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Biogeosciences Discussions

Interactive comment on "Representing methane emissions from wet tropical forest soils using microbial functional groups constrained by soil diffusivity" *by* Debjani Sihi et al.

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Anonymous Referee #3 Received and published: 26 August 2020

C: The manuscript of Debjani Sihi and colleagues brings up a very interesting topic on disentangling gross methane emission and uptake from wet tropical forest soil using a combination of microbial functional group CH4 model and a diffusivity module. This work clearly shows how landscape topography and climate affect net CH4 emissions due to shift of substrate production, soil redox conditions, and diffusivity of O2, H2, and acetate under drought and recovery phases. The experimental work is well performed, convincing and well discussed in the context of previous literature. The manuscript is

well organized and clearly written and I enjoyed reading it. I only have a few comments that should be addressed: R: Thank you kindly for the positive comments and for the constructive suggestions, all of which we have adopted.

C: Line 54 Should it be "increased consumption of atmospheric CH4"? R: Good catch. Thank you, the manuscript will be corrected as suggested.

C: Line258 The correlation seems stronger and more negative in 2015 (-0.36) than 2016 (-0.61). R: The reviewer is correct. The sentence L258 should be changed to "The correlation between CH4 emissions and O2 concentrations was stronger and more negative in 2015 than 2016."

C: Line 321-322 You defined pre-drought period from DOY 57-115 instead of DOY 200. The details in results should be checked. R: I believe we mean to say "during the drought period (DOY 200)". We will double-check all other similar references and ensure there are no additional errors. Thank you.

C: Fig. 1 I appreciate the conceptual figures herein, but it looks a bit confusion and I do not well understand what means in panel a. How to relate microsite frequency with soil properties? R: We agree this figure could use some revisions. Our caption says currently: Top panel (a) shows the model representation of soil microsite distribution (modified from Sihi et al., 2020, also see Eq. 13). Different shades indicate substrate concentration [Si], soil moisture (SoilMi), diffusion (Diffi) of solutes and gases, production (Prodi) and oxidation (Oxi) processes at each microsite.

We propose to revise the caption as follows: "Top panel (a) shows the model representation of soil microsite distribution (modified from Sihi et al., 2020a, also see Eq. 14). The cylinder refers to the volume beneath the soil chambers. The intensity of different cylinder colors refers to rate of a process or the intensity of a concentration inside microsites in each theoretical cylinder, e.g., a dark color means a higher rate/intensity, and a light color means a lower rate/intensity for a given process. The 2D graph on the right refers to the probability density function of the rate of the process or intensity of

the concentration in the bulk soil. A wide distribution skewed to the right (dark colored line) implies higher bulk rates of the process or higher concentrations, and a narrow distribution skewed to the left (light colored line) implies lower bulk rates of the process or lower concentrations, of any of the following: soil moisture, solute concentration, gas concentration, gas diffusion, solute diffusion, methane production, or methane oxidation."

FYI, we have revised the figure from the original as follows: Added an arrow on the x axis pointing towards the right, denoting increasing concentrations or rates. Moved the light-colored function to the left of the dark-colored function and made it much more narrow and signify less impact on bulk rates/concentrations compared to the dark-colored function (more impact on bulk rates/concentrations).

Please see revised Figure as pdf, uploaded separately.

C: Do substrate concentration, soil moisture, diffusivity of solute and gas present the similar pattern for one kind of microsite? R: The frequency distribution for the microsites is the same for all of these, according to Eq 14. But, the diffusivity of liquids is according to Eq 11 and 12; diffusivity of gasses according to Eq 8, 9, and 10. Here is a little more information on the microsites that will be included in the revision methods Section 2.4.2: We assumed that size of the microsites should be at least an order magnitude lower than the bulk soil measurements we had for soil methane fluxes. Using this logic, we decided that "diameter" of microsites should be in "mm" scale as the diameter of soil chambers we used are in "cm" scale (15.24 cm). Thus, we did the math to come up with the number of "total microsites" (i.e. 10000) such that the diameter of microsites meets our criteria. This is why the frequency of microsites is the same for both low rate/intensities (light yellow line Fig 1a) and high rate/intensities (dark line Fig 1a) (see also Fig. 7 in manuscript and Fig. S10 in SI).

C: Why this figure links to Eq.13? R: This figure should link to Eq 14; apologies for the confusion. It will be corrected in the revision.

C: Also in panel b, it would be more clear for readers if you could adjust it to a better shape or based on the clue of the present study. Can you try to improve the conceptual figure and clarify this in the legend? R: We propose to remove the Air/Soil diagram at the top of this figure, and to remove the word "solute diffusion" from the figure. Panel b should only represent the geochemical pathways that the model is representing, and we should rely on panel (a) to address diffusion. We hope that makes the content of both panels more understandable.

We propose to revise the caption from the current version: Bottom panel (b) is the schematic of the microbial functional group-based model coupled with a diffusivity module (Microbial Model for Methane Dynamics-Dual Arrhenius and Michaelis Menten, M3D-DAMM) for simulating soil methane (CH4) dynamics in field soils (Modified from Xu et al., 2015), where SOM = soil organic matter, CO2 = carbon dioxide, DOC = dissolved organic carbon, H+ is the hydronium ion, and H2 = dihydrogen molecule. Proposed revised figure caption: Bottom panel (b) is the schematic of the microbial functional group-based model for simulating soil methane (CH4) dynamics in field soils (modified from Xu et al., 2015). The schematic represents the decomposition of soil organic matter (SOM) and plant litter into carbon dioxide (CO2) and dissolved organic matter (DOC); the production of acetate and hydronium ion (H+) from decomposition and fermentation of DOC which also decreases pH, the production of acetate and hydronium ion (H+) from homoacetogenesis which decreases pH; and the production of dihydrogen ion (H2) and CO2 from decomposition of DOC. The intermediary products then have three possible non-mutually exclusive pathways (1) acetoclastic methanogenesis, which is the production of methane from aqueous acetate found in soil solutions, (2) hydrogenotrophic methanogenesis, which is the production of methane from hydrogen, and (3) methanotrophy, which is the oxidation of methane into carbon dioxide.

Please see revised Figure as pdf, uploaded separately.

C: Fig.3 and 4 The label of y-axis for soil moisture and oxygen should between 0-1

rather than 0-100, as the unit is V V-1. Otherwise, the unit should change to %. R: Thank you for pointing this out. We will adjust the unit of the axis in Figs 3 and 4, S8(g)(h)(i), and S10(i)(j).

C: Fig.4 and 6 The unit of CH4 emission should be uniform. Some of them are nmol m-2 S-1, while others are nmole m-2 S-1. Also the unite of acetate (Fig. 2). R: Thank you, we should use nmol and ïA■mol (and not “mole”). Corrections will be made to figures 2,3,4,7, and S5,S6,S7,S8,S9,S10.

Please also note the supplement to this comment:
https://bg.copernicus.org/preprints/bg-2020-222/bg-2020-222-AC2-supplement.pdf

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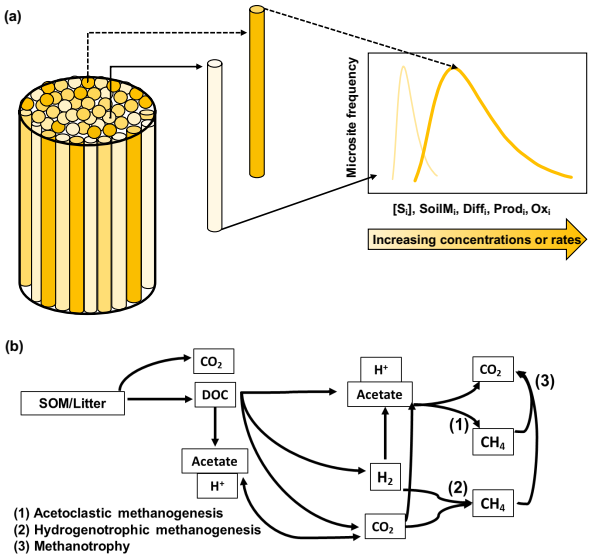

Fig. 1. Revised Fig 1 See text file for caption