Detailed response to the reviewer

First of all, we would like to thank the reviewer for her/his constructive comments, which have allowed further clarification of the manuscript. We have addressed each of the concerns as outlined below.

Specific Comments from the Reviewer

P4 L3 "However, the magnitude of simulated nitrite is lower compared to the observations." Is this sentence for the inshore nutrients?

Yes, the underestimated nitrite is on the inshore. Sentence is now clarified, as follow:

Addition to the text, section 2.1, page 4, line 2:
However, the magnitude of simulated inner-shelf nitrite is lower compared to the observations

P5 L7 "Despite reproducing the subsurface nitrite maxima, the simulated concentrations are an order of magnitude lower compared to the concentration within the observed eddy" Which observation is this? Is it in-situ observation?

Yes, the mentioned observed eddy correspond to an in-situ observations. Sentence is now clarified as follow:

Addition to the text, section 2.2.2, page 5, line 7-8:
Despite reproducing the subsurface nitrite maxima, the simulated concentrations are an order of magnitude lower compared to the in situ observations of nitrite concentration within eddy (Stramma et al, 2013).

P6 L6 "and and" Remove one of two "and".

Changed accordingly.

P6 L29 "These results show that the low nitrate (high nitrite) within the eddy Asim is not primarily controlled by local biogeochemical dynamics within the eddy Asim" What missing in the presented analysis in Figure 7 and 9 is that there is no information about the time evolution of the eddy volume. In addition, as the eddy travels, some portions of the water can be transported as the eddy flux depending on the nonlinearity i.e., u/c, where u is the current velocity of an eddy and c traveling speed of an eddy, and some water is not. This is problematic. If the volume of water, which the authors tracked for the analysis in Figure 7 and 9 is all trapped within the eddy, all variations in tracers must be controlled by the local processes. In contrast, if the eddy is a completely linear wave, and no water is fluxed by the eddy, the biogeochemical

processes within the tracked eddy (wave) is all nonlocal processes. Instead, it is just looking at different water column as the wave propagates. In reality, as authors pointed, some water is held inside the eddy and some not. In summary, it is very difficult to say if it is caused by the local processes or not, if the volume of the water is varied as the eddy evolves.

First, we would like to clarify the term local processes. In this study the local processes refer to the biogeochemical processes (which are the source-sink terms) occurring within the eddy structure. Indeed, if the eddy does not exchange water properties with the surroundings, the tracers quantities will be affected only by the local processes. This is not the case for the analysed eddies. The water masses as well as the tracer fluxes show some exchange of water with surrounding environment while the eddy moves. This gives an indication that remote processes can influence the tracer dynamics within the eddy.

Further, the eddy volume varies as the eddy moves, mainly due to changes in horizontal structure of the eddy. This variation of the eddy volume is accounted while calculating the contribution of the local processes on a concentration basis, i.e. per cubic meter. We admit that there is no perfect way of describing local and remote processes in a changing water volume. We thank the reviewer for the suggestion to show the variations in the eddy volume, which gives the reader a chance to better understand what is going on.

The variation of the eddy volume is now presented in the supplementary information.

We have added to the section 2.3, line 23 " (Fig. SI-2 in supplementary information for further details)."

Figure 7 Caption "Bsim" should be "Asim".
Changed accordingly.

P7 L13 "In the eastern tropical ocean, eddies have been observed to carry low-oxygen waters out of the core region of the OMZ"
Is this applicable for only anticyclonic eddies or both cyclonic and anticyclonic eddies?

So far and to our knowledge, observations only show anticlyclonic eddies carrying low-oxygen waters out of the core region of the OMZ. This is now clarified.

Addition to the text, section 3.2, page 7, line 9:
In the eastern tropical oceans, anticyclonic eddies have been observed with low-oxygen waters out of the core region of the OMZ.

Figure 10 and 12, and related text
The unit of the flux is not for flux. It is flux divergence.
Similar to the comment for Figure 7 and 9, time variation of the volume tracked is needed.

Changed accordingly. The variation of the eddy volume is now presented in the supplementary information.

We have added to the section 2.3, line 23 " (Fig. SI-2 in supplementary information for further details).”

Figure 11 and 13 and related text
These results are rather descriptive hydrography in the numerical model, and sounds more like discussion as the authors speculate the importance of the advection just by the T-S diagrams. If water properties are horizontally (along isopycnally) uniform, T-S properties are unchanged by the lateral (along isopycnall) advection. These water exchanges could be addressed more quantitatively by the Lagrangian particle tracking.

The Lagrangian particle tracking is presented in the manuscript, section 3.3.

P8 L20 “(Fig. 11-e-f).n)”
There is no panel n.

Sorry about this typo. This is now removed.

P9 L7 “Subsurface anticyclonic eddies…”
I did not realized a fact that this study focused on the subsurface anticyclonic eddies. If so, these previous studies for mode water eddies or under current eddies should be in the introduction. If the study is focused on the subsurface eddies, the detection method needs to be modified for them.

The study focus on the mode water eddies. Altabet et al. (2012) and Stramma et al. (2013) are mentioned in the introdution, on page 2, line 2-5.

We do not agree with the reviewer comment on the need of change the detection method. As for the observed mode water eddies in the region off Peru and tropical North Atlantic Ocean, the simulated mode water eddies present a surface signal on the sea surface height. This characteristic allows a detection by the method applied in our study.

P9 L27 “similar the observed” should be “similar to the observed”.

Changed accordingly.

P8 3.3 Eddy stirring and nutrient entrainment
It is good that the authors conducted a Lagrangian simulations. The results would show importance of the water exchanges, but are not clear. This is because these entrained particles do not necessarily represent the main body of the water inside the eddy. It is better if the particles are back tracked from the inside eddy with different depths. This is more direct to know where the water comes from.

The back tracking of particles from the inside eddy would indeed tell us the origin of the particles present at a given time during the eddy propagation. This would, however, not tell much about the exchange with the surrounding environment during the eddy propagation, which is one of the themes of that subsection. By analysing the particle dynamics during the eddy propagation, we could show that the eddies in this region exchange properties with the surrounding environment and that this contributes to the dynamics within the structure. Else, it also emphasizes that the concentration of a given tracer at the vicinity of an eddy structure can substantially affect the tracer's concentration within the eddy.

Figure 14b includes the number of particles inside Asim and shows that it is not largely changing compared to that of other eddies. This is not consistent with the claim that there is strong advective inputs of nitrate into Asim.

In the first month, the eddy A_{sim} have lost around 40.10^6 particles/liter, a number much higher compared to the other eddies. We would like to call your attention to the scale variation in the Figure 14b.

We have added to the figure caption "Note the change of the scale on the vertical axes."

P9 L27-33 "In the low nitrate (high nitrite) Asim eddy (Fig. 4-c), the on-going nitrate reduction by denitrification is lower than the nitrate production by nitrification. This fails to explain the low subsurface nitrate within the eddy, which is in contrast to the interpretation of the observations by Altabet et al. (2012) and Stramma et al. (2013). Further, we find in our simulation that the advective fluxes across the edge of the eddy Asim shows a strong nitrate supply into the eddy, in the first days prior to the eddy formation. This nitrate supply, which is predominately horizontal, is a consequence of the exchange of water masses with the surrounding environment during the eddy propagation."

I'm confused by these sentences. The results indicate that local biogeochemical processes, which imply increase in nitrate, and the advective flux divergence also results in a net increase in nitrate. So both estimates cannot explain the low nitrate inside the eddy?

The reviewer is correct, both local processes and advective fluxes of eddy A_{sim} show a net increase of nitrate. This shows the complexity and points out that the origin of supplied water is of importance when interpreting eddy dynamics. At the instant following the eddy formation both shelf and offshore waters are present within the subsurface layer of the eddy interior. However, the offshore waters, depleted in both nitrate and nitrite, dominate the water masse properties. During the eddy propagation, shelf waters dominate the water masses within the eddy interior, as shown in the TS diagram. Shelf waters have relatively high nitrate concentrations and are rich in nitrite in comparison to the offshore environment. This results in the net nitrate (nitrite) supply during the eddy propagation.

This analysis is now clarified in the manuscript. To simplify the analysis, the Figure 11-i-l and 12-i-l (as well as in the supplementary information) show temperature, salinity and tracers at 200 m depth, which is the lower limit of the eddy volume instead of 250 m depth as previously shown.

Addition to the text, section 3.2, page 7, line 32-34 and page 8, line 1-5:
Further down (at 200 m depth), warmer and saltier shelf waters dominate the properties within the eddy A_{sim} (Fig. 11-i,j). At the eddy formation, both shelf and offshore waters occupy the eddy interior (Fig. SI-3-i-k). The surrounding offshore waters have higher concentrations of both nitrate and nitrite (Fig. SI-3-k,l). With the eddy propagation, water properties are modified (Fig. 11-k). Shelf waters, which have lower nitrate concentrations compared to the offshore environment, are kept in

the eddy centre and advected during the eddy propagation (Fig. 11-l). Thus, the nitrate concentrations in the eddy interior are lower than those of the surrounding waters, even though interior concentrations show an increase over time during the propagation of the eddy.

P10 L27- "The model results show a decoupling between local nitrate reduction (nitrite production) via biogeochemical processes and total changes in nitrate (nitrite) within the eddy"
As mentioned in my comments above, it is difficult to separate local and advective processes, because how much water is trapped affects the locality with respect to the moving eddy.

We are sorry about the confusion. This, as well as the comment to P6L29 is the consequence of us having failed to define "local processes". We have done this now in the revised version of the manuscript: "Local processes" refer to local, on-going biogeochemical sources and sinks (as opposed to the effects of divergent physical transport processes or initial conditions)

As it is clear in the conclusion, the results of this study could not successfully close the budget. The both local and advective processes do not explain the nitrate concentration within the eddy quantitatively.

The aim of the present study is to understand the processes effecting nitrate patterns within the eddy. To address this objective, we looked at different processes, which had been suggested previously. We could demonstrate that local biogeochemical processes alone cannot quantitatively explain the observed patterns. We then analysed both water mass properties and advective processes. This analysis has shown the complexity of dynamics within the eddies, where many processes impact on the tracer's distribution. We could see that (1) the conditions at the place of eddy formation imprint a long-lasting nutrient signature within the eddy. (2) These initial conditions are modified by physical transport processes occurring at the edge of the structure. The contribution of advective processes on the nutrient signal within the eddy was quantified.

These results have been supported by Lagrangian particle tracking. If we take as example the eddy A_{sim}, which was formed close to the source of particles release, it exhibits a high amount of particles within its core. When the eddy moves out of the particle-release source, the number of particles declines. This is mainly due to exchange with the surrounding waters poor in particles.

The conclusion of the present study was, therefore, based on these three elements (1) local processes, (2) origin of trapped waters and (3) advective processes.

P11 L1 "shaping the nutrient patterns within cyclonic eddies"
Where are the results for cyclonic eddies?

We were suggesting that the water mass exchange with surrounding environment might also influence the nutrient pattern within cyclonic eddies, even though we do not yet have any direct evidence for this claim. This sentence is now removed from the new version of the manuscript.