Answer to Referee #1

We thank Referee nr.1 for the time spent on reviewing our manuscript and for his/her thoughtful comments that have helped us to better understand the role of our small detritus pool and the sensitivity of our results with regard to our treatment of organic matter. This will improve the quality of our manuscript. We include below our detailed answers to all the raised questions/comments.

Answers to Major comments

Major Comment nr.1:
The NPZD model is very simple which is not a problem by itself. It performs enough well to be suitable for that study. This is quite clearly shown in the validation section of the paper. However, according to me, it lacks a critical reservoir especially concerning the objectives of that study: DOC or more precisely semi-labile and semi-refractory DOC. Concentrations of semi-labile DOC range from typically 20 to 40 umol/L in the upper ocean (Hansell et al., 2009; Hansell and Carlson, 2014). Its lifetime is also quite long and ranges from weeks to years which makes it possible for that pool to be transported far away from its production region. It has been shown to potentially play an important role in the subtropical gyres (e.g., Roussenov et al., 2006; Torres-Valdés et al., 2009). In the present study, this pool is omitted and thus, a potentially large contribution to the lateral export of organic carbon is not represented. This needs at least to be discussed in the discussion section.

Answer to MC1:
As correctly stated by this reviewer, our NPZD model does not include an explicit DOC pool, which at first sight could be considered as a serious shortcoming given the potentially substantial contribution of DOC to the lateral transport of organic carbon. However, our model includes, in addition to the standard pool of fast sinking (large) particulate organic carbon (Large Detritus, LDet), also a pool of very slowly sinking particles (Small Detritus, SDet). Given its sinking speed of 1 m day^{-1} SDet represents essentially a suspended POC pool. Thus, this pool has some similarity to a (semi-refractory) DOC, particularly regarding its susceptibility to being subject to strong lateral transport. The important difference is that SDet coagulates to LDet, while this is not the case for DOC, i.e., SDet has a somewhat shorter lifetime in the surface ocean than the semi-refractory DOC. At the same time, the rate of production of DOC is likely smaller than that of SDet, since most of the organic matter produced in the surface ocean is routed first through SDet, while this is not the case for DOC. Thus, while we are clearly not representing DOC in our model simulations, we do not expect the explicit consideration of DOC to completely change our results. Or in other words, we would argue that the impact of this shortcoming is smaller than possibly inferred at first sight.

In order to explore the potential impacts of our lack of consideration of DOC more quantitatively, we ran a sensitivity study where we altered the behavior of SDet to become like DOC. Specifically, we set the sinking speed of the SDet pool to zero, i.e., w_{SD}=0, and reduced the coagulation time scale t_{coag} to 3/5 of its baseline value to mimic as closely as possible a dissolved organic carbon pool. No adjustments were made to the parameterization of the LDet pool to compensate for the strong reduction in the routing of organic carbon toward this pool. This sensitivity study thus needs to be considered as an extreme scenario - i.e., is meant to explore the potential contribution of DOC rather than an attempt to quantify it in detail. We spun up the model with the new biological parameters from year 24 of the baseline run (6 years of spinup) and used years 30-35 for the analysis, as we did for the baseline run.

The results of this sensitivity simulation (see Figures MC1-1-3 below) suggests that a dissolved pool of organic carbon would tend to intensify the lateral fluxes of organic carbon in the euphotic layer and stimulate the local recycling of organic matter, increasing both primary production and heterotrophic activity in the near-surface layer, but not alter net community production in a major manner. These apparently contradictory conclusions can be rationalized by our modifications resulting in a substantial increase in the average lifetime of SDet. Rather than becoming subject to sinking and coagulation, SDet now remains in the surface ocean, increasing the standing stock of POC there substantially, which increases also the offshore transport. However, due to the reduced reactivity of SDet resulting in a longer lifetime, the net horizontal divergence of SDet remains roughly the same, even though the transport is larger and reaching further out into the open North Atlantic. The roughly unchanged horizontal divergence of organic matter transport implies a roughly unchanged net community production as well. Thus, for the key question at hand, i.e., can the offshore transport fuel net heterotrophic conditions in the offshore regions of the Canary CS, the answer essentially remains unchanged.

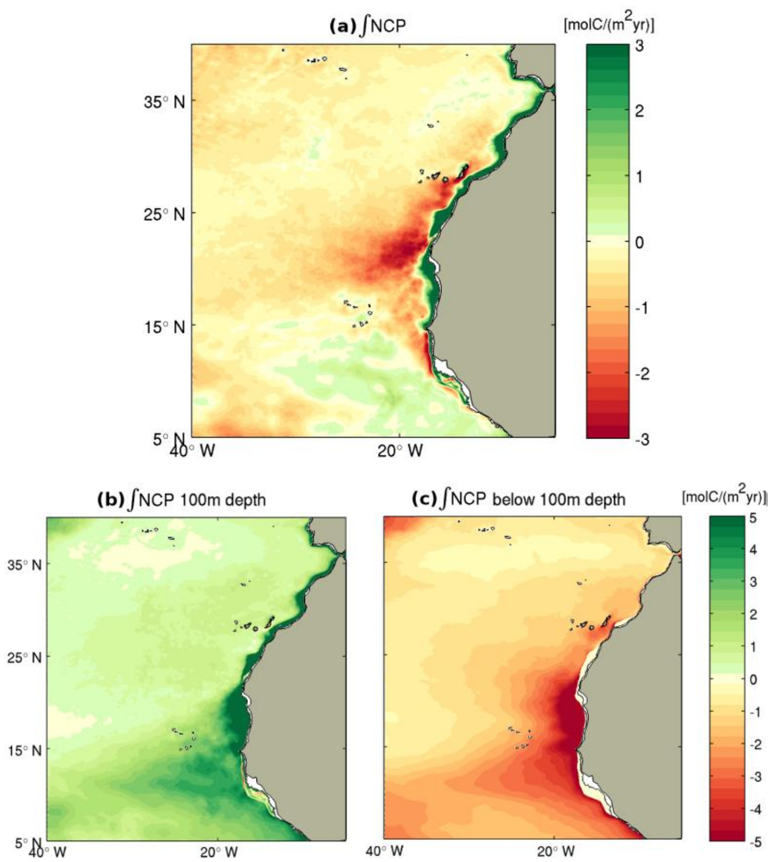

Figure MC1-1: Map of Community Production including sediment remineralization in the sensitivity study with reduced sinking and coagulation of SDet: (a) vertically integrated in the whole watercolumn; (b) vertically integrated in the first 100m depth; (c) vertically integrated below 100m depth. Compare to Figure 6 in the main text.

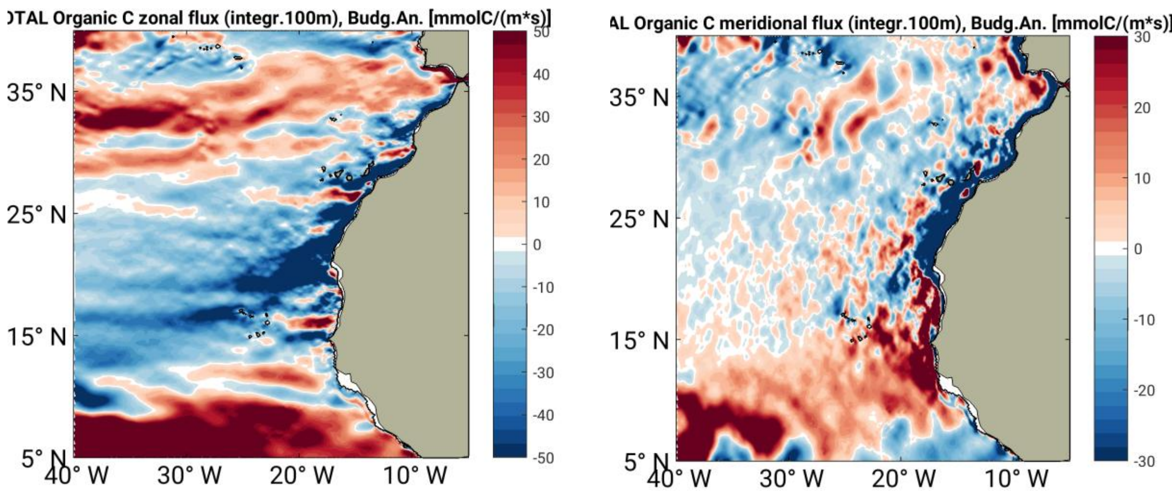

Figure MC1-2: Map of horizontal transport of POC in the sensitivity case with a non-sinking and very slowly aggregating SDet pool. (a) zonal transport of total POC in the top 100 m. (b) as (a), but for the meridional transport. Contrast this to Figure 11 in the main text.

In response to this comment, we will clarify the role of SDet and our lack of consideration of an explicit DOC pool in the text. Concretely, we propose to include a dedicated paragraph in the discussion section to examine the potential contribution of DOC to the lateral redistribution of organic carbon. This paragraph will include some literature-based discussion on the base of the relevant papers kindly suggested by this referee, as well as the results of this sensitivity simulations (w/o figures). We further will make sure throughout the text that the reader remains aware that our model-based study deals with the lateral transport of POC only, and not of total organic carbon. A comment to this effect will also be added to the abstract.

Major Comment nr.2:

In this study, the importance of mesoscale features is emphasized several times but never clearly quantified. It would have been nice to have such a quantification. I would suggest two possible means to do that: 1) to perform a classical separation technique between the mean and eddy components of the transport; 2) to perform a simulation in which the non linear terms in the Navier-Stokes equations for momentum are cancelled such as in Gruber et al. (2011). Otherwise, any discussion of the effect of the mesoscale circulation remains quite speculative and qualitative.

Answer to MC2:

We agree with Referee nr.1 that mesoscale processes play an important role for the lateral redistribution of organic carbon in the region and that their contribution needs to be discussed more quantitatively. However, we are of the opinion that a full in-depth analysis goes well beyond the scope of this paper, which is already quite detailed and long. Our preferred strategy is to leave this aspect to a second, dedicated publication that focuses exclusively on the role of mesoscale processes for the long-range transport of organic carbon in the region. This follow-up study will include an analysis of the decomposition of the fluxes into their mean and turbulent components, some sensitivity studies and a study of the influence of mesoscale eddies on the offshore transport and transformation of organic matter. The strategy we propose for this present paper is to strengthen the discussion of the mesoscale contribution with more concrete references to previous literature and also mentioning our knowledge obtained with the analysis that we are currently developing. We also propose to add in the present paper a reference to the follow-up study that we are currently working on.

Answers to Detailed comments

DC1: Page 2, line 1 - *"resuspension of bottom sediments and can create ... " I guess something is missing in this sentence.*
Thank you. The “and” is a typo, we will correct it to: “resuspension of bottom sediments can create...”

DC2: Page 4, line 33 - *In the list of state variables that are listed, you should add O2.*
Thank you, we will add it.

DC3: Page 5, lines 11-12 - *Phytoplankton can coagulate with small POC to form large POC. Is it also the case for small POC with small POC?*
Yes. To clarify this we will mention the smallPOC-smallPOC coagulation in the text.

DC4: Page 7, lines 28-33 - *You should refer to figure 3 to illustrate the different regions.*
Thanks for the suggestion. We will add a reference to the Figure.

DC5: Page 10, lines 8-13 - *Almost everywhere, except near Cape Blanc, high values of Chlorophyll are too narrow and too much trapped near the coast. As mentionned by the authors, this bias is especially strong in the Southern part of the CanUS domain.*
Yes, we acknowledge the limitation of the modeled surface Chlorophyll. However, along the whole northern coastline from 32°N down to Cape Blanc (21°N), surface Chlorophyll is not narrower than in the satellite product. Below Cape Blanc, Chlorophyll is underestimated at the surface due to a deepening of the chlorophyll maximum, as discussed in pages 10 and 11.

DC6: Page 11, lines 1-6 - *The authors here discuss the characteristics of the modeled sub-surface maximum of Chl (DCM) and they refer to Figure B2. This is not always easy to see from Figure B2. The most obvious bias that emerges from the figure is the too high values of Chl at depth below 50m. Otherwise, it is hard to quantify from that plot the depth of the DCM in the model and in the data.*
We take note of this comment. In response, we will add a better description of the figure to the paper. In particular, we will ensure to better explain the pattern of latitudes and depths.

DC7: Page 17, lines 3-6 - *For sure in the interior of the ocean, the contribution of small POC to the vertical sinking flux of organic matter should drop very quickly with depth. A figure showing the contribution of the different pools of organic matter to total organic carbon would be nice.*
We have added a plot of the mean vertical profiles of the four pools of organic carbon in the CanUS, as visible in the following Figure DC7-1. This figure will be included the Appendix of the paper.

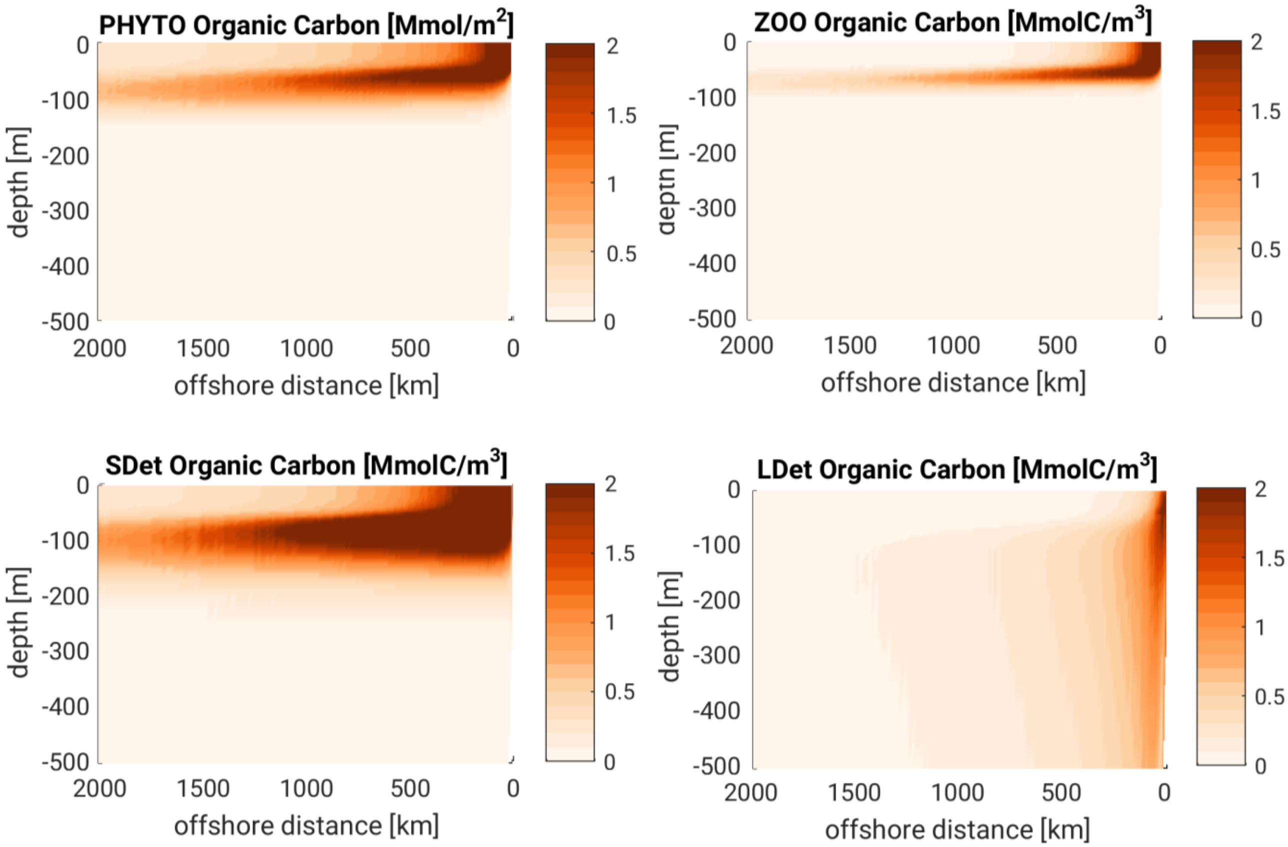

Figure DC7-1: Mean vertical offshore sections of the organic carbon components in mmolC/m^3; x-axis:offshore distance [km], y-axis: depth [m]

DC8: Page 18, Figure 9 - *The fluxes in the different boxes are not balanced (the imbalance is however small). Is it because the model is not fully at steady state or because of the internal variability related to the mesoscale activity?*
There are a few reasons why the fluxes are not completely balanced. The first reason is indeed the lack of a complete steady-state, which leads to changes in the size of the standing stocks, which we computed, but did not add to the figures. In addition, we also did not include in our analysis the contribution of horizontal and vertical mixing fluxes associated with the background diffusivity. However, these fluxes are very small. Another small source of error is the fact that our 3D analysis boxes are defined by horizontal boundaries that correspond to the position of the long-term mean sigma-levels, where the sigma levels define the terrain-following coordinate used in ROMS. However,

sigma-levels slightly move due to relatively small differences in SSH at each time step and this can result in slight miss-matches of the mean flux calculation.
In response to this comment, we will add some text to the figure caption to explain the reasons for the lack of closure.

DC9: Page 18, lines 1-6 - *The DeltaE diagnostics is interesting. It accounts for two processes that can increase the export without changing the NCP: 1) The organic matter that is being transported laterally and that sinks out of the upper ocean increases the export and thus DeltaE. 2) The organic matter that is being transported laterally and that remineralizes in the upper box. This stimulates the biological activity which produces more organic matter which is sinks out of the upper ocean. In that case, NCP is not changed (the increase in PP compensates for the remineralization of the laterally supplied organic carbon) and export is increased which increases DeltaE. This two mechanisms should be explained here, especially because in the discussion section it is shown that the second process dominates.*
We thank Referee nr.1 for his/her comment and we agree that it would be relevant to introduce this discussion before. In response we will use this suggestion and already explain the two possible mechanisms in the Results section, and then reconnect to this passage in the Discussion section where we discuss their relative contribution.

DC10: Page 20, line 22 *"and quantify the contribute of the different zonal bands ..." I guess it should be contribution*
Thanks. Will be corrected.

DC11: Page 22, line 25 *"and quickly channel water ..." It should be channel.*
Thanks. Will be corrected.

DC12: Page 24, line 8 *"becomes particularly important the offshore waters" Some words are missing here.*
Thanks, we will correct it to “important in the offshore waters”

DC13: Page 25, lines 18-20 - *The splitting between the contribution of the mean flow and of the eddy transport is not really clear here. See my second major concern above.*
We will be more specific and add a more detailed discussion of the mesoscale contribution as mentioned in our answer to the second major comment.