Biogeosciences Discussions

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Comment on bg-2021-114

Anonymous Referee #2

Referee comment on "Seasonal flux patterns and carbon transport from low-oxygen eddies at the Cape Verde Ocean Observatory: lessons learned from a time series sediment trap study (2009–2016)" by Gerhard Fischer et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2021-114-RC2, 2021

General comments :

This paper provides a precious data set of moored particle traps (1 and 3 km) off the African West coast, North East of Cape Verde, in an area where low oxygen eddies are frequent. I find high value in the data set presented, and recommend publication, but feel a number of important issues need to be addressed prior to publication. I'm not sure that the authors really provide strong data to evidence the effect of low oxygen eddies on C export efficiency, since, as I understand it, not all eddies reported are low oxygen systems. This distinction lacks clarity in the manuscript. Some efforts on identifying these low oxygen eddies in the figure or the text should be made, or maybe reformulate the paper's title to better fit the paper's data content ? I also have some issues with a few of the hypotheses developed in the paper, as explained in details below. Also I have some issues reconciling the presence of a fossil (to the best of my knowledge, but I could be wrong) diatom (*Borogovia*) in the traps, with the dismissal of sediment resuspension events ? I was a bit frustrated not to have more details on diatom cell counts and sample imagery data which could have helped support some of the hypotheses made more strongly. I would also suggest broadening the literature citations to better place these data in perspective.

Detailed comments :

-The carbonate content is the dominant flux in the traps (from Figure 6), what is the origin of the carbonate, this is not discussed at all ? Is it from forams, pteropods, coccolithophores, and why is this flux not discussed in relation with the Corg flux ? Is the Carbonate included in the lithogenic flux component in Fig 7 (if not, could the results be added to this figure)? If this is calcite from organisms, this should be distinguished from lithogenic material, as BSi is.

-I have difficulties identifying in Fig 5 and 6 if "ACME" events are also low oxygen eddies events. Could you make the distinction between eddies clearer in your figure legends ?

Line 19 : low oxygen eddies are mentioned a bit abruptly without introducing why they are of importance in this area. Maybe add a reformulation of line 40 "The eastern tropical North Atlantic hosts one of the major Oxygen Minimum Zone of the world oceans..." before this to give a bit more context.

Line 24 : "quite consistent **sine-wave flux**". From your figures, the mass flux does not really match with this description, which is OK for Figure 2 (Chla/SST). Maybe change this term ?

Line 32 : "large diatom aggregates are formed due to strong sear" Sometimes turbulence or shear stress is invoked for aggregation or disaggregation processes". Please substantiate the hypothesis with references (maybe later in the text).

Line 65 : "High phytoplankton and particle concentration, **high carbon degradation**... have been reported (Fiedler etc...)." How do you reconcile these data with your statement line 70 : "it is assumed that organic carbon attenuation of larger particles in the water column is reduced..."

Line 85 : "(e.g. eddy OPAL)". Please add a reference for this information, is this a program, a particular eddy observed in one of the previously cited papers ?

Line 89 : "Oxygen to total nitrate stoichiometry in an ACME north of Cape Verde was found to be twice as high (16) compared with surrounding waters (8.A)" I don't understand this, do you mean nitrate to oxygen ? In a low oxygen eddy, wouldn't you expect the oxygen to nitrate ratio to be lower than in surrounding waters ?

Line 105 : "additionally, we found a massive increase of organic matter flux with increasing depth, pointing to particle flux focusing (Fischer et al., 2016)." What about sediment resuspension ? Do you have data to substantiate this ? In Fischer et al 2016, the authors state : « Resting spores of several coastal species of Chaetoceros, and tycoplanktonic/benthic Delphineis surirella, Neodelphineis indica and Pseudotriceratium punctatum, are secondary contributors. » Does the presence of benthic species such as these, also not point to sediment resuspension or nepheloid layer circulation from the African west coast plateau offshore ? Is it completely excluded that these species could originate from the Cape Verde's plateau ?

Line 131 : "as a consequence, the mooring, which has it head buoy" typo "it**s** head buoy".

And subsequent phrase : if the head buoy was mostly in an upright position, does it mean it was sometimes reversed ? and how do you infer from that, that the sediment trap had no tilt or that it did not affect collection efficiency ? I find no such details in Fischer et al. 2016 ?

Line 147-148 : I find the justification for the positioning of the catchment area NE of the trap a bit light, could retro-trajectories modelling not be used to better infer the surface catchment are of the trap ? Have you tried varying different positioning of this rectangle to see if this modified your results?

Line 154 : Can you please explicit what you use as "seasonality index" ? it is not clear from the cited reference what this refers to exactly ?

Line 160 : BSi extraction method : how is the formula used to express BSi in mg ? SiO2 ? Si ? SiO2nH2O ? please explicit the molar conversion used. Also please add the total extraction time for the leaching method. How sure are you of the absence of leachate from labile LSi which can be digested in NaOH?

Line 206 : " Unfortunately, oxygen data were not available for the winter season in 2016 but the relationship to the salinity values (Fig 3b) suggest that a low-oxygen ACME was passing in winter 2016 as well." This relationship is not very clear from Fig 3B, could you substantiate this assertion with a correlation or another statistical test?

Line 240 : I have never heard of the diatom genus *Bogorovia* before, and looking up the literature this appears to be a fossil genus, mostly found in Neogene sediments. Worms also indicates this genus as fossil https://www.marinespecies.org/aphia.php?p=taxlist

Could you comment on how you find these diatoms in the traps? Are there some species indeed still living (please substantiate), and if not, this rather proves, maybe also supported by higher mass fluxes in the bottom trap, that some sediment resuspension occurs from the seafloor. This should at least be discussed somewhere. Also how would this affect your BSi measurements with the method chosen if abundant sediments are found in the cups ? How can you distinguish between particle focusing from above, and resuspension from the sea floor/lateral advection ?

Line 247 :

In this first sentence you mention overall composition (is this an average value for all trap samples, a yearly average ? please explicit) in the upper and lower traps, but this does not refer to Fig 6 ? I am missing a figure that would translate Fig 7 for instance into

relative % contribution of each fraction along a temporal line.

Line 257 : "only organic carbon content remains rather constant, despite...". What about absolute amounts, are these constant also, or do they decrease with depth?

Figure 6 : I'm not sure I understand the rationale for choosing these particular dates in the upper trap only, please elaborate in the text as to why.

Line 274 : the authors cite Fisher et al 2016 to corroborate the focusing hypothesis, but I find nowhere in this paper any proof of that. It is also a mere suggestion in that paper. The authors should discuss the different possible explanations (resuspension, lateral advection from another catchment area?, sediment trap collection efficiency ....) as the sediment focusing theory is not convincing as presented. Could the composition of these particular deep samples help in anyway ? For instance is the proportion of *Bogorovia* high in this sample (could point to resuspension) ? Is it ever found in the upper trap or in the lower trap only ?

Line 320 "Overall, only winter organic carbon fluxes showed a tendency to increase with satellite chlorophyll (table 3) but this relationship is statistically not significant." Indeed,there are only 5 points in this table, and lack of correlation is obvious. Please add p values or reformulate this sentence according to data. Also please specifiy if you mean organic fluxes in the upper trap only or both upper & bottom traps.

Line 325 and paragraph : can you comment on the differences in seasonality between your study and others carried out in the North Atlantic (for instance PAP where high fluxes are usually recorded in summer) ?

Line 333 : the "flux focusing within a funnel-like structure (Fischer et al., 2016) " is again not explained nor substantiated in the cited paper. Can you find other references for this process maybe?

Line 334 : Table 2. Please add the legend to your column headers (full name of the parameter and unit). In table 2 you use Carb, in table 3 CaCO3, please use consistent terms. I seem to better understand now that Figure 6 and Table 2 show the fluxes composition or correlation during the passage of an ACME. But is there any information to be given about their oxygen content ? are they all low oxygen ? Maybe indicate this somehow as also suggested for Figure 4 & 5 (see below).

Line 342 : the authors state the hypothesis that large diatoms aggregates form at the eddies edges and sink passively. Why are grazing and transfer via fecal pellets ruled out in

this explanation? Were the cup samples observed in microscopy for fecal pellets or aggregates?

Line 357 and following : This is an interesting result, more than half the yearly diatom flux reach the traps in less than 70 days. Again why is the grazing hypothesis ruled out so swiftly ? The cleaning treatment of diatom valves is most likely to have disaggregated any organic material covered aggregates or fecal pellets, any direct observations made?

Line 362 : "the decline of the diatom maxima" where ?

Line 372 : I don't really understand the explanation for the discrepancy between the two BSi peaks in the trap in 2016 and the diatom valve peak. The two distinct BSi peaks are associated to super low diatom valve flux, how is this possible? The difference in Si content between small but highly silicified cells such *Chaetoceros* resting spores or *Thalassionema nitschioides* var *parva* and slightly larger pennates does not seem like a credible explanation. Are pictures, maybe SEM images or cell counts data (with cell size) available for each of these cups? The fluxes in BSi and diatom valves seem completely anti-correlated for 2016. Has a mix up of cell count samples been envisaged? BSi and Corg fluxes seem consistent.

Line 383 : "However, small particles seem to react differently and show a normal to higher attenuation". A normal to higher attenuation compared to what ? Large particles ? Is this phrase addressing your results, or those of Rasse and Dall'Ormo, I'm confused.

Discussion overall : I find the discussion section a bit confusing, contradictory hypothesis are invoked but no clear data really helps one way or another. There is a relative smaller use of the literature in the discussion section to help explain potential processes, and it is mostly focused on companion papers and does not really place the study in a broader perspective. I feel this section could be reworked a little to make its conclusion more credible.

Conclusion : I would suggest editing your conclusion as to remove the bullet points format.

Line 447 : still not convinced by this. If smaller diatoms are conveyed to depth within larger fast settling diatom aggregates, then there should also be a lot of OrgC associated to these aggregates, and figure 5 shows a low point in Corg fluxes as well during this valve peak event similarly to low BSi.

Flux data such as these are precious, I suggest adding a supplementary in which all flux

data per cup for all fractions (total mass, BSi, Carbonate, Corg, Lithogenic) can be found.

Discussion/References

Other historical long term surveys of mass flux, with specific composition, at PAP but also at BATS have been highly documented for the North Atlantic, yet I did not really see citations or comparison of your data with these studies, I believe the discussion could improve with this perspective.

Figures

Fig1 : 1B. What is the time coverage of the composite chla images ? one month, 3 months ? please specify. Also could you add the white rectangle to your Fig1b for better assessment of surface heterogeneity ?

Fig 2 legend : line 677 : "wi sp su fa" there seems to be a typing or format glitch here. Oh this means winter spring summer fall... this did not occur to me before long, please clarify this text.

Fig 3. Maybe add a panel c for statistical correlation/relationship between these datasets ?

Fig. 5 the relative contribution of each fraction (to 100%) in a panel d, along the same temporal axis would be a helpful addition to your figure.

Figs 4 and 5. I find the legend of ACME difficult to relate to one cup measurement in particular. Could you maybe draw an arrow to show which bar is concerned by the passage of an ACME. Also, I would find it useful to identify on these figures somehow the passage of low oxygen eddies ? It's very difficult to overlap Fig 3a to Fig 4&5 mentally.

Fig6. the choice of these events is not very clear from the text nor from the legend, what do the authors want to show with this particular figure ?

Fig 8 . the grey shaded area is very faint when printed. But OK on the electronic version. I also suggest choosing two disctinct colors for your sinusoids and fig C. Such subtle shades of green are difficult to distinguish for many people.

I find Fig.8c very briefly invoked in the discussion (paragraph from line 322-339), and again I don’t really understand what is this seasonality index, and how are the values 2.3 and 2.6 calculated ? this figure needs to be better explained/justified, or removed.

Figure 9 : is there any way to estimate a C transfer efficiency from your dataset ? Can the rectangle data with Chla averages be used to convert into surface POC to calculate this ?