

Biogeosciences Discuss., author comment AC1
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Reply on RC1

Gerhard Fischer et al.

Author 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.,
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Comment on bg-2021-114 Anonymous Referee #1

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

RC#1 General comments

Fischer et al. use the time-series (2009–2016) sediment trap record of downward particle flux to 1 km and 3 km depth at oligotrophic site Cape Verde Ocean Observatory (CVOO) to investigate the transfer of particles from different types of eddies against the oligotrophic conditions. Specifically, they focus on the flux peaks observed during fall and winter period when low-oxygen Anticyclonic Midwater Eddies (ACME) passed over the sampling site and compare meso- and bathypelagic particles fluxes to oligotrophic conditions. The authors show that during the passage of low-oxygen eddies in late fall and winter the particle flux at CVOO significantly exceeded fluxes during oligotrophic conditions in spring and summer. A strong seasonal pattern of increased diatom fluxes was observed during the passage of ACMEs, which authors attributed to the pulsed nutrient injection by eddies stimulating the growth and subsequent export of diatoms. Fischer et al. also reported the reduction in carbon flux attenuation between 1 and 3 km depth during the passage of low-oxygen eddies. They suggest that higher POC fluxes compared to oligotrophic settings are eddie-induced and may result from a combination of higher surface production owing to upwelled nutrient supply, increased aggregation of small diatoms at the eddie boundaries, and low oxygen concentrations within eddies which hinder both the degradation of organic matter and zooplankton grazing.

An interesting observation is of BSi flux exhibiting higher seasonality compared to lithogenic fluxes and POC fluxes. The latter two also correlated well in years 2010 and 2012. Authors suggest that different particles have different source within ACMEs and also different transport pattern.

The study is methodologically and scientifically robust and builds on the earlier work by Fischer et al. 2016, which investigated the impact of hypoxic-anoxic eddie passage on the downward particle flux to the abyss at the same site in 2010. Now resolved at several

years (2009-2016), these observations of particle fluxes during the time of passing eddies, bring valuable insights into our understanding of impacts of low-oxygen eddies on the magnitude of carbon export and sequestration and controls over those. They also accentuate the complexity and variability of physical and biogeochemical conditions within mesoscale eddies (both cyclonic and anticyclonic), whose workings and impact on surface processes/production and downward particle flux still need to be understood.

I thus highly recommend the publication of this article in Biogeosciences. There are some comments below that I suggest the authors to address.

AC:

We thank reviewer #1 for providing the review of the paper. We are sure that his/her suggestions will greatly improve our manuscript. The complex variability and interaction of physical and biogeochemical conditions and the small-scale processes still require further multi-disciplinary research on different timescales and water depths within different types of eddies. Our manuscript further contributes to the understanding of the deep-water processes associated with eddies in the open ocean.

Specific comments

RC#1:

In line 147 the authors should specify which environmental data they used. It only becomes apparent in the results section that the authors refer to SST, wind speed and dust deposition data.

AC:

We clarified this issue in the revised version in chapter 2.2. (...MODIS chlorophyll, SST, surface wind speed and dry dust deposition rate).

RC#1:

Figure 2 shows an increase in surface chlorophyll following/during enhanced dust deposition. The authors should discuss the role of dust as a source of nutrients in addition to it being a ballast material and/or an inducer for aggregation.

AC:

Although this comment is correct, there is no statistically significant correlation between satellite dust deposition rate and chlorophyll concentration. However, the occurrence of major dust peaks shows a temporal correspondence with the maxima of the dust deposition rate. The role of dust as nutrient source for marine production is a matter of intense debate and is discussed controversially. It is a complex issue and we tried to omit this discussion and -instead- focussed on the role of dust for aggregate ballasting (which mainly bases on our research experience). Some researchers argue that dust plays no significant role in the open NE Atlantic Ocean influenced by coastal upwelling (e.g. Neuer et al. 2004, GBC), while others suggest a positive effect of dust supply (e.g. Fomba et al., 2014, ACP) on coccolithophorid production in the pelagic Atlantic (e.g. Guerreiro et al., 2021; L&O). In the revised manuscript, we tried to find a compromise and included a short section on this issue in the discussion section chapter 4.1, including the relevant

references for this study area.

RC#1:

Lines 330-345: the discussion of the particle sources needs to consider local particle formation (within eddy interior and boundary) or remote whereby particles have already been formed away from CVOO and travelled to the site within the eddy. The source and hence age/state of particles might also influence the observed C:N ratios of the particles reaching the traps.

AC:

This is right and we discussed this in the section before Line 330-345. From a relative high seasonality in the deeper traps, we concluded that lateral advection is less relevant at site CVOO and particles derived mostly from local eddy sources. A high lateral component in the deeper traps would lead to a more smeared flux pattern with less seasonality. However, we observed the opposite. We now clarified this in the new version at the end of section 4.1. In Fischer et al. (2016), flux focusing is discussed for the CVOO-3 time series (2009-2010), meaning a 2-3 fold increase in all bulk flux components with depth at the same time in winter 2010. Also, the lithogenic fluxes show an almost perfect relationship between upper and lower traps ($R^2=0.97$, $N=17$, $p\text{-value} < 0.05$). This observation also points to more local particle sources within the eddy and a particle concentration mechanism ('wine class effect', e.g. Waite et al. 2016) within the 2010 low oxygen ACME (see first chapter in 4.1.).

C:N ratios were discussed in the lower part of chapter 4.3. We now added this comment of reviewer #1. However, the extremely high C:N ratios in the range of 15-20 (winter ACME 2010) are best explained by nitrate limitation (Fischer et al., 2016).

Technical corrections

RC#1:

Keep consistent with how subplots are labelled (capital letter in Fig 1 vs lower case letters in other figures).

AC:

We accordingly changed to lower case letters in Fig. 1

RC#1:

Figure 1A: colour bar needs a title

AC:

It has been corrected.

RC#1:

Line 673: refer to link in text instead of providing it in figure caption.

AC:

This follows BG editing standards, as it was a correction of BG after the initial submission. The link is given in the text as well (chapter 2.2).