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).

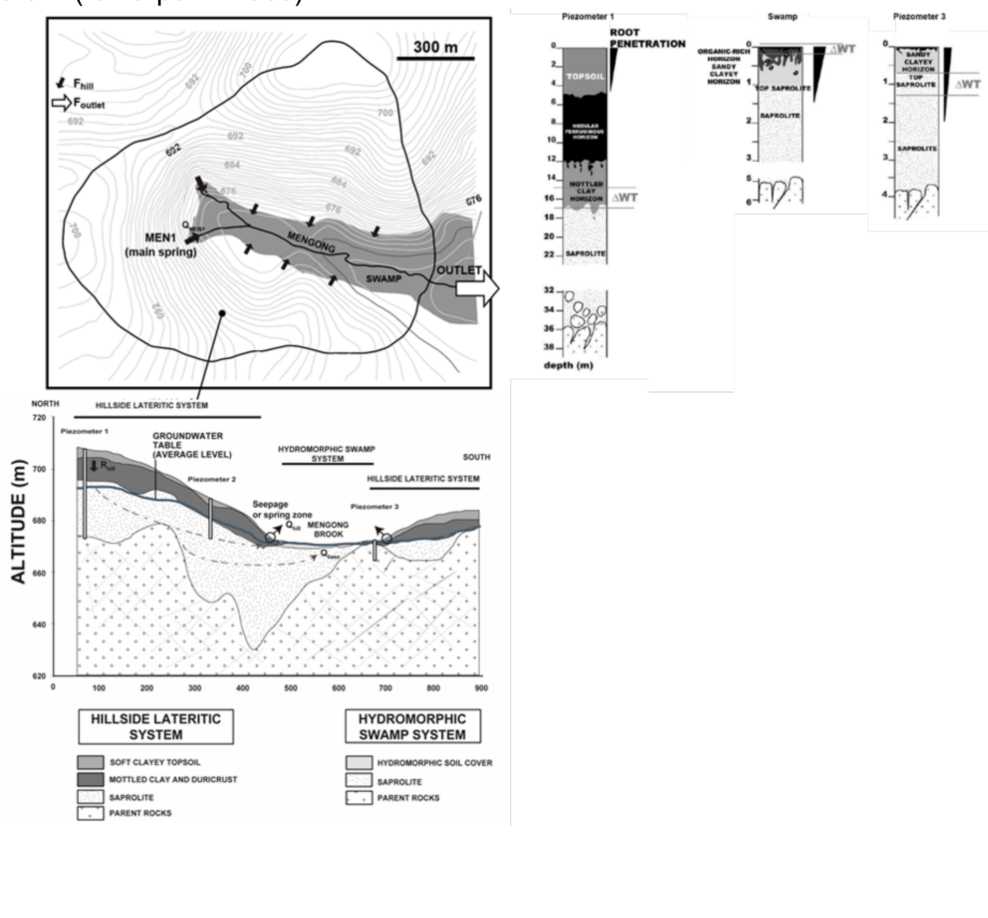


Figure 1 showing the hydrological functioning of the Mengong catchment (first order catchment) and the soil characteristics in piezometer 1, 3 and the wetland (water table level in piezometer 1 and 2 is presented in the figure 2). Adapted from Braun et al. (2005, 2012)

- **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)*

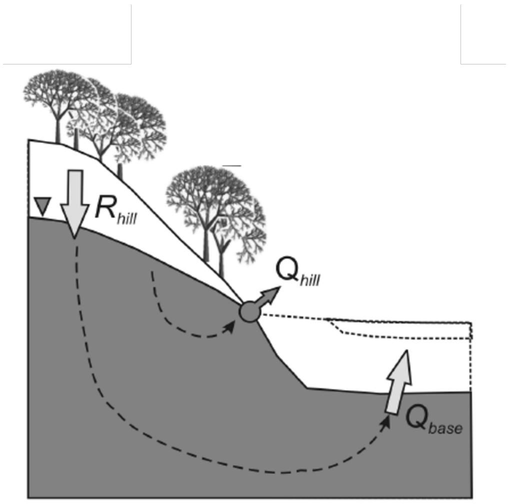
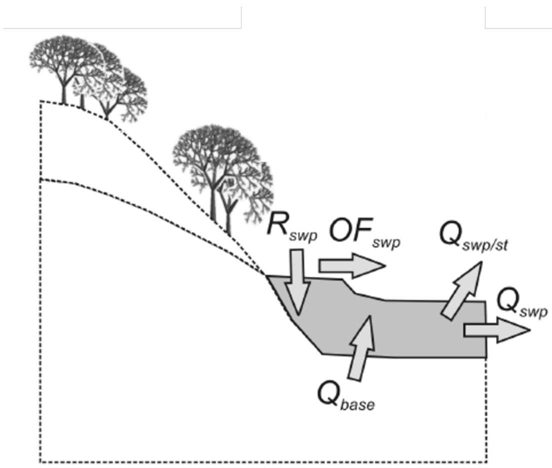


Figure showing the hydrological functioning of the hillside system, adapted from Maréchal et al. (2013)

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

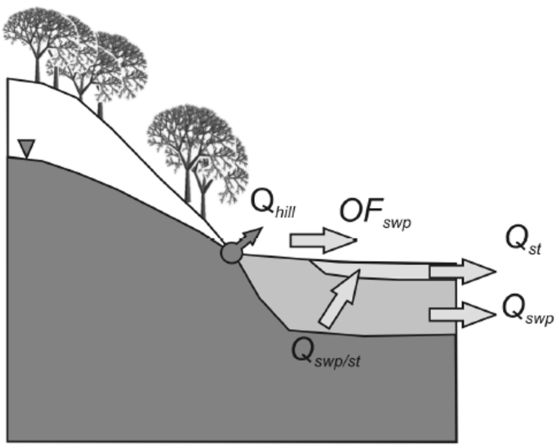


Figure showing the hydrological functioning of the Mengong catchment system, adapted from Maréchal et al. (2013)

- **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.

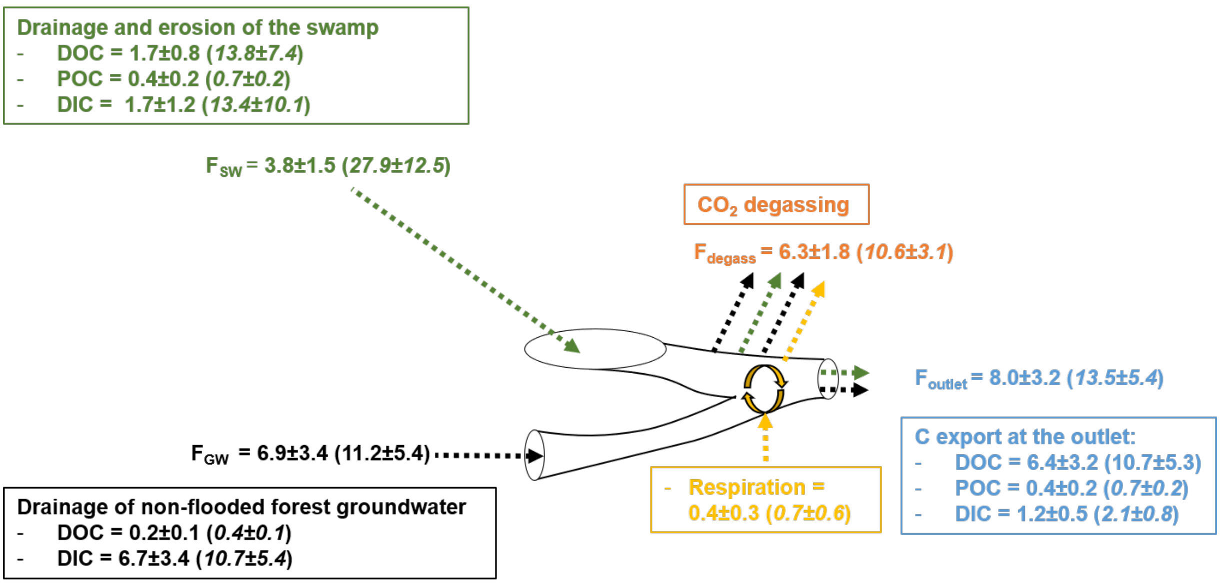


Figure showing the C budget at the Mengong catchment scale in t C yr^{-1}. Number between brackets are in t C km^{-2} yr^{-1}. For the drainage of the wetland, the flux between bracket is weighed by the wetland area (0.12 km²), for the drainage of non-flooded forest groundwater it is weighed by the surface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

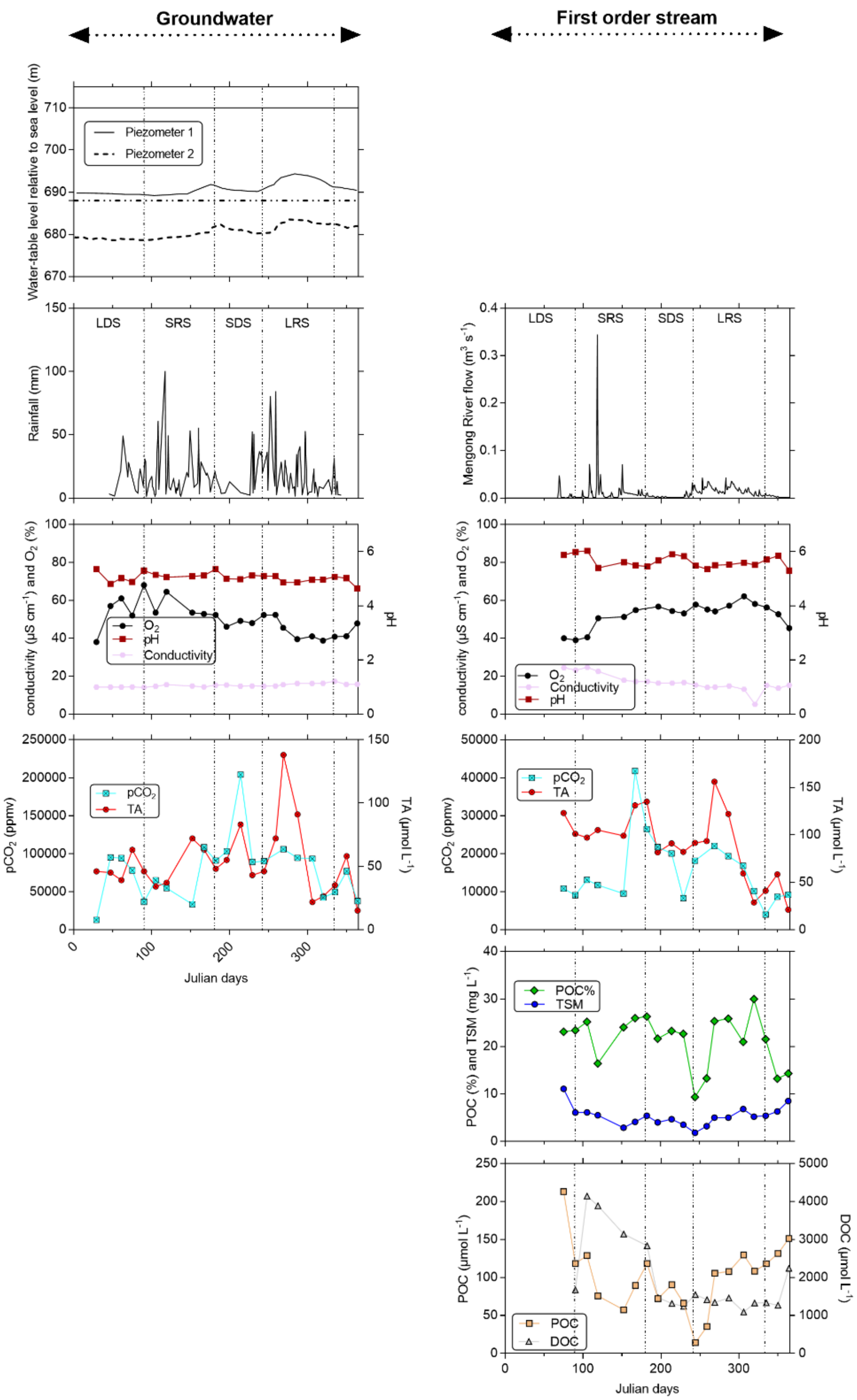
Groundwater pCO2 started to increase at the end of the SRS, concomitantly with the rise of the water table level (Figure 2). It is likely due because the water table has risen closer to the root's penetration zone (Figure 1) where soil respiration is more intense, as observed in other catchments (e.g., 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.

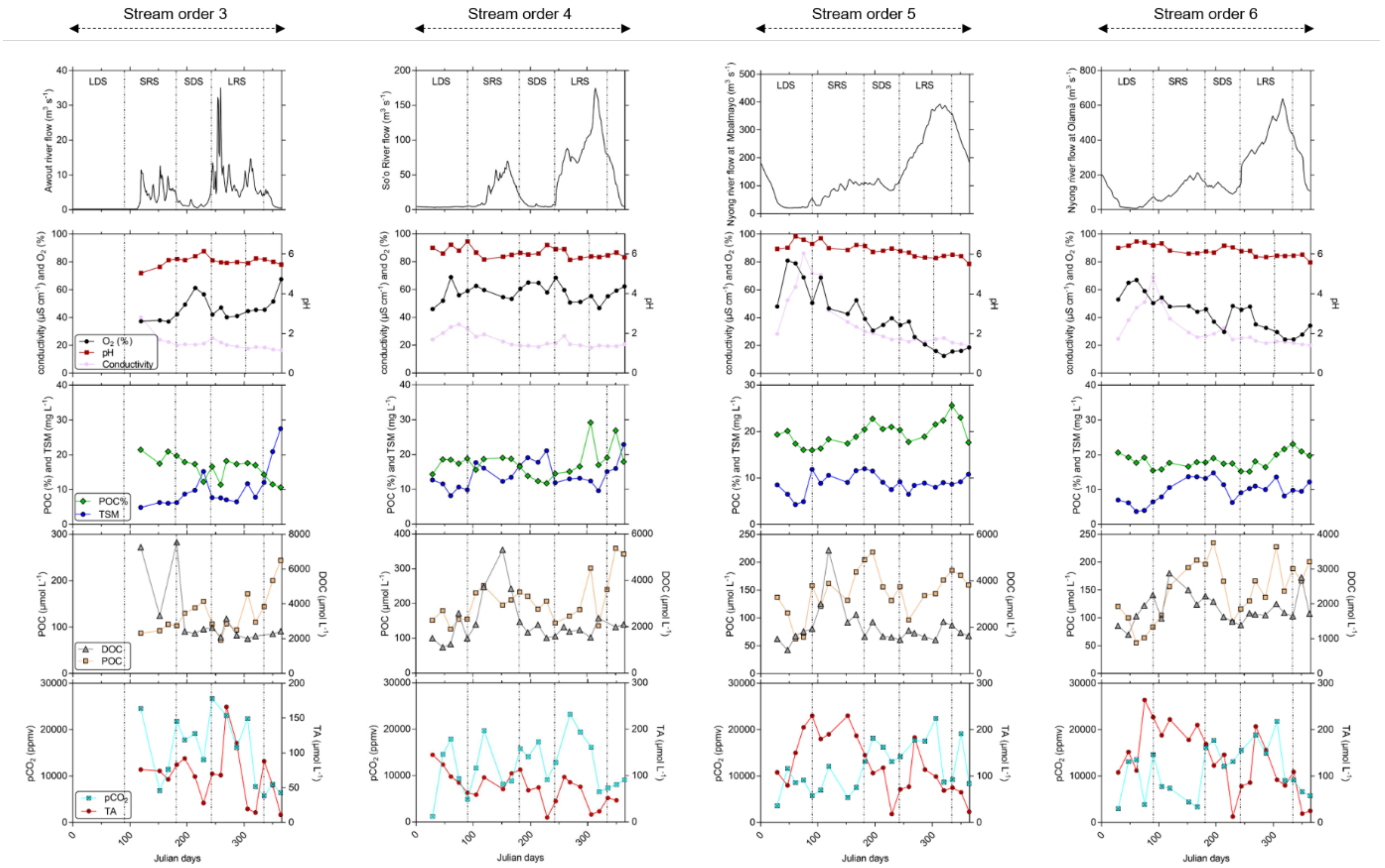


Figure 3: temporal variations of river discharge and carbon parameters in surface waters of the Nyong watershed

END OF THE GENERAL RESPONSE:

Reviewer (R#3) 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 authors have been compiling a large carbon data set from a river in Cameroon (monitored since 1993!) and use it to weigh in the hot topic of river metabolism and C budgeting. Their main goal is to assess the relative contributions of wetlands and uplands to river carbon, finding that wetlands are somewhat more important with a 60/40 split. The authors also conclude that upland forests, in addition to being less important than the wetlands for C export, apparently only export some 4% of their net C uptake, suggesting that they are indeed potent carbon sinks and not simply "leaking" carbon away to be reemitted by streams. Beyond the trendy C attribution angle, the authors also have a loosely-defined goal of describing spatial and temporal variations in their river C data set as part of assembling an overall budget for the catchment and they devote much of the results section to describing different trends and patterns. These deep technical dives are not so well conceived, lack a conceptual framework and are largely divorced from the broader narrative arc of the paper. There is no doubt important information here, but the reader has little help gleaning it from paragraphs without topic sentences. Overall, this dataset is definitely worthy of publication and makes an important contribution to understanding riverine C dynamics in a poorly understood region (tropical Africa). Below I point out a few key issues to address and make some recommendations for improving the narrative structure.

Answer: we thank the reviewer for her/his comprehensive and overall positive evaluation and overall of our work. Please see the general response where we present substantial modifications that will be included in the revised manuscript.

Comment: the idea of assessing relative contributions of wetlands/uplands to the river C is well grounded in active literature discussions and effectively pitched as a topic of interest (and is rightfully highlighted in the title). In contrast, the goal of: [describing spatial and temporal variations in river C], absent any problem statement or hypothesis is not well-conceived and sets up a results section that is largely strings of facts. There are plenty of significant patterns to be found in such a large data set, but what do they mean? How are they useful? What questions do they answer? Without any of this framing the reader is left wondering: what is the point of all this work and analysis? After re-reading these sections several times I had an idea of why this information was useful, but this was not so easy. There is no problem with the mechanics writing (few typos aside), but rather an issue of conceptualization and paragraph design.

Answer: Referee is totally right, and this was also mentioned by the two other referees. Actually, the main goal of the revised manuscript is to separate riverine carbon sources between wetland and non-flooded forest groundwater in the Mengong catchment (because we cannot estimate these two sources in streams with order higher than 1, please see the general response). Accordingly, the second goal is to test the hypothesis that temporal patterns of carbon concentrations in surface waters of the Nyong watershed (Cameroon, 27800 km²) 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.

Note that we will rewrite the Abstract after the in-depth revision of the manuscript, it will be based on the following text:

"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 km²) 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 km²). 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 10^{7} t C yr^{-1} while we estimated a degassing of 7.2 10^{5} t C yr^{-1}, a river heterotrophy of 5.9 10^{4} t C yr^{-1} and a total riverine export of 2.0 10^{5} 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".

The revised goals now read: "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."

Comment: The discussion subsection topics similarly lack a thread holding them together. They give detailed glimpses into specific parts of the system: forest groundwater, headwater stream, catchment scale patterns… They could really us a narrative arc that ties them together—a clear objective or a question. The descriptions are great, well-supported with data and references, but lacking an overarching motivation or glue. I would suggest laying out a framework in the introduction that explains why looking in detail at these different components of the catchment C system are important for understanding the functioning of the whole and then referring back to the framework with topic sentences. Give the reader some guidance as to why this all matters.

Answer: Thank you for these very constructive comments that will be taken very seriously in the revised manuscript. Overall, the results and discussion sections will be deeply rewritten according to the general answer and the new study goals that are both presented above in this document.

Besides, the new plan of our revised manuscript follows:

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 and fluxes

4.3 Regional significance of carbon fluxes of the Nyong watershed

Comment: In the introduction and throughout the manuscript, take care with terminology. The authors might try using "upland" to refer to well-drained ecosystems/forests. They occasionally use "Terrestrial" to refer to non-wetlands, but this would likely would include within it many types of wetlands (room for interpretation/confusion in the mind of the reader) and even "forests" will likely also include many wetlands since they are treed with palms. This is quite important to define clearly since distinguishing between the role of wetlands and non-wetlands within the catchment is main goal of the study.

Answer: Yes, we fully agree. Please see the general response for the description of wetlands (i.e., wetland located in the depressions with a mix of C3 and C4 vegetation) versus what we called terrestrial compartment (i.e., non-flooded forest groundwater with mature forest). 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 in high-order streams. In the revised version, we will mostly used non-flooded forest groundwater to refer to well-drained ecosystem as suggested by reviewer 1 and when needed we will use upland forest.

Comment: How solid is the estimation of catchment wetland area? Is there no more localized data source for the wetland area? Gumbricht et al. 2017 is a global-scale wetland map and probably is not very accurate at such a small spatial scale. Check if there are better wetland maps for the region, if not then make some sort of a statement that local/regional maps are unavailable and that using a global map is the only option. How sensitive are the results to accurate delineation and counts of areal coverage of wetlands vs. uplands?

Answer: Gumbricht et al. (2017) is one of the most accurate global-scale wetland maps but it is true that it is not very accurate at small spatial scale. However, our estimate of the wetland surface area of the Mengong catchment is based on field measurements (wetland surface area is 20% of the Mengong catchment), so this estimation is supposed to be robust. In the revised version of our manuscript, we will estimate the wetland surface area of the whole Nyong watershed from Olivry (1986), based on field measurements. His estimation of wetland surface area in the Nyong watershed was also 20%. This surface area was used by Borges et al (2015) to show how the wetland fraction of the catchment was related to CH4 concentrations in African rivers. In the revised paper, we will use Gumbricht et al. (2017) only for displaying wetlands in the figure 1.

Comment: Logic of transport pathways (Fig. 6) The authors model two C transport process between terrestrial ecosystems independently: Forest -> Stream; and Swamp -> Stream. But in a high percentage of cases will these not be linked? i.e. Forest -> Swamp -> Stream ? It seems that this logic opens the possibility that some important portion of wetland C export might have been "inherited" for surrounding hillside forests. This might mean that the importance of wetland C export relative to forest C export might be exaggerated by this analysis.

Answer: It is a very good point raised by the referee. Please see the general response where we present the hydrological model of the Mengong catchment. Actually, as there is no surface runoff on the hillsides of the Mengong catchment, POC from forest cannot reach the wetland. Therefore, POC in the wetland might not have been inherited from the forest. Non-flooded forest groundwater is also free of DOC for the reasons described in the general answer and therefore DOC from the wetland cannot have been inherited from the non-flooded forest groundwater. However, a portion of the wetland DIC might have been inherited from the non-flooded forest groundwater, but our revised budget take this into account (see equation 8 and 9).

Comment: Framing of conclusions "The current paradigm…" I had to refer back to the introduction, to try to figure out where this paradigm comes from and can find no sign of it. This appears to be a bit of a "straw man" argument? Yes, the paradigm is that headwater streams are heterotrophic, but I don't see any sources stating that the DIC/CO2 is produced exclusively or dominantly through heterotrophy, rather than inherited in inorganic form from groundwater…

Answer: In the 2000s, several studies have shown that respiration exceeds primary production in inland waters, meaning that inland waters are predominantly net heterotrophic (Del Giorgio et al. 1997, Cole 1999, Cole et al., 2007; Duarte & Prairie 2005). These studies also proposed that this net heterotrophy was one of the main factors explaining oversaturation of CO2 in comparison to the overlying atmosphere and so the net CO2 emissions from inland waters to the atmosphere. From 2008 this vision changed with the seminal paper of Battin et al (2008) where they estimated a global river heterotrophy significantly lower than the net global CO2 emissions from inland waters. The former hypothesis being outdated, we will remove the word paradigm in the revised manuscript

Comment: Minor comments Line 58: "anthropogenic budget"? So far, the processes being described do not involve human activities…

Answer: Referee is right. We deleted the term anthropogenic

Methods: Describe handling times of samples, preservation methods (kept cool?) and analysis location (Europe somewhere?)

Answer: All samples were analyzed in France at the Géocsiences Environnement Toulouse laboratory (Toulouse, France). TA is conservative and vials were preserved at ambient temperature. DOC was kept cool at 4°C in the dark. DIC vials were preserved at ambient temperature in the dark. TSM and POC filtrations and subsequent drying of the filters were done in Cameroon at the Insititut de Recherche Géologique et Minière (Yaoundé, Caemroon). Then, filters were stored in the dark at ambient temperature and brought back to France for subsequent analysis.

Comment: Statements of precision/repeatability "The repeatability was better than 0.1 mg/L" "Precision was +/- 0.1 mg/L" It isn't totally clear what parameters these statements refer to or what exactly they mean. Is it analytical precision (ie the balance measures to the nearest 0.1 mg?) Or did the authors take replicates and calculate standard errors?

Answer: for the scale we written precision because we refer to the analytical precision of the scale. For DIC and DOC, we wrote repeatability because we did not sample DIC and DOC in replicates but we did two measures with one sample.

Comment: Lateral inputs. I struggled to follow the logic i this paragraph regarding a 0.48 km2 "hillside." Unclear how this relates spatially to or represents behavior of a catchment of 27,800 km2. How does a hillside have "base flow" ?

Answer: Please see the general answer where we described the hydrological functioning of the Mengong catchment. We believe now that it is clearer and we will modify this section in the revised manuscript according to the general answer.

Comment: Line 310 (data not shown) Why not add to supplement? If important enough to mention in the text, the authors should somehow report the data.

Answer: In the revised manuscript we will show all the data in supplementary, as also suggested by the two other referees.

Comment: Line 323 why reverse order here? DIC, DOC, POC vs POC, DOC, DIC… best to be consistent…

Answer: You right, thank you for careful reading.

Comment: Section 4.1 The key information is buried way down on line 350. The authors are interested in understanding whether groundwater CO2 is coming from rock-water interactions, deep soil respiration or surface soil respiration. Based on their evidence, they posit the latter. Make the goal of this section clear from the start. The reader is left wondering for 22 lines of evidence what the point is…

Answer: It is true, we will do so in the revised paper.

Comment: Section 4.2: Lots of descriptions here, but not connected to any explicit goals. What's the point of all of this?

Answer: The goal of this section was to describe the biogeochemical processes occurring in the first order basin (Mengong catchment) that could explain the concentrations of the different carbon forms observed at the river outlet, we will make it clearer in the revised manuscript

Comment: Section 4.3 Same as above. The authors reach several conclusions in this section… "It confirms…" "This confirms…" But there was never any explanation of what tests were being done or any specific hypotheses. This is both a challenge for readability (lots of evidence is presented before the research question has been explained, making the logic difficult to follow); and also, scientifically: we should be laying out tests, with clear possibilities that the data and other evidence from literature can support or refute. Just describing the data and then saying it confirms something is not exactly the scientific method.

Answer: In the revised paper we will pay particular attention to these constructive comments in order to improve the readability of our manuscript.