

Interactive comment on “Upwelling and isolation in oxygen-depleted anticyclonic modewater eddies and implications for nitrate cycling” by Johannes Karstensen et al.

Anonymous Referee #1

Received and published: 13 April 2016

1 General Comments

The present article presents a series of observational surveys relating the existence of an oxygen-deprived mesoscale eddy core in the North Atlantic to near-inertial wave dynamics and (maybe) large-scale Ekman transport. A sequence of observations and hypotheses are suggested to account for the fact that the eddy is mostly isolated from the outside waters, but not quite. I'm actually still confused about what stays in the eddy and what gets in and out, but amendments to the articles should remedy it. At least that's my take on it is but, but I am just a physical oceanographer and I don't spend much of my time thinking about biogeochemistry.

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In general, the processing is well done, and the graphic depictions and the accompanying text show convincing signals, raising interesting scientific questions. I would be very happy if the authors left it at that, and maybe tried their hand at process guessing in a discussion section, with larger error bars around their allegations. But in my opinion, they stretch the interpretation of their data way too far about how things are fluxed in and out of the eddy (or not), and how it explains the property structure inside of it. As far as I understand the article, they just see very interesting patterns, but are not able to prove many pieces of their model anyway. Either they are wrong, in which case this piece of text will fall into oblivion (although fig. 7 might unintentionally enjoy some form of posterity), or they are right, and the credit will go to whoever is able to prove this mechanism. Either way, I don't think they'll get citations for that part of the text. And I don't think that the article needs that to be publishable. Unless this model heavily relies on data published in other articles of their series, in which case they should consider publishing a separate article, because no-one has the time to read a whole series.

Considering that 12 co-authors could have proof-read it, the number of typos and English mistakes is rather large, even for non-native speakers. Not being a native English speaker myself, I have to let the editorial staff to correct these mistakes, but I have a list of my own if needed. Quite often, the authors prefer to use common words rather than field-specific terms ('normal eddy', 'erosion'), which would be fine if it didn't lead to ambiguities.

2 Specific Comments:

I will now switch to 'you' when referring to the authors.

1. P01L32: you and I seem to disagree on the specific definition of the submesoscale range. Some authors have it ranging from 1-10 km

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(10.1029/177GM04), some others have it ranging from 1-50 km or even 1-100 km (10.1038/ncomms7862), but everyone seems to agree on a key value of 10 km at mid-latitudes, and $Ro, Ri = O(1)$ in general (which is perhaps the universally accepted definition). I'm fairly confident when I say that 1 km as an upper bound is too low, and 10 meters is too small, by a long shot. There has to be some influence of the Coriolis force, that I'm certain of.

2. 1st paragraph of the intro: I'm not sure how useful this paragraph is.
3. P09, last paragraph (continued P10): I don't understand this. Why would the accumulation of NIW energy in high-N environments around an eddy shield it from mixing? If you accumulate NIWs anywhere, they tend to break, and bring mixing right at the door of the core. It sounds like planting wasp nests around one's house to prevent a wasp invasion. The whole article is confusing actually. I didn't understand it until way after, when you showed fig. 7.
4. P10L4-12: I am not sure what this paragraph is about. My take on it: does mixing work differently for nutrients than it does for other quantities? But I'm still unsure of the answer.
5. P10L22-29: A bit of ray tracing would not add much work, and could greatly improve the credibility of your hypothesis.
6. P11L14-26: my take from this paragraph: there is now an exchange pathway between the mixed layer and the core. Then what about everything you said in the preceding paragraphs? Is there a contradiction or is this a different issue?
7. P12L29-P13L15: Same problem as above. I don't find this paragraph very convincing. It is an interesting scenario, but fig. 7 is not substantiated by diffusive fluxes measurement/estimates. If Beal 2007 actually has something to say about it, you might want to use her article more, not cite her in passing. My suggestion

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is that this part be moved to the discussion section, with a much more honest depiction of how little you know about why some properties are exchanged, and why some others aren't, and with a much more measured use of process-based interpretations (at least for the physical processes; I can't judge the chemistry part).

8. P11L11-15: I thought I knew what flux was until I read these sentences. What do you mean by flux? Advective flux, diffusive flux? What do you mean by erosion? What does the phrase 'NO₃-oxygen from the eddy core is primarily outward' mean? Why would a flux necessarily transfer stuff from the outside? Are you talking about a mass flux, which in all rigour should be advective? Or a diffusive flux, in which case you may or may not be right depending on the concentration distribution? And what non-dimensional number quantifies the statement 'erosion rather than flux'?
9. P11L27-32 and figure 5b: are this paragraph and figure the only ones that actually lay out your case for an influence of Ekman transport on the ACME? If so, it is a very weak case, not enough to make it to the body of the article in my opinion, and certainly not enough to make it to the abstract, Once again, it could make it to the discussion section, in passing. Thomas 2005 considers a wildly different parameter regime by the way, I don't see how it can help you support your case without more calculations.
10. P09L13: Could the low oxygen property have originated from the coast and simply have been transported all the way to here? I know that you report a decrease from 8 to 3 micromoles/grams over the course of the experiment, but I don't know the error bars on these measurements. And as far as I can tell, you simply say at some point in the text that the signal looks real or something, but that's not quite the quantified statement, especially since so much hinges on it.
11. P14L23-25: 'The NIW concept (...) numerical models': it depends on which mod-

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els you're talking about. Numerical process studies could resolve these sorts of scales (for a low-res version of what is achievable, see 10.1175/JPO-D-14-0097.1; I am not an author, and I am not suggesting that you cite it), and could be the most obvious types of studies that could substantiate the viability of your hypotheses. So, I'd like this sentence to be rephrased in order to sound less like 'mission accomplished' and more like 'idealised process studies are needed'.

3 Technical Comments:

1. P01L14: extending from about 60 to 200 m depth and...?
2. P01L21: possibly
3. P02L03: 'has been conducted' => 'were conducted by Chaigneau...'
4. P02L10-13: you are describing a vertical stacking, or a baroclinic structure. Took me a while to figure out that it wasn't a radial shielding structure. And what do you mean by 'normal'? Surface-intensified or barotropic? I don't see why one is more normal than the other anyway. I would also talk about ACEs rather than AEs, to be in line with ACMEs. And can't there be CMEs?
5. P02L26-29: something odd in that sentence. Perhaps the wrong verb ('explains') is used, or a comma is missing between 'ACME' and 'with', but something is odd.
6. P03L04: 'Mesoscale eddies often have R_o close to 1' => 'Although usually characterised by $R_o \ll 1$, mesoscale eddies often feature local values of R_o closer to one'. See my Special Comment 1 though: you might disagree with me.
7. P03L25-26: 'the modelled ... eddy core.' If that's the message of the paragraph, it should be placed at the beginning.

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8. P03L29: by rim, do you mean top/bottom or lateral rim or both? I would say edge or boundary actually. Rim sounds like lateral boundaries, which is what you might be referring to.
9. P04L15: 'and that' => 'which'
10. P04L26: 'but purely opportunistic': huh? I think you can delete anyway, no one is judging.
11. P06L10: S_A => S_A
12. P07L16-17: 'During the last survey... 120 m': I actually see two minima, both at 120 m. Do you mean in the vertical again?
13. P08L06: I don't see how the spiciness section shows the contrasting impact of Theta and S_A on isopycnals. I don't see Θ at all actually, and I don't remember the definition of spice.
14. P08L13: 'but separating the eddy surrounding water from...' => 'but well separates the eddy core from the surrounding waters'.
15. P08L16: in the stability ratio, what is the z index supposed to mean? Besides, you mix up θ and Θ here and in subsequent lines.
16. P09L09: 'but for the deeper levels more' => 'but more for the deeper levels'?
17. P09L30: 'downward also': missing word in-between?
18. P09L31: a word on what a typical AE stratification is?
19. P09L34: 'and that also' => 'which also'
20. P10L4-5: 'Having explained the isolation as..., it is tempting to...'

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21. P10L06: what do you mean, 'concept'? conceptual model?
22. P11L14: 'Only vertical propagation of internal waves does not generate mixing, but (...)' => 'Vertical propagation of internal waves by itself does not generate mixing. In order to do so, ...'
23. P11L15: I find it hard to conceive critical layer absorption not followed by KH.
24. P11L19-20: 'Here the mean ... vertical mixing': I don't understand this sentence.
25. P12L25: Is the double minus in NO₃- intentional?
26. P13L04: what's PON?
27. Fig. 7: A few of my colleagues (not in this field) and I unanimously agree: this figure looks too much like a particular piece of anatomy. We all suggest that you change the aspect ratio, make it less symmetric, and/or replace the blue and yellow lines by different lines. Once seen, it can't be unseen.

Besides that, I thought oxygen was not transported in an out of the eddy (P14L15), so what's up with the yellow lines? I'd also like to see arrowheads on the blue and yellow lines, even if bi-directional (I don't think they would be). Finally, I'd like to see the huge converging arrows towards the centre of the eddy removed. I get it that some stuff is retained inside the eddy, but let's not forget that in a vortex, geostrophic or not, velocities are mostly azimuthal. I understand that this is meant to reinforce your point, but in the end, it is misleading. Or make them squiggly, which would evoke diffusion.

Interactive comment on Biogeosciences Discuss., doi:10.5194/bg-2016-34, 2016.