Biogeosciences Discussions

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Reply on RC1

Sergey N. Vorobyev et al.

Author comment on "Fluvial carbon dioxide emission from the Lena River basin during the spring flood" by Sergey N. Vorobyev et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-109-AC1, 2021

REVIEWER: The reviewer No 1 correctly pointed out that "some of the conclusions draw by the article to be lacking complete discussions and support by references and other supporting ideas".

RESPONSE: In fact, the present study was not designed to address the mechanisms of CO_2 generation in the Lena River main stem and tributaries. Such an investigation requires quite different sampling and measurement design. We would like to note that some discussion on CO_2 -related processes is provided in L 302-336, whereas thorough comparison with relevant literature data is given in section 4.2. In the revised version, we extended the discussion and provided necessary references.

REVIEWER: Some of the parameters discussed in the methods and results section are not discussed in the discussion section. Discussion of these parameters would strengthen the arguments made by the authors.

RESPONSE: The reviewer made a good point here. However, most of these parameters turned out to be non-correlated to pCO_2 in the river water. As such, there is no reason to discuss the lack of control by this or that environmental parameter given that we cannot ascertain the reason for this case.

REVIEWER: PCA results are presented in the results sections with no description in the methods section. The PCA results should be revisited in the discussion section.

RESPONSE: We totally agree with this pertinent comment and we would like to provide more discussion on the PCA results. However, the PCA demonstrated extremely low ability to describe the data variability (12% by F1 and only 3.5% by F2). We believe that the most likely reason of weak PCA capacity is rather homogeneous distribution of CO_2 and CH_4 across the river transect and among tributaries, primarily linked to the specific hydrological period, studied in this work - the springflood. During this high flow period, the local lithological and soil heterogeneities among tributaries or the segments of the main stem virtually disappear and surface flow (via vegetation leaching) becomes most

important driver of riverine chemistry, as it is known from adjacent permafrost territories of Central Siberia (i.e., Bagard et al., 2011). Nevertheless, some specific features of the data structure could be established. The first factor, significantly linked to pCO_2 (0.72 loading), strongly acted on the sample location at the Lena transect, the watershed coverage by deciduous needle-leaf forest and shrubs, riparian vegetation, but also the proportion of tundra, bare rock and soils, water bodies, peatland and bogs (> 0.90 loading). This is fully consistent with spatial variation of pCO_2 along the permafrost and climate gradient in the main channel and sampled tributaries. Positive loading of riparian vegetation, peatlands and bogs on F1 (0.927 and 0.989, respectively) could reflect a progressive increase in the feeding of the river basin by mire waters, increase in the proportion of needle-lead deciduous trees, and an increase in the width of the riparian zone from the SW to the NE direction.

Methods: For the PCA treatment, all the variables were normalized as necessary in standard package of STATISTICA-7 (http://www.statsoft.com) because the units of measurements of various components were different. The factors were identified via the Raw Data method. To run the scree test, we plotted the eigenvalues in descending order of their magnitude against their factor numbers. There was significant decrease in the PCA values between F1 and F2 suggesting therefore that maximum two factors were interpretable.

REVIEWER: The reviewer also stated that 'On line 322, the authors suggest that in-stream processing of dissolved terrestrial organic C is not the main driver of CO_2 supersaturation in the river waters of the Lena River basin, but offer no alternative pathways for this phenomenon.'

RESPONSE: The relevant mechanisms of CO_2 supersaturation are discussed in L327-334. We extended this discussion in the revised version as following. The main sources of CO_2 in the river water include but not limited to i) underground discharge of CO_2-rich waters, ii) lateral influx of CO_2-rich soil waters; iii) DOC and POC processing in the water column via bio- and photodegradation, and iv) phyto, zoo-plankton, periphyton and sediment respiration. As indicated in the text (L327-331), there was no relationship ($p < 0.05$) between the proportion of carbonate rocks on the watershed and the pCO2 in the tributaries (Fig. S6 B), whereas for the Lena River main stem, the lowest CO2 concentrations were recorded in the upper reaches (first 0-800 km) where the carbonate rocks dominate the background lithology. This makes unlikely the impact of underground CO2 from carbonate reservoirs on river water CO2 concentrations. Given that we have not recorded any sizable diurnal variations in pCO_2 over the full transect of the Lena River, the respiration of photosynthetic organisms (plankton and periphyton) cannot be the reason for persistent CO_2 supersaturation over day and night. Furthermore, these was no significant ($p < 0.05$) link between DOC and CO_2 concentration, so we do not expect sizable impact of bio- and photodegradation of DOM. A lack of lateral (across the river bed) variations in pCO_2 witnesses against sizable input of soil waters from the shore, although we admit that much higher spatial coverage along the river shore is needed to confirm this hypothesis. Therefore, other sources of riverine CO2 may include POC processing in the water column (Attermeyer et al., 2018), river sediments (Humborg et al., 2010) and within the riparian zone (Leith et al., 2014, 2015). Quantifying these impacts at the scale of the Lena River basin will certainly require further investigation.

REVIEWER: The reviewer also noted that the text 'needs to be reviewed and edited by a native English speaker'. The revised text will be subjected to thorough editing by a native English speaking scientist. We would like to point out that the APC of Biogeosciences include thorough English style and grammar revision, and we hope to use this option for our manuscript.

Specific comments of Reviewer No 1:

Line 331 POC is not defined. Response: Particulate Organic Carbon, will be added to revised text.

Line 344 FCo2 not defined. Response: This is CO2 emission flux, will be corrected.

Line 344 Unites should be United. Response: We are sorry for this misprint and will correct it accordingly.