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Biogeosciences Discussions

Interactive comment on "Oxygen Utilization and Downward Carbon Flux in an Oxygen-Depleted Eddy in the Eastern Tropical North Atlantic" *by* B. Fiedler et al.

Anonymous Referee #1

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Review: Oxygen Utilization and Downward Carbon Flux in an Oxygen-Depleted Eddy in the Eastern Tropical North Atlantic

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General Comments:

This is a descriptive study presenting observations of physical and biogeochemical properties of an anticyclonic mode water eddy (ACME) in the eastern tropical North Atlantic (ETNA). The topic is a current one and studies addressing biogeochemical characterization of mesoscale eddies are currently limited. The observational approach

using dedicated survey is novel, and presents a framework for the design of future studies. The main result is intriguing, suggesting that physical properties are preserved within the core of the eddy, while biogeochemical properties are evolving with time as the eddy 'ages' (the consequence being severe oxygen undersaturation and low pH and aragonite saturation state). As such, these systems could serve as a natural mesocosm for studying ecosystem responses to severe ocean conditions in the future, e.g. OA. I feel this study therefore makes significant contribution to our understanding of biogeochemical processes in low oxygen ACME. I recommend the paper to be accepted with minor revisions. Below are my comments and suggestions:

General comments:

1) Boundary definition: The authors are rather vague about the definition of eddy boundaries (the lateral boundaries, but in particular the lower boundary of the eddy core), as well as the processes leading to exchanges, or lack thereof, across those boundaries. I would suggest the authors provide more details on eddy boundaries, the depth of the mixed layer, and the depth of euphotic zone, as well as provide a stronger case for rationalizing why eddy waters don't mix with the surrounding ocean waters. For example, is the depth of the euphotic zone (Dez) and mixed layer depth in the eddy core equal to the outside water? Or is Dez different due to higher light attenuation by particles?

2) Episodic events: Throughout the paper a steady state biogeochemical system is implied (or at least a slowly evolving biogeochemical state). Yet the physical processes that allow for these balances are episodic and submesoscale (e.g. evidence for the re-supply of nutrients into the upper layer is lacking, and yet required for the equilibrium biogeochemical state in the mixed layer). Is this vertical nutrient flux driven by interaction of eddies with the overlying wind field, Ekman pumping, or internal waves displacing isopycnals and mixing? How frequent are these episodic events?

3) Downward carbon flux - POC export: This seem to be the weakest part of the paper.

The authors need to provide more details on physical and biological assumptions in the simple downward flux model, and whether its assumptions are valid in the eddy core. Is a steady state balance implied for model? A constant diffusivity? What about small non sinking POC export by eddy flow field subduction of surface waters with high POC concentrations? (See Mahadevan et al., 2015, Science). Consequently, the carbon flux model and Figure 8 may not make a meaningful contribution to the study.

4) Significance (and a Budget): What is significance of 1 to 2 ACMEs generated every year that propagate into the open ETNA waters for biogeochemistry and ocean acidification of the region, or even the ocean basin? Is this a phenomenon that might be expect to occur elsewhere (does the study have much broader implications? To help address this it might be worth carrying out at a budget/balance exercise to quantify, for example, whether the supply of nutrients exceeds export of nutrients, which leads to than increased productivity.

Detailed comments:

Abstract:

1) Page 1, Line 13: Define the extreme low oxygen environment.

2) Page 1, Line 22: Define the lower boundary of the euphotic zone.

3) Page 1, Line 27: Define the lower boundary of the surface mixed layer. Is this shallower than the euphotic zone?

4) Page 2, Line 1: an enhancement of apparent oxygen utilization rates. . .at what depth?

5) What is the significance of your findings for the biogeochemistry of ETNA?

Introduction:

6) Page 2, Paragraph 2: A figure showing ETNA, OMZ, EBUS, , CVFZ would be helpful. Maybe add on to Figure 1.

7) Page 3, Line 9: Define anticyclone mode-water eddies.

8) What is the main objective of this paper?

Methods:

9) Page 5, Line 8: At what depth were water samples collected?

10) Page 6, Line 26: At what depth were the water samples for DO collected?

11) Page 7, Line 10: same as above, define depth of DIC and TA samples.

12) Page 7, Lines 21-24, using which software?

13) Page 9, Line 4: Define apparent oxygen utilization rate.

Results and Discussion:

14) Page 10, Lines 15-20: This text is repetitious, and can be omitted.

15) Page 10, Lines 22-24: Specify depth.

16) Page 11, Line 20: (100m)- not clear if is this at 100m, or from 0 to100m?

17) Page 11, Lines 16-18 (sentence 2): move to after describing the results.

18) Page 11, Line 27: Why elevated nitrate, nitrite and phosphate but not silicate? Also, did you look into nitrate:phosphate ratio as evidence of denitrifying bacteria?

19) Page 12, Lines 1-5: How often do these sporadic events occur? Are they wind induced, or due to passage of internal waves?

20) Page 12, Lines 7-9: This sentence is a repetition from Methods and can be omitted.

21) Page 12, Line 26: “phytoplankton communities are exposed to these acidified conditions”. How often? (the pH minimum is located just below the euphotic zone).

22) Page 13, Lines 25-29: is this consistent with your Chl-a observations?

Conclusions:

23) Page 17, Line 30: “intense increase”. . .specify where.

24) Page 18, Line 9: Is the 3-fold increase in primary productivity consistent with your observed Chl-a?

25) Page 18, Lines 20-25: I would replace this text with a sentence on the significance of the 1 to 2 ACMEs generated every year that propagate into the open ETNA waters for biogeochemistry and ocean acidification of the area.

Tables:

26) Table 1: Add: negative values correspond to. . . Are these average anomalies over some depth range?

Figures:

27) Figure 2: SACW missing?

28) Figure 8: This figure and the associated carbon flux model (eqn 2) does not make a significant contribution to the paper as it stands. See general comment #3 above.

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