Biogeosciences Discussions

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Reply on RC2

Alexandra Klemme et al.

Author comment on "CO_2 emissions from peat-draining rivers regulated by water pH" by Alexandra Klemme et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-13-AC2, 2021

Referee:
The contextualization and general justification of the paper could be revised. The authors justify their research to explain the discrepancy between estimates of CO2 evasion by "global models" and those based on field measurements by their own group (for example Wit et al. 2015). The "global models" of Raymond et al. (2013) and Lauerwald et al. (2015) are not and not mechanistic models but in fact extrapolations of pCO2 data calculated from pH and alkalinity measurements of unverified quality, that usually give results that are incorrect (Abril et al. 2015), and with a very coarse and extremely irregular spatial coverage. If you look at the maps of data point distribution of those two papers (in the supplements), for SE Asia there a handful of points in Thailand in the Raymond paper, and these data points did not meet the selection criteria of Lauerwald. In the Lauewarld paper that are in fact no data points at all for SE Asia.

Response:
We thank the reviewer for the work with the manuscript. The use of the term "model-based" was also criticised by the first reviewer and we changed the statement to: » *Despite scarcity in river CO2 measurements from Southeast Asia, studies suggest it as a hotspot for river CO2 emissions (Lauerwald et al., 2015; Raymond et al., 2013) due to the presence and degradation of carbon-rich peat soils.* «

The reviewer is right in that the mismatch between those studies and measured data is not surprising considering the data scarcity and consequential uncertainties. Furthermore, the results by Lauerwald et al. (2015) are within the range of measured CO2 concentrations (Wit at al., 2015). Thus, according to the reviewer's suggestion, we shift the motivation of our study from discrepancies between those upscaling studies and measurements towards the surprisingly low CO2 measurements in rivers of high DOC concentrations. In the revised manuscript we state: » *However, despite high leaching rates that cause DOC concentration which can be more than four times higher than those in temperate regions (Butman and Raymnond, 2011; Müller et al., 2015), measured CO2 fluxes from tropical peat draining rivers (25.2 gC $m^{□2}$ $yr^{□1}$) hardly exceed those measured for rivers in temperate regions (18.5 gC $m^{□2}$ $yr^{□1}$; Butman and Raymond, 2011; Wit et al., 2015).* «

Referee:
In conclusion, the mismatch between field measurements and those predicted by Raymond et al. (2013) and Lauewarld et al. (2015) only shows that these "global models" are extremely unreliable, and does not reveal a hidden mechanism that lowers CO2

emissions.

Response:
As we state above, it is not only the mismatch between these specific studies and measurements that we want to explain. The question we want to answer is the cause for the rather moderate CO2 concentrations measured in tropical peat-draining rivers given the high DOC concentrations. The presence of carbon-rich peat soils and consequently high concentrations of DOC in peat-draining rivers should result in high CO2 concentrations, but the measurements show that the CO2 concentrations in these rivers are only insignificantly higher than emissions from temperate regions (Wit et al., 2015). In this study, we aim at explaining the process that is limiting the CO2 production given the high DOC concentrations.

Referee:
Conversely, the pCO2 values reported for SE Asian peatland rivers, ranging between 2000 and 8000 ppm according to figure 2 of Wit et al. (2015) are within the range of pCO2 reported in African tropical rivers (Borges et al. 2015) and also in rivers and streams of the Amazon River network (Abril et al. 2014). So the pCO2 values in SE Asian peatland rivers seem relatively "normal" for tropical rivers, and not abnormally low.

Response:
This is exactly what we want to explain. Despite high DOC concentrations in tropical rivers, the CO2 emissions are relatively moderate (Wit et al., 2015). It is not the aim of our study to discuss or explain that CO2 values in Southeast Asian rivers are abnormally low in contrast to other tropical rivers. What we refer to when mentioning moderate CO2 is the stagnating concentration in rivers of high peat coverage, in which DOC concentrations are extremely high. Yet, while DOC concentrations can be by a factor 5 higher than in temperate regions, CO2 emissions are not even twice as high as those stated for temperate rivers. Similarly, for the rivers in our study, CO2 concentrations do not change significantly for rivers with DOC concentrations between 2,000 and 4000 μmol L$^{\square 1}$. Since our dataset is specifically based on measurement campaigns in Southeast Asian rivers, we focus on quantifying the limitation factors for rivers within this area. However, we explicitly state that a similar limitation is likely present in tropical peat-draining rivers in general (line 190-191). According to a suggestion of reviewer #1, this section was adjusted to: » *A similar pattern of stagnating CO2 concentrations has been observed in river sections of high DOC at the Congo river (Borges et al., 2015). The CO2 and DOC concentrations measured in these rivers are comparable to those measured in our study, indicating that the underlying process is valid not only for Southeast Asian rivers but for tropical peat-draining rivers in general.* «

Referee:
The core topic of the paper is to look into the limitation of organic matter degradation (and subsequent CO2 production) by low pH and low O2. While it is intuitive that low O2 and low pH might not be optimal to microbial growth, micro-organisms tend still to growth in sub-optimal conditions if there are substrates to metabolize. The correlations of CO2 concentrations and pH/O2 based on the data in Table 1 of the ms (see below) indicate on the contrary that the high CO2 were associated to low pH and low O2. And even if the conditions of pH and O2 were sub-optimal, the micro-organisms were still able to degrade enough organic matter to produce large quantities of CO2.

Response:
The correlation of CO2 concentrations and pH/O2 pointed out by the reviewer neglects the DOC concentration. The rivers of low pH and low O2 are the rivers with a high peat coverage in the catchment and therefore high DOC. Obviously, the CO2 concentration is high in these rivers, since the DOC decomposition increases with the amount of available DOC in the rivers. This is why we define the decomposition rate as produced CO2 per

available DOC. If this decomposition rate was not limited by parameters like pH or O2, the CO2 production would linearly increase with DOC concentrations, which would result in a fairly linear increase of CO2 concentrations with DOC and therewith significantly higher CO2 concentrations than observed in peat-draining rivers.

Referee:
Minor comments P1 L20: there could be a need to revise this statement in light of the work of Dargie et al. (2017).

Response:
It is a good suggestion to include the study by Dargie et al. in our manuscript. Their results increase the total tropical peat carbon store from approximately 89 PgC to 105 PgC. Southeast Asian peatlands are estimated to store more than 60 PgC (Page et al, 2011). Thus, these data conform with our original statement that more than half of the known tropical peatlands are located in Southeast Asia. In the revised manuscript we state: » *More than half of the known tropical peatlands are located in Southeast Asia (Dargie et al., 2017; Page et al., 2011), whereat 84 % of these are Indonesian peatlands, mainly on the islands of Sumatra, Borneo and Irian Jaya (Page et al., 2011).* «

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