Interactive comment on "Phosphorus addition mitigates N_2O and CH_4 emissions in N-saturated subtropical forest, SW China" by Longfei Yu et al.

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Referee #1

General comments:

Yu and co-authors present an interesting dataset of nitrous oxide (N2O) and methane (CH4) flux, nitrate (NO3-) concentration and other ancillary measurements from a forest ecosystem P-addition experiment conducted in a N-saturated (N-deposition is about 40 to 65 kg ha-1 yr-1) secondary Masson pine-dominated forest at TieShanPing (TSP), Chongqing, SW China (developed after a clear cut about 50 years ago) over a period of 18 months. After a single dose of P (applied as solid NaH2PO4*2H2O at a rate of 79.5 kg P ha-1) was added, Yu and co-authors found out that both N2O and CH4 emissions and NO3- concentrations in soil water decreased following P-addition during the 18-months period. They speculate that P-addition may have stimulated mineral N uptake by P-limited plants or microbes leading to decreased NO3- concentrations and N2O emissions. Concomitantly, decreasing mineral N concentrations may have relieved N inhibition of microbial CH4 oxidation leading to decreased CH4 emissions. Spatial and temporal dynamics of nutrient imbalances and their effects on biogeochemistry in forest ecosystems are very complex and difficult to decipher but important to understand in order to predict impacts of global change processes on trace gas fluxes in forest ecosystems. The results from Yu and co-authors are very interesting and valuable. Nutrient-addition experiments in whole forest ecosystems are very difficult to conduct but their results are often much more realistic than countless laboratory experiments trying to mimic whole ecosystem conditions.

R 1.0: We thank referee #1 for the appraisal and valuable comments intended to improve the presentation of the data. We have responded below to the comments.

However, I have major concerns and recommend a reanalysis of the dataset:

1) I would suggest to reanalyze the whole dataset using linear mixed effects models (Koehler et al. 2009 and Jones et al. 2016) to account for repeated measurements (monthly measurements over 1.5 years) and for within-group variance of a stratification (block-design of the study) which has not been done so far.

R 1.1: We agree with the referee that Linear Mixed Effects Models would be better to capture within-group variances, even though the overall result may not differ substantially. In the revision, we will document the details of our statistical tests for different parameters, and present our final outcomes with reanalyzed results.

2) Please take into account that all of your replicates in your plot are pseudo-replicates because they depend on one single block (which is your true replicate). In total you have three independent samples for the P-addition plots and three independent reference samples. Consequently, the dataset and figures should be reanalyzed and presented appropriately. If the blocks are so heterogenous you may show patterns in different blocks or outliers but your whole discussion should focus on significant results of the reanalyzed dataset based on plot means and not subplots.

R 1.2: We agree with the referee's suggestions and will change the manuscript accordingly.

3) I doubt that chronic N deposition alone has transformed TSP soils to a regional hotspot for N2O and CH4 emissions. You have not measured that. Changes in soil bulk density/soil compaction following a clear-cut about 50 years ago may be even more important. Water-filled pore space or gravimetric water content in soils are major controllers of N2O and CH4 production. These variables are almost always measured in soil trace gas flux studies and highly depend on soil bulk density which has also not been measured or is not presented in the manuscript. Since there was a clear-cut at the TSP site about 50 years ago and the soil type at this site is a Haplic Acrisol, where clay translocation processes in mineral horizons form clay-enriched horizons. Such a soil is prone to soil compaction. Especially in these clay-enriched horizons soil compaction may lead to increased bulk densities, may promote oxygen limitation and therefore increase rates of microbial denitrification and methanogenesis that eventually may lead to net CH4 and N2O emissions from this forest site. It would be great if authors could provide data about soil bulk densities, soil properties in general and soil water content variables.

R 1.3: N saturation, indicated by significant nitrate leaching from soils, has been previously confirmed at TSP, (Chen and Mulder, 2007; Huang et al., 2015; Zhu et al., 2013b). Accordingly, annual N_2O fluxes previously observed at TSP were among the highest fluxes reported in literature (Zhu et al., 2013b). Chronic N deposition does not only increase soil N availability, but also contributes to soil acidification (Huang et al., 2015), which is believed to facilitate large N_2O emission factors (N_2O flux: total N input) (Liu et al., 2014). Therefore, based on the previous findings, our study mainly addresses the P-addition effect on GHG emissions at TSP.

We also agree with the referee that edaphic factors, specific to Haplic Acrisols, play a role in the N_2O and CH_4 emissions in TSP. Though WFPS was not directly monitored throughout our observation, the range of WFPS and its effect on N_2O emissions in TSP have been well presented and studied by Zhu et al (2013b). The clear cut of the forests in the 1950s may affect the edaphic conditions in clay-rich horizon in soil, but not likely for the organic top horizon, where microbial activities such as denitrification were found to be strongest (Zhu et al., 2013a). In the revision, we will provide a better description of the soil properties for TSP referring to detailed data from previous studies (Sørbotten, 2011; Wang et al., 2007; Zhu et al., 2013b).

Minor comments:

Line 28 to 30: Nutrient imbalances in forest ecosystems and their effects on greenhouse gas emissions are very complex and shift in space and time. The present study analyzed effects of a single dose of P fertilizer on trace gas fluxes in an approximately 50-years old secondary forest over a period of 18 moths. It is simply too daring to extrapolate results from this special forest site to acid forest soils in general. Please do not speculate so much.

R 1.4: Our results have potential implications for other N-saturated subtropical forests, despite that further tests are needed. We will rephrase our conclusions and largely confine them to our site.

Line 127: change to: "In each block, plots were randomly assigned to a reference (Ref) and a P treatment."

R 1.5: Agreed

Line 164-165: How often and when did you measure trace gas fluxes? Did you take water samples (NH4+ and NO3- concentrations) at the same time? A different sampling time may explain the lack of correlation between N2O emissions and NO3- concentrations.

R 1.6: Gas flux measurements were conducted monthly in the warm season and bi-monthly in the cold seasons. Soil water samples were retrieved on the same day the gas fluxes were measured and analyzed for NO_3^- and NH_4^+. A lack of correlation between N_2O emissions and NO_3^- concentrations has been observed in other studies at TSP, e.g. by Zhu et al. (2013b), who attributed this finding the non-limiting NO_3^- concentrations in the well-drained hillslope soils.

Line 251-254: Why do you use different units (μg N m-2 hr-1; kg N ha-1 yr-1) for the same variable?

R 1.7: We will revise the units, but stick to μg N_2O-N m^{-2} h^{-1} for instantaneous fluxes (e.g. Figs. 2 and 5) and kg N_2O-N ha^{-1} yr^{-1} for cumulative fluxes, as common in the GHG literature.

Line 282: change to atmospheric

R 1.8: OK.

Line 362: Your study does not demonstrate that chronically high N deposition has transformed TSP soil to a regional hotspot for N2O and CH4 emissions. You have not measured that.

R 1.9: This has been discussed in R 1.3 and previously demonstrated by Zhu et al. (2013b).

Figures: Please provide information about sample size and if you use SD or SE in all of your figures.

R 1.10: OK.

Reference: Jones et al. (2016) Biogeosciences, 13, 4151–4165 Koehler et al. (2009) Global Change Biology, 15, 2049 -2066

Reference 1

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