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Interactive comment on "Mesoscale contribution to the long-range offshore transport of organic carbon from the Canary Upwelling System to the open North Atlantic" *by* Elisa Lovecchio et al.

Anonymous Referee #1

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This study investigates the role of eddies and filaments in offshore carbon transport in the Canary Upwelling System, using Reynolds decomposition, and structure based eddy and filament decomposition to the results from a coupled biogeochemical model. The results indicate that the filaments provide the most intense and fast lateral transport within the regions 1000 km from the coast, with long-range isolated conduits to the farther offshore regions >2000 km caused by mesoscale eddies, with the dominant contribution from cyclonic eddies. These results are important findings for Canary Upwelling System, where there has been no such comprehensive study conducted so far. However, I have several concerns, which should be addressed by the authors before its publication. One of these issues is that the mean vertical carbon flux presented

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in Figure 6c and 8c. There seems to be clear contrast between northern and southern regions separated at C. Blanc in plan view of the vertical carbon flux, which looks somewhat similar to the distribution of the mean meridional flux in Figure 6b. Also, in the vertical section, there is an upward flux at 60-70 m depths, right under and above the downward carbon fluxes. I'm puzzled by these mean vertical and meridional carbon flux distributions, and consider that this needs to be clarified. Also in some part, although the authors tried to explain the resultant interesting patterns obtained by the Reynolds decomposition and structure based extraction of eddy and filament contributions, they are often stated without sufficient evidence and would make readers feel that they are rather speculative. For example, the high covariance between anticyclonic eddies and carbon anomaly in northern offshore, is explained by the upwelling induced by the anticyclonic eddy spin down, without any analysis. To be concise, section 6 and 7 could be combined into one section. Other specific comments are as follows.

P2L13 "Coastal filaments are narrow (<50 km wide) structures that extend from the coast to several hundred kilometers into the open sea with rather large velocities (between 0.25 and 0.5 m s-1) " Is this velocity in "with rather large velocities (between 0.25 and 0.5 m s-1)", propagation speed or current velocity?

P2L15 "Offshore transport by filaments is typically accompanied by intense subduction, due to the high density of the cold upwelled waters" The subduction is intense in the cold filaments because frontogenesis at a cold filament generate two cell ageostrophic cross-frontal circulations, which work together to restratify the two fronts at the edge of the filament, and to narrow the width of the filament, producing the strong downwelling in the filament. This sentence seems not accurate, and I suggest that it should be modified with a reference of McWilliams et al. 2009, Cold filamentary intensification and oceanic surface convergence lines".

P2L26 "These non-linear structures propagate with velocities of a few centimeters per hour, about one order of magnitude slower than the filaments . . ." "a few centimeters per hour" is 10 μms-1, and should be too slow for the mesoscale eddy propagation speed.

P4L17 “CanUS also showed that eddies tend to reduce coastal production through the lateral export of the upwelled nutrients ” I think that the reduction is caused by both lateral and vertical nutrient transport.

P5L8 “F =F +FâĂš, were ” Typo. “were” should be “where”.

P6L4 “The last term r = uCâĂšorg + uâĂšCorg term represents the sum of the residuals which we verified to be small, at least one order of magnitude or more smaller than the other terms” The original rule of the Reynolds decomposition is that the mean of the fluctuation is zero, and the mean of the mean is the same mean, but the authors’ choice allows non-zero values for the former, as we as difference between the mean and the mean of the mean. Is there any difference between the results using the original method, in which monthly average has just one value at each grid point for each month, and that with the authors’ method? If the difference is about 10%, which is the order of magnitude of r, then which method is better?

P6L20 “First, the above reference mean SST field. . .” This definition of the filament, does not include any shape criteria, and allows the region between straight upwelling front and the coast to be detected as a filament. Is it okay?

P7L21 “representation of turbulence” should need “geostrophic” after “of”. The term “turbulence” throughout the manuscript sounds not adequate as it includes the meaning of three-dimensional microscale turbulence. The scale of the “turbulence” should be specified, or replace “turbulence” by “eddy”

P8L1 “The AVISO datasets. . .”. The 1/4 degree is the resolution of the grid for mapping, the actual AVISO sea surface data’s resolution should be even coarser.

P11L2 “small eddies are abundant found in the. . .” This should be “small eddies are abundantly found in the. . .” or “small eddies are abundant, and found in the. . .”

Figure 6c mean vertical flux Why is the mean vertical flux directed upward in a fairly wide region in the southern part, and vice versa for the norther part? Is it vertical flux of omega flux, in which horizontal flux can contribute through the sloping grid bottom faces?

Figure 7e What is the green color?

P16L4 “Switching to the vertical fluxes, the differences between the mean and turbulent flux components are even more pronounced“ and Figure 8c. I’m puzzled by the mean vertical carbon flux. The bands of down-up-downwelling flux indicates the increase of carbon at 20 m and the decrease at 80 m depth on average, unless there is compensating lateral flux divergence. I don’t understand how the Ekman pumping results in this structure.

P16L30 “This signature is typical of that expected from an eddy-induced vertical displacement of the nutricline (McGillicuddy, 2016). ” If this is the case, the eddy is linear Rossby waves, and not trapping to carry carbon when it propagates. I think eddy propagation speed c is a few centimeter per second, and velocity u > 0.2 m/s, so u/c>1, suggesting that eddy is nonlinear, which can hold a large volume of water inside to travel together westward, which is the dominant signal discussed in this manuscript, rather than wave induced isopycnal displacement.

P17L7 “In the offshore waters, ACE can also. . .” Is this mechanism same as the warm core eddy spin down, accompanied by weak upwelling at the center (e.g. Frictionally induced circulations and spin down of a warmâĂŘcore ring by Glenn R. Flierl and Richard P. Mied)? Do you have any evidence to support that this is the cause of positive C’org within ACE?

P22L3 “Between 100 km and 500 km from . . .” and Figure 15d The structure based estimate mean flux divergence between 100-500km is negative. Does it mean that the mean flux is removing the carbon from the shore? If so this makes sense, because Ekman transport from the coast should act to remove carbon from the shore. But the distance is somewhat too far from the coast. Why does it start from 100 km not 0 km?

Also, in Figure 15, why does the Reynolds decomposition based mean flux divergence in 100-500 km show different results from the structure based results?

P22L12 "...offshore reach due to the their..." remove "the".

P22L19 "...mean deflection of their trajectories (Chelton et al., 2011)" The earlier study should be included "McWilliams,ÂăJ., andÂăG.ÂăFlierl,Âă1979:ÂăOn the evolution of isolated, nonlinear vortices.ÂăJ. Phys. Oceanogr.,Âă9,Âă1155–1182."

P22L28 "In particular, ACE are responsible for the northward ... due to their relatively fast decay that results in a slowing down of the clockwise rotation while they move offshore, these eddies induce a net northward transport of Corg" I don't understand this explanation for the net northward carbon transport by ACE. Considering the positive carbon gradient in zonal direction with clockwise stirring, the southward transport should be stronger. How is this result related to Reynolds decomposed eddy meridional flux in Figure 6e?

P22L31 "In the vertical direction..." I don't understand why NE-NF vertical flux is the stronger than eddy components. Also do these vertical carbon fluxes reflect the lateral structure of the vertical flow itself or carbon distribution? For confirmation, the total mean vertical flow at 100 m depth should be presented in appendix. The mean vertical flow should be largest at $\sim$O(10-5 ms-1) along the coast with the internal Rossby radius as the lateral width, which is very narrow compared to the model domain.

P23L4 The convergence at filament is revisited with the theory of frontogenesis by "McWilliams et al. 2009, Cold filamentary intensification and oceanic surface convergence lines"

P25L15 "Nagai et al. (2015) showed that this subduction happens primarily at the filament tip..." Remove "tip" and insert "periphery of" before filament

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