

Biogeosciences Discuss., author comment AC1  
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## Reply on RC1

Alexandra Klemme et al.

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Author comment on "CO<sub>2</sub> emissions from peat-draining rivers regulated by water pH" by  
Alexandra Klemme et al., Biogeosciences Discuss.,  
<https://doi.org/10.5194/bg-2021-13-AC1>, 2021

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### Referee:

The manuscript by Klemme et al. presents a study explaining why tropical peat draining rivers are only a moderate source of CO<sub>2</sub> to the atmosphere, which stands in contrast to what was assumed for global estimates. Klemme et al. test the hypothesis that decomposition and thus CO<sub>2</sub> production in these organic C rich waters is limited by pH and O<sub>2</sub> availability. For this, they use a comprehensive dataset of observations of DOC and CO<sub>2</sub> concentrations, pH and other relevant physical and chemical parameters from SE Asian, peat draining rivers in combination with a conceptual model representing limitations of DOC decomposition by low pH and O<sub>2</sub> concentrations. They find that DOC decomposition in those peat draining rivers is likely more limited by pH than by O<sub>2</sub>, and suggest that increased loads of carbonates due to agricultural liming or enhanced weathering could increase decomposition of DOC and thus CO<sub>2</sub> emissions from those peat draining rivers.

The study is original and of great interest for the readership of Biogeosciences. The manuscript is well written, the methodology is clearly described, and results are clearly presented and support the main findings of this study. I suggest publication after minor revisions. Please, find my comments below.

### Response:

We thank the reviewer for the work with our manuscript and are pleased about their positive response to the concept and findings of our study. The suggestions by the reviewer were very helpful and improved the manuscript.

### Referee:

L15-17 : Other studies have shown that large amounts of CO<sub>2</sub> evading rivers are actually put in as dissolved CO<sub>2</sub> from soil respiration (both heterotrophic and root respiration) (Abril and Borges, 2019; Lauerwald et al., 2020). Maybe you should mention that source as well.

### Response:

We included this suggestion in our manuscript. In the revised manuscript we state: » ... *riverine CO<sub>2</sub> is fed by decomposition of organic matter that is leached from soils (Wit et al., 2015) and by the leaching of dissolved CO<sub>2</sub> from soil respiration (Abril and Borges, 2019; Lauerwald et al., 2020).* «

**Referee:**

L17-18: These are actually not model based studies that would represent peat soils. Those are more upscaling studies that lacked observations from these important systems

**Response:**

We realise that the use of the term "model-based studies" is imprecise. As the reviewer points out these studies do not include soil models but are based on upscaling. We corrected this and in the updated manuscript we state: » *Despite scarcity in river CO<sub>2</sub> measurements from Southeast Asia, studies suggest it as a hotspot for river CO<sub>2</sub> emissions (Lauerwald et al., 2015; Raymond et al., 2013) due to the presence and degradation of carbon-rich peat soils.* «

**Referee:**

L42: In peat draining rivers, is there also less instream production by algae that would otherwise be a source of O<sub>2</sub> to the water column?

**Response:**

Indeed, low nutrient concentrations (Baum and Rixen, 2014) as well as the dark water colour of peat-draining rivers that limit the light availability to algae (Wit et al., 2015) cause low rates of instream production. This further decreases O<sub>2</sub> concentrations within those rivers that due to the high DOC and the concomitant high O<sub>2</sub> consumption by decomposition exhibit low O<sub>2</sub> concentrations. In the corrected manuscript we state: » *Due to high rates of decomposition caused by the carbon rich environment and low rates of photosynthesis due to low nutrient concentrations and dark water colours that limits light availability to algae, peat-draining rivers are usually undersaturated with regard to atmospheric O<sub>2</sub> (Wit et al., 2015, Baum and Rixen, 2014).* «

**Referee:**

L48-51: You should link these quite specific objectives here again to the more general research objective (or hypothesis to be tested): explain the moderate CO<sub>2</sub> emissions from peat draining rivers by the effect of low pH and O<sub>2</sub> limitation.

**Response:**

We included this as suggested. In the revised manuscript we state: » *This study aims at quantifying the impact of pH and O<sub>2</sub> on the DOC decomposition in peat-draining rivers in order to explain the measured moderate CO<sub>2</sub> emissions from those rivers by the limiting effect of these parameters.* «

**Referee:**

L95-97: I don't understand why you have used such a projection for determining areas. For that purpose, I would rather use an equal area projection, like an equal area projection after Lambert or the EckertIV projection.

**Response:**

Our phrasing at this point was misleading. We did not use the projection to determine catchment sizes but instead the Hydro-SHEDS data that our calculation of catchment sizes was based upon were provided in that geographical projection (Lehner et al., 2006). In the revised manuscript we rephrased this section to: » *Catchment sizes were derived from Hydro-SHEDS (Lehner et al., 2006) at 15s resolution in WGS 1984 Web Mercator Projection. Subbasins belonging to the catchments were identified using the HydroSHEDS 15s flow directions data set and added to the main basins.* «

**Referee:**

L110-112: The exponential limitation factor related to pH, which is defined as negative decadic logarithm of H<sup>+</sup> activity - would that be comparable to a linear factor relating to the H<sup>+</sup> activity? That might be worth discussing here in one or two sentences.

**Response:**

The logarithmic pH relation in the exponential limitation factor is indeed striking. Yet, it would not result in a linear correlation with the H<sup>+</sup> activity but with this activity by the power of the exponential constant  $\lambda$  divided by  $\ln(10)$ , which for the rivers we studied results to approximately 0.2. We included this information in the revised manuscript. In the methods we state: » *Considering the definition of pH as negative decadic logarithm of H<sup>+</sup> activity ( $\{H^+\}$ ), the exponential limitation factor can be written as  $\{H^+\}^{(\lambda/\ln(10))}$ .* « and in the discussion we write: » *The exponential pH coefficient is  $\lambda = 0.5 \pm 0.1$ . Thus, in terms of H<sup>+</sup> activity the correlation is given by  $\{H^+\}^{(0.5/\ln(10))}$ , which roughly equals the fifth root of  $\{H^+\}$ .* «

**Referee:**

L122-123: That would require that dissolved CO<sub>2</sub> inputs via groundwater inputs and CO<sub>2</sub> consumption by autotrophic production is negligible. These are strong assumptions that would be worth mentioning here explicitly and some discussion later on.

**Response:**

We included this suggestion. In the methods we state: » *This approximation assumes photosynthetic CO<sub>2</sub> consumption and direct CO<sub>2</sub> input from leaching to be negligible.* « and later on we include discussions in form of: » *For this study, we neglect the leaching of CO<sub>2</sub> from soils as well as the consumption of CO<sub>2</sub> by autotrophic production. Since CO<sub>2</sub> leaching rates are high for peat soils and autotrophic production is limited in peat-draining rivers, both of these processes would work against the observed recession in CO<sub>2</sub> growth. This indicates that exclusion of those processes could cause underestimation of the limitation factors rather than overestimation.* «

**Referee:**

L140: "spatially as well as temporally"

**Response:**

We changed this as suggested.

**Referee:**

Figure 3: The grey lines, are those regression fits or the 1:1 line, or both?

**Response:**

Those lines represent the 1:1 line. We included this information in the revised manuscript.

**Referee:**

For figures 3 and 4, it would be great if you could report in addition the RMSEs.

**Response:**

We included those as suggested.

**Referee:**

L184: There's a "c" missing in "concentration".

**Response:**

We changed this.

**Referee:**

L189-191: Do Borges et al. also report CO<sub>2</sub> emission rates or CO<sub>2</sub> concentrations which are comparable to those in your study?

**Response:**

Yes, the CO<sub>2</sub> and DOC concentrations by Borges et al are comparable to the

concentrations measured in our study. In the revised manuscript we included this information and state: » *A similar pattern of stagnating CO<sub>2</sub> concentrations has been observed in river sections of high DOC at the Congo river (Borges et al., 2015). The CO<sub>2</sub> 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.* «

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