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Interactive comment on "Automatic high-frequency measurements of full soil greenhouse gas fluxes in a tropical forest" *by* Elodie Alice Courtois et al.

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SC2, Referee #5 (Remarks to the Author):

This manuscript focused on a very important topic about soil CO2/CH4/N2O fluxes in tropical rainforest. The experiment was well designed. Particularly, this may be the world's first report about in situ and simultaneously measurement of soil CO2/CH4/N2O fluxes at low latitude (between 10âŮęN and 10âŮęS). I would like to give the authors my comments.

Response: Thank you for this positive comment.

1. Important references: To date, through the "Web of Science", I could not find any publication about continuous measurement of soil CO2 efflux (Rs) using the automated chambers in the low latitude tropical forests that between 10_ N and 10_ S. Though two campaign studies in very humid forests (ï'C Âÿs3500 mm of annual precipitation) using automated chambers each in northeastern Australia (17_ S) (Kiese and Butterbach-Bahl, 2002) and northeastern Puerto Rico (18_ N) (Wood et al., 2013) were conducted only less than 6-month period, they observed similar phenomenon with Rs was higher during the dry season but lower during the wet season. Kiese and ButterbachBahl (2002) also measured N2O flux. Conversely, a 4-year continuous measurement of Rs in a seasonal dry (1,250 mm of annual precipitation) tropical forest in western Thailand (14_ N) showed higher Rs in wet season than that of dry season (Hanpattanakit et al., 2015).

Response: In fact, a very recent paper reported continuous monitoring of Rs during three years in the tropical forest of Panama (Rubio and Detto, 2017). Moreover, a previous study conducted at the same site as ours (Paracou site, near the Guyaflux tower) also reported 577 days of Rs measurement (Rowland et al., 2014). Both references highlighted a significant effect of soil moisture on seasonal and diurnal cycles of Rs. Together with the two other references from tropical that you cited, there provide evidences that Rs in tropical forest soils are typically higher in the wet than in the dry season. The other study that you cited (Hanpattanakit et al., 2015) was conducted in a seasonally dry forest which are apparently reacting differently than typical tropical wet forest (precipitations > 2000m/year). Nonetheless, the results that we are presenting in our study were conducted from June to September 2016 which corresponds in our site to the end of the wet season and the onset of the dry season. With these data, we cannot discuss seasonal effects, at least one full year, or more, of measurements would be necessary for this.

Rowland, L., Hill, T. C., Stahl, C., Siebicke, L., Burban, B., ZaragozaâĂŘCastells, J., Ponton, S., Bonal, D., Meir, P. and Williams, M.: Evidence for strong seasonality in the carbon storage and carbon use efficiency of an Amazonian forest, Glob. Change Biol., 20(3), 979–991, 2014.

Rubio, V. E. and Detto, M.: Spatiotemporal variability of soil respiration in a seasonal tropical forest, Ecol. Evol., 7(17), 7104–7116, 2017.

2. CO2 flux: Empirically, also see the above references, CO2 flux is largely controlled by soil moisture (rain events) at tropical forests. However, based on Fig 3, during 4-month experiment (June-September 2016), most of the chambers did not show temporal variation in CO2 flux. Thus, the authors are suggested to add soil moisture (and temperature) data to Fig 3 and provide some discussion about the (lack of) relationships between Rs and soil moisture and temperature.

Response: As discussed in above, a four months period is limited to go deep into such relationships, especially in tropical forest where temporal and spatial variability of fluxes are high. You can find below a figure that can now be found in the supplementary material of the manuscript displaying the relationship of the three gases with soil moisture. Nonetheless, going deeper in the discussion of the effect of rain event, soil moisture and the relative importance of spatial, seasonal and diurnal variability of fluxes cannot be done with these dataset that was specifically constructed to demonstrate the feasibility of running the system under tropical conditions.

3. CH4 flux: Generally speaking, upland forest soil is a CH4 sink, even lowland tropical forest soil. Compared to Rs, however, CH4 flux is more complex and generally has large spatial variation, because the termite activity can emit CH4 thus offset a partial of the soil CH4 sink. I am confused with Table 2, because ten of the sixteen chambers showed CH4 source. Li-Cor soil chamber (8100-104) can be considered to block most activity of the termite, because the chamber base (collar; 7 cm in height) was inserted _7 cm into the soil and left another 4 cm above the soil; in addition, the chamber has relative additional big metal base surround the collar. On the other hand, inserted chamber base (collar) into the tropical (clay) soil can (sometimes) cause waterlogging

inside the Li-Cor soil chamber (8100-104), which might convert the CH4 sink to CH4 source. Same with CO2 flux, temporal variations in CH4 fluxes also could not be detected in Fig. 4. Also, megascopically, the chambers did not show the common pattern of temporal variation in CH4 fluxes (Fig 4). Sure, this forest has plentiful precipitation (about 3000 mm) and very low elevation, both of these abiotic factors may cause the site as CH4 source. Thus, the authors are suggested to provide some more discussion about (the lack of) spatio-temporal variation in CH4 flux.

Response: Again here, this result can be easily explained by the time frame of the study. Tropical soils are generally considered as sink at a yearly basis but much study show that there are seasonal variation in CH4 fluxes and that tropical soils tend to shift from a sink in the dry season to a sources during the wet season. Here, a four months period is limited to go deep into such relationships, especially in tropical forest where temporal and spatial variability of fluxes are high. You can find below a figure that can now be found in the supplementary material of the manuscript displaying the relationship of the three gases with soil moisture. Nonetheless, going deeper in the discussion of the effect of rain event, soil moisture and the relative importance of spatial, seasonal and diurnal variability of fluxes cannot be done with these dataset that was specifically constructed to demonstrate the feasibility of running the system under tropical conditions.

4. Appendix Figure A1: This figure shows a very general (basic) chamber-problem for measurement of soil GHGs fluxes. Long closure time will cause higher GHGs concentration (if the soil is GHGs source) or lower GHGs concentration (if the soil is GHGs sink) inside the chamber, which will induce underestimation of GHGs flux (saturation effect). Saturation effect is generally positively associated with both flux rate and ratio of the effective chamber volume to the measured soil surface area. Empirically, I believe the 2-mintute closure time is enough for measurement of both CO2 and CH4 flux in tropical forests, even for most temperate and boreal forests. For Li-Cor soil chamber (8100-104), the ratio is (0.0040761/ 0.03178=0.12826 m) = 12.3 cm. However, for

many of the custommade soil chambers, the ratio is generally higher than 12.3 cm, thus this is might be the specific problem (issue) only for Li-Cor soil chamber (8100-104). I suggest the authors feedback this problem to Li-Cor and suggest Li-Cor to draw this problem to their instrument user manual.

Response: Thank you for this feedback. Following comments from the other reviewers, we used exponential fit for estimating all fluxes which improved this saturation issue. Also, as stated in the manuscript, we always used 2 minutes estimation for CO2 fluxes to overcome this issue.

5. Also for Appendix Figure A1: The authors are suggested to re-draw the Appendix Figure A1 indicating different symbols (or color) for each of the four chambers.

Response: Following comments from the other reviewers, this figure has been moved to the main text and now also include N2O. We decided to use different colours (black and grey) for the two distinct weeks that were used for this comparison instead that different colours for the different chambers because it allows a better view of the fact that these two weeks are covering almost the whole range of fluxes that can be encountered in the site.

6. Closure time: When compared Table 1 with Table 2, the closure time of 10 minutes for measurement of N2O flux was enough. Thus, the Table 1 is suggested to be deleted.

Response: We disagree with this comment. A closure time of 10 minutes would have led to a MDF of 0.009 instead of 0.002. In this case, only 82% instead of 96% of the fluxes would have been considered of reliable. We therefore decided to maintain Table 1 in the manuscript as it allows to show that a MDF of 0.002 can only be achieved with a 25 minutes closure time.

7. Additional suggestion 1: To prove the data quality or measurement precision, the authors are suggested to add a plot showing changes in CO2, CH4 and N2O concen-

trations in the chambers. Following is a sample plot (Sample Fig).

Response: This information has been added.

8. Additional suggestion 2: As I mentioned in the above, this may be the world's first report about in situ and simultaneously measurement of soil CO2/CH4/N2O fluxes at low latitude (between 10_N and 10_ S). I believe this paper will be a potential high citation rate if the authors can give some more discussion about spatio-temporal variation in CO2/CH4/N2O fluxes and their control factors. For example, the coefficient of variation (CV) was used to represent the spatial variation. CV of Rs can be calculated by CV = (SD/(mean Rs))_100.

Response: Mean and SD per chambers are available in Table 2 and we added a figure with mean value of each chamber per days for the three gases allowing to visualize the spatio-temporal variability of fluxes.

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