Response to reviewer 1

We thank you very much for your constructive and relevant comments and suggestions. Below the reviews are reproduced in black font and our responses interspersed in blue and preliminary updates of the text in green.

The study by Many et al., used the 3-D numerical model to simulate the physical and biogeochemical processes in the Gulf of Lion shelf, one of the well-characterized coastal regions in the world ocean. The encouraging agreement between model projections and field measurements gives confidence in the accuracy and rationality of model simulations. With the particular focus on the POC budget, temporal and spatial variability of multiple POC fluxes and associated underlying mechanisms were discussed. Overall, the manuscript is well organized and this work represents an important step toward better understanding the interactions between physical and biogeochemical processes as well as the regional carbon cycling. However, some major concerns need to be addressed before getting published.

Reply: We appreciate this overall positive assessment and believe we can address the Reviewer 1 concerns as detailed below.

Major concerns:

1) Confusion on the research goal: toward closing regional POC budget or just analyzing the spatiotemporal variability of some of key POC fluxes? "POC budget" was mentioned in the title and many places throughout the main text. In principle, the "budget" means the effort to balance the time rate change of POC inventory by the multiple processes including biological activity and physical transport. If so, the paper should start with the introduction about the mass balance equation (i.e. $POC/dT= POC_{bio}+POC_{horizotnal}$ advection + $POC_{depostion}+POC_{export}+....$) and go over the main processes. From the mass balance perspective, the NEP is the best term to represent the net biological process in governing the time rate change of POC and partition into GPP, NPP CR and seems redundant. Also, given that horizontal advection is important as the author mentioned in the introduction, it should be discussed in the main text. I envision the paper should end with a schematic diagram, something like a box showing how different processes balance the change of POC in the seawater. However, in the current version, the authors seem to focus on some POC fluxes that authors are interested in rather than a comprehensive overview of POC fluxes with the aim to balance the time rate change of POC. I am not saying the present way is wrong. I am open to both strategies and it depends on the study goal. Therefore, I think the author should be cautious in using "POC budget" and be more clear about the research goal.

Reply: We agree with the comment of the reviewer. As we plan to close the carbon budget in a future work (i.e. with the integration of the inorganic carbon cycle in the model), we here focus on the POC dynamics through the study of the main POC fluxes over the shelf. The manuscript title and main text will be adapted toward this goal. We will thus change all the mentions of "budgets" to "dynamics"in the revised version, notably in the title.

2) Issue about DOC portion in GPP, NPP and respiration: the author refers GPP, NPP and respiration to one of POC fluxes. Primary production and respiration both include POC and DOC production, even though some field measurements of primary production (i.e. ^{14}C-based approach) is biased toward POC production because of methodological problems. I am not mistaken, primary production and respiration in the model encompass both DOC and POC portions. In the coastal region, the DOC production/consumption are significant. Since this study focuses on POC dynamics, did the author pay any effort to isolate the DOC portion in these biological terms?

Reply: The biogeochemical model ECO3M-S simulates the biogeochemical cycles of C, N, P, O_2 and the dynamics of the main nutrients in the Mediterranean Sea, NO_3, NH_4, PO_4, SiO_4, 3 size-classes of phytoplankton, 3 size-classes of zooplankton, one bacteria compartment, dissolved organic matter, light and heavy sinking detrical particles, and dissolved oxygen. Thus, DOC and POC fluxes are calculated separately in our model. To clarify how POC and DOC fluxes were calculated in the model we will add a brief description of the biogeochemical model in Section 2.1.2 and a more detailed description (Text S1) in a Supplementary Material document, with a figure showing the biogeochemical model structure and the biogeochemical processes interacting between compartiments (Figure S1) and tables with the list of state variables (Table S1), biogeochemical fluxes and functions (Table S2), parameters (Table S3) and equations of the biogeochemical fluxes (Table S4). In the first version of the manuscript we mainly discussed the POC/DIC fluxes. However we agree with the Reviewer 1 that the magnitude of DOC fluxes in the Gulf of Lion are significant as for instance the DOC exudation (mean of 120 t C yr^{-1}) . Therefore to accurately answer this question we will estimate all the POC/DOC fluxes and add their estimates in Section 4.1.3.

3) Missing the information about the methodology in simulating POC fluxes: as the core components, I have not seen the descriptions about how multiple POC fluxes were calculated in the model and definitions about different processes. As mentioned above, how did you calculate the primary production, respiration and partition the POC portion from the total organic carbon term? How did you define/differentiate the POC deposition, cross-shelf transport and horizontal advection? It should introduce in the method section briefly rather than citing the previous paper.

Reply: We hope that the added description of the biogeochemical model in Section 2.1.2 and in Supplementary Material, with the equations of the different fluxes, in the revised manuscript clear up these concerns. The POC deposition is the sum of the concentration of micro-phytoplankton and particulate detritus (in carbon) at the near-bottom level of the model grid, multiplied by their respective settling velocity. To ensure clarity, the term "horizontal advection" will be replaced by cross-shelf transport throughout the revised manuscript. The cross-shelf transport is the flux of water, nutrients or POC through a vertical section along the slope, from the sea surface down to the bottom, shown on Figure 1. A sub-section "2.1.3 Estimation of water, nutrients and POC transport" will be added in Material and Method of the revised manuscript to clarify our methodology.

Minor comments:

Line 170: provide the link for accessing the satellite data.

Reply: The link (https://oceancolor.gsfc.nasa.gov/) to access the satellite data will be added to the manuscript (section 2.2.2).

Figure 3: add the “surface” and “bottom” on the top of the panel for clarification (like Figure 2).

Reply: Clarification will be made in the Figure.

Figure 6c: Introduce the way to calculate stratification index in Method section.

Reply: Clarification will be added to the manuscript. The definition of the Stratification Index will be added to the section “4.1.1” as it is only used here.

“The stratification index is estimated as the vertical integration of density profiles along depth (expressed in kg m^{-2}), then spatially averaged over the shelf. It represents the amount of buoyancy to be extracted to mix the water column from the surface to the bottom and achieve a homogenous density equal to the bottom density.”

Table 2: does the “stock POC” mean the POC inventory (t Cyr-1) or the time rate change of POC inventory (t Cyr-1)? The other terms listed in this table are all flux (t Cyr-1).

Reply: Here the stock of POC is the annual mean POC inventory over the shelf, expressed in t C. Fluxes are annually estimated and are thus expressed in t C yr^{-1}. This clarification will be explained in the legend of the table. We will change the POC “stock” to POC ”inventory” throughout the text.

Section 4.2: Regarding the primary production, do you have a specific reason to focus on NPP rather than GPP or both?

Reply: As the NPP is generally presented in similar modeling studies and measured *in situ*, we focused on its variability to be able to compare and discuss our estimates with previous works (Cruzado et Velasquez, 1990; Lefevre et al., 1997; Conan et al., 1998; Durrieu de Madron et al., 2000; Lazzari et al., 2012).

Line 500: does primary production refer to the NPP or GPP? Please clarify herein

Reply: Here the primary production refers to the NPP. Clarification will be added to the manuscript.

Revise the expressions throughout the text: change Chl-a, umolC L^{-1}, NO3 and PO4 to Chl-*a*, umol C L^{-1}, and , respectively.

Reply: Clarification will be added to the manuscript and figures. We will change the “Chl-a” in “Chl-*a*”, the “tC, tN, tP” in “t C, t P, t N” (same with µmol, g, and other units).

References

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Durrieu de Madron, X., Abassi, A., Heussner, S., Monaco, A., Aloisi, J. C., Radakovitch, O., Giresse, P., Buscail, R., and Kerhervé, P.: Particulate matter and organic carbon budgets for the Gulf of Lions (NW Mediterranean), Oceanologica Acta, 23, 717–730, https://doi.org/10.1016/S0399-1784(00)00119-5, 2000.

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