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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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In the recent years, several studies highlighted the need for continuous measurements of soil GHG other than CO2, which has been technically challenging for long time. However, combination of different new instrumentation allows addressing this challenge nowadays. I think this manuscript a timely technical note addressing one of the most important issues regarding continuous measurements: which is the balance between frequency and reliability of measurements? Despite some of the points discussed in the paper are instrument specific considerations (Li8100 and G2308), I think that most of them apply for high-frequency studies using other instrumentation. In my

opinion, two points could be covered more in depth in order to make the manuscript more strong and inspiring for the community:

(i) suitability of linear or exponential fits for estimating GHG fluxes, especially under high emissions and long chamber closure time

Response: We first decided to use linear flux calculations only because we thought that the saturation effects characterised by a plateau after a certain time would be low. However, following your comment and comment from other reviewers, we changed flux calculations in the new version of the manuscript to use exponential estimations.

(ii) which threshold criterions do we have to apply for low rate fluxes and which are the consequences of using different criterions on temporal patterns (both short and long term scales) and on accumulated emission estimates.

Response: Some information regarding this issue were added in the new version of the manuscript.

Finally, I want to recognize the challenge of running this complex instrument setup in a tropical forest. Dealing with high moisture when using IRGAS and CRDS is not easy, but the authors succeeded.

Response: Thank you for this positive comment.

I am looking forward to see the data in the full experiment context with their ecological implications. Here you could find some specific comments, suggestions and open discussion points: Pg3 L19-28. Li-8100 can detect really small fluxes of CO2 as well. I guess that the main reason for using both Li-8100 and Picarro G2308 is that one instrument controls the chambers and the other measures the three gases. Additionally, measuring simultaneously CO2 with two independent systems is a good control to validate the proper performance of the instruments. I wonder which was the agreement in CO2 between Li8100 and G2308.

Response: In our system, the automated chambers were controlled by the Li-8150,

which was controlled by the Li-8100A. The gas analysers were Li-8100A for the CO2 and PICARRO G2308 for the CH4 and N2O. We recommend using the Li-8100A to determine the soil CO2 effluxes but recognise that CO2 information provided by the PICARRO can still be used to check for potential leaks in the analysers / tubing.

P4 L24-28. I don't know if I understand this statement, but SoilFluxPro (Li-COR software) allows to directly upload hundreds of Picarro files simultaneously (up to 2 months). You can choose to open all the files in one single file, and directly merge it with the Li-COR data.

Response: When we first used this import function in SoilFluxPro, we realised that there were problems when importing Picarro files (that are split in one file per hour) by suing the function IMPORT. When a measurement was overlapping two distinct hours (for example a flux estimation from 8:50 am to 9:15 am, the function RECOMPUTE in SoilFluxPro only take into account the first Picarro file. We contacted Licor for this issue and they agree that this was a weakness of the software. They are currently working on it to implement this in a new version of the software. In the meantime, the use of the R function that we developed and that can be found in the supplementary material to merge all Picarro files in one file allows to overcome this issue.

P4 L28-30. One of the best things of using SoilFluxPro is that calculates the fluxes using both linear and exponential fits, which could result in substantial differences in fluxes (see the attached example from my own data). My experience is that exponential equations usually fits better than linear ones (in terms of R2), especially for high flux rates under long chamber closure times.

Response: See responses to previous comments, exponential fits were now used for all flux computations.

P4 L29. Which was the actual length of each measurement without including the dead-band?

Response: See comment from RC2

P5 L5. Why are you not using CO2 measured with Picarro?

Response: Please, see our response to reviewer 1 above (6.).

P5 L7-8. I guess that it has to be the volume of the system (chamber, Li8100, Picarro, multiplexer and tubing). This is really important since the volume of the system is a parameter controlling the minimum detectable flux, so Table 1 might substantially change depending on this "detail".

Response: Yes, it is the volume of the whole system.

P5 L16-17. Again, this can be solved using exponential fits.

Response: See responses below

P6 L7, L13 and L17. I guess these are not the correct figures.

Response: This has been corrected

P6 L14-20. As far as I understood, you kept values higher than MDF (for emissions) and lower than –MDF (for sinks), but what happen with values close in between (-MDF < x < MDF)? What did you do with values close to 0 flux? And what happen if a flux was higher than MDF but had low R2? The same applies for N2O. Which criterion we have to use when measuring gas emissions at low rates? Is it a 0 flux, NA, should we keep the calculated flux regardless of the R2? Choosing one or other criterion might have several implications in order to estimate cumulative or mean fluxes, especially if the data does not have normal distribution and it's not 0 centered. In L11 you describe an R2 criterion for considering stable micrometeorological and chamber conditions based on CO2. Then, why we should apply other criterion for the other gases if the conditions are stable? I understand that for this might not be super relevant for a technical note, but this is a key question if you want to quantify emissions in natural conditions. In my opinion, this is the core of the study, and one of the most challenging issues we need

to address when measuring CH4, N2O and other trace gases. When we have high fluxes, everything is clear, but when we have low fluxes, it turns more complicated. We were discussing this issue in Petrakis et al. 2017, but I still don't have the answers. I guess there is not a silver bullet.

Response: We agree with the reviewer that this is one of the main challenge of CH4 and N2O soil fluxes estimation. For CO2, fluxes from tropical soils are always high so the R2 criterion allows to easily detect measurement issues such as imperfect chamber closure. In this case, it is logical to remove fluxes estimation for the three gases. For CH4 and N2O, we decided (1) to consider fluxes below MDF as null fluxes (i.e. fluxes so small that they are below detection limit) (2) to consider fluxes above MDF but with a low R2 were considered as NA (Not available, fluxes estimation impeded by unknown measurement issues).

Figure 1A. There is something in this panel it's not completely clear. As far as I understand, the air goes from the chamber to the multiplexer, to Li8100, to G2308, to the external pump, to the multiplexer and again into the chamber. However, in the schematic view there is a black circuit (T piece sub-sampling loop) that connects the multiplexer, Li8100, G2308 and the external pump. Since the air composition does not change between these four elements, why the subsampling tub was not inserted in serial at one point of the circuit?

Response: Inserting the subsampling loop in parallel rather in in serial was a proposition from the manufacturer that we followed here.

Table 2. I wonder which closure time did you use in this table (2 or 25min). It would be interesting a comparison between 2 and 25 closure times. I'm not sure you will find differences in the means. This would suggest that short closure times might not affect the annual balance but deviation of the data (as we can see in Ap Figure 2).

Response: In this table, we used all fluxes estimation available after quality checking. Your proposition is interesting but as 2 and 25 minutes estimation were not made on

the same weeks, it is difficult to compare them. We therefore propose to keep this table as it is but we stated in the table caption that this estimation was made using all the data available and we also added the number of data points that were used for this estimation.

Appendix Figure A1. In my opinion, this is one of the most interesting figures in the manuscript and I think it should be place in the main manuscript.

Response: The figure was placed in the main text

Some suggestions: a) Regressions will have better fit if you use exponential equations for estimating the flux. For each flux you can choose linear or exponential depending on the R2.

Response: Exponential fits were now used for all fluxes estimation.

b) Could you display R2 and the coefficients of the regressions between 2 and 25min? Regression B shows a good fit, but it seems that 2 min fluxes tends to overestimate fluxes compared to 25min estimates. Again, this could be an artifact of using linear regressions and not exponential.

Response: This figure has been modified by using exponential fits and the R2 were added

c) It would be interesting plotting the regression for N2O including all values (without removing data using R2 or MDF criterions)? This is related to my comment on Table 2. Apendix Figure A2. Please, edit the figure caption. Petrakis, S., Barba, J., Bond-Lamberty, B. and Vargas, R.: Using greenhouse gas fluxes to define soil functional types, Plant Soil, 1–10, 2017. âĂČ

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