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Biogeosciences Discussions

Interactive comment on "What drives the spatial variability of primary productivity and matter fluxes in the North-West African upwelling system? A modelling approach and box analysis" *by* Pierre-Amaël Auger et al.

Anonymous Referee #1

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Summary

The paper by Auger et al. has the goal to explain the spatial variability of chlorophyll in the North-West African upwelling system. To do so, Auger et al. present the results of a modelling study based on the coupled models ROMS and PISCES run on a high resolution regional grid. Their results show that the upwelling intensity in the form of vertical velocity does not necessarily follow the forcing seasonality, but is strongly influenced by topography and alongshore flow. They also show that local productivity does not always depend on the local upwelling of nutrients, but it can

rely in great part on the lateral advection of nutrients. In fact, while productivity in the northern and southern sectors of the upwelling system depends on the vertical nitrate supply, the central Cape Blanc subregion is particularly impacted by this convergent lateral advection, both from the northern and the southern boundaries. This central sector is also characterized by high levels of regenerated production (about half of the total production) and subduction of water and tracers resulting from this stream convergence. Auger et al. also show that, except in the Senegalo-Mauritanian region, phytoplankton biomass distribution itself depends on the advection of phytoplankton from the adjacent regions. As regard to the offshore waters, Auger et al. assert that the fast decline of phytoplankton concentration in the region above Cape Blanc is due to strong vertical mixing that redistribute it below 100m, limited offshore advection and strong southward alongshore transport. On the contrary, below Cape Blanc lateral advection of nutrients and phytoplankton sustain a wider offshore extension of the chlorophyll concentration. Around Cape Blanc the flow convergence explains the persistent wide chlorophyll extension.

Contribution

The North-West African upwelling system hosts one of the most rich and productive marine ecosystems. Despite this, dedicated studies on this systems have not been as abundant as for other upwelling regions for a long time. In the last few decades many precious data have been collected in this region and several modelling studies have been focusing on this system. Thanks to these efforts, an always more comprehensive understanding of the local ecosystem as well as of the complex pattern of currents is being achieved. The paper by Auger et al. adds some other important pieces of information to this picture and clarifies the mechanisms that lie behind the observed pattern of chlorophyll in the region.

One important novelty and strength of this paper is comparing the alongshore lateral fluxes of nutrients to their upwelling supply. The authors prove that these lateral fluxes are relevant in most sectors of the system, where the upwelling of nitrate is not the dominant supply of nutrients. They also prove that in one particular region lateral advection of nitrate is the fundamental key to explain the observed pattern of chlorophyll that persists despite the lack of upwelling. Similarly, alongshore advection of phytoplankton can account for as much biomass as the local production in some regions. This conclusions represents a change of perspective in the understanding the dynamics of the upwelling system especially in the nearshore region. It may also be an interesting subject of study in other upwelling systems.

Recommendation

I find the paper by Auger et al. particularly new, exciting and suitable to be published in Biogeosciences. The paper is well organized, overall nicely written and the results are relevant.
I strongly suggest that it is accepted for publication after minor revisions are done.
Suggested revisions are listed in the next Major and Minor Comments sections.

Major Comments

1) Verbose "Results" Section
The paper by Auger et al. has the great merit of analyzing in depth the results of the model and of using cross-analysis of several different quantities to validate the hypothesis of the Authors. However, I have found the Results section pretty heavy to read, especially due to the amount of numbers listed within the text. This has a peak in sections 3.1.3 and section 3.2.3. I strongly suggest to summarize the results sections since the plots already contain much of the information that is explained in words in

these chapters. The many many numbers listed in sections 3.1.3 and section 3.2.3 could instead be included directly in the pictures, for example above the bars, or in a table. As a general comment, I suggest to summarize/reorganize the Results section and use it to highlight general features and important trends in the Figures, rather than describing them element by element. This way the readers can really grasp the major highlights and findings without getting lost in too much information, while they can still look at the plots/tables for more details.

2) Why Spring
It was not clear to me until the Discussion section 4.3 the reason why some of the analysis in the paper was focusing on spring and I am still not sure that I have comprehended all the rational behind it. I suggest to motivate this choice more in depth before to present the results to the reader, stressing on the motivations that lie behind the choice of presenting a detailed analysis of the fluxes in this specific season only, despite all the known subregional variability of upwelling and seasonality in the system.

3) Model Evaluation: Nitrate
Most of the discussion in the paper by Auger et al. is focusing on Nitrate, however there is no model evaluation of the nitrate distribution in the model. I suggest to include this in the paper.

4) Box analysis Figures
The paper by Auger et al. presents most of the results in the form of fluxes analysis. However, some of the Figures are confusing.
Figure 7, Figure 13: Why are there 2 arrows of different color and size for each one of the lateral fluxes between the boxes? Eg, in Figure 7 the meridional flux between SS and SM in the nearshore is represented by both a large red arrow and a not so large orange arrow, so there are 2 arrows of different size for a single flux. What does this

mean? Isn't the size of the arrows proportional to the intensity of the fluxes? Is the size of the arrows of one box comparable with the size of the arrows in the other boxes or do each box have a different scale?

Minor Comments

1) page 3: title "Material and Methods" maybe should be "Materials and Methods"? (missing s)

2) page 3, lines 24-25: What is the output frequency of the model? Monthly means?

3) page 4, lines 30-31: The large cyclonic recirculation introduced here and fed by the NECC is generally referred to as Mauritanian Current [J. Arístegui et al./Progress in Oceanography 83 (2009) 33–48] in its northward alongshore component. This current is referred to again in page 5 lines 7-12

4) page 5 lines 1-2: "Maximum velocity is found equatorward in the coastal upwelling jet": this sentence is a bit odd as regard to English syntax, it may be reformulated in a clearer way

5) page 5 line 3: (and all the next occurrences) Cape Boujdour (FR) in English is called Cape Bojador

6) page 6 lines 9-18: this block of lines sounds more like a "Model Results" paragraph and it seems out of place; if moved somewhere else the Box Analysis section actually sounds much more coherent; maybe it can be located in a more adequate position

7) page 10 line 12: I don't think that "enlightened" is the right word here (eg, enlightened = Having or showing a rational, modern, and well-informed outlook; spiritually aware)

8) page 10 line 28: at the bottom of the offshore boxes (missing "the" before "offshore boxes")

9) page 10 lines 31-32: the sentence about vertical velocities and nitrate supply is not clear to me, this finding may be better explained

10) page 11 line 10 page 12 line 2: Annual Mean? Or Spring Mean? In general, I suggest always to remark throughout the discussion and conclusions section whether your sentences are referring to the annual mean or spring mean analysis

11) Figure 14: Why are the lines in subplot c and d dashed?

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