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

Anonymous Referee #1

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The study "Representing methane emissions from wet tropical forest soils using microbial functional groups constrained by soil diffusivity" by Sihi et al. tries to explain soil methane emission dynamics in tropical forest soils of Puerto Rico during normal and drought conditions. They combine field measurements with modelling efforts (Microbial Model for Methane Dynamics-Dual Arrhenius and Michaelis Menten (M3D-DAMM). Overall, I think it is a really nice study that tries to combine microbial with biogeochemical data to investigate ecosystem methane dynamics. However, I have some general and some minor comments.

The authors should describe the concept of "microsites" more in detail. The au-

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thors focused on the top 10 or 10-30 cm of their Ultisol although methane production/consumption dynamics in the deeper clay-accumulating horizons may be more important for the overall net methane emissions from their Ultisols. The authors do not discuss that and do not compare with other soils. How does the abundance of microsites change with soil type, soil depth and other ancillary variables?

Minor comments: L22-25: Is it important to give this information? I would only include the most significant ones that support your guiding questions! What is the difference between “<” and “«”. The abstract should self-explanatory.

L33: write aceticlastic methanogenesis instead of “acetotrophic” and “acetoclastic” (check the whole manuscript)

L43: what are wet tropical forest soils? What are wet tropical forests and what is the difference between wet tropical forest soils and upland soils? How do you define that?

L53-65: What are the soil types in the different studies? Since methanogenesis and methanotrophy are substrate-limited, the soil type with its specific biogeochemistry is very important. The authors mention that there are several studies that report effects of drought on net methane emissions across different wet tropical forest soils. Consequently, they should mention the different soil types.

L66-74: Oxygen may not be the only factor for methane emissions upon rewetting. The observed rapid flush of methane in response to a wetting event may be driven by rapid depletion of other electron acceptors, as well. The major focus of this paragraph is on oxygen but what is with acetate, H2 and CO2?

L85-86: and why not H2 and CO2? How do you account for acetate formation during fermentation and homoacetogenesis? How do you account for syntrophic acetate oxidation? How can you explain the “contrasting patterns of observed CH4 emissions”, when sources and sinks of acetate etc. is not measured or simply not known?

L97-105: The dominant soil type in the current study is Ultisol. I guess the whole

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methane cycling will be very different in other tropical soils (What is with Oxisols?) What are the soil types in the other studies mentioned in the introduction? It would be great to see a more detailed description of the soil type. How did bulk density change with depth? At what depth does clay accumulation (subsurface zone) start? How big is the eluvial horizon?

L107: Why was soil only sampled from the top 10 cm of the soil? I guess methane consumption dominates at the surface due to oxic conditions while in the deeper soil horizons methane production dominates due to more anoxic conditions.

L111-114: What was the detection limit for acetate?

L117-120: The chemical data (what chemical data? Only pH?) for bulk soil is from the 0-10 cm soil depth and acetate and DOC from the pore water from 10-30 cm soil depth? I do not understand how you relate this information, taken from different soil depths, to each other. Finally, where do you find or where do you assume these microsites? (only in the top 10 cm or below? Or may be even below 30 cm?

L144-148: What is with methylotrophic methanogenesis. You should discuss about the potential contribution of methylotrophic methanogenesis (see Norrow et al. 2019).

L173-174: Why not?

L206: Why 15 cm?

L214: How do calculate “total microsites”? I would assume that there are way more microsites in clayey horizons below 15 or even 30 cm soil depth? Overall, I think you have to explain the concept of microsites, more in detail? You are scratching only the soil surface at the moment but in my opinion the biggest methane production potential occurs in deeper parts of the Ultisol.

L270-272: Why are acetate and hydrogen production decreasing when aceticlastic and hydrogenotrophic methanogenesis also decrease? Aceticlastic and hydrogenotrophic methanogens consume acetate and hydrogen, respectively. So, if there is a decrease

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in aceticlastic methanogens, I would first assume an increase in acetate concentration and thereafter a sharp decrease if oxygen levels further increase.

L280: How do explain that?

L286-287: Why does the increasing production of acetate lowers the pH?

L301-306: If the diffusion of H2 increases during drought, one may think that hydrogenotrophic methanogenesis should increase as well. However, it does not increase because of increasing oxygen levels. That should be made clear!

L304-309: The diffusion of acetate increases upon rewetting but that of H2 decreases. Why do you observe an increase in overall gross methane production. First, I would assume that under relatively acid conditions, hydrogenotrophic methanogenesis dominates. I think the overall increase of methane emissions upon rewetting is because of oxygen depletion and therefore the stimulation of methanogenesis in general .... and not because of increasing acetate concentrations or a shift in the methanogenic pathway of methane formation. If it is really aceticlastic methanogenesis that is stimulated, you should provide some isotopic data. There is competition for acetate between several microorganisms. In the end it could be simply stimulation or inhibition of fermentation or homoacetogenesis that drives changes in the amount of observed acetate concentrations.

L318: Again, how do you define the microsites?

L346-348: Again, what makes you so sure that it is acetate that drives net methane emissions and not H2/CO2 and a decrease in oxygen?

L369-372: and homoacetogenesis?

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