

Interactive comment on “High-resolution physical-biogeochemical structure of a filament and an eddy of upwelled water off Northwest Africa” by W.-J. von Appen et al.

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Received and published: 17 January 2020

We thank the reviewer for their very positive general assessment of the paper and for the specific suggestions that improved the quality of the paper.

Please note that we also added an additional piece of information in section 2 (old line 96) on the technical setup which we had forgotten before: “The Triaxus flew a so-called saw-tooth pattern (Figure 1a) and was slightly deflected to the side by yaw flaps so as not to measure in the ship’s wake.”

Comment:

C1

I am puzzled by some of the information in the paragraph beginning on line 236. I think the authors are arguing that the + nitrate excess in the core of the anticyclone is due to 1) upwelled water with high nitrate, low DO (high AOU), and zero nitrate excess; 2) the residence time in the ML before the water is subducted in the eddy formation is $\hat{\Delta}$ ij weeks; 3) the residence time is long enough for air-sea flux to raise DO (lower AOU), but too short for PP to lower nitrate and hence leads to + nitrate excess. I am not an expert on this subject but time scales of O(weeks) seem long enough for PP to be significant. Further down in the manuscript it is mentioned that the phytoplankton doubling time is 1-2 days. Or am I misunderstanding the argument?

Response:

We assume that your comment regarded the paragraph beginning on (old) line 321 (not line 236).

We appreciate that the reviewer made us think through the argument again. We think that the argument about the time scale over which primary production acts was an inadvertent red herring. We have removed it from the discussion on the nitrate excess and instead we clarified the role of gas exchange:

Added sentences: “Assuming that the correlation in Figure 7c corresponds to the near Redfield behavior of phytoplankton growth and remineralization in the study area, primary production and remineralization acting in a parcel of water can move it parallel to the correlation line (black line in Figure 7c), but not change its nitrate excess (i.e. move it further away from the line). A change in the nitrate excess can only be achieved by a process that acts differently upon nitrate than upon oxygen. Gas exchange with the atmosphere likely plays that role as it only acts upon oxygen, but not upon nitrate. The gas exchange rate also depends upon how far from equilibrium with the atmosphere (100% oxygen concentration) the parcel of water is. That is, the gas exchange rate will be faster upon upwelling of the extremely undersaturated water thereby pumping oxygen into the water from the atmosphere. This corresponds to a reduction of AOU and

C2

a corresponding increase in the nitrate excess. After primary production has acted, the water may be close to saturation or slightly super-saturated. However, because the water is closer to equilibrium then, the loss of oxygen to the atmosphere will be comparatively slower. Thus a nitrate excess can be present in the mixed layer relatively soon after upwelling (as measured by the relatively slow gas exchange near equilibrium). If the water gets subducted (stopping the gas exchange) during that time, a nitrate excess can also be observed later on.”

Delete sentences: “At the same time, the residence time in the upper ocean probably was not long enough for primary production to utilize available nitrate before the water was subducted. We hypothesize that the water in the core of the anti-cyclone during our section spent only a short time (åLijweeks) in the mixed layer before being subducted (i.e. removed from equilibrating processes in the mixed layer) to form the anti-cyclone.” and “In a similar sense, the filament south of 21°N must have been part of an offshore advection “highway” from the upwelling region whose advective time was short enough for the above argument to hold.”

Comment:

Line 92. I suggest that “. . .we describe the used data.” be replaced with “. . .we describe the data used.” or simply “. . .we describe the data.”

Response:

Changed to “we describe the data”.

Comment:

Line 125. I am a little confused about the statement of identical gradients traversed in opposite directions by the saw tooth pattern. Is the idea that the vertical gradient is essentially the same in the downcast as the upcast?

Response:

C3

Yes, that is the idea, but we agree that it was not clear enough in the original text. Thus we elaborated this point in more detail: “Near the upper and lower turning points of the saw tooth pattern (see Figure 1), the vertical property gradients in the ocean are traversed in opposite directions (upwards and downwards) within short periods of time. Since the gradients (at least on average) will not have changed over that time period, the upcast and downcast data should show the same. For temperature, this is roughly the case, but for other sensors it is not due to their sensor lag. Attempting to shift the sensor data in time with respect to temperature such that the gradients, on average, become identical allows for a determination of the sensor lag.”

Comment:

Line 236. I suggest changing “. . .small scale aspects that could be resolved at much higher resolution than by traditional CTS casts ...” with “...small scale aspects that were resolved at much higher resolution than would have been by traditional CTS casts ...”

Response:

We changed the wording similar to your suggestion to “small scale aspects that were resolved at much higher resolution than would have been possible with traditional CTD casts or with satellite observations.”

Comment:

Line 419. Replace “lead” with “leads”

Response:

Thanks for pointing out this problem, but we meant to use the past tense (see preceding and succeeding sentences) of “to lead”, not its present “leads”, hence we replaced it with “led”.

Interactive comment on Ocean Sci. Discuss., <https://doi.org/10.5194/os-2019-108>, 2019.

C4