

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

N. Liang

liang@nies.go.jp

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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 10° N and 10° S). I would like to give the authors my comments.

1. Important references:

To date, through the “Web of Science”, I could not find any publication about continuous

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measurement of soil CO₂ efflux (R_s) 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 (̄C̄s3500 mm of annual precipitation) using automated chambers each in northeastern Australia (17° S) (Kiese and ButterbachBahl, 2002) and northeastern Puerto Rico (18° N) (Wood et al., 2013) were conducted only less than 6-month period, they observed similar phenomenon with R_s 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 R_s in a seasonal dry (1,250 mm of annual precipitation) tropical forest in western Thailand (14° N) showed higher R_s in wet season than that of dry season (Hanpattanakit et al., 2015).

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 R_s and soil moisture and temperature.

3. CH₄ flux:

Generally speaking, upland forest soil is a CH₄ sink, even lowland tropical forest soil. Compared to R_s, 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

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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.

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-minute 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 $(0.0040761 / 0.03178 = 0.12826 \text{ m}) = 12.3 \text{ cm}$. However, for many of the custom-made 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.

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.

6. Closure time:

When compared Table 1 with Table 2, the closure time of 10 minutes for measurement

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of N₂O flux was enough. Thus, the Table 1 is suggested to be deleted.

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

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 R_s can be calculated by $CV = (SD / (\text{mean } R_s)) \times 100$.

9. Useful reference:

(1) Hanpattanakit, P. et al., 2015. Multiple timescale variations and controls of soil respiration in a tropical dry dipterocarp forest, western Thailand. *Plant and Soil*, 390(1-2): 167-181.

(2) Kiese, R. and ButterbachBahl, K., 2002. N₂O and CO₂ emissions from three different tropical forest sites in the wet tropics of Queensland, Australia. *Soil Biology & Biochemistry*, 34(7): 975-987.

(3) Wood, T.E., Detto, M. and Silver, W.L., 2013. Sensitivity of Soil Respiration to Variability in Soil Moisture and Temperature in a Humid Tropical Forest. *PLoS One*, 8(12): 7.

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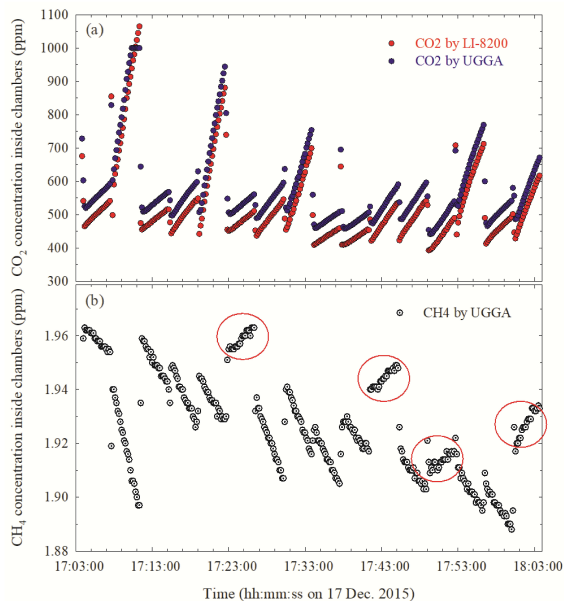
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Sample Fig. Changes in CO₂ and CH₄ concentration inside the chambers. This is an *in situ* soil CO₂ and CH₄ flux measurement in a low latitude (<3° N) lowland rainforest using a 16-channel custom-made automated chamber (70×70×50 cm, L×W×H) system coupled with an IRGA CO₂ analyzer (LI-820, Li-Cor Biosciences) and a cavity ring down spectroscopy CO₂/CH₄/H₂O analyzer (UGGA, LGR). Half (eight) of the sixteen chambers were trenched for measurement of heterotrophic respiration. Figure shows one measurement cycle (1 hour) for the sixteen chambers with each sequentially closed for 225 s. CO₂ concentration measured by both LI-820 and UGGA shows linearly increased for all chamber during the 225 s closure time (a). CH₄ concentration (b) shows linearly decreased in all trenched and half (four) of the control chambers but increased in another half of the control chambers (red circles).

Fig. 1. Sample Fig

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