Dear Editor,

Thank you for your efforts and those of the reviewers in evaluating and handling our manuscript bg-2021-69, “Partitioning carbon sources in a tropical watershed (Nyong River, Cameroon) between wetlands and terrestrial ecosystems – Do CO_2 emissions from tropical rivers offset the terrestrial carbon sink?”.

We will revise the manuscript according to our responses to the reviewers’ comments, which responses are detailed below. Briefly, in the revised manuscript, we will add new figures showing relationships between river discharge and the different variables (see figures below in this document). Also, we will add a new figure describing the Mengong catchment (first order catchment) with characteristics soil profiles and longitudinal sections in the Mengong catchment, which helps better interpret the biogeochemical characteristics of waters drained from the land and wetlands. In addition, as suggested by the reviewer#1, our study design might not allow the estimation of the drainage of non-flooded forest groundwater and wetlands in streams order higher than 1 (we only can assume that a similar drainage occurs in all stream orders but it is too speculative). Therefore, we estimate the riverine carbon budget (drainage of non-flooded forest groundwater and wetland, carbon evasion and carbon export) in the Mengong catchment only. However, we will also keep the estimations of carbon evasion and carbon export at the catchment scale as described in the previous version of our manuscript but we will not estimate the partitioning of carbon coming from the drainage of non-flooded forest groundwater and wetland at the catchment scale. In addition, as suggested by two referees, we will estimate the two latter fluxes (carbon evasion and export) from monthly concentrations instead of yearly averages. This allows us to discuss the monthly variability of carbon evasion together with water surface area and gas exchange rates (see figures below in this document). Accordingly, we changed the title of our revised manuscript that now reads: " Partitioning carbon sources between wetland and non-flooded forest in a first-order catchment in the tropics - Implications for understanding carbon cycling in the whole watershed ".

Best regards / Moustapha Moussa, Loris Deirmendjian & Frédéric Guérin

With the exception of the "GENERAL ANSWER", all of our response text sections begin with "Answer" immediately following reviewer comments.

GENERAL ANSWER

Here, we respond more generally to questions about the hydrological functioning of the Mengong catchment (first-order catchment), the carbon mass balance calculation in the Mengong catchment, and the spatial and temporal variations of the different carbon forms as a function of river discharge at the whole catchment scale, which have been asked by the three reviewers.

Hydrological functioning of the Mengong catchment (first order stream)

- **Study site**

The landform of the Mengong catchment is composed of convexo-concave relief that ranges from 669 m at the river outlet to 703 m at the top of the hill, separated by flat wetland (Figure 1). The wetland covers 20% of the watershed (Figure 1). Semi-deciduous rainforest (*Sterculiaceae-Ulmaceae*) covers most of the rounded hills, and cultivated food crops, including tubers, manioc, peanuts, palm trees, and plantain, cover the remaining. In addition, farmers practiced cultivation without external chemicals. The vegetation cover on the hillsides limits the erosion. Most of the wetland vegetation comprise semi-aquatic plants of the Araceae family and tree populations of Gilbertiodendron deweverei *(Caesalpiniaceae*) and Raffia monbuttorum (raffia palm trees).

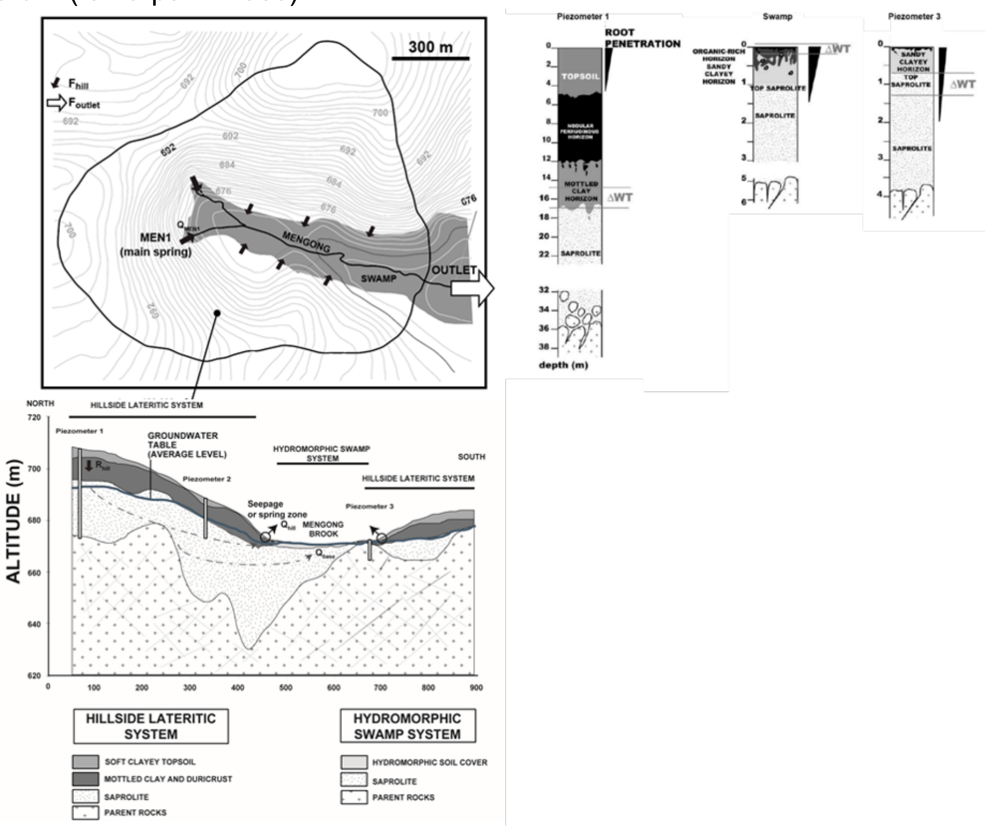


Figure 1 showing the hydrological functioning of the Mengong catchment (first order catchment) and the soil characteristics in piezometer 1, 3 and the wetland (water table level in piezometer 1 and 2 is presented in the figure 2). Adapted from Braun et al. (2005, 2012)

- **Soil cover on the hillside and the wetland**

The hillside soil cover is composed of a thick saprolite and complex polygenetic lateritic soil that consists of three main horizons, namely from the bottom to the top, the mottled clay horizon, the nodular ferruginous horizon, and the soft clayey topsoil (Braun et al. 2005; Figure 1). The thickness and distribution of these soil layers depend on the topographic position. The soil cover is 15 m thick at the top of the north hill (piezometer 1); the depth however, decreases progressively towards the flat wetland. The roots of the hillside vegetation are essentially concentrated in this topsoil horizon, which has a depth of 5 to 6 m at the top of the hill (at piezometer 1) and has a depth of 3 to 4 m (at piezometer 2) at the mid-slope (Braun et al. 2005; Figure 1).

In the wetland, a dark-brown organic-rich sandy material with a thickness ranging from 0.1 to 1 m tops the hydromorphic soil. In the poorly drained zone, the organic horizon is composed of a thick mat of dead and living roots and tubers of the wetland vegetation. In the well-drained wetland zones, towards the outlet, the sandy clayey material is covered by a much thinner organic accumulation (Braun et al. 2005). All year long, the wetland is flooded and fed by groundwater seepage coming from the hillside (Maréchal et al. 2013). We adopt, here, the common definition of wetlands as habitats with continuous, seasonal, or periodic standing water or saturated soils (Mitsch et al., 2012)

- **Hydrology of the Mengong catchment**

The groundwater floods the fractured bedrock, the entire saprolite, and partly the mottled clay horizon (Braun et al. 2005; Figure 1). In the piezometer 1 profile, the maximum water table fluctuation is about 3 m (Figure 2). A part of the groundwater draining the hillside emerges at springs (Q_{hill} in the figure below, it is where we sampled carbon parameters and that we called “forest groundwater” in the previous version of the manuscript, but based on reviewer#1 comment, we call now the groundwater that emerges at springs “non-flooded forest groundwater”) in the watershed head and at specific seepage points (Q_{base}) all around the hill-side/wetland boundaries and then is conveyed to the stream. Indeed, the groundwater that emerges at specific seepage points and springs is conveyed over the ground with negligible interaction with the wetland (Maréchal et al. 2013)

According to observations made in the Mengong catchment during most of the rainfall events by Maréchal et al. (2013), it is assumed that the overland flow can be neglected on the forested hillside (i.e., no surface runoff is occurring). The water budget of the hillside/bedrock aquifer system, as shown in the figure above, is therefore:

$R_{hill} = Q_{hill} + Q_{base}$ *(Eq. 1)*

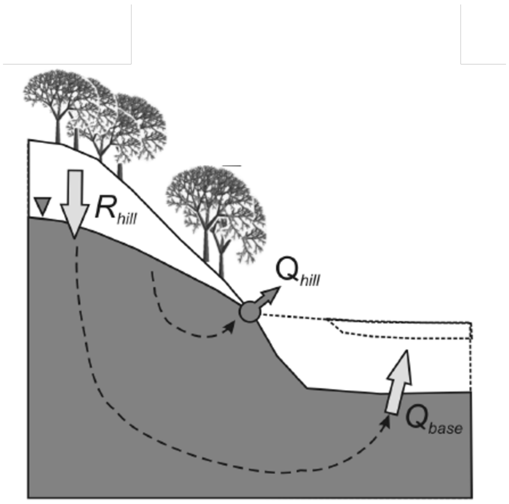
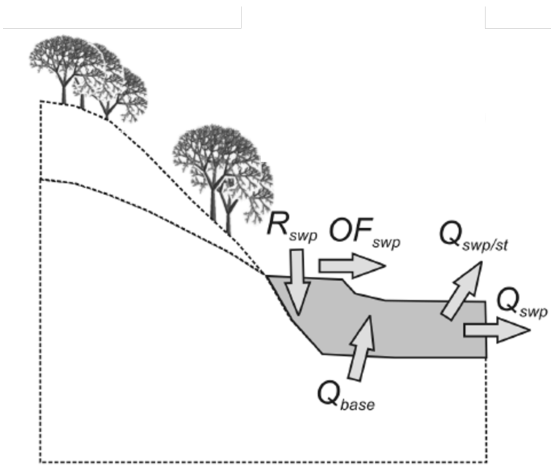


Figure showing the hydrological functioning of the hillside system, adapted from Maréchal et al. (2013)

In the wetland aquifer system as shown in the Figure below, inflows are the recharge rate on the wetland ground surface (R_{swp}) and the baseflow from the bedrock aquifer (Q_{base}), while outflows are groundwater flow below the weir at the outlet (Q_{swp}) and exchanged with the stream ($Q_{swp/st}$). The groundwater budget of the wetland is therefore:

$Q_{base} + R_{swp} = Q_{swp} + Q_{swp/st}$ *(Eq. 2)*

Figure showing the hydrological functioning of the wetland system, adapted from Maréchal et al. (2013)



The total streamflow at the outlet of the Mengong catchment as shown in the Figure below is the sum of the contributions of the bedrock aquifer, the exchange flow between the wetland and the stream and the overland flow on the wetland surface as the following:

$Q_{st} = Q_{hill} + Q_{swp/st} + OF_{swp}$ *(Eq. 3)*

where OF_{swp} is the overland flow on the surface of the wetland

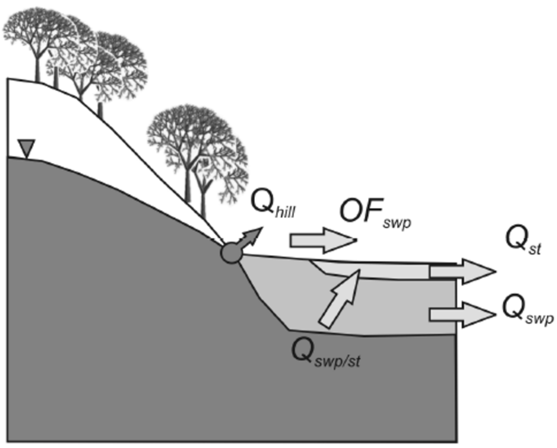


Figure showing the hydrological functioning of the Mengong catchment system, adapted from Maréchal et al. (2013)

- **Carbon inputs to the first order stream of the Mengong catchment**

At the Mengong catchment scale; as described above there are two sources fueling the stream with carbon: non-flooded forest groundwater and the wetland.

According to equations 1, 2 and 3, at the scale of the Mengong catchment, we can estimate the quantity of dissolved carbon leached to the stream from non-flooded forest groundwater (F_{GW}) as the following:

$F_{GW} = R_{hill} * [C]$ *(Eq. 4)*

Where [C] is the concentration of DOC or DIC in the non-flooded forest groundwater.

We can estimate the quantity of dissolved carbon leached to the stream from the wetland (F_{SW}) as the following:

$F_{SW} = (OF_{swp +} Q_{swp/st}) * [C]$ *(Eq. 5)*

Where [C] is the concentration of DOC or DIC in the top soil solution of the wetland.

In addition, as mentioned in the previous version of our manuscript and above in this document: in the Mengong catchment the surface runoff is negligible and there is no particulate C in non-flooded forest groundwater. Therefore, the POC at the Mengong outlet should originates mostly from the erosion of the wetland and can be estimated as the following:

$F_{SW} = Q_{st} [POC]_{outlet}$ *(Eq. 6)*

Where [POC] is the concentration of POC at the outlet of the Mengong catchment.

- **Carbon outputs from the stream of the Mengong catchment**

At the Mengong catchment scale, there are two outputs of riverine carbon: carbon evasion from the stream to the atmosphere and carbon exported by the stream at the outlet of the catchment:

Based on equation 3, the quantity of carbon exported at the outlet of the catchment can be estimated as the following:

$F_{outlet} = Q_{st} [C]_{outlet}$ *(Eq. 7)*

Where [C] is the concentration of POC, DOC or DIC at the outlet of the Mengong catchment

It has been shown that a large fraction of carbon evasion in headwaters was actually missed by conventional stream sampling because a large fraction of the degassing occurs as hotspots in the vicinity of groundwater resurgences (e.g., Deirmendjian et al., 2018; Johnson et al., 2008). Therefore, we estimated carbon evasion with a hydrological method that calculates the loss of the dissolved CO_2 between non-flooded forest groundwater (or wetland water) and surface water, using CO_2 concentrations and drainage data as the following:

F_{degass} from gw = $([CO_2]_{GW} - [CO_2]_{outlet}) * R_{Hill}$ *(Eq. 8)*

F_{degass} from sw = $([CO_2]_{sw} - [CO_2]_{outlet}) * (OF_{swp} + Q_{swp/st})$ *(Eq. 9)*

F_{degass} = F_{degass} from gw + F_{degass} from sw *(Eq. 10)*

Where F_{degass} is the estimation of carbon evasion at the scale of the Mengong catchment, which is the sum of the stream carbon degassing fed both by the non-flooded groundwater and the wetland

- **C budget at the Mengong catchment scale**

Now, we can estimate the riverine DIC and DOC budgets:

imbalance of the DIC budget in t C yr^{-1} = inputs – outputs

imbalance of the DIC budget in t C yr^{-1} = $F_{sw} + F_{gw}$ + respiration - F_{degass} - F_{outlet}

imbalance of the DIC budget in t C yr^{-1} = 1.7 + 6.7 + 0.4 – 6.3 -1.2 = 1.3

DIC inputs and outputs fluxes are not statistically different although they are different by 17%. In the revised manuscript, we will discuss about the imbalance (17%) of the DIC budget at the Mengong catchment scale which can be attributed to a potential overestimation of heterotrophic respiration as it was measured in the dark (preventing potential primary production) and a potential underestimation of CO2 outgassing downstream of the spring due to our sampling strategy.

imbalance of the DOC budget in t C yr^{-1} = inputs – outputs

imbalance of the DOC budget in t C yr^{-1} = F_{sw} + F_{gw} - respiration – F_{outlet}

imbalance of the DOC budget in t C yr^{-1} = 1.7 + 0.2 – 0.4 – 6.4 = -4.7

Thus, the imbalance of the DOC budget is -4.7 t C yr^{-1} (-257%), which shows that a major DOC input flux was not measured. Indeed, Braun et al. (2005) measured during 4 years of field sampling an average DOC concentration in the throughfall of the Mengong catchment in the range 3.6±3.5 mg/L. Applying this number to the average precipitation in 2016 and the catchment surface area, it gives us an input DOC flux from precipitation in the range 4.3±4.1 t C yr-1, which very likely allows closing the DOC budget at the Mengong catchment scale.

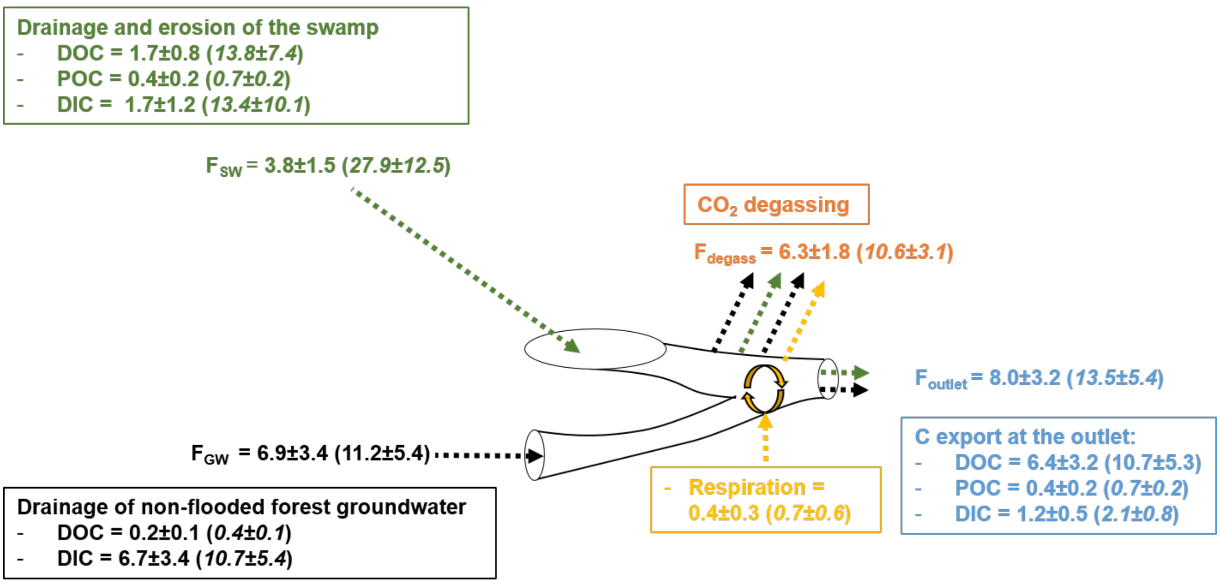


Figure showing the C budget at the Mengong catchment scale in t C yr^{-1}. Number between brackets are in t C km^{-2} yr^{-1}. For the drainage of the wetland, the flux between bracket is weighed by the wetland area (0.12 km²), for the drainage of non-flooded forest groundwater it is weighed by the surface area drained by the hillside (0.48 km²) and for the other fluxes it is related to the catchment surface area (0.6 km²)

In addition, Nkounde et al (2008) estimated the NPP and litterfall (including mature and wetland forests) at the scale of the Mengong catchment at 1 495 and 645 t C yr^{-1}, respectively.

However, POC exported at the outlet of the Mengong catchment is 0.4 t C yr^{-1}, which is ~1 500 times lower than the litterfall. This suggests that most of the litterfall reaches the soil where the litter is degraded and, so contributes to soil respiration and export of IC to groundwater but due to limited surface runoff only a small organic fraction of the litterfall is exported to the stream.

From our revised estimations of the carbon mass balance of the Mengong catchment we show that the drainage of the non-flooded forest groundwater plus the drainage of the wetland represent 0.7% of the NPP of the catchment. About 60% of this carbon exported to the stream is quickly degassed in the vicinity of the water resurgences. If we consider DOC input from the throughfall, the carbon evasion represents 42% of the total C inputs to the stream. The river heterotrophy represents 6.5% of the degassing. Quantitatively, non-flooded forest groundwater exports 1.8 times more carbon than the wetland, however, in terms of quantity weighed by the surface area drained by each system, the wetland exports 2.5 times more carbon than the non-flooded forest groundwater.

- **Carbon variations in groundwater**

In the revised manuscript, we will add a new figure (see figure 2 below) showing hydrological and carbon parameters in the groundwater and first order stream of the Mengong catchment system (first order catchment). This revised figure 2 shows the temporal variations of rainfall in the Mengong catchment, water-table level and soil surface in piezometer 1 and 2 (see the figure 1) in the Mengong catchment, river discharge at the outlet of the Mengong catchment, and pCO2, TA and ancillary parameters (O2, pH, conductivity) in non-flooded forest groundwater (measured at the spring, see the figure 1 and the description of the figure 1) and stream of the Mengong catchment. In addition, TSM, POC content of the TSM, POC and DOC are shown for stream water at the river outlet. In the revised version of our manuscript, we now separated (but not binned) the hydrograph into the 4 seasons that occurs in Cameroon (LDS as long dry season, SRS as short rainy season SDS as short dry season, LRS as long rainy season), which we believe is more representative of the hydrological functioning of the Nyong catchment.

Groundwater pCO2 started to increase at the end of the SRS, concomitantly with the rise of the water table level (Figure 2). It is likely due because the water table has risen closer to the root's penetration zone (Figure 1) where soil respiration is more intense, as observed in other catchments (e.g., Amundson 1998 and references therein). The percolation of rainwater through the soil pores that facilitate the transport and the dissolution of soil CO_2 to the underlying groundwater, a process discussed in the previous version of our manuscript, appears now not significant because we did not observe any increase of groundwater pCO_2 when the rainfall was strong at the beginning of the SRS.

In Amazonia, Johnson et al. (2008) showed at the onset of the dry season the pCO_2 increased in the deep soil due to increases soil water uptake and roots activity. Subsequently, pCO_2 in the deep soil decreased later in the dry season because of drainage and diffusional losses. They showed that pCO_2 in groundwater followed this trend, with increase in concentrations at the onset of the dry season and decreasing after the peak of the dry season. In groundwater of the Mengong catchment, we observed a similar trend as groundwater pCO_2 was higher during the SDS and then was diluted as water table increase during the following LRS. Also, groundwater pCO_2 peaked during the LDS but less significantly than during the SDS, likely because the water table during the LDS is deeper than roots penetration zone (Figure 1). Johnson et al. (2008) showed indeed that groundwater springs in Amazonia closely reflect the CO_2 concentration in the deep soil.

At the beginning of the SRS, when the water table level is the deepest, groundwater O2 is maximal, showing that atmospheric air invaded the groundwater during this period, which is consistent with d13C-DIC values close to the atmospheric equilibrium of -10‰ measured during this period by Nkounde et al. (2020).

Groundwater TA is low and almost stable during the year but peaked during the LRS a couple of days before the peak of the water table and decrease when the water table dropped. This might be due to the fact that the groundwater has risen close to the mottled clay horizon which is more weatherable than the saprolite horizon (Braun et al., 2005). In addition, the weathering is controlled by soil humidity, which is higher during the LRS (Braun et al., 2005, 2012).

Groundwater is free of DOC (below the detection limit) all year long, as mentioned in our manuscript. In a temperate catchment with podzols in which DOC is well complexed and stabilized with iron oxides in the topsoil, Deirmendjian et al (2018) showed that the water saturation of the top soil was necessary to allow the leaching of DOC in the groundwater and therefore to generate high concentrations of DOC in the groundwater. As shown by Braun et al. (2005) in the Mengong catchment, DOC in the upper soil is also well complexed and stabilized with the iron-rich mottled clay horizon and the water table never reaches the surface horizons of the soil where DOC is high (Braun et al. 2005), very likely explaining the fact that the non-flooded groundwater in the Mengong catchment is free of DOC.

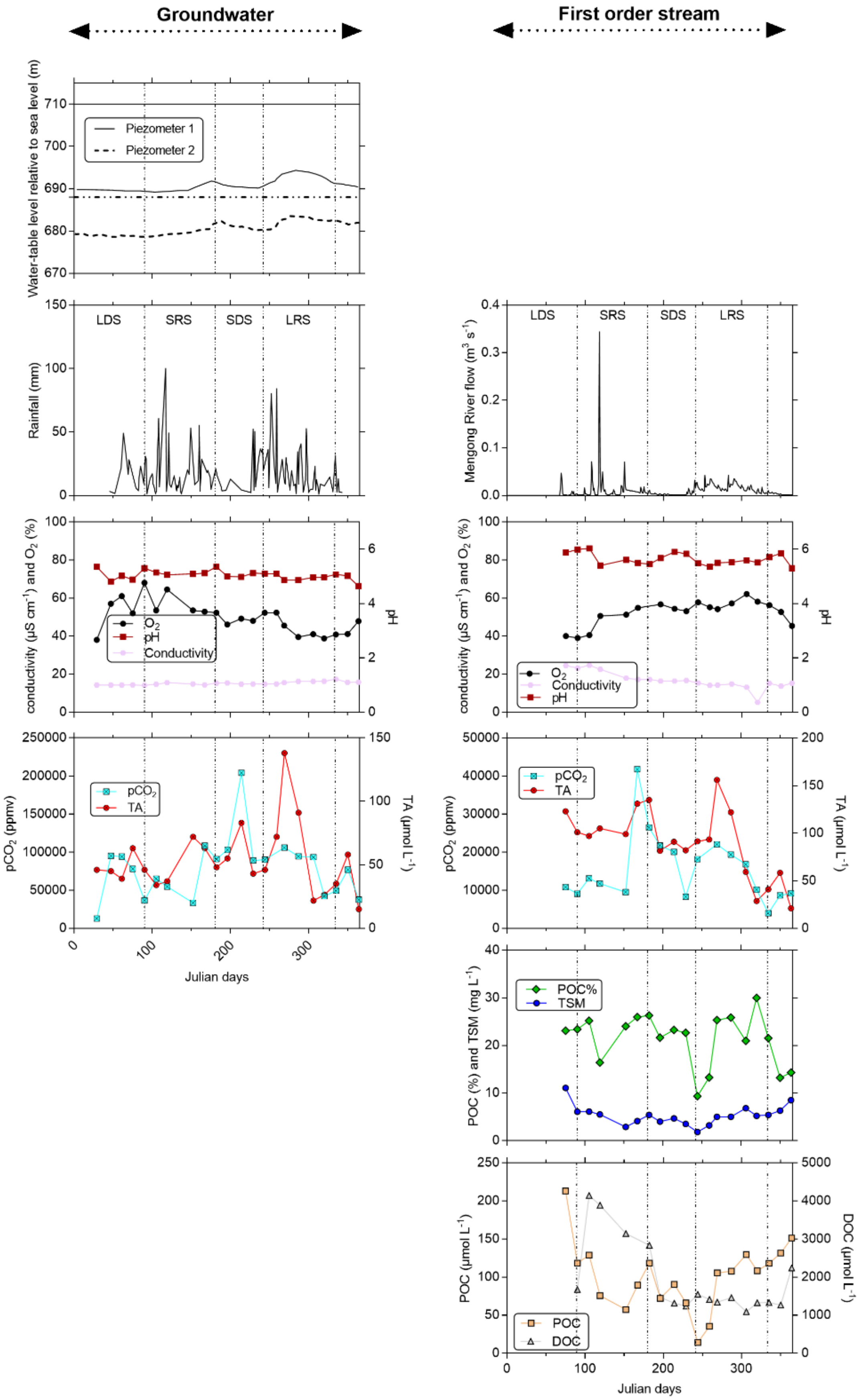

Groundwater
First order stream
Water-table level relative to sea level (m)
Piezometer 1
Piezometer 2
LDS
SRS
SDS
LRS
Rainfall (mm)
Mengong River flow (m3 s-1)
conductivity (µS cm-1) and O2 (%)
O2
pH
Conductivity
pCO2 (ppmv)
TA (µmol L-1)
pCO2
TA
Julian days
POC (%) and TSM (mg L-1)
POC%
TSM
POC (µmol L-1)
DOC (µmol L-1)
POC
DOC

Figure 2

- **Carbon variations in surface waters**

Overall, in first order stream, there are weak relationships between carbon concentrations and river discharge (Figure 2), suggesting that the hydrological and biogeochemical responses as a function of the rainfall events in this first order basin is faster than our sampling frequency. Indeed, some authors have shown that rainfall events in the Mengong catchment induced a rapid hydrological response at the river outlet (Maréchal et al., 2013; Nkoundou, 2008). Nevertheless, in the first order stream, DOC quickly increased at the beginning of the SRS when the river flow started to increase (Figures 2). In other stream orders, similar DOC increase occurs at the beginning of the SRS but with a slight delay of about a couple of weeks in comparison to the first order stream (Figures 2, 3). After this peak, DOC decreased to reach minimum values during the SDS, and then DOC concentration is stable until the first rains come again in the SRS. Nkounde et al. (2008) described the translatory flow (piston effect) that occurs at the beginning of the SRS in the Mengong catchment. This mechanism assumes that water received by the hillside induce a pressure wave downstream, causing immediate exfiltration at the bottom of the slope (i.e., in the wetland). This means that wetland DOC is quickly flushed during the first rains and DOC comes from the subsurface horizons of the wetland. The lag time between the peaks of DOC in first and sixth order streams might be due to the time the water needs to flow from upstream to downstream. Subsequently, the DOC decrease is due to dilution with non-flooded forest groundwater with a low DOC content.

POC increased in two steps. A first increase occurred at the end of the SRS whereas a second increase occurred during the LRS (Figures 2-3). During wet seasons (after the translatory flow has occurred) the water table in the wetland rises which causes the leaching of the wetland surface where particulate organic matter has accumulated (Nkoundou et al., 2020). During the dry seasons, POC decreases because wetlands shrink and the connectivity between wetland and surface waters water also decreases (Nkoundou et al., 2020). In addition, a slight POC increase occurs during the LDS (in particular in lower stream orders) (Figures 2, 3). In the surface waters of the Nyong, POC and TSM were negatively correlated ($r = -0.4$, $p<0.001$). During the LDS, the wetlands shrink and thus streams are mainly fed by non-flooded forest groundwater. As a result, POC from wetland might not contribute significantly to the total POC discharge by rivers due to very limited drainage in the wetland during LDS. Therefore, most of the organic load of rivers is of autochthonous origin, due to phytoplankton (e.g., Meybeck 1993), which was suggested by Nkoundou (2008) who measured d13-POC close to the phytoplankton value during the LDS in the Mengong catchment. However, we also believe that the contribution of C4 plants in the wetland/watershed could have also increased the d13C-POC. At the onset of the LRS (August-September), abundant silt and clay fractions of terrigenous origin from erosion of wetlands and river banks become dominant. Concomitantly, primary aquatic production is inhibited by high turbidity, which minimizes the OM content of autochthonous origin (Meybeck, 1982) in favor to allochthonous organic carbon. The low concentrations of POC observed during high water are due to the dilution of the POC by the increasing flows of groundwater in the drains.

The pCO2 in first order stream increased at the end of the SRS and at the beginning of the LRS (Figures 2, 3). As we observed no concomitant increase in groundwater pCO2 at the end of the SRS or at the beginning of the LRS, this suggests that this increase is rather due to the drainage of the wetland than the drainage of non-flooded forest groundwater. Even if we cannot exclude the outflow of CO2 originating from non-flooded forest groundwater, it probably quickly degasses in the vicinity of the springs, and therefore CO2 in stream is more influenced by the wetland which is closer to the stream than the groundwater springs. During dry seasons, pCO2 in surface waters decreases as the connectivity with the wetlands and the stream decreases too. In addition, decreasing river flow and turbidity during dry seasons allows aquatic primary production.

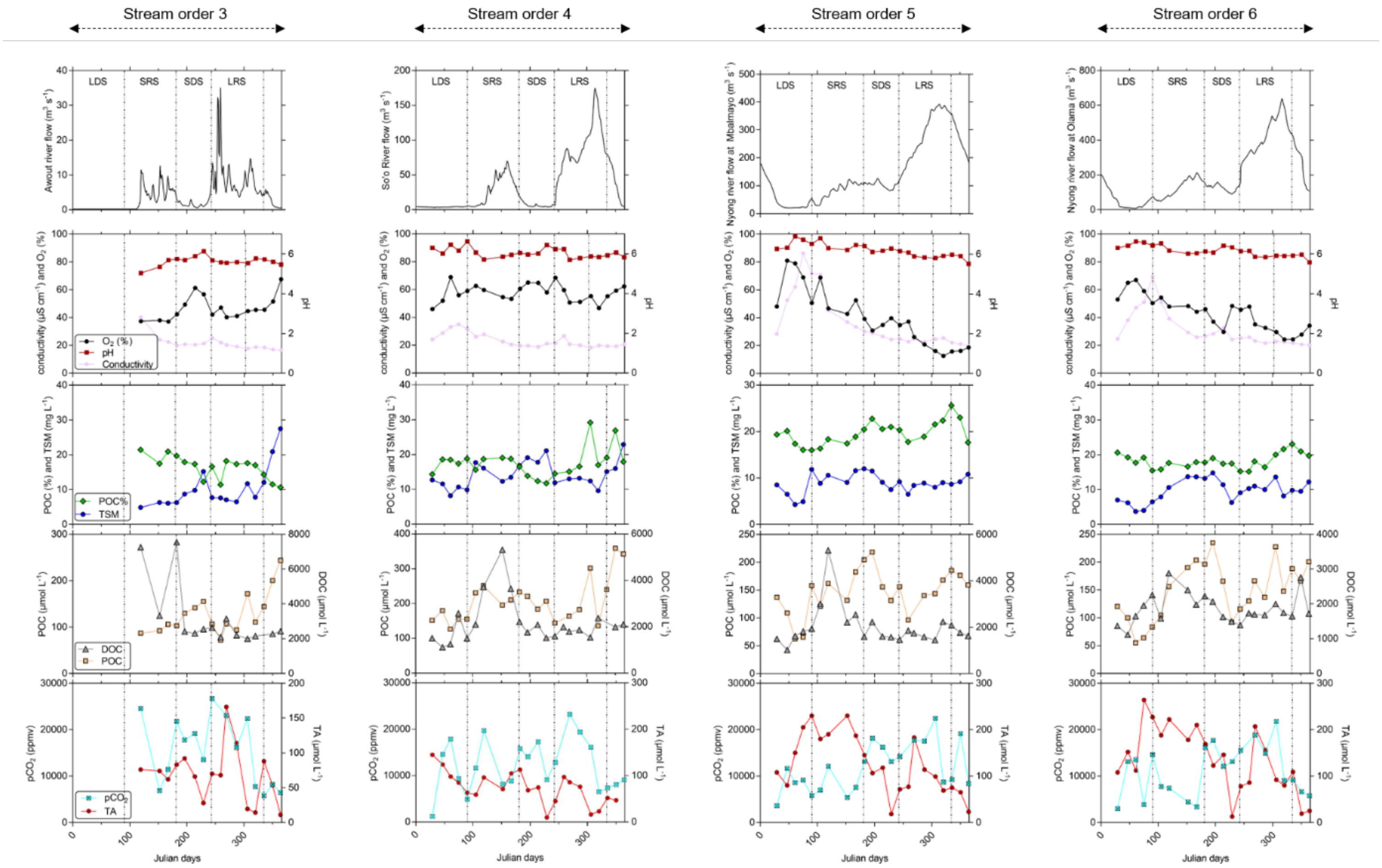


Figure 3: temporal variations of river discharge and carbon parameters in surface waters of the Nyong watershed

END OF THE GENERAL RESPONSE:

Reviewer (R#1) comments and author responses to manuscript bg-2021-69. Reviewer comments are given in normal style and with author responses in blue italic.

Comment: The manuscript "Partitioning carbon sources in a tropical watershed (Nyong River, Cameroon) between wetlands and terrestrial ecosystems – Do CO_2 emissions from tropical rivers offset the terrestrial carbon sink?" by Moussa Moustapha et al. address an important question of the sources of organic materials fueling the high CO2 emissions from tropical rivers and streams, which is within the scope of BG. The manuscript contributes especially with relevant information increasing the understanding of the hydrologic influence on the C dynamics in African aquatic environments. The discussions that drive the conclusions still need more support from the literature. The overall methodology is robust but needs some clarifications.

Answer: We thank the reviewer#1 for her/his overall positive evaluation of our manuscript.

Comment: The results would benefit from some extra description especially regarding the relationships between discharge and the main variables considering the entire period instead of the binned evaluation for only 3 seasons that do not show relationship. These extra results would strengthen the conclusions.

Answer: The reviewer#1 raised some very constructive and important points regarding the relationships between river discharge and carbon parameters that indeed needed clarifications and further data exploration. Due to the strong hydrological temporality in tropical watersheds we acknowledge that the fact that we previously binned discharge into three periods only was too coarse to establish relationships and to well describe the temporality of carbon concentrations with discharge.

The relationships between river discharge and carbon parameters are described in the "general answer".

Comment: Several key results are not shown ("data not shown").

Answer: We will show those results in a supplementary material.

Comment: The title is not very clear and the question in the title is not really answered.

Answer: The referee#1 is right. We modified the title of our manuscript as follows: "Partitioning carbon sources between wetland and non-flooded forest in a first-order catchment in the tropics - Implications for understanding carbon cycling in the whole watershed wetland". We feel now that the title is more adapted to the content of our revised manuscript.

Comment: The abstract could have a short justification highlighting the importance of such study and the sentences describing the results need to be rewritten to improve the flow.:

Answer: The abstract will be significantly modified in the revised version and will be based on the following text that still need to be shortened: "Tropical rivers emit large amounts of carbon (C) to the atmosphere but African rivers in the tropics are understudied in comparison to south American and Asian rivers. In addition, it is now well recognized that two different sources are fueling tropical rivers with carbon, namely, the land (soil and non-flooded forest groundwater) and wetlands. However, the partitioning of these two carbon sources is poorly known, especially in African rivers. We test the hypothesis that temporal patterns of carbon concentrations in surface waters of the Nyong watershed (Cameroon, 27800 km^2) are due to the connectivity with wetlands, therefore increasing carbon concentrations during wet periods when the hydrological connectivity between surface waters and wetlands is higher. In addition, based on hydrological and carbon data gathered in a first order catchment that drains a mature forest in the hillside and a wetland at the bottom of the catchment, we estimated the carbon supply by the land (i.e., non-flooded forest groundwater that drains the hillside) and by wetland in a first order catchment (0.6 km^2). In 2016, we measured fortnightly at 6 locations, in non-flooded forest groundwater and in streams from order 1 to 6, total alkalinity, dissolved inorganic C (DIC) used together with pH to compute pCO2, dissolved and particulate organic C (DOC and POC) and total suspended matter and with occasional measurements of river respiration. In the first order stream, DOC, POC and DIC increased significantly at the beginning of the wet periods because the drainages of the wetland increased whereas the same parameters decreased during the dry periods when the wetland shrinks. In higher stream orders, the same increase in DOC, POC and DIC occurs during wet periods but with a slight delay in comparison to the first order stream. This lag time is due to the time the water needs to flow from upstream to downstream showing that wetland in low-order streams are significant sources of C for downstream. In the first order catchment, we showed that the hydrological export of C from non-flooded forest groundwater (6.9±3.4 t C yr-1) and the wetland (3.8±1.5 t C yr-1) represent 0.7% of the NPP (1 495 t C yr-1) of the catchment. About 60% (6.3±1.8 t C yr-1) of this carbon exported to the stream was quickly degassed in the vicinity of the water resurgences whereas the river respiration represents 6.5% (0.4±0.4 t C yr-1) of the degassing. In terms of quantity, the non-flooded forest groundwater exports 1.8 times more carbon than the wetland, however, in terms of quantity weighed by the surface area drained by each system, the wetland (27.9±12.5 t C km-2 yr-1) exports 2.5 times more carbon than the non-flooded forest groundwater (11.2±5.4 t C km-2 yr-1). At the scale of the Nyong watershed, the terrestrial primary productivity (NPP) was 4.3 107 t C yr-1 while we estimated a degassing of 7.2 105 t C yr-1, a river heterotrophy of 5.9 104 t C yr-1 and a total riverine export of 2.0 105 t C yr-1.

Therefore, C degassing plus C export represents 2% of the NPP whereas the river respiration represents about 8% of the C degassing. The study shows the importance of lateral inputs from wetlands that represents about 35% of the total C exported to first order streams and thus ignoring the river–wetland connectivity can lead to the misrepresentation of C dynamics in tropical watersheds."

Comment: Data could be further explored, especially regarding the temporal variability, and extra figures could be added as supplementary information. In conclusion, the manuscript presents a valuable database that will contribute to the understanding of the carbon cycle and CO_2 emissions from streams in the understudied Africa region. However, several points need to be considered before the manuscript is suitable for publication.

Answer: The results section will be deeply rewritten according to the "general answer" that deals with the spatial and temporal variability in riverine carbon in non-flooded forest groundwater and surface waters.

Besides we will change the organization of our revised manuscript as the following in order to integrate all constructive general comments by the three reviewers:

3 Results

3.1 Carbon concentrations in groundwater

3.2 Carbon concentrations in surface waters

3.3 Carbon budget at the Mengong catchment scale

3.4 Carbon evasion and export to the ocean at the Nyong watershed scale

4 Discussion

4.1 Carbon sources in the Mengong catchment

4.2 Influence of wetland-river connectivity on carbon concentrations ad fluxes

4.3 Regional significance of carbon fluxes of the Nyong watershed

Comment: The as many parts of the text that is hard to follow and not so precise. Careful English revision is needed.

Answer: We agree with the referee#1, none of the authors are native English speakers and, therefore, some sentences can be poorly written. In the revised version of our manuscript we will make and extra effort to carefully check English language, and if it is not enough we will go through English Editing services.

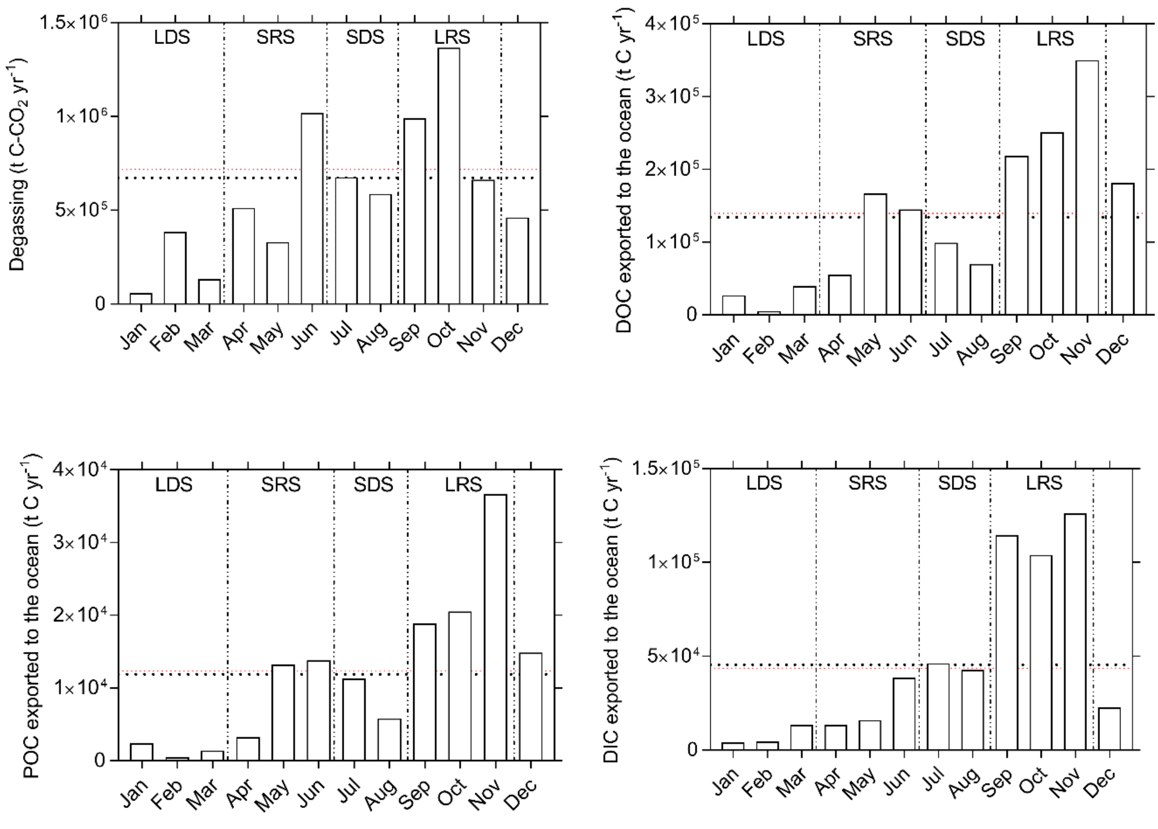
Comment: The temporal evaluating would benefit from monthly estimates of C degassing, lateral input, metabolism, and export to the ocean. The annual budget should then be calculated considering the temporal variability instead of the annual average. It would be interesting to compare the final result of both estimates

Answer: It is a very good point raised by the referee#1 but, actually, we have chosen to rely on annual average concentrations of riverine carbon (instead of monthly concentrations) to establish our riverine carbon budget because for three fluxes (respiration and hydrological export of carbon from the wetland and non-flooded forest groundwater) it was not possible to estimate them on a monthly basis. Indeed, respiration was only measured occasionally, as mentioned in the manuscript. In addition, the hydrological model by Maréchal et al., (2013) that allows us to estimate the drainage of the non-flooded forest groundwater and the wetland gives us only yearly drainages.

To explore further the point raised by the referee#1, we estimated in each stream order, carbon degassing from monthly concentrations of CO_2, rivers width and velocity and gas transfer velocity. We found that carbon degassing estimated from monthly concentration was 21.6±13.1 t C/km2/yr whereas carbon degassing estimated from annual averages of CO2, rivers width and velocity and gas transfer velocity, was 25.8±10.2 t C-CO2/km2/yr. Therefore, there is an overestimation by 18% when we estimate carbon degassing from annual averages, but the two estimates are not significantly different. This difference might be due to the combination of monthly fluxes together with the monthly water surface variations which cannot be adequately account for with annual means of both parameters. This will be discussed in the revised manuscript.

We also estimated export of C to the ocean at the most downstream station from monthly concentration or annual averages. For DOC we found 4.8±3.6 (monthly) vs 5.0±0.4 (annual average). For POC we found 0.4±0.4 (monthly) vs 0.4±0.4 (annual average). For DIC, 1.6±1.5 (monthly) vs 1.8±0.4 (annual average) t C-CO2/km2/yr. Therefore, both estimations were very consistent.

In the revised manuscript, we will put the following figure that estimates monthly fluxes of C export to the ocean and C degassing. The horizontal dashed lines represent the annual flux from monthly estimates (in red) and from yearly averages (in black)



To sum up, for the riverine C budget in the Mengong catchment we will keep estimations from yearly averages since our hydrological model does not allow a better temporal resolution. However, for fluxes at the entire Nyong watershed we will show both annual and monthly calculations and we will discuss the comparison. In addition, we will add some of the points raised by the referee#1 in the M&M section to inform the reader why we chose to rely on annual averages for the Mengong catchment.

Comment: Since the seasonal variability is regulated by hydrology, it would be good if the authors could explore correlations between discharge and the different C compartments observed in the rivers.

Answer: With our study design it was not possible to estimate the partitioning of the different carbon compartments (wetland vs non-flooded forest groundwater) observed in the rivers with order higher than 1 because we do not have groundwater discharge in higher river orders (water and carbon isotopes would be needed). However, in the revised manuscript, we will describe better the relationships between carbon parameters and river discharge for surface waters and between carbon parameters and water table level in the groundwater, as described in the general answer.

Comment: Section 2.4.2 is hard to follow, see specific comments below. Please reformulate it. The authors could also make a schematic figure to help explain the lateral input of carbon from these two sources. Please, also include information about the direct input of POC from the forest to the streams.

Answer: Please see the revised description of the hydrological functioning of the Mengong catchment and the figures in the general answer.

Nkounde (2008) measured litterfall (including mature and wetland forests) at the scale of the Mengong catchment. Their estimation was 9.6 t C/ha/km2 or 645 t C/yr for the Mengong catchment. This flux is approximately 1500 times higher than POC exported by first order stream at the outlet of the Mengong. This implies that litterfall is accumulating in hillside and wetland soils rather than hydrologically exported in the form of POC. However, after degradation, it might contribute to the DOC and DIC flux. In addition, we found the same areal weighed quantity of POC exported from first order streams and the whole watershed (in stream order 6, Nyong at Olama), suggesting that POC sources are similar whatever the stream order. Therefore, as we show for order 1 catchment that direct litterfall from non-flooded forest to the stream is negligible and thus POC mainly originates from wetland erosion, we hypothesis that the same occur in higher order catchment.

Comment: It is unclear if the site Mengong outlet is a wetland or if it is a 1 order stream draining a wetland. Also, how representative is this environment as a 1st order stream in the entire Nyong River basin?

Answer: As mentioned in the general answer, the Mengong outlet is a first order stream draining a wetland located in the bottom of the catchment (i.e., in the depression) and a non-flooded forest groundwater from the hill and hillside. Several studies have highlighted that this catchment is representative of the other first order streams in the Nyong watershed (e.g., Audry et al. 2020; Braun et al 2005; Boeglin 2002; Nkoundou 2008). Indeed, most of the Nyong catchment is covered by a dense permanent forest whereas semi-aquatic plants such as raffia or palm trees predominates in the depressions, similarly as in the Mengong catchment. In addition, soils cover, rainfall and catchment slope are rather uniform in the Nyong catchment (Audry et al. 2020).

Please see the general response for the description of the wetland in the catchment. In addition, as described by Olivry (1986), there are no floodplains (in contrast to the Amazonian basin) or permanent flooded forest (in contrast to the Congolese basin) in the Nyong watershed, as wetlands in the Nyong watershed are mostly located in the depressions of low-order basins or riparian wetland in high-order streams.

In the Mengong catchment, two resurgences in the hills fuel the Mengong stream. Only one of these sources is perennial, the other dries up during dry periods. We considered as the source of the Mengong a single source whose flow is the sum of the flows of the different resurgences (Eq. 1). Surface runoff is almost zero, whatever the time of year (Eq. 1). This is explained by the vegetation cover and the horizons of porous clay and humus material. During wet seasons, the flow is linked to rainfall through the resurgences and favored by waterlogging of the wetland. The piston effect and aquifer intumescence (rising water table) are the two mechanisms that explain the main contribution of the waters of the wetland (Ndam Ngoupayou, 1997). The piston effect is induced by the water which infiltrates the soils on the slopes of the hills and allows the wetland area at the bottom of the valley to be flushed.

Comments: It seems that the authors assume that the input of C via forest groundwater observed in the spring is the same for all streams regardless of order. Wouldn't the input of groundwater increase with stream order, since the catchment area is much larger. Consequently, wouldn't the potential input of pCO2 from groundwater directly to the streams increase with stream order?

Answer: it is a good point raised by the referee that indeed need clarifications. The referee 1 is right, we assumed similar inputs of C via non-flooded forest groundwater for all streams regardless of the order. However, the inputs of non-flooded forest groundwater in higher stream orders must decreased because the drainage (river flow divided by the catchment surface area, in general in L/s/km²) decrease. For example, mean annual drainage is 14 L/s/km² at the Mengong outlet catchment but 10 L/s/km² in the Nyong at Olama. However, after looking for additional data to answer this reviewer comment, we feel that our method was too coarse to estimate hydrological carbon export (from the wetland and the non-flooded forest groundwater) at the Nyong watershed scale. Therefore, in the revised version of our manuscript, we will estimate the riverine carbon budget in the Mengong catchment only. This allows to close the riverine carbon budget in a first order basin and to partition the different sources fueling the stream with carbon on an annual basis (see the general answer). This result will be clear of any assumption regarding hydrology as all the hydrological parameters needed for the estimation of the riverine C budget are based on the model of Marechal et al. (2013) designed for the Mengong watershed only.

We can still estimate the carbon degassing and the carbon export to the ocean at the scale of the entire watershed (as previously done) but we will not compare it with hydrological carbon export from wetlands and non-flooded forest groundwater.

Comment: Plotting and testing the relationship between the main variables and discharge using sampling events instead of binned into only 3 seasons would strengthen many points of your discussion

Answer: We fully agree with this comment. We have described better the relationships between river discharge and carbon parameters in the general response

Comment: The authors could include more information to cover what is the proportion of carbon derived from wetlands in high-order streams? An estimate of the input of POC from the forest canopy would also be interesting.

Answer: Actually, we cannot estimate the proportion of carbon derived from wetlands in high-order streams and tracers would be necessary to properly answer that question. As mentioned above in the general answer we now estimate carbon derived from wetlandwetland only for the Mengong catchment. An estimate of the input of POC from the forest canopy is now included in the carbon budget of the Mengong (see genral answer).

Comment: The discussion in many cases is speculative and lacks support from the literature. I acknowledge the lack of data for African rivers, but you make comparisons with a few temperate systems without mentioning the many studies carried out in the Amazon basin containing useful information that should be included in your discussion. Check for example Johnson et al 2008, Rasera et al 2008, Amaral et al 2019, Salimon et al 2013, Neu et al 2011, Scofield et al 2016, Ellis et al 2012, among others. The discussion would also benefit from information about other potential fates of C.

Answer: We fully agree with this comment. These references will be read with care and discussed in the revised manuscript. We will add also Duvert et al. 2019; 2020a-b

Borges et al 2015 discuss the different wetland-river connectivity between rivers in the Congo and Amazon basin. The connectivity in the studied catchment is similar to which one? How would you describe how the patterns you found in this study for both conditions and larger rivers?

Answer: Please see the general response for the description of the wetland in the catchment. In addition, as described by Olivry (1986), there are no floodplains (in contrast to the Amazonian basin) or permanent flooded forest (in contrast to the Congolese basin) in the Nyong watershed, as wetlands in the Nyong watershed are mostly located in the depressions of low-order basins or riparian wetland in high-order streams.

Comment: The main conclusion of the larger contribution of wetlands is speculative because groundwater input of C directly to high-order streams was not measured. So, the limitations for this conclusion need to be mentioned. The terrestrial sink is barely mentioned in the discussion, and you don't really answer the question in the title.

Answer: We fully agree with this comment that is why we now estimate our carbon mass balance only in the Mengong catchment and so the impact of wetlands on the riverine carbon budget will be discussed only at the scale of a first order catchment and not at the scale of the whole watershed. Please see the general answer.

Specific comments:

Abstract

L20-21. Explain the gradient groundwater to the main stream to mention that groundwater was measured in the forest (non-flooded?) and wetlands.

L23. Please report the pCO2 value. The abstract is hard to read. Maybe start with a short contextualization and focus on the overall results instead of describing every single result.

L30-31. Please mention the heterotrophic respiration and CO2 emissions from the river above when you describe what you measured.

L34-36. Please clarify what you mean by "unique terrestrial source", and specify what you mean with the "whole amount of carbon". I read this sentence many times and I'm still not sure I got the point. Are you highlighting that wetlands are the most important source of carbon to rivers? Please rewrite this sentence to make your message clearer.

Answer: Actually, as mentioned in the previous version of our manuscript, we did not measure carbon parameters in the wetland of the Mengong catchment. To estimate the quantity of DOC and DIC exported from the wetland we used DOC and DIC concentrations measured in the soil solution of this particular wetland by Nkounde et al (2020). In addition, we assumed that the quantity of POC exported from the wetland was similar to the quantity of POC exported from the first order stream of the Mengong catchment as surface runoff does not occur and forest groundwater is free of POC.

We will rewrite the Abstract after the in-depth revision of the manuscript, it will be based on the tentative abstract given at the beginning of the answer to reviewer comment.

Introduction

L38-41. Please rewrite in fewer sentences, merging some of this information to give better flow.

Answer: "Despite their small surface area worldwide, inland waters have a critical role in the global carbon (C) cycle because they receive large amounts of C from terrestrial ecosystems that subsequently are processed and transferred to the atmosphere and the ocean (Allen and Pavelsky, 2018; Cole et al., 2007; Ludwig et al., 1996; Meybeck, 1982). Besides, terrestrial aquatic ecosystems are significant hotspots of C dioxide (CO2) evasion (e.g., Raymond et al., 2013) because inland waters are usually supersaturated in CO2 compared to the overlying atmosphere."

L69. I noticed you cite three different studies by Borges from 2015 in the introduction (Borges et al 2015, Borges et al 2015a, Borges et al 2015b) but you only have one reference in the Reference list. Please correct this inconsistency.

Answer: this will be corrected as suggested

L77-79. You could mention how this study benefits from this M-TROPICS effort. Otherwise, this piece of information is loose here and could be removed.

Since 1994, hydrological and environmental parameters have been measured at both local (experimental watershed as in the Mengong catchment) and regional scales in the Nyong River Basin (Cameroon) which belongs to the Critical Zone Observatories (CZOs; Gaillardet et al., 2018) network named Multiscale TROPIcal CatchmentS (M-TROPICS) (Audry et al., 2020). Therefore, our study benefits from this M-TROPICS effort because we used rainfall and water table level measured at the Mengong catchment, river discharge measured at the different gauging stations, and DOC, TA and SPM concentrations on a fortnightly basis. A few words will be added in the revised manuscript.

L79-82. Rewrite the study objectives more directly and clearly. You are evaluating the changes in C concentration across groundwater to different stream order over the seasons.

Answer: Referee is right. The objective now reads: "The first objective is to estimate the carbon mass balance of a first order catchment, the Mengong watershed, a nested sub-basin of the Nyong watershed. The estimated C fluxes are lateral hydrological inputs from land (i.e., from non-flooded forest groundwater) and from wetlands (i.e., from wetland) to the stream, river heterotophic respiration and the C degassed and exported from the stream. To the best of our knowledge, our study is the first to estimate lateral hydrological export of C both from wetland

and from well-drained terrestrial ecosystem (i.e., from non-flooded forest groundwater) in a tropical catchment. In lines with recent studies in tropical rivers (Abril et al., 2014; Borges et al., 2015; 2019), we expect that lateral inputs of C from the wetland to the river network are significant in comparison with C exported laterally from non-flooded forest groundwater in this first order stream. The second objective of this study is evaluating the changes in C concentration across groundwater to different stream order over the seasons in the waters of the Nyong basin Ultimately, the variations of the carbon concentrations in the Nyong basin throughout a water cycle will be compared with those observed in the Mengong sub-basin in order to evaluate how the biogeochemical cycle of carbon and its resulting CO2 emissions to the atmosphere in a large tropical basin is affected by the connectivity with the wetland domain.

L86-87. You did not assess the complete terrestrial C export. Please specify only the component analyzed (groundwater). Change “terrestrial ecosystem” to non-flooded forest groundwater or something similar.

Answer: Corrected as suggested, please see the general response.

L89-90. You need to give more context to clarify the study hypothesis. What is the link between the net C sink and the riverine C budget?

Answer: please see our answer above in this document where we rewritten objectives and assumptions

Methods

Describe the wetlands in more detail. Are they flooded forest or open areas with grass? Do they differ between the headwaters and high-order streams? Please number the equations.

Answer: Please see the general response for the description of the wetland in the catchment. In addition, as described by Olivry (1986), there are no floodplains (in contrast to the Amazonian basin) or permanent flooded forest (in contrast to the Congolese basin) in the Nyong watershed, as wetlands in the Nyong watershed are mostly wetlands located in the depressions of low-order basins or riparian wetland in high-order streams.

L97. Remove the “the” before swamps.

Answer: Corrected as suggested

L99- Change “experiences” to has.

Answer: Corrected as suggested

L106. Mengong source and outlet are not displayed in Fig 1.

Answer: In addition to the map of the Nyong basin, we will introduce a new figure showing the hydrological functioning of the Mengong catchment as discussed in the general response.

L110. Export is misspelled “epxorted”.

Answer: Corrected as suggested

L113. Start saying that this is the first order basing.

Answer: Corrected as suggested

L115-117. Needs a reference or should be rephrased using “likely” instead of “eventually”.

Answer: Corrected as suggested

L113-126. Please rewrite more concisely and clearly. Try going straight to the point of why this information is useful.

Answer: We will deeply modify this section as following our general response.

L.129-130. It is not clear if the Mengong source is only groundwater.

Answer: please see the general response;

L130. Explain how samples were taken from the stream. Using the Niskin bottle?

Answer: Yes, indeed we used a 3L Niskin bottle

L132. State what TA stands for.

Answer: TA stands for total alkalinity.

L134-142. This part needs to be rewritten. The physicochemical data explanation is very fragmented. You could just say that from Jan to March you used one probe and after that another. After that the details about calibrations.

Answer: the text now reads: "The water temperature, pH, dissolved oxygen and specific conductivity were measured in situ using portable probes (WTW®) between January and March 2016 and using a multi-parameter probe (YSI ProDSS) between April and December 2016. Calibration of sensors was carried out prior to the sampling campaigns and regularly checked during the campaigns. For the WTW® probe, the conductivity cell was calibrated with a 1000 µS cm $^{-1}$ (25°C) standard whereas the pH probe was calibrated using NBS buffer solutions (4 and 7). The multi-parmater probe YSI Proplus was calibrated before each sampling campaign using standard protocols."

L143-161. State the number of replicates you have for each analysis.

Answer: No replicates were made

L217. What do you mean by terrestrial groundwater?

Answer: We meant non-flooded forest groundwater that drains the hillside of the Mengong catchment. Please see the general response

L220. What the "r" in "[C]GWr" stands for? Define what is FexGW.

Answer: it was a typo. FexGW was a typo too, we meant Fgw. Please see the general response.

L222-223. Please reformulate this sentence. The flow of what? Please specify. Why the flow rate unit is in metric not volumetric? Clarify what surface area the swamp drain? Is it the sub-basin area of the non-flooded forest? What is the total area of wetland in the catchment?

Answer: please see the general response.

L223. Please be consistent using wetland or swamp throughout the text.

Answer: Yes indeed, we will use the term wetland in the revised version of our manuscript

L228-229. Explain how did you estimate DOC and DIC from this study.

Answer: please see the general response for DOC and DIC fluxes. However, the sampling method and measurements of DOC and DIC was already described in the previous version of our manuscript.

L230. Need citation for the negligible surface runoff.

Answer: Maréchal et al., (2013), Nkounde et al (2008)

L239. Include the site depth in table 1 and mention in the methods that it was measured.

Answer: depth was estimated from the curve discharge vs water depth established during the M-tropics project.

L279-282. Merge these two sentences.

Answer: we will do so in the revised manuscript

L280. Substitute "peaked" by significantly higher. Peaked works for a temporal description of a site, but to compare different sites is better using higher or lower than.

Answer: we will do so in the revised manuscript

Results

Section 3.4. Please also describe the results after accounting for the respective areas of the streams in t Cyr-1.

Answer: we will do so in the revised manuscript

Discussion

L349. If you are not testing this hypothesis, rephrase the sentence using "suggesting that…". Also here, mention how deep is the groundwater level and how far the groundwater is from the organic layer of soil. Information regarding the C distribution in the soils would be helpful.

Answer: please see the general response for the soil's characteristics and the variations of the ground water table level. This info will be added and discussed in the revised version of our manuscript.

L358-359. Wouldn't this then be groundwater respiration?

Answer: please see the general response (section carbon variations in groundwater). Briefly, we do not think that groundwater respiration could be significant because groundwater is free of DOC all year long as the water table never reaches organic horizons and DOC in the upper soil is also well complexed and stabilized with the iron-rich mottled clay horizon (See Braun et al. 2005).

L362-363. pCO2 does not change significantly between seasons. How can this explain the high O2? The O2 is higher than I would expect for groundwater. Could this be a sampling artifact? Since this was a seep and you have the water flowing through a pipe, the water may have been oxygenated, and a lower volume of water flowing during the base flow period would get oxygenated faster. If that is the case and considering that most of the DIC in the groundwater was as free CO2, is it possible that your pCO2 may be underestimated?

Answer: With the revised figures based on non-binned data, the seasonal variations of groundwater pCO2 are now visible. Actually, as described by Nkounde et al (2020), in the Mengong catchment, there is a very thin humus layer that does not protect the soil with atmospheric exchange and the soil is also very permeable and porous. Therefore, it allows a strong equilibration between atmospheric soil and air. This is consistent with d13C-DIC values close to the atmospheric equilibrium of -10‰ measured in the groundwater by Nkounde et al. (2020).

We believe that groundwater O2 or CO2 measurements are correct.

We can be confident with the CO2 dataset since the DIC budget at the Mengong catchment scale is balanced. In addition, the external part of the pipe (the part that it is not sunk into the hillside) is few centimeters long, therefore, equilibration between spring water and atmospheric air could occur during one second as maximum. Also, each sampling bottle was left to overflow to avoid catching bubble air.

For O2, the oxygen status of groundwater is determined by the rate of oxygen transport from the atmosphere and by the rate of oxygen consumption. We showed above in the document that the lithology allows the penetration of atmospheric O2 in the soil atmosphere and we also showed that the groundwater is free of DOC that very likely limiting the consumption of groundwater O2. There are numerous studies showing that microbial activity is indeed limited in many aquifers by the availability of DOC (please see Malard and Hervant 1999 and references therein). In addition, we measured groundwater O2 in the range of 3-4 mg/L and in their review on oxygen supply in groundwater, Malard and Hervant 1999 showed a range of 0.1-7 mg/L for shallow aquifers. We also often measured groundwater O2 around 40% for *groundwater with low DOC concentrations in temperate environment (see Deirmendjian et al. 2018).*

L372-374. What type of vegetation predominates in the wetlands, C4?

Answer: It is a mix between C3 and C4 vegetation. Please see the general answer.

L377-379. Couldn't this also be attributed to the deposition of inorganic materials due to the reduced water flow in wetlands in comparison with streams?

Answer: This question is confusing; do you mean organic materials?

L379-382. A similar process wouldn't also happen in forest soils with trees and their roots reaching the groundwater and supplying labile OM below the lateritic layer?

Answer: In the hillside, as mentioned above in the document, the deep soil CO2 is isotopically equilibrated with atmospheric air, showing that atmospheric penetrates deeply in the soil profile. Therefore, we believe that oxygen in the deep soil and thus in the groundwater originates from atmospheric air invasion in the soil rather than transported by the roots of the trees. Another reason for that is that groundwater table is sometimes way deeper than the root penetration zone but still oxygenated.

L403-404. In Figure 5 you don't show a relationship, but only a difference between low and high water. Make a correlation test.

Answer: this figure will be removed in the revised manuscript. Correlation tests will be included, see answers to reviewer #2

L419. Change "confirms" to suggests.

Answer: corrected as suggested

L421-423. Explain why substantial input of pCO2 via groundwater is not expected to sustain high pCO2 in high-order streams.

Answer: The drainage in high order streams is significantly lower than the drainage in low-order streams. This implies that, in high-order streams, the quantity of water coming from the drainage of groundwater is significantly lower (even not significant) than the quantity of water *coming from upstream (i.e., from lower order streams). The corollary is that in low order streams, much of the water is coming laterally (from groundwater) rather than from upstream (i.e., from lower order streams).*

L443. What do you mean by “invested”?

Answer: We meant invaded.

L461. Add inside parenthesis what are the components of this ratio, and why you show three components and only two for Ciais et al 2013?

Answer: the component is the ratio between the C exported to the ocean and emitted to the atmosphere as written in the manuscript. We believe the referee misread the sentence. We will try to find a better formulation in the revised manuscript.

Tables and Figures

Table 1. Is the slope unit correct? What slope is this? The average basins slope?

Answer: Yes, the slope is correct. Yes, it is the average catchment slope

Tables 2 and 3. Explain if the NA is because samples were not collected or because it was below the detection limit, or another reason.

Answer: it was below the detection limit

Figure 1. Add River order in the legend. It could be good to display river order in a shade of blues to differentiate more from wetlands. What is the unit of the coordinates? Why the site Yaoundé is shown with a large red dot?

Answer: Corrected as suggested for the legend. Coordinates are in decimal degree. We previously have chosen to show the capital of the country in a large red dot, but it was confusing. The revised map for the revised manuscript follows:

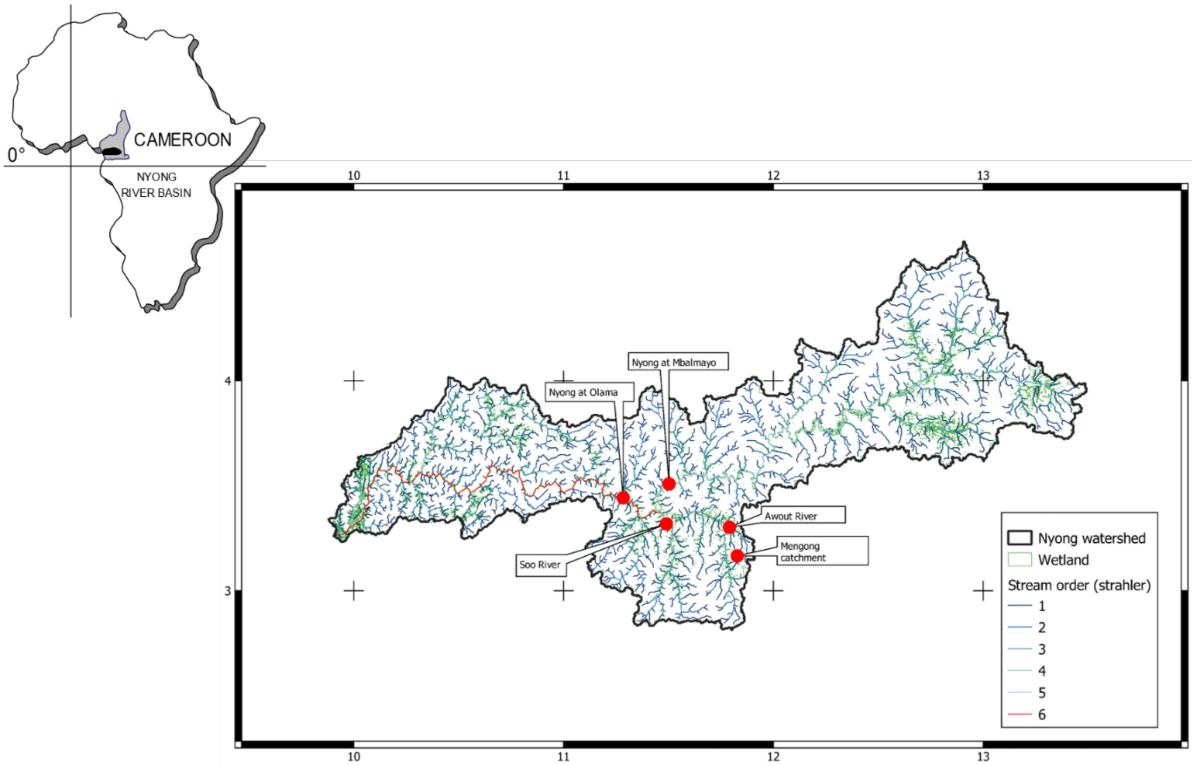
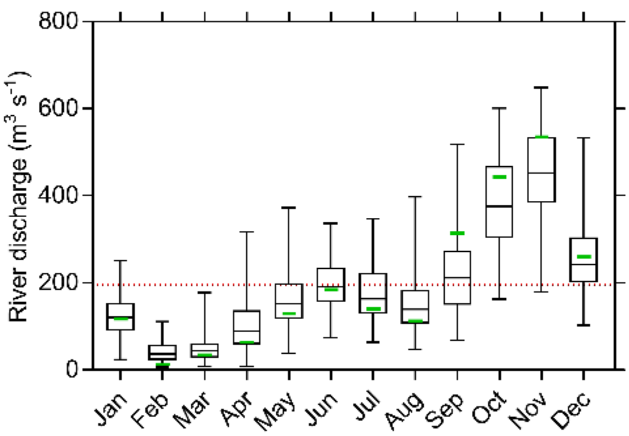


Figure 2. Do you mean river discharge? Please show the historical mean and variability of monthly discharge.

Answer: Yes, we meant river discharge. We will put a new figure in the revised manuscript (in supplementary) showing historical mean and variability of monthly discharge for the Nyong River at Olama (Nyong outlet in this study) as follows:



The box plots represent the monthly discharge from 1998 to 2020, with minimum and maximum discharge for extreme box plots values, the green lines represent the average monthly discharge in 2016, and the red dashed line represents the yearly average discharge for the 1998 to 2020 period of 194.5 m3/s (very close to the yearly average discharge of 195 m3/s in 2016)

Figure 6. Present the results after multiplying by the respective areas of the entire basin and river's surface. Also, add the unit in the figure caption.

Answer: Yes, please see the general answer where we present our C budget in t C/yr and in t C/km²/yr