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Interactive comment on "River inflow and retention time affecting spatial heterogeneity of chlorophyll and water–air CO_2 fluxes in a tropical hydropower reservoir" *by* F. S. Pacheco et al.

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We would like to thank the Referee 1 for his/her thorough remarks and comments. We address them below and we will upload the revised manuscript as soon as we receive further instruction from the Editorial Support.

Regarding the general comments:

We agree that the sediment is an important driver for the carbon cycling in reservoir. In the reviewed version of the manuscript, we emphasize the role of the sediment in the carbon cycling in Funil reservoir. Further, we analyzed the available data presented

within the Ometto et al. 2013 reference as suggested by Referee 2 to show that sediment can be important to carbon emission especially as source of methane.

We also clarified the discussion about the data of CO_2 fluxes. We remade the statistical analyses; we found significant differences between the spatial data of the rainy and dry seasons; between spatial and temporal data; and between seasons over the year. The significant difference is mainly explained by the large sample size (hourly data). More details and results of statistical analysis were included in the manuscript.

The error in Equation 2 is a typo and we used the correct equation to calculate the fluxes. We clarified the units of the components in the Methods section to match with the flux unit.

Regarding the specific comments:

Following the suggestion made by the Referee 1, the manuscript were carefully revised and all the grammar mistakes were fixed. Some abbreviations suggested by the Copernicus Production Office such as 'meter above sea level (m a.s.l.)' and 'Local Time (LT)' were clarified or introduced at the first appearance.

(answers are quoted by "AR")

8533, line 17 – ' considering data..' re-cast, sentence is awkward. The average calculated CO2 fluxes were x based on temporal data near the dam versus x using the spatial data collected throughout the reservoir.

AR: We rewrote the sentence as suggested.

8533, line 20 – '. . .change completely the role. . .' perhaps re-cast. Be more specific – the take home message is that using temporal vs spatial data to calculate CO2 fluxes results in the reservoir acting as a sink or a source of CO2 (which can have implications towards regional and global C budgets).

AR: We rewrote some sentences in the abstract. 'The average CO_2 fluxes was -10.3 and 7.2 mmol m^{-2} d^{-1} considering data collected near the dam and spatial data, respectively, in seasons of high retention time. In this case, the use of temporal data alone to calculate CO_2 fluxes results in the reservoir acting as a source instead of a sink of CO_2. This suggest that the lack of spatial data to calculate C budgets in reservoirs can have implications towards regional and global estimates.

8535, line 21 – Cwa? Koppen system? Please clarify.

AR: We considered Köppen Climate Classification System to classify the climate in the region. We removed this classification as suggested by Referee 2.

8539, equation 2 - This equation is not correct. The correct equation to calculate kco2 from k600 is: kco2 = k600(Sc/600)$^{-0.5}$.

AR: The error in Equation 2 was a typo; we used the correct equation to calculate the fluxes.

k600 is the k for a Schmidt number (Sc) of 600 at a given temperature (not necessarily at 20C, as incorrectly stated in line 2 on the same page – please correct/clarify).

AR: We rewrote the sentence in order to clarify the context. k_{600} is the k for CO_2 at 20°C. We used the equation in Wanninkhof (1992) to determine the Sc at a given temperature. Once k and Sc is known for CO_2 at 20° (k_{600}), k can be calculated for CO_2 at a given temperature by the ratio of the Schmidt numbers (Jahne et al., 1987).

What k was used? K at 20C or k at temperature? Given the description of equation 3, I am assuming at temperature and not at 20C. Please clarify. K at temperature should have been used to calculate CO2 fluxes.

AR: We clarified the Methods section. We used k at temperature to calculate CO_2 fluxes.

Units? Line 1, same page – k units are described for equation 1. However, to be consistent, please clarify all units of each component of the all equations throughout the manuscript (especially in regards to k – since k can be described as a velocity (units of distance time-1) or a coefficient (units of time-1)).

AR: We fixed the units to match with the flux unit: CO_2 Flux (mmol m^{-2} d^{-1}); gas transfer velocity – k (m d^{-1}); solubility coefficient of CO_2 – α (mmol $m^{-3}\mu atm^{-1}$); pCO2 (μatm). We calculated K_{600} in cm h^{-1} and converted to m d^{-1}.

Also, regarding the calculation of k600 from Cole Caraco 1998, did the authors consider using other equations for k600 which may account for the stratification of the reservoir? The reservoir was stratified at the time of sampling. Why was that not taken into consideration for calculating reaeration? Given previous literature on reservoirs impoundments on CO2 outgassing, sedimentation is often a high source of CO2 (and other green house gases). I wonder if not taking into account the stratification of the lake, a component is missing in regards to scaling up CO2 fluxes. Such equations are described in Staehr et al. 2012 Limnology Oceanography (57(2), pages 1317-1330)).

AR: We considered using other equation as suggested by the Referee. We compered k_{600} calculated using the Cole Caraco (1998) equations and the equations described in Saehr et al. (2012) and MacIntyre et al. (2010). The equations to calculate k_{600} described in MacIntyre et al. (2010) and used by Staehr et al. (2012) indicates that k_{600} is negatively and significantly correlated to buoyancy flux when the lake is cooling. Applying the proposed equations to calculate k_{600}, we observed an increase in the fluxes mainly between Abril and June (Dry – Autumn) when the surface temperature decreased. The fluxes calculated with this method were -28.58, 8.08, 23.70 and -0.41 mmol m^{-2} d^{-1} for the periods of

Oct-Dez, Jan-Mar, Abr-Jun and Jul-Sep, respectively. The equations proposed by MacIntyre et al. may improve the fluxes estimates; however, the differences did not change significantly our results. The comparison between k_{600} calculated by these methods was added to the manuscript.

8539, line 16 – please include the equation and units used to calculate k600 for the riverine zone.

AR: We added the equation from Borges et al. (2004).

$$k_{600current} = 1.719 w^{0.5} h^{-0.5}$$

Where $k_{600current}$ is the gas transfer velocity of CO_2 (cm h^{-1}), w is the water current (cm s^{-1}), and h is the depth (m).

8540, line 6 – Re-cast sentence into two separate sentences.

AR: Done

8540, line 26 – I don't quite follow what is meant by 'numerical domain'. I follow that some measure of continuous data or transect was converted to discrete subsets, but what exactly – I don't follow. Please clarify.

AR: We assume 'numerical domain' referring to the digital representation of reservoir bathymetry and was defined based on the bathymetric data available for this study. The depth samples (latitude, longitude and depth) collected during the field campaigns were interpolated to a regular grid with 100 X 100 m and then we used as the 'numerical domain' during the simulations with ELCOM model. It was clarified in the text by the insertion of "We assume 'numerical domain' referring to the digital representation of reservoir bathymetry and was defined based on the bathymetric data available for this study."

8541, Paragraph starting on line 7 – Within this paragraph, the authors describe 2 sub-models that were 'activated'. Re-cast this section to clarify the role of these sub-models.

AR: We clarified the role of the sub-models. The atmospheric stability sub-mode was active during the simulation due to the presence of persistent unstable atmospheric conditions over tropical reservoirs (Verburg and Antenucci, 2010); this procedure is appropriate in the cases in which the meteorological sensors are located within the internal boundary layer over the surface of the lake and data is collected at sub-daily intervals (Imberger and Patterson, 1990). In this manner, at each model time step the heat and momentum transfer coefficients were adjusted based on the stability of the ABL. The stability of ABL is evaluated through the stability parameter, derived from the Monin-Obukhov length scale. ELCOM uses the similarity functions presented in Imberger and Patterson (1990) for both cases, stable (negative values stability parameter) and unstable conditions (positive values). The Coriolis sub-model was also activated during the simulation and then Coriolis force was considered in the Navier-Stokes equation. This force causes the deflection of moving objects (in this case the water currents) when they are viewed in a rotating reference frame (e.g. the Earth).

8542, line 22 – re-cast to present the results in chronological order. January to July first, then July to September – it perhaps would be easier to follow.

AR: We rewrote the results in chronological order as suggested.

8546, line 4 – re-cast sentence, awkward, not concise. I would break this point into more than one sentence.

AR: We rewrote the sentence to clarify: 'Since nutrient availability in Funil Reservoir is high during the entire year (Table 2), phytoplankton growth is not limited by nutrients in the lacustrine zone. However, seasonal variation of factors that

controls stability and stratification, such as temperature, wind and mixing zone depth may inhibit algal growth near the dam especially between April and June.'

8546, line 9 – probably 'measured' or 'observed' would be more appropriate than 'we found net uptake. . ..'

AR: We changed the words as suggested.

8546, line 15 – mineralization – of what to what? Transformation? Please clarify. Also include a 'the' before carbon.

AR: We clarified that. 'In lacustrine zone, the higher depth and high temperature may promote the mineralization of dead phytoplankton to CO_2 or CH_4 in the water column before it reaches the sediment.'

8547, line 5 – insert a 'the' before transition zone and this not a full sentence – re-cast (I think the authors meant 'The position of the transition zone of the reservoir moves as a result of the season).

AR: The sentence was rewrote as suggested.

8647, line 26 – here Chlorophyll a is specifically mentioned. Throughout the manuscript, Chl was used, which I understand was a combination of several chlorophyll pigments. Please be consistent throughout.

AR: The value of Chl is a combination of chlorophyll pigments and we corrected this specific mention in the manuscript.

8548, line 7 – perhaps recast. The conditions are not right when the surface water is dominated by riverine water. It isn't until the conditions are more 'lake' – like that the conditions are optimal for phytoplankton to bloom.

AR: We rewrote the sentence. 'Favorable conditions for phytoplankton blooming will only exist down-reservoir in transition zone where the inflow mixes with the reservoir and loses velocity (Vidal et al., 2012).'

8548, line 10 – sentence beginning with . . .'The results. . .' Please re-cast sentence. Awkward and difficult to discern what the authors are attempting to convey. Also, the sentence following this particular sentence needs to be clarified. I am unsure what is meant by 'The daily scale variation. . ."?

AR: We rewrote the sentences. 'The simulation of the rainy season (Fig. 6) showed the low influence of the river inflow in the surface water suggested by the thermal stability at transition zone (Fig. 5a). The simulation of the dry season represented the overflow, especially at night (Fig. 6b). However, the simulation did not represent the intrusions of river water on different depths (every 2.5 m) suggested by temperature profile at transition zone (Fig. 5b). The variation of the river inflow over the day (Fig. 6) occur as response of the lagged change of temperature of the river and reservoir over the day. In the rainy season, this oscillation facilitate the injection of nutrient in the euphotic zone when the reservoir surface temperature decreases and the river temperature reaches its maximum in the end of the day (Table 3).'

8549, line 27+ – spatial heterogeneity discussion? Re-cast/clarify. There are quite a few areas within this entire paragraph that should be re-written. The writing is unclear and too colloquial.

AR: We rewrote the entire paragraph as suggested.

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