Response to comments (second revision)

Dear Dr. Ray:

Thank you for submitting your revised version to Biogeosciences. Your revised version has been evaluated again by two referees. They agree that your paper addresses an important topic, but they also believe that it needs another round of revision before publication. Specifically, both argue that the limited replication lowers the robustness of your conclusions. They recommended articulating clearer the exploratory nature of your study and the consequences of limited replication for the conclusiveness. The referees also made some additional remarks that need attention (mainly grammar).

On the basis of these reviews, I cannot yet accept this paper for publication and invite you to submit a revised manuscript resolving the last issues remaining.

With best regards,

Jack Middelburg

Response:

Dear Prof. Middelburg,

Thank you very much for the decision. In the revised version, we have addressed all the comments made by the reviewers. Below are some bulleted reflections on the major revision

- ➔ We realized that our dataset is enough to evaluate the effect of age, and this is the most important point of this work. In contrast we believe that the dataset is not sufficient to convincingly evaluate seasonal variations, and seasonal variation is out of the scope of chrono-sequential analysis. Hence, we reanalyzed GAM and ANOVA with only considering type and depth.
- ➔ Box plots are adopted in Fig. 2 instead of chart plots, to minimize lack of replication.
- ➔ The aim of the study (i.e OC changes with chronosequence) remained robust and intact, and after addressing the issue of limited sample sizes, conclusiveness has not deviated.
- ➔ English is rechecked by our expert member of team.

We thank you again, and looking forward to receive positive response after the first review.

Rev#1 2nd round of comments to: bg-2021-359

The authors have improved the quality of the manuscript since the last edition. There are still grammatical errors present throughout the manuscript. In the authors responses' to comments they stated someone has revised the English, I suggest this is done again as there are still mistakes in the English. Please change "stock" to "stocks: throughout. Also, the sample replicate number is still low. I have suggested one of the figures is changed give the readers a better understanding of the number of data points used and their spread.

Response: Thanks for the suggestion. We have checked language again and refined further. We thank our expert on editing, Dr. Charissa for that.

For the figure, as suggested, it has been changed to box plots for all the parameters.
Line16: I don’t think mangroves can be considered ‘macro-climate regulators’
Response: Agreed. This word is deleted from the main text.

Lines 90 to 163: I would include somewhere in one of these sections (study area or sampling procedure), a description of where in the sampling area samples were taken from. The parameters being measured in this study (mangrove OC etc.) have been shown to associate with distance to seaward edge or landward edge.

Response: Thanks for the comment. New sentence describing parameters is added under subsection 2.3

LN140-43 *The variables tested at each sampling sites from BS to MM were sediment thickness, coarse fraction, pH, ORP, bulk density, specific surface area (SSA), concentrations and isotope ratios of carbon and nitrogen, and pore water dissolved organic carbon (DOC).*

Description of study field has been provided in more details under a new subsection 2.2. Mangrove chrono-sequence

New sentences added as below-

LN 119-20 *Sediment sampling locations are different from each other in terms of mangrove development, elevation from mean sea level, and inundation pattern.*

LN122-30 *The ages of the mangroves are typically known from their plantation period (Salmo et al., 2014). In this study, mangrove categories are partly influenced by Fromard et al. (1998) who examined the chronosequential sedimentary OC in naturally growing Avicennia-dominated mangroves in the French Guiana muddy coast where PM were established on the seafront after stabilization of mud banks, or on the sandy offshore bar (height <2 m), followed by further maturation to younger stands (YM, height <8m). According to Fromard et al. (1998), both PM and YM colonize rather unstable marine clays/sands that are regularly flooded by tides. From the river mouth to upstream, the stands (adult and mature) become older and taller (8–15 m, Rhizophora spp. in French Guiana), phenomena that are linked to river dynamics rather than tidal movement. In Bakhawan Ecopark, MM and AM sampling sites are farthest away from the water areas while BS and PM are closest to the sea (Fig. 1).*

LN132-34 *There is steep increment of elevation from seaward to landward sampling sites (-1.2 to 0.45m; refers to section 3). Seaward sites are featured by sandy sediment compared to silty clay sediment at the landward sites.*

Lines 107 to 108: What remotely sensed data? Is this a previous publication? If so, it should be referenced. If not, this data in supplementary information would be useful for readers.

Response: Thanks for the comment. We have now added citation for this statement.
LN107-08 *“Based on remotely-sensed data, it was found that the land area of the forest increased by 52.42% on average every five years since 1985 (Landicho et al., 2018).”*

Lines 117 to 119: I think it would be better for readers to give more detail about Marchand et al.’s (2003) chrono-sequential design. It is unclear to me how certain ages of forest types were determined. How did the authors determine a 'young mangrove' stand? How did authors determine an 'adult mangrove'? Also, it seems quite circular to me that the purpose of this study is to look at OC accumulation/stocks in different mangrove ages, but the authors used a study that used OC to determine mangrove stand age.

Response: The main purpose of this study is to understand changes of sediment OC (stock and burial) and other associated parameters with development of mangroves of known ages (refers to section **2.2. Mangrove chrono-sequence and 4.1 Relevance of chrono-sequence approach).**

We have also replaced the Marchand e al., citation with Fromard et al., (1998) who first coined the terms like pioneer, young, adult, mature mangroves in French Guiana.

New text added:

LN122-23 *The ages of the mangroves are typically known from their plantation period (Salmo et al., 2014).*

LN123-30 In this study, mangrove categories are partly influenced by Fromard et al. (1998) who examined the chronosequential sedimentary OC in naturally growing Avicennia-dominated mangroves in the French Guiana muddy coast where PM were established on the seafront after stabilization of mud banks, or on the sandy offshore bar (height <2 m), followed by further maturation to younger stands (YM, height <8m). According to Fromard et al. (1998), both PM and YM colonize rather unstable marine clays/sands that are regularly flooded by tides. From the river mouth to upstream, the stands (adult and mature) become older and taller (8–15 m, Rhizophora spp. in French Guiana), phenomena that are linked to river dynamics rather than tidal movement. In Bakhawan Ecopark, MM and AM sampling sites are farthest away from the water areas while BS and PM are closest to the sea (Fig. 1).

Lines 416 to 493: Figure 1 shows, the MM site was furthest away from water areas, while BS and PM were closest. Which also corresponded to higher and lower C stocks in the present study. Authors should mention that mangrove carbon stocks have been shown to vary with distance to seaward and landward edges (references below) due to tidally driven nutrient cycling, OM retention and transport of allocthonous material.

Response: Thank you for the suggestion and citations. We have added them in the list and revised the text as

LN463-65 At the Bakhawan Ecopark, OC stocks have been shown to vary with distance to seaward and landward edges (Kauffman et al., 2011; Wang et al., 2013; Chatting et al., 2020) due to tidally driven nutrient cycling, OM retention and transport of allochthonous material.

Kauffman, J.B., Heider, C., Cole, T.G., Dwire, K.A. and Donato, D.C., 2011. Ecosystem carbon stocks of Micronesian mangrove forests. Wetlands, 31(2), pp.343-352.
Chatting, M., LeVay, L., Walton, M., Skov, M.W., Kennedy, H., Wilson, S. and Al-Maslamani, I., 2020. Mangrove carbon stocks and biomass partitioning in an extreme environment. Estuarine, Coastal and Shelf Science, 244, p.106940.
Wang, G., Guan, D., Peart, M.R., Chen, Y. and Peng, Y., 2013. Ecosystem carbon stocks of mangrove forest in Yingluo Bay, Guangdong Province of South China. Forest Ecology and Management, 310, pp.539-546.

Figure 2: Since the sample replicate number is low, I would recommend changing figure 2 to something other than bar charts. Possibly boxplots or even better would be faded boxplots with raw data points overlaid on top. This approach would make it clearer to the reader what the spread of the data was and would be more transparent regarding the number of data points these reported averages and confidence intervals are based on.

Response- Thank you for the recommendation on changing figure pattern.
In the revised boxplots, depth-wise data of each core were used reflecting sample size.

However, to clarify one thing that might help getting over confusion around sample replication/statistical analysis (GAM and ANOVA), kindly be noted that total 92 subsamples have been used to understand the effect of each explanatory parameter (type, depth) on $\delta^{13}C$, $\delta^{15}N$ and C:N ratio of SOM pool. We have 8 bulk cores in total and subsamples are 92. Sample sizes for each parameter are given in the Results section. Furthermore, we realized that our dataset is enough to evaluate the effect of age, and this is the most important point of this work. In contrast, we believe that the dataset is not sufficient to convincingly evaluate seasonal variations, and seasonal variation is out of the scope of chrono-sequential analysis. Hence, we reanalyzed GAM and ANOVA with only considering type and depth. Accordingly, Table 1, and text in Results and discussion are slightly modified. We did not change Fig 3,4,5 that is because to differentiate different collection period (i.e., dry and wet) from same collection sites (BS to MM).

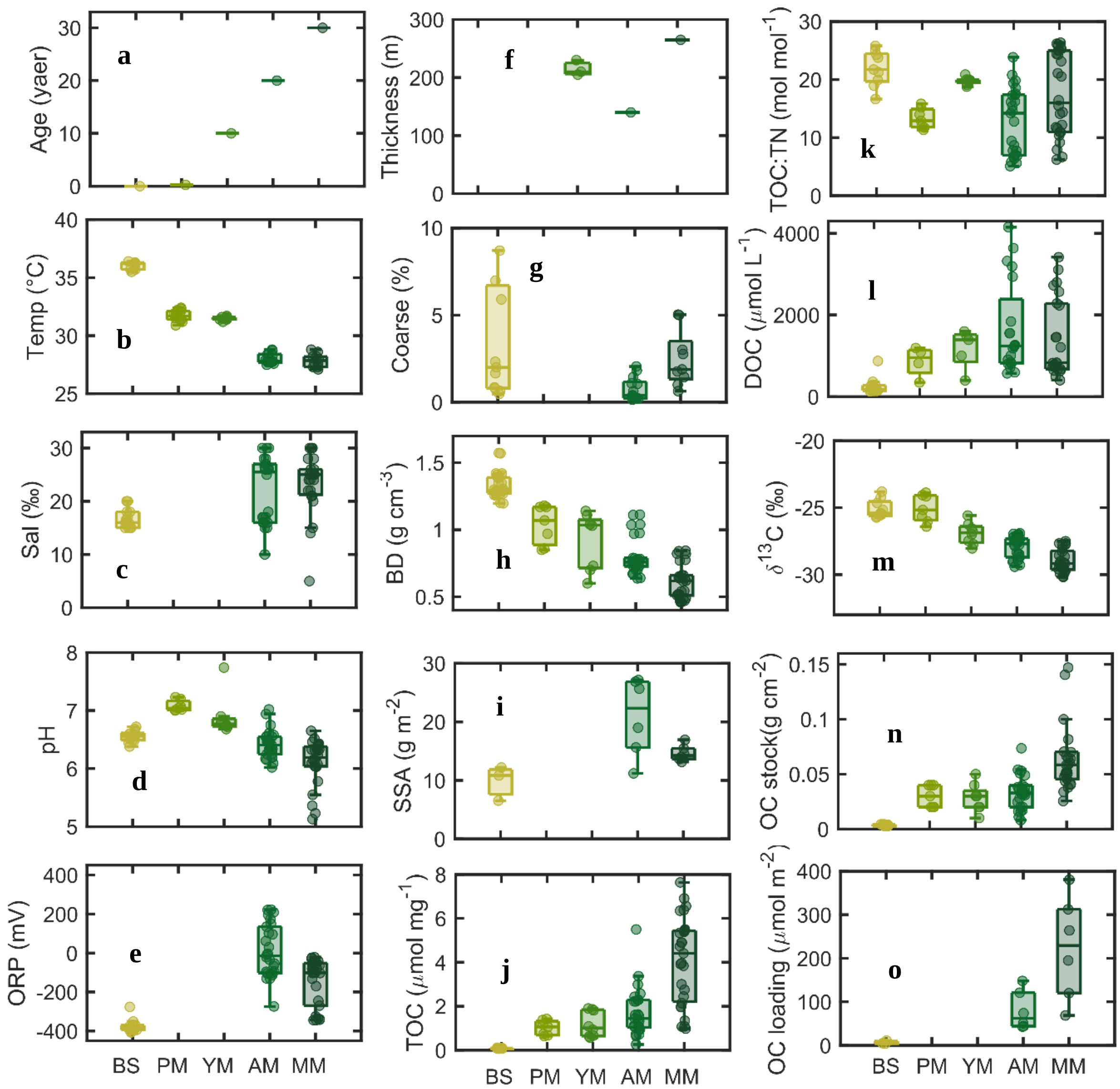

Fig. 2. Box plot diagrams of physical and biogeochemical parameters in the sediment subsamples according to mangrove development.

Reviewer#2

The authors have improved the ms by re-arraning some parts of the text and by adding several smaller modifications. However, the main issue raised is not fully adressed: There is a mismatch between the sample size (5-6 cores) and the variables studied (age, season, depth). The uncertainty bounds in figure 8 are informative but do not provide an answer to this issue. I believe that the authors should be very clear about the exlporatory nature of their study and consider the limitations of their observational database in both the interpretations and conclusions. A thoroughly revised ms that considers this could be considered for publication in bgs in my opinion

Response- Thank you for the constructive comment.

To clarify one thing that might help getting over confusion around statistical analysis (GAM and ANOVA), kindly be noted that total 92 subsamples have been used to understand the effect of each explanatory parameter (age, type, depth) on $\delta^{13}C$, $\delta^{15}N$ and C:N ratio of SOM pool. We have 8 cores in total and subsamples are 92. Sample sizes for each parameter are given in the Results section. Furthermore, we realized that our dataset is enough to evaluate the effect of age, and this is the most important point of this work. In contrast, we believe that the dataset is not sufficient to convincingly evaluate seasonal variations, and seasonal variation is out of the scope of chrono-sequential analysis. Hence, we reanalyzed GAM and ANOVA with only considering type and depth. Accordingly, Table 1, and text in Results and discussion are slightly modified. We did not change Fig 3,4,5 that is because to differentiate different collection period (i.e., dry and wet) from same collection sites (BS to MM).
However, we have acknowledged that overall number of cores are limited when considering age and stock relationship. In conclusion, we do not see any significant changes that might occur because of that. The rationale has been clarified in the discussion part (section 4.4 Increase of organic carbon with mangrove development

New text added –

LN228-29 *Results from subsamples of each core were used to for the model (total core = 8, subsamples used for analysis = 92)*

LN10-20 *Finally, it is important to highlight that the progression patterns of C stocks and/or CAR with mangrove age are observed out of total seven cores only, and the present dataset doesn't have enough numbers to test the effects of many other variables to the relationship between C stocks, CAR and mangrove age. Such relationship could be changed by environmental factors such as topography, hydrodynamics, geomorphology, biodiversity. We also found significant effect of soil depth on OC concentration (Table 1). However, as mentioned in section 4.1, environmental variabilities like hydrological processes do not largely vary among the sites, and have been relatively stable over ~ 30 years after restoration, and biomass development follows a similar trajectory of soil salinity, plantation spacing and species richness. Comparative data of chrono-sequential based OC accumulation rates with other restored mangrove forests also gives overlapping ranges, thus confidence of this work. Therefore, the results or conclusion of this study might not significantly change due to lack of replicates of sediment cores from the restores site. Nonetheless, acknowledging this as a limitation of the study, we further recommend that several cores are required for drawing a robust carbon and age relationships, especially for the regions where environmental variabilities can be significant drivers of these relationships.*

New references

Chatting, M., LeVay, L., Walton, M., Skov, M.W., Kennedy, H., Wilson, S., and Al-Maslamani, I.: Mangrove carbon stocks and biomass partitioning in an extreme environment. Estuar Coast Shelf Sc. 244, 106940, doi.org/10.1016/j.ecss.2020.106940, 2020

Fromard, F., Puig, H., Mougin, E., Marty, G., Betoulle, J.L., Cadamuro, L.: Structure, above-ground biomass and dynamics of mangrove ecosystems: new data from French Guiana. Oecologia 115: 39-53, doi.org/10.1007/s004420050489 1998

Kauffman, J., Heider, C., Cole, T.G., Dwire, K.A., and Donato, D.C.: Ecosystem carbon stocks of Micronesian mangrove forests. Wetlands. 31: 343-352. doi.org/10.1007/s13157-011-0148-9, 2011

Landicho, K.P., Blanco, A.C., Francisco, R.R., Gatdula, N.: Google earth engine-based assessment of expansion of Bakhawan Eco-Park using vegetation and water indices derived from LANDSAT images. Proceedings Asian Conference on Remote Sensing 2018. Page 332. ACRS 2018 PROCEEDING.pdf (a-a-r-s.org)

Wang, G., Guan, D., Peart, M.R., Chen, Y., and Peng, Y.: Ecosystem carbon stocks of mangrove forest in Yingluo Bay, Guangdong Province of South China. Forest Ecol Manag. 310, 539-546, doi.org/10.1016/j.foreco.2013.08.045, 2013.