were not able to detect significant differences in CH4 fluxes between the N addition and control plots in both sites (line 480-486). We further discuss why a stimulation of CH4 uptake does not automatically lead to a change in CH4 fluxes (lines 486-488), and the possible mechanism of how increased NO3- levels may lead to stimulation of methanotrophic activity (lines 489-492). We believe we clearly explain the correlation between CH4 fluxes and mineral N and give possible reasons why despite indications of N-limited CH4 uptake we did not detect statistically significant differences between control and chronic N addition plots, and thus we do not think that these results are inconsistent.

2 'Since significant effect of N addition on soil CH4 fluxes was not detected in this study, I would suggest that the title of this paper change from "Indications of nitrogen-limited methane uptake in tropical forest soils" to "Effect of N addition on soil CH4 fluxes in two old-growth tropical forests in Panama ' .

Answer: It is common practice nowadays to include the major finding in the title of a paper, instead of general description of what one studied. For examples, we refer in the reference list of our present study to the following papers that all have a title that

BGD

10, C2653–C2658, 2013

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incudes its major result: Arnold et al., 2008; Hietz et al, 2011; Martinson et al., 2010; Wright et al., 2011; Zhang et al., 2011. By including the word 'indications' in the title it is also immediately clear that 100% proof was not found.

3 'Page 6014, Line 6, 2.2 Site description and experimental design "At both sites, four replicates of N-addition plots and four controls were established." I wonder how these treatments arranged. Was a paired-plot design used in this experiment? What is the average slope for these sites? The large spatial variation in CH4 fluxes may be related to "high slope" in these sites'.

Answer: Details of the plot arrangement of in the lowland forest are summarized in appendix A of the publication: (Wright et al., 2011), see Ecological Archives E092-136-A1, with maps showing the location of the study site, its topography and locations of each experimental plot. For the present study, we only used the plots demarcated as N (for N addition) and C (for control). In the lowland forest, treatment plots were blocked perpendicular to the direction of a gentle slope from the northeast corner to the southwest such that both N-addition plot and the respective control plot in a replicate block were located at similar positions along the slope. Average slope in the lowland site was less than 3°. The plots in the montane forests were arranged in a paired plot design, where also each pair of plots (N addition and control) was located on similar landscape position. All plots were located in areas where no gaps, swampy areas, streams or slopes steeper than 15° were located (Adamek et al., 2009). We added only a short description of the experimental design (lines 209-212) because this has been described in detail in the previous papers from the same experiment. Finally, had landscape position affected our results we would expect it to show up in the soil water content, which was not the case (see Fig. 1 a, b of our manuscript).

4 'Page 6018, Line21, "CH4 fluxes from the lowland forest control plots (21.47 ± 1.57 gCH4 Cm 2 h 1) did not differ from the fluxes of the montane forest control plots (3.99 ± 3.40 gCH4 Cm 2 h 1; Fig. 3, Table 1)." Here, the difference between these two forests is about 5 times (21.47/3.99 = 5.38), very large! However, the difference from

BGD
10, C2653–C2658, 2013

Table 1 between these two forests is much smaller. For example, in 2006, -1.69 $\pm$ 0.36 for montane forest V.S. -1.93 $\pm$ 0.24 for Lowland forest. Difference for this is 1.93/1.69 = 1.1.'

Answer: The CH4 fluxes mentioned on Page 6018, line 21 are mean values over the entire 4-year period, for which the statistical test (linear mix effects model, used for parameters measured repeated over time) was conducted. Table 1 shows the annual estimates. If you look at Fig. 3 for 2006, CH4 fluxes from the montane and lowland control plots were all negative while in other years we measured occasional CH4 emissions from the montane control plots, and the last year included many CH4 emissions because it was exceedingly wet. This observation from Dr. Mo illustrates the strength of our study where we present a 4-year dataset, while very often data from remote tropical regions are limited to one year at most.

5 'Page 6018 Line15. "These opposing correlations of CH4 fluxes with NH+4 and NO 3 were because the temporal patterns of NH+4 and NO 3 showed the opposite trend." Why the temporal patterns of NH+4 and NO 3 showed the opposite trend? Do you have any data to support it?'

Answer: The data are presented: if you look at Fig. 2c,d for the organic layer and Fig. 2e,f for the mineral soil such pattern can be deciphered. We therefore added this figure reference in line 345. In the control plots of the montane forest there is some natural variability in extractable N such that when extractable NH4+ tends to decrease, extractable NO3- tends to increase. We should however also point out that the NO3- values are extremely low (NO3- concentrations were barely above the detection limit) and the NH4+ concentrations were one to two orders of magnitude higher than the NO3- concentrations. Thus, it is logical that when we assess the relationship between CH4 fluxes and total mineral N, the correlation follows that of NH4+. The opposing pattern of NH4+ and NO3- across four years was probably related to the high water-filled pore space during the wet year of 2009 (last year of measurement) as shown in Fig. 1b (clearly shown by the mineral soil). However, differences in NO3- levels

BGD
10, C2653–C2658, 2013

between years were all not statistically significant, because we are talking about only small values (barely above the detection limit). The only distinguishable pattern that can be deciphered from the data is that of Fig. 2c-f. Hence, we mentioned this but did not discuss it in much detail.

6 'Page 6009, page 3 "Based on these findings, it is unlikely that elevated N deposition on tropical forests will lead to widespread inhibition of CH4 uptake." This conclusion especially "widespread" is not supported by this study and the studies from other tropical forests. There are so far only two researches including this research dealing with response of soil CH4 fluxes to N addition in tropical forests.'

Answer: It is obvious from our study that we did not detect inhibition of CH4 uptake as a result of N additions, nor did we found indications that this is the case. We actually hypothesized that in the lowland forest soils N additions would lead to inhibition of CH4 uptake (see hypothesis 1 in the introduction). However, even in this ecosystem which has a naturally high N availability this was not the case. Since the two ecosystems are very different (highly weather soil vs. relatively young soil; lowland forest vs. montane forest; N limited tree growth vs. not N limited), we do think that we cover quite a lot of the natural variability that is found in tropical forests, which was the basis for this sentence. We have however followed the suggestion of Dr. Mo and have adjusted the sentence to: 'Based on these findings, it is unlikely that elevated N deposition on tropical forest soils will lead to a rapid reduction of CH4 uptake'.

References:

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10, C2653–C2658, 2013

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