Reviewer (R#2) comments and author responses to ms bg-2019-486

Reviewer comments are given in normal style and with author responses in *italic*

Inland waters and specifically headwaters emit significant amounts of CO2 to the atmosphere; however, studies focusing in agricultural streams and including continuously measured in-situ CO2 from are rather rare. In this MS, the authors continuously monitored CO2 with cost-effective Co2 sensors during one year and explored the spatio-temporal variations of CO2 throughout the year as a function of hydrology and metabolism.

General comments

The MS bg-2019-486 provides an interesting study about CO2 dynamics in one stream draining a catchment largely dominated by agriculture. An important finding is that stream intermittency can cause rapid pulses of CO2 even in catchment with no pronounced dry and wet seasons. I think this is an important matter to better understand carbon emissions from streams at the global scale, in the context of climate change (change in hydrology). In line with this result, it could be useful to add somewhere in the discussion the spatial representativeness at the global scale of the stream studied here. In addition, it could be nice to add discussion/comparison of this agricultural stream with other agricultural streams worldwide, because the hydrology should be very different. To increase there adability, I suggest to better define some terms used in this study, particularly, open-water season, and the different periods, and also define better the time-intervals of these seasons throughout the text. Indeed, to my opinion, those terms are specific to boreal systems, and sometimes it is difficult to follow for a reader who is novice with boreal landscapes. A second important finding is the strong biologic control (aquatic primary production) of the CO2 dynamics during baseflow that should decrease CO2 emissions during this period. Indeed, during base flow it is common to observed higher CO2 concentration in streams because deeper levels of groundwater are involved. Perhaps the authors could further developed this. Overall, I found the dataset very interesting; it is rare to have such continuous measurements for CO2 in streams. In addition, I found the paper well written. Perhaps the quality of some figures could be improved. Overall, I support publication of this manuscript and below are some more detailed comments.

Response: We thank reviewer #2 for their overall positive evaluation of our manuscript and are happy that publication in Biogeosciences is recommended after a revision. We believe that we in the revised manuscript have better discussed the spatial representativeness of our findings and also elaborated more on the primary production part. We further improved the quality of the figures (also in line with comments from R#1).

Specific comments

Abstract

L. 15-16: It would be nice for the reader adding the size of the catchment, the date of open-water season, and the time-step of CO2 measurements.

Response: We agree and have in the revised version added catchment size and total number of days of measurements. We have further replaced "continuous" with "hourly" to clarify the temporal resolution of the measurements.

Introduction

L.31-33: The authors can check this reference that suit with their study (Deirmendjian et al, 2019. Importance of the vegetation-groundwater-stream continuum to understand transformation of biogenic carbon in aquatic systems – a case study based on a pine maize comparison in a lowland sandy watershed), where the concentration of CO2 in agricultural and forested streams (and in groundwater) in a temperate catchment was compared. They found no differences between both streams because degassing in agricultural streams was prevented.

Response: We agree that this reference is very suitable and have added two sentences using information from it.

L. 43-45: Please clarify this sentence. You mean that different level of soils are exported in function of the change in hydrology?

Response: Yes, we mean that dependent on hydrological conditions different source areas in the catchment soils are hydrologically connected and contribute differently to the stream CO2. The variability in source areas are both vertically and laterally distributed in the soils and are hence activated differently dependent on groundwater position and dominating pathways. This pattern is further dependent on the catchment characteristics and land use. We have in the revised version tried to clarify the lateral and vertical consideration of source areas.

L-40-55: To my opinion, there is a lightly lack of spatial references in this paragraph. Indeed, I guess that agricultural streams in tropical or boreal areas are very different in terms of hydrology and carbon dynamics. Could you mention spatial references?

Response: We agree that the spatial coverage among the given references might look limited. We base this section solely on studies that have used high-frequency CO2 sensor data. This is now clarified. Also, the two references originally given (Dinsmore et al. 2013 and Crawford et al. 2017) both include data from multiple sites including boreal, temperate, alpine and subtropical areas. They further represent a large variety of forest, wetland and mountainous coverage. Hence, we believe that we have a relatively good spatial coverage, but to further support the tropical side we have added the very suitable Johnson et al. 2007 paper and adjusted the text according to this.

L. 69: High-resolution: what is the time-step of measurements?

Response: We have in the revised version added "(hourly)" after "high-resolution". Although we used 30 min resolution in 2017 and 60 min resolution in 2018 (in order to save power) "hourly" is likely the best option here. Further details on the different temporal resolutions are given in the method section.

Methods

L.78: What kind of cropland it is? This is important for the d13C-DIC

Response: The land is mainly used for cereal production and pasture. This clarification is now added.

L. 83: Lower end: how much lower?

Response: It is hard to give exact percentages as the variables including in "nutrients" are so many. We have instead added, as a general approximation, that the studied stream is within the 25th percentile of the monitored agricultural streams in Sweden when it comes to DOC and nutrient levels.

L. 85: Growing season: what is the time interval?

Response: The length of the growing season is on average ca 210 days starting in mid-April and ending in early November. This information is now included.

L. 97: what was the concentration of gas standards?

Response: Four standards were used (400, 1000 and 5000 ppm as well as 2%)

L.100: discharge rates lower than 0 L/s: so you mean when the stream was dry or when the stream was frozen? Or both? It is a bit confusing.

Response: This mean that CO2 data was just analyzed if runoff was generated over the V-notch dam i.e. excluding standing water or completely dry conditions. The instrument was never measuring during ice or snow conditions. This is now clarified.

L.101: Figure S1

Response: Yes, this figure reference is now given in ln??

L109: You wrote one measurements each minute but then a temporal resolution of 30. It is a bit confusing what is the meaning of temporal resolution here?

Response: As for many sensor-based systems averaging high-frequency data reduce the noise of the measurements and make them more reliable. The given averaging time needs to account for relevant time-scales for the processes you want to study but also consider practical limitations as power consumption, data storage etc. In this case we measured at a 1 min interval and stored average values based on these 1 min measurements every 30 min (in 2017) or 60 min (in 2018). This is now clarified.

L.120: What is the volume of the injections?

Response: The volume of the injections was 100 µL i.e. 7 × 100 µL per sample. This info is now added.

L.129: Please specify that these streams were not located in your catchment and add the reference to the figure S2

Response: This is now clarified.

L. 145: Please define better your four periods. What are the time intervals?

Response: We have now added number of days per period. We have also added a new table to the supplementary information that gives the full period description.

Results

L.157: Please refer to figure 3

Response: Figure 3 is now referred to.

L.168-172: Please add corresponding pCO2 for reference, as you did

Response: We have chosen to present the CO2 data as a concentration in the unit of mg C/L as this normalize for solubility and makes it directly comparable with for example DOC/TOC concentrations if total aquatic C export would be of interest. We give corresponding pCO2 values as an example for how they compare. But we don't think it is reasonable to give pCO2 values to all given CO2 concentrations in the manuscript while no addition has been made.

L.166. To my opinion, I suggest to do that for the remainder of the text because pCO2 in ppmv is more "understandable" that CO2 in mg/L.

Response: See comment above. We think this is also very much a matter of personal taste and as stated above we see clear advantages of presenting the CO2 data as concentrations rather than a volume fraction i.e. ppmv.

Discussion:

L.225: I would not rush on conclusion about zero/limited tree cover along agricultural streams, at the global scale. I am agree considering your figure S2 that this is the case in your catchment. However, in temperate climate it is very common to observe riparian forest along agricultural streams.

Response: We agree that the statement was maybe too strong and have revised it. We still believe that canopy cover is important and that agricultural streams to a larger extent than for example forest streams are exposed to direct sun-light, even at the global scale.

Figures

Figure 1: In the left part, I suggest to add a map of Europe rather than just Sweden. Please add a scale in the left part too.

Response: We have updated the figure for the revised version.

Figure 2: I suggest to separate the different periods (autumn, snowmelt, spring, dry period) with dotted lines, as you did in the next figure.

Response: Good idea, this is now added

Figure 4: It is not very intuitive what the time interval is for A, B, C and D.

Response: The figure is now updated with appropriate font sizes

Figure 5: Same remark

Response: The figure is now updated with appropriate font sizes

Figure 7: Perhaps add regression line with slope

Response: Here we have used Spearman's Rank (which assumes a monotonic, not linear, relationship), not regression, so fitting a line would not be appropriate.