

Biogeosciences Discuss., author comment AC2
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Reply on RC2

Boyi Liu et al.

Author comment on "Spatial and temporal variability of $p\text{CO}_2$ and CO_2 emissions from the Dong River in south China" by Boyi Liu et al., Biogeosciences Discuss.,
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RC: My one main concern is in relation to the way the dataset was collected. It appears that the data was not collected with replicates and in a kind of snapshot approach across a large river basin. It is therefore very challenging to standardise for hydrological conditions, time of day etc. when co-ordinating sampling from such a large basin. However, there should be some analyses and discussion around this point to explore how this might impact the results as presented. One of the aims of the study is to "investigate the spatial and temporal pattern of $p\text{CO}_2$ and CO_2 emission along stream size spectrum" – how would different sampling conditions affect this? Not enough context is provided to reassure the reader that artefacts of the sampling process are not driving at least some of the variability observed in this dataset.

AC: Intending to improve the representativeness of our dataset, we have carefully chosen the location and time of our fieldwork campaigns. In this study, six reaches from the mainstream of the Dongjiang River and 37 rivers from eight main sub-basins were sampled. In total, five fieldwork campaigns were performed during different hydrological conditions, including two campaigns in the dry season and three in the wet season, and each campaign took about 2 weeks. Even so, we agree that sampling conditions could affect the result, and we will discuss the possible impact of the sampling process in our revised manuscript. As for data collection, the measurements of $p\text{CO}_2$ and FCO_2 at each site were repeated twice, and the average was then calculated and used in this study. Meanwhile, the variation between the two measurements was less than 5%, and extra measurements will be conducted if the difference is larger than 5%. Detail about the measurement will be further elaborated in the manuscript.

RC: L55. Please indicate which references refer to which so that the reader can use this as a pointer towards specific studies which observed one or the other pattern.

AC: Thank you for your advice. References will be changed accordingly.

RC: L96. What type of forest? Just to clarify, these "plains and hills" are predominantly covered by this forest? Please provide some more information on the extent of coverage.

AC: Overall, about 67% of the catchment is covered by evergreen Broad-leaved Forest. More detail will be provided in the manuscript.

RC: L127. Please provide details of the flow meter, including accuracy etc.

AC: Flow velocity was determined by using a Global Water Flow Probe FP111 with a precision of 0.1 m s^{-1} . Detail will be provided in the manuscript.

RC: L130. Can you provide an indication of how big this underestimation might be? An order of magnitude, or just a few percent?

AC: Flow velocity measured near the bank is about 60% to 80% of that in the middle of the river. Detail will be provided in the manuscript.

RC: L142-3. These volumes are larger than what are typically used for headspace extractions. Did you test this method for accuracy compared to smaller volume methods or can you provide a reference to back up this approach? Mostly to confirm that full equilibration between water and headspace is occurring within 1 min of shaking.

AC: Large headspace has been used in previous studies. For example, a 600ml conical flask has been used by Müller et al. (2015), and we also used large volume headspace in our previous study (Ran et al., 2017). According to our test, shaking the flask for one to five minutes could yield a similar result if we shake it vigorously (200 times per minute). Related references will be mentioned in the revised manuscript.

RC: L162. Think this is supposed to be eq 3.

AC: Thank you for your advice. We will revise it in the manuscript.

RC: L189. Does this include replicates at any sites? Or were single measurements only of FCO₂ and pCO₂ undertaken at each site? It seems strange to omit any kind of replication at each measurement site, so I would encourage the authors to explain why and discuss whether this lack of replication had any major impact on their findings. Further, were sites measured all in the same day or over multiple days? If so, how might time of day or hydrologic conditions varied across these measurements within each campaign? I know you can't go back and fix any of these potential issues after the fact, but some discussion of potential issues here would be useful to convince the reader that these decisions made when designing the sampling strategy have not substantially impacted the data that is presented here. This is most concerning when I look at Table 1. The values appear very consistent across all the sites, yet the standard deviation compared to the means are very large in some cases.

AC: The measurements of pCO₂ and FCO₂ at each site were repeated twice, and the average was then calculated. Meanwhile, the variation between the two measurements was less than 5%, and extra measurements will be conducted if the difference is larger than 5%. In total, five fieldwork campaigns were performed during different hydrological

conditions, including two campaigns in the dry season and three in the wet season, and each campaign took about two weeks. During the dry season, the hydrological condition was relatively stable due to the lack of precipitation. In contrast, the hydrological conditions could vary during the wet season. However, we believe that it may not drive the spatial pattern observed since both small and large rivers have been sampled before, during, and after precipitation events. As for the time of day, all measurements were conducted during the daytime, so the CO₂ concentration might be slightly lower than the night time. However, it may not have major impacts on the spatial and temporal pattern observed. Because Chl a in the Dongjiang River is relatively low, so as the impacts of photosynthesis on riverine CO₂. Nevertheless, We will discuss the possible impact of the sampling process in our revised manuscript.

RC: L197. Change Q to "discharge."

AC: Thank you for your advice. We will revise it in the manuscript.

RC: L225. What did this "strongest increase" actually relate to? Stream order is just a proxy for many things, including discharge, catchment characteristics etc. This is not fully discussed or addressed in the discussion.

AC: Initially, we are looking forward to a gradual decrease or increase in pCO₂ from low order to high order streams. However, we have observed a strong increase in pCO₂ from the third order stream to the fourth order stream. Meanwhile, first to third order streams have similar pCO₂ values, and fourth to seventh order streams have similar pCO₂ values. That's why the discussion mainly focus on the difference between small rivers (first to third order streams) and large rivers (fourth to seventh order streams) in pCO₂, k₆₀₀ and FCO₂. All discussion about small and large rivers are actually related to stream order.

RC: L245. Clarify the sentence here: "indicating that the majority of the river network is a carbon source".

AC: Thank you for your advice. We will revise it in the manuscript.

RC: L259. Not sure what this means, between wet vs dry seasons?

AC: Among five fieldwork campaigns, two of them were performed in the dry season, and three of them were performed in the wet season. Here we have compared the result between different campaigns in the same season. We will clarify it in the manuscript.

RC: L264. High compared to what?

AC: It is high compared with other months. We will clarify it in the manuscript.

RC: L273. This too broad a statement to really be useful. This is dependent on the river

and its setting etc. Perhaps rethink the purpose of this opening sentence and target it more directly to the immediate discussion.

AC: Thank you for your advice. We will revise it in the manuscript.

RC: L310. Which "should" lead to a decrease? Because you then observed $p\text{CO}_2$ to increase, rather than be diluted.

AC: Decrease in $p\text{CO}_2$ was observed in small rivers from April to August. It could result from dilution and depletion effects.

RC: L322. Decomposition of organic carbon "within the water column" (internal DOC decomposition)?

AC: Thank you for your advice. We will revise it in the manuscript.

RC: L331. Plenty of studies have indicated that DOC can be readily decomposed in headwater streams, e.g. Vonk et al. 2013 (doi: 10.1002/grl.50348), Dean et al. 2019 (doi:10.1029/2018JG004650).

AC: Thank you for your recommendation. Indeed, DOC can be readily decomposed in some headwater streams, but it also depends on their setting. Headwater streams in the peatland or permafrost region tend to have a low gradient and, thus, more favorable conditions for DOC decomposition. In contrast, headwater streams in the Dongjiang river basin usually have a high gradient and high flow velocity due to a predominantly hilly landscape. Therefore, it will be more difficult for DOC to be decomposed here. Nevertheless, it might be a good idea to include the result of those two studies in our discussion to support our arguments.

RC: L334. Should you not then see a correlation between DOC and $p\text{CO}_2$?

AC: Yes, higher DOC and $p\text{CO}_2$ were both observed in the wet season comparing to the dry season. However, we also found that changes in DOC and $p\text{CO}_2$ were not simultaneously. For example increase in $p\text{CO}_2$ was not observed for large rivers in April, although an increase in DOC concentration suggesting more external C input. Instead, a significant increase in CO_2 concentration was observed in July, even though the DOC concentration was slightly lower compared with April. Therefore, favorable conditions for OC decomposition might be more critical for the increase of $p\text{CO}_2$ compared to the concentration of DOC.

RC: L343. In line with previous studies, e.g. Long et al. 2015 (doi: 10.1002/2015JG002955). Fig 8. I suggest repositioning the legend so that single blue dot is more obvious.

AC: Thank you for your recommendation. We will include the reference in our discussion and reposition the legend.

RC: L393. For all rivers? Or large rivers? Because the earlier discussion suggested internal production of CO₂ was more important for the larger rivers.

AC: We believe that the internal production of CO₂ was more important for the large rivers. However, for small rivers, respiration could also contribute to high CO₂ in the summer, even if it's not the primary driver. Meanwhile, high DO and CO₂ occurred simultaneously in summer in the nearby Xijiang river, indicating that photosynthesis is strong and C source other than respiration should be responsible for high CO₂ concentration. We will rephrase the sentence to clarify our arguments.

Reference

Müller, D., Warneke, T., Rixen, T., Müller, M., Jamahiri, S., Denis, N., Mujahid, A., and Notholt, J.: Lateral carbon fluxes and CO₂ outgassing from a tropical peat-draining river, *Biogeosciences*, 12, 5967, 2015.

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