Biogeosciences Discuss.,
doi:10.5194/bg-2015-648-RC3, 2016

Biogeosciences Discussions
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EGU

Interactive comment on "CO_2 emissions from German drinking water reservoirs estimated from routine monitoring data" *by* H. Saidi and M. Koschorreck

Anonymous Referee #3

Received and published: 16 February 2016

This manuscript reports a study using drinking water reservoir data from 39 reservoirs in Germany to estimate CO2 emissions. This is, to the best of my knowledge, one of the first papers to report on any greenhouse gas emission from drinking water reservoirs; therefore, the data is valuable to have in the literature. However, the paper requires major rewriting of sections that includes (1) a more thorough introduction, (2) better explanations in the methods and results, (3) deletion of the pH results/discussion and (4) the inclusion of a conclusion. With significant major revisions, the manuscript could be considered for publication; however, there is nothing new to be gained from this paper other than CO2 emissions from drinking water reservoirs. Perhaps the authors can come find a storyline to tell that would make this dataset more interesting for

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Discussion paper

publication.

General comments: Language: Recognizing that English is likely not your mother tongue, I commend you on the grammar throughout the paper. However, I urge you to take advantage of this time to expand your English scientific writing skills. A good example to do so is by trying to make slightly longer, more eloquent sentences instead of very short ones. I have pointed out some examples in specific comments below. First paragraph of introduction can be expanded upon. Discuss the importance of GHG emissions from inland waters in general and their contribution to carbon cycle. Then reservoirs and how they are man-made impoundments and thus would be considered anthropogenic sources of GHG. Next about the focus on hydropower reservoir GHG emissions because they are supposed to be a green source of energy. Lastly, any information about GHG emissions from drinking reservoirs, which I am guessing there are not a lot, and why it's important to also measure that. These subjects could easily be 3 paragraphs of the introduction. Then go into what is usually measured in drinking water reservoirs and how it can help estimate CO2 emissions from them but the data can be sporadic (basically P2, L25 starts this paragraph). Then a paragraph about potential drivers of CO2 emissions (the things you will test for, like DOC; P3, L7-13). Then end with a paragraph describing the aim of your study. Methods: The methods need a lot more work to be comprehensive. The structure is also odd. More data is need for Section 2.2.1. Section 2.2.2 needs to be corrected a bit and given more description. Section 2.2.3 needs more description. Section 2.2.4 is highly confusing and needs much more description and better structure. See specific comments for more details. The results need a lot of restructuring and explanations as well. The most confusing part is understanding what fluxes, calculated how, were being used for the results. I also do not agree with the pH and alkalinity relationships with CO2 flux as being meaningful as those two parameters were used to calculate CO2 in the first place. The only way to meaningfully make any statements regarding the use of pH as a proxy for CO2 is if you have independent measurements of both CO2 and pH. Therefore, the section in the discussion regarding this is also an issue. The paper needs a conclusion

paragraph of some type. It ends too abruptly as is. I suggest a discussion of how drinking water reservoirs could and should implement CO2 emission monitoring into their normal routines.

Specific comments: P1, L19 – I assume you mean that this median flux implies it's a relevant process for the carbon budget of each individual reservoir. Is that right? P1, L19-21 – Move the sentence 'In total, German drinking reservoir emit 44000 t of CO2 annually. . .' to the last sentence of the abstract P2, L3 – Mention different types of reservoirs here in the first sentence – the ones that St. Louis mentioned. P2, L5-7 – Move the sentence 'Existing studies on GHG emissions. . .' to the second sentence of the paragraph and you must have an example reference for each type of reservoir you mention (hydro in boreal, hydro in tropics, dammed rivers) P2, L4 – preface this sentence by saying that 'Hydropower reservoirs have a been a central focus of GHG emission studies from reservoirs as any emissions of these gases would counter the 'greenness' of this type of energy supply.' P2, L7-8 – You need a reference for this sentence about drinking reservoirs. If the reference is Knoll et al. 2013 then you should move that citation to the first sentence P2, L10 – I do not understand the point of this sentence: 'However, existing CO2 emission studies focus on few intensively studied reservoirs'.. please clarify P2, L13-14 – why is it still challenging? P2, L15-25 – I don't think this information regarding methods is necessary for your introduction. You are not really discussing these particularly methods as a bias for data calculation and interpretation. You are mostly concerned about P2, L25-32 – Start the next paragraph with a discussion about what is usually measured in drinking water reservoirs and how that can be used to estimate CO2 emissions, but that the resolution is heterogeneous so annual budgets are difficult to come up with. P2, L32-P3, L2 – this sentence belongs with the last paragraph of the introduction that describes what you aim to do in this study P3, L5 – don't say 'By applying simple regression analyses'. . . more like 'We aim to find relationships that help explain. . .' P3, L7-L13 – all of this information about potential drivers of CO2 emissions deserves it's own paragraph above P3, L11 – DIC is not defined yet P3, L18 – Mention some of the 'routine water quality monitoring

data' particularly the ones you used for your calculations. I am guessing some of them are in Table S2, so you should also reference that Table here, but clearly make it now Table S1 as it is appearing before the table you reference on Line 29. P3, L24-27 – These few sentences starting with 'A first quality control. . .' are not necessary. P3, L29 – Change to Table S2 if you are adding the other table reference above as suggested. P4, L3 – change to 'fluxes from the reservoir surfaces.' P4, L6-7 – replace 'the difference between gas and concentrations in surface water and air' with 'the CO2 concentration gradient' P4, L10-14 – don't list these as bullets. Place them in normal lines separated by ';' P4, L12 – list the units P4 L15 – add a sentence after the last sentence about density that states: 'All calculations and procedures to determine the variables for the basic flux equation are described next' P4, L17-20 – Give more details about these equations/R packages and how CO2 is actually calculated. There were no measurements of actual dissolved CO2 or pCO2 in the datasets? P4, L20 – If you used the seacarb package definitively then add to the end of the last sentence 'Both tools gave the same results, but we decided to use seacarb because. . ..' Why did you decide on that one? P4, L25 - change 'P' to 'pCO2' . . . and type the equation properly (although I imagine the editor will do this): ãĂŰCOãĂŮ_2(air) = ãĂŰpCOãĂŮ_2/K_H P4, L26 – move sentence P5, L5-6 where you define KH to just after you state equation 2; Then discuss how you derive pCO2 P4, L26 – Just call the variable pCO2 P4, L26 and P5, L4 – define the 'mixing ratio' somehow P4, L30 – 'It represents a reference site' . . .. Change 'presents' to 'represents' P5, L3 – do you have a reference for this equation? P5, L13-14 – place these variable definitions in the text after 'where' on L12 P5, L13 – were all of the met stations taking wind speed at 10m? P5, L14 – give a quick reason why the Schmidt number is necessary and that it is based on temperature. You do not need to define the equation P5, L15 – delete this equation – not necessary P5, L11 – You need to add at the end of this section an explanation of the exponents (-2/3 or -1/2) and how and why you use chose which one to use. I am guessing you used something similar to Wanninkhof 1992 which was based on Jahne 1987 where -1/2 is used for wind speeds under 3 m/s and -2/3 used for wind speeds over 3 m/s. P5,

L17 – Calculation of seasonal budgets: I find this section a bit confusing. You are not only calculating monthly, hourly, seasonal fluxes here, but also daily fluxes. And I don't understand dhow you 'merge data'. You should start with the highest resolution and move to lowest. . . so hourly, then daily, then monthly, then seasonal, then annual. And be explicit at each step and give them proper names and then use those names later on because it's highly confusing in the results to know what you used for what. P5, L19 – CO2 concentration here being the concentration in the water? P5, L19-20 – I do not understand how you have 'typically available for 12 days per year' but you have a possibility from 4 to 293 days? I would add 'days' in those parentheses. But what is the 12 day number? Is that an average? P5, L22-23 – You state that you 'determined the mean wind speed for the same day and computed a daily mean flux' – but how many hours of wind speed of the hourly data did you use to determine the wind speed? Be specific. I would also state that you 'we determined the mean wind speed from the hourly data using XX hrs' P6, L1-3 – So you had hourly wind data and then you tried to find the closest CO2 concentration data to each hour? But you had at best maybe daily data but apparently not that often if you have a range of 4 to 293 and an average of 12 days in the year. I do not think that an hourly flux is then reasonable to calculate. What were the smallest time differences? P6, L4 – rewrite: 'Seasonal mean fluxes were calculated by finding the means for each month, then the available monthly means. . .' P6, L7 – these daily fluxes are calculated from those used to make the monthly data, right? P6, L8 – Were these reservoirs always ice-covered? I don't believe they could be and their ice on periods likely varied quite a bit. Do you have any data on this? P6, L14 – replace 'done' with 'conducted' P6, L17 – use scientific notation for '11991' and you can use 'μM' for the units. These number 0.002 and 11991 don't match Table 1. Should they? P6, L18 – replace 'single' with 'individual' and change units P6, L19 – use scientific notation with units of μM for 2.4 mmol/L P6, L19-21 – combine these two sentences 'The reservoirs were...' and 'Under-saturation was observed. . .' and give the saturation value of CO2 in μM in the sentence too. P6, L20 – so since you observed undersaturation then you should have had some uptake fluxes (i.e., negative

CO2 fluxes), yet I do not see those in Fig. 1c. Why not? P6, L21 – instead of saying '25 reservoirs', please give % of reservoirs. NOTE: Do this for every time you discuss how many reservoirs were like this or that. Use % and not number of reservoirs. P6, L21 – this median concentration is of all measurements – make that explicit P6, L22-24 – give wind speed values for the low and high winds. Stating that the K values were mostly 'around 0.5 m' is not very precise. Use some sort of statistic to state this. In fact, most values actually look above 0.5. I would give % here for things as well. Figure 1 – change y-axes to % instead of count. Log the CO2 concentration and the CO2 flux to better see the distribution. The fluxes shown in 1c are median annual fluxes, but how were these annual fluxes calculated? P6, L25 – delete 'If we consider all the seasons' and just start with 'We observed. . .' and be explicity that these were the seasonal budget calculated from monthly means. P6, L29 – what does 'resp. wind speed' mean? P6, L30 – what season does the 0.63 m/d refer to? Both spring and summer? If so, be explicit P6, L30-31 – Rewrite: 'Consequent of both low CO2 concentrations and low K, fluxes were lowest in summer.' P6,L31 – P7, L1-2 – Combine these two sentences 'Median fluxes were. . .' and 'Also the variability. . .' P7, L3 – using the terms 'with' and 'without inclusion of hourly wind' is not useful here, I think. Use the suggestions made earlier in the methods about how to label each resolution of calculation and stick with it throughout the paper. P7, L4-5 – rewrite and combine with sentence from P7,L11-12 about the underestimation: 'Both approaches gave similar results with hourly fluxes slightly higher and a consequent 22% underestimation using monthly-based data on average' and put a R2 here. Figure 3 – are those 1:1 lines in the figures? Put in the caption if they are P7, L5-7 – change the count of reservoirs to %. And rewrite: 'Hourly-based median annual CO2 fluxes were higher than monthly-based median annual CO2 fluxes in XX% of reservoirs, while in XX% of reservoirs the values were within 10% of each other and in XX% of reservoirs hourly-based were lower.' P7, L13-16 – Begin this paragraph with the second sentence describing how you calculated the total flux. Then combine the first and third sentences into one. I am confused how you calculated these values. You have multiple years of measurements from reservoirs so how do you

account for this in calculating the total per year, especially when you don't have a value for every year for every reservoir? Once you clear that up and make it explicit, then also explain how you calculated the mean annual flux – such as did it mean that you also had negative fluxes and you averaged those as well? What about instead of using an annual mean flux, you used your monthly fluxes, calculated a monthly emission rate in tons/month and then added those up to get the yearly loss. Would you get a different total emission rate? Which would be more representative? P7, L17-18 – how did you extrapolate to all of the other reservoirs you didn't measure? Please explicit. P7, L19-25 – This paragraph has a good point but it's not clearly written. Make it obvious in the first sentence that you used the mean annual flux from each reservoir (is this right? That if a reservoir had 10 years of measurements then you would take the average of that for this Figure 5?). In the second sentence, state what resolution calculation you are looking at for each individual reservoir. Do you have a figure for these? And use % instead of reservoir counts. Do you think the fact that the individual reservoirs have a correlation with K is dependent on the resolution of calculation you used – for example if you used the hourly than you have better wind data? Or even if you used the daily then you have a daily wind speed rather than an average for the all year. I cannot determine if the K correlation is real for individual reservoirs or an artefact of how you made your calculations. Figure 5 – try logging the x-axis P7, L26-31 – Since you did calculate CO2 with pH and Alkalinity data, it is obvious and expected that you would see a relationship between CO2 flux and those parameters. I believe this makes this correlation a bit circular, not valid, and not worthy of discussing. Equation 6 is thus also not very useful. P8, L2-6 – The discussion of a DOC relationship is valid however. P8, L10 – why did you choose this value instead of the monthly? Why not use a range of 148-167 and you are closer to St Louis value. Also cite Table 1 again here. P8, L11 – should look like this: 'in the reviews of St. Louis et al. (2000) and Barros et al. (2011) with values of 150 and 120 g m-2 y-1, respectively.' P8, L14 – rewrite 'Streams are known to be oversaturated with CO2 (XX) with small streams (i.e., lower order) typically. . .' P8, L15-16 – rewrite: 'Drinking water reservoirs are preferably located in

upstream areas close to headwaters to ensure high quality drinking water and are thus receiving water from lower order streams that typically have higher pCO2.' P8, L17-18 – rewrite: 'This is supported by our observation of the highest CO2 concentrations occurring in the smallest reservoirs.' P8, L18-20 – I don't understand what you are trying to say with this sentence. Please clarify P8, L21-26 – Area and areal flux doesn't matter as much in this case as does the relative totals of different sources of CO2 emissions. Is there a better reference to use here to discuss the implication of drinking water reservoir emissions? Also, you are citing a negative flux in a German forest site and say that the drinking water emissions are low. That doesn't make any sense. And you need a ref for the drinking water reservoir surface area of 0.03% P8, L28 – is TIC defined earlier? P8, L30-31 – You say 'total TIC inventories of reservoirs' – does mean only the 8 reservoir for which you have data? If not, then clarify how you extrapolated. The residence times of 2 – 302 days is based on what exactly? The flux of 167 g C/m2/d x the 1t to 66 t range over the area??? Explain better. P9, L1 – how do you know the annual CO2 flux was of the same order of magnitude as the TIC content? Please clarify P9, L6 – the increased surface concentration during autumnal mixing was because of the CO2-rich hypolimnion being mixed upwards in fall, correct? You should state this a bit clearer here. P9, L9 – change to 'in spring and fall at the cost of less. . .' P9, L13 – change to 'the exact duration of ice cover has to be..' P9, L14 – you state that the accumulation of CO2 under ice is probably unimportant but there are studies about this. State some. If it turns out it could be important and you just don't know, that is fine but you must state that. P9, L15 – why are there high flow conditions in winter under ice? P9, L22 – use the uppercase K P9, L23 – get rid of quotes around 'high K reservoirs' P10, L11-12 – rewrite: 'not only directly influence K but also CO2 as a result of enhanced surface mixing.' P10, L16-17 – rewrite: 'should all the prediction of whether the. . . wind data has the potential. . .' P10, L24 – delete comma before 'because' P10, L25 – add 'a' before 'diurnal' P10, L27 – rewrite 'and thus enhances gas..' P10, L28 – rewrite 'Neglecting convective mixing is..' P10, L31 – delete comma after 'thus' P11, L3-4 – rewrite: 'The variability

in the. . . caused by CO2 concentration in the surface..' P11, L4-5 – avoid using 'This was' to start a sentence. That type of beginning can be very ambiguous. Be specific. Consequently, I don't really understand your point with this sentence. Please clarify. P11, L6-7 – it is not necessarily more important to get CO2 concentration than wind data. I would rather say they are both equally important, especially if you have no idea of the wind conditions. Fluxes are in fact considerably enhanced in high winds. P11, L7-9 – instead of 'Since the' use 'We suggest that surface CO2' and continue 'We suggest that surface CO2 concentration. . . determined by inflow water quality (i.e., CO2 from inflowing streams) rather than internal processes, which implies that CO2 emissions are largely regulated by catchment processes..' P11, L10 – again, do not begin with 'This'. . . rewrite: 'Other studies had similar results showing that. . .' P11, L12-14 – Why are catchment processes and inflow water quality more important? Because there was no relationship seen with K? Be specific P11, L14-15 – rewrite: 'Internal processes seem to have the largest effect during summer when CO2 fluxes are lowest, likely due to primary production.' P11, L17- rewrite: '. . .because CO2 accumulated in the hypolimnion during stratification is. . .' P11, L22 – rewrite 'by light-dependent photosynthesis; thus sampling time has an influence on the. . .' P11, L28-30 – rewrite ' .. DOC concentration (REF), which is in contrast. . .' and delete the rest after the Borges reference. P11, L30 – rewrite: 'One explanation for this is that our DOC. . .' P12, L2-5 – There is not simple link – that is true. But you also don't have a lot of measurements either of the other processes so that is why you cannot truly judge the contribution of the reservoirs to the carbon balance. You should state that more explicitly P12, L7–12 – I have a real issue with this discussion as the correlation found in your own data is not valid. The only way to determine if pH is a proxy for CO2 is to independently measure both of those parameters and compare and not calculate one based on the other. P12, L18-30 – The first half of this paragraph is useful to support your use of pH to calculate CO2. But then you begin discussing your pH-CO2 flux relationship again, which you cannot do because again you calculated CO2 based on pH. P12, L31-P13, L2 – This could be combined with some of the above info to support your use of pH to calculate

CO2, but that is all. Figure 6 – I don't believe you can use the relationship of pH and alkalinity with flux as they are used in the calculations. Figure S1 – Cannot read the axes at all of this figure.

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