

Reponse to Reviewer 2

We would like to thank Reviewer 2 for taking the time to provide a useful critique of the manuscript and in particular for providing detailed suggestions for improving the clarity of the discussion. We have responded to their concerns in blue and copied their original comments in black for ease of reference.

Pg 11, lines 6-8: this sentence is rather vague - can you rephrase it to state specifically what you think is occurring (perhaps with a reference)?

We have simplified the statement on Page 11: *“This may impart reflect the fact that seasonal variations in rainfall and temperature become more pronounced with elevation across this transect (Fig. 1).”* The issue is more appropriately discussed with reference to temporal relationship between net flux and WFPS in the following section. Page 12, Line ~16

Pg 11, line 15: can you suggest what you might have done differently?

We have expanded the text on Page 11: *“Emissions were more prevalent in the premontane forest, accounting for 29 % of fluxes, suggesting that emission hotspots are possible in these soils but may not have been captured by our sampling strategy (Delmas et al., 1992; Silver et al., 1999). Assessing and studying the potential for emissions from these ecosystems is likely to require higher resolution observations to capture spatial and temporal variability (Liptzin et al., 2011; Silver et al., 1999) combined with experimental manipulations (Hall et al., 2013) and a better understanding of below-ground CH₄ cycling (von Fischer and Hedin, 2007; Teh et al., 2005).”*

Pg 11, line 32: 'dissimilarities' is vague - please rephrase this sentence to explain specifically what you mean.

We have reworded the text on Page 11: *“Notably, this relationship appears to be driven by decreased WFPS and increased CH₄ uptake in the upper montane forest plot during the dry season.”*

Pg 12, line 11-12: the purpose of this sentence is unclear, please rephrase and/or expand on what you are trying to say here.

We have expanded on text on Page 11: *“However, we may also have expected increases in available NO₃⁻ to competitively suppress methanogenic activity (Chidthaisong and Conrad, 2000). This is counter to the observation that net CH₄ is positively correlated to available NO₃⁻ and that emissions are most prevalent in the premontane forest. Greater below-ground productivity at lower elevations (Girardin et al., 2010), potentially driven by greater nutrient availability and temperature, may also stimulate CH₄ production in the rhizosphere through the supply of labile substrates to methanogenic communities or maintenance of anaerobic microsites through the O₂ demand of heterotrophic respiration (Bodelier, 2011). Such a mechanism, not observed in this data, might be supported by a positive relationship between net CH₄ and CO₂ fluxes (Verchot et al., 2000).”*

Pg 13, line 10: discussed where? Are you referring to Pg. 11? If so, this is again quite vague. Can you suggest another possible driver?

We have expanded the text on Page 13: *“From these contrasts, it is possible to suggest that relationships with temperature identified here, as discussed with reference to spatial correlations across the Peruvian transect in the previous section, and in Ecuador (Wolf et al., 2012) result from covariance with other drivers like soil moisture or nutrient availability rather than as a result of the temperature sensitivity of CH₄ uptake.”*

Pg 13, line 17: what mechanism? You comment on differences and go on to suggest they may be related to soil structure, but can you specifically describe a possible mechanism?

We have expanded the text on Page 13: *“Increased WFPS, a function of decreasing soil porosity and increasing precipitation across the transition from upper montane to premontane forests, appears to limit CH₄ uptake in Peru through diffusional constraints on the supply of CH₄ to methanotrophic communities. Whilst a similar pattern in soil porosity with elevation can be inferred from the presence organic horizons in montane forests studied in Ecuador (Wolf et al., 2012), the alignment between increasing precipitation and decreasing CH₄ uptake across this transect might suggest that diffusional constraints, in response to changes in soil moisture, might provide a generalised explanation for the patterns observed. Indeed, Veldkamp et al. (2013) invoke gas diffusional control to explaining positive correlation between net annual CH₄ fluxes and rainfall in a meta-analysis of 7 tropical forests above 800 m elevation.”*

Figure 4: Double-check your statistical theory here, but as they are currently presented, I don't think these graphs should have regression lines. I believe that once you choose to treat the 3 elevations as forest replicates, the within-elevation replicates would need to be averaged in order to avoid pseudoreplication.

Reviewer 2 also raised this point and we have copied our response here. Reviewer 2 also raised this point and we have copied this response there. Our decision to treat measurement plots within a 'forest type' (or elevation band) as independent replicates of net CH₄ exchange is based on the assumption that spatial autocorrelation is limited to short distances (i.e. operating at sub-plot scales of ~ 1 to 10s of m). The plots in our study were more than 100 m apart. We treat our observations as longitudinal data to investigate the possible drivers of the relationship between net CH₄ flux and elevation within our study area. In an attempt to synthesise this information, we then discuss CH₄ exchange in terms of the ecosystem transitions (or 'forest types') seen across the landscape. This approach is adopted from the literature, for example, across montane forest landscapes (Purbopuspito et al., 2006, p.3) and more recently across lowland tropical forest landscapes (Hassler et al., 2015). We state our approach in the manuscript on Page 6, Line 19 – 21: *“Despite the three plots within each forest type broadly occurring within the same forest stand they were considered independent replicates of forest type as spatial correlations between net CH₄ fluxes in tropical forests are small (Ishizuka et al., 2005a; Purbopuspito et al., 2006)”*. However, we acknowledge the concerns of both reviewers. The use of site (n = 3) or plot (n = 9) means in correlation tests does not fundamentally change the pattern or effect size of the relationships which form the basis of our discussion in section 4.2. For example, focussing on the most robust relationships identified between CH₄ exchange and environmental conditions (Table 3 (Pearson's $r > 0.8$, $p < 0.05$, $n = 9$) and then graphed in Figure 4): n = 3, net CH₄ flux vs. elevation (Pearson's $r = -0.85$, $p = 0.35$), soil temperature (Pearson's $r = 0.86$, $p = 0.34$), WFPS (Pearson's $r = 0.99$, $p = 0.10$) and NO₃ (Pearson's $r = 0.92$, $p = 0.25$). In an attempt to minimise confusion caused by the text, we have altered the somewhat unclear use of 'site' on Page 4 to fall into line with the way we treat the data and how the experimental approach along this transect has previously been described (e.g. Teh et al., 2014, p.2)

Throughout the paper (most mistakes occur in the discussion) use only past tense rather than mixing past and present.

Done, thanks.

When citing references, it is more helpful for the reader if you put references directly behind the information they refer to instead of grouping them at the end of the sentence (i.e. Pg 11, line 5, Pg 12, line 3, Pg 13, line 21).

Done, thanks.

To avoid unnecessary confusion, consider using 'efflux' or 'emissions' to refer specifically to positive fluxes. For example, on Pg. 8, line 3, one could argue that larger fluxes actually occurred at the higher elevations.

Done, thanks.

Pg 8, line 3,16: at lower 'elevations'

Done, thanks.

Pg 8, line 11: use consistent language. Rather than saying 'negative fluxes', use 'uptake' as you do elsewhere.

Done, thanks.

Pg 9, line 2, Pg 10, line 31, Pg 13, line 13: A semi-colon is used to join two related (complete) sentences. Whilst or while are conjunctions, which can be used to compare two (normally contrasting) ideas in a single sentence.

Done, thanks.

Pg 9, line 14: by 'species' do you mean 'forest type'?

Changed to 'compounds'.

Pg 9, line 28: plot 'means'

Done, thanks.

Pg 10, line 2,8: delete 'for example'

Done, thanks.

Pg 10, line 28: delete 'together'

Done, thanks.

Pg 10, line 30: did you do this statistical comparison over time or only comparing wet vs dry season? If the latter is true, then you can't say "with the procession of"

We have reworded the text on Page 10: "*However, the time-series of net CH₄ flux (Fig. 2 a) for the upper montane forest does suggest that CH₄ uptake increases with the procession of the dry season; ultimately equating to a ~ 30 % difference in uptake between dry and wet season. Our inability to detect a statistically significant difference between seasons at this site (Table 2) may reflect interannual variability, and the fact that environmental conditions change gradually across seasonal transitions (Clark et al., 2014).*"

Pg 11, line 1: 'differences', the fact 'that'

Done, thanks.

Pg 11, lines 12-13, Pg 12, line 32: 'source activity' is awkward. Change to 'emissions' or 'efflux'.

We have reworded the text on Page 11: "*Indeed, emissions represented only 1 – 2 % of fluxes in the upper and lower montane forests of this study.*"

Pg 11, line 32: 'underpinned' sounds awkward here, perhaps 'supported'?

Done, thanks.

Pg 11, line 29-33 (and elsewhere): This part of the discussion would be improved if you indicated which tables/figures correspond to the results you are discussing.

Agreed, thanks.

Pg 12, line 17: 'Similar' to

Done, thanks.

Pg 12, lines 20, 26: 'the' positive correlations, 'the' wet and dry seasons

Done, thanks.

Pg 13, line 1: 'constrained' seems odd in this context, do you mean 'understood'?

Done, thanks .

Pg 13, line 4: move the reference to Table 5 from line 1 to here, after 'for these studies'

Done, thanks.

Pg 13, line 5: 'in this respect' doesn't fit here, can you reword?

We have reworded the text on Page 13: "*The soils of the montane forests in these three studies are differentiated from those of the premontane forests by the presence of thick organic horizons at the surface.*"

References

Hall, S. J., McDowell, W. H. and Silver, W. L.: When wet gets wetter: decoupling of moisture, redox biogeochemistry, and greenhouse gas fluxes in a humid tropical forest soil, *Ecosystems*, 16(4), 576–589, 2013.

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Purbopuspito, J., Veldkamp, E., Brumme, R. and Murdiyarso, D.: Trace gas fluxes and nitrogen cycling along an elevation sequence of tropical montane forests in Central Sulawesi, Indonesia, *Global Biogeochemical Cycles*, 20(3), doi:10.1029/2005GB002516, 2006.

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