

We wish to thank referee #3 for his/her detailed analysis and his/her thoughtful comments, which will improve the quality of this manuscript. Here, you will find a detailed reply to each comments :

Response to Referee#3's Comments

General comments

Title could be shortened to: What drives the spatial variability of primary productivity and matter fluxes in the North-West African upwelling system? A modelling approach.

We agree and will shorten the title as suggested by the referee.

Throughout the manuscript 'explicit' is used as a verb. It is not a verb, it can be used as a noun (eg. The explicitness of the data allow us to draw some very solid conclusions) but usually an adverb (The data allow us to explicitly show that...) or adjective (e.g. The data is explicit, it shows that...).

The term « explicit » will be replaced by an adequate verb each time it was badly used in the manuscript.

It seems a bit unclear as to why the spring means are used for the offshore domains and annual means for the coastal domains. It is mentioned only later in the discussion, but it should be clearer sooner. Why not show the spring mean for coastal and offshore domains (surely using the annual mean for the coastal domain masks the seasonal signal and is therefore unrealistic?). Does it make sense to link the coastal and offshore domains in terms of the offshore fluxes for example if you are looking at averages for different periods?

This comment is related to comments of the 2 other referees who asked for introducing the choice of the spring period earlier in the paper.

The main justification is that observed offshore extension of Chl-a do present a marked seasonal variability with a peak in boreal spring. Therefore, focusing only on annual averages would have raised questions about the significance of our results during the time period that sees most of the offshore export. Choice has thus been made to show annual average but also the spring period.

Interestingly, there is very little change in the repartition of the fluxes driving nitrate and phytoplankton concentrations in spring compared to annual average, as shown by the little difference between Figures 7 and 13. We feel that this finding is a result on its own and would not appear as "evident" to a new reader. Even if *a posteriori*, Figures 7 and 13 appears as redundant, we feel that, *a priori*, a new reader would ask to see the seasonality of the fluxes we are discussing, particularly during the peak period. Therefore we feel that it is justified to keep those 2 figures unchanged.

However, we will stress the little difference between both figures and what it means in the Discussion Section 4.3, p.16/l.18 : « Nonetheless, our conclusions are also valid on annual average since the drivers of nitrate and phytoplankton biomass in offshore boxes are similar on spring and annual average (see Fig. 7 and 13). »

The results section is very laborious and therefore difficult to read, especially sections 3.1.3 and 3.2.3 (the percentages in parentheses are not necessary),

and could be shortened.

According to the referee's suggestion (shared with referee #1), numbers in sections 3.1.3 and 3.2.3 will be removed from the text. The Results Section will also be clarified to highlight the major features of the study region shown in the figures.

We agree with most of the minor comments made by the referee, and we wish to thank him/her for his/her great effort. We only answer to a few comments either to answer a question or indicate an important correction that will be made to the manuscript.

Specific comments

page 2, line 4: 'of coastal topography are' should be 'of coastal topography is' **OK**

page 2, line 5: '...and then the response of nutrient upwelling to wind forcings'. This is unclear. Are you saying that the large scale circulation pattern impacts the wind driven upwelling of nutrients?

Large scale circulation patterns actually affect the response to the wind forcing of the vertical velocities at 100m depth (which we attribute to coastal upwelling), and so the vertical nutrient inputs in the euphotic layer.

Introduction

Page 3, line 17: 'in regards of environmental forcings' should be 'with regard to environmental forcings' **OK**

Page 4, line 2: 'To this end, comparative box analysis...' should be 'To this end, a comparative box analysis...' or 'To this end, comparative box analyses.....have been conducted'. **OK**

Page 4, line 3, 'Those subregions' should be 'The subregions' **OK**

Page 4, line 4, 'in regards of' should be 'with regard to' **OK**

Page 4, Line 14: 'explicit' cannot be used as a verb, try 'identify', **OK**

Last two paragraphs of Introduction are laborious and could be more succinctly summarised.

According to the referee's comment, the last two paragraphs will be modified as follows :

« First, we present the model configuration and a validation of near-surface circulation and surface chlorophyll biomass using in-situ and satellite data (Section 2.1 and 2.2, respectively). Then, we describe the meridional variability of wind forcings, ocean response and primary productivity as simulated by the model in the different coastal (Section 3.1) and offshore boxes (Section 3.2), on annual mean and also during spring (seasonal maximum of the chlorophyll offshore extension as shown in Lathuilière et al, 2008). Each section is split in three parts which describe the meridional variability of (i) the wind

forcings, current velocity and nitrate fluxes, (ii) the primary production (PP), phytoplankton biomass and phytoplankton fluxes, and (iii) the sources and sinks of nitrate concentration and phytoplankton biomass. Finally, we discuss in Section 4 (i) the sensitivity of coastal upwelling to the wind forcing along the NW African coast, (ii) the meridional variability of coastal phytoplankton biomass and PP (new and regenerated production) in relation with matter transfers and (iii) the meridional variability of the offshore extension of coastal chlorophyll off NW Africa. »

Last two sentences of Introduction seem out of place.
Indeed, these two sentences will be removed.

Methods

Page 4, line 26: unbalanced parenthesis **OK**

Page 5, line 23: 'thinner' is ambiguous in this context, 'narrower' is clearer **OK**

Page 6, line 3: 'The upwelling filaments off Cape Ghir and Cape Boujdour are responsible for strong seaward deflections of the coastal current.' I wouldn't necessarily say that the filaments are responsible for the seaward deflection - they are 'connected', both associated with the same initial mechanism (perhaps wind/topography) and then they probably enhance one another. **OK**

Page 6, Line 2: 'explicit' cannot be used as a verb, try 'identify' **OK**

Page 6, line 2-4: '.....the meridional variability of primary productivity off the NW African coast, we carried out a box analysis focusing on nitrate (the main limiting nutrient) and phytoplankton carbon budgets (12-27°N, see Fig. 1)', rather say: '.....the meridional variability of primary productivity off the NW African coast between 12-27°N, we carried out a box analysis focusing on nitrate (the main limiting nutrient) and phytoplankton carbon budgets' **OK**

Page 6, line 7: '...was split into five latitudinal bands.' rather: '...was split into five latitudinal bands (see Fig. 1).' **OK**

Page 6, line 12: remove 'On the opposite,', start with 'In the southernmost...' **OK**

Page 6, line 17: what do you mean by 'globally'? It usually refers to something involving the whole globe/world.
The term 'globally' will be removed since it is not essential.

Page 6, line 20: 'In like manner...' rather 'Similarly..' **OK**

Results

Page 8, line 6: 'Wind curl shows a clear maximum off Cape Blanc but a weak meridional variability'. This sentence is not clear. Do you mean that the meridional variability in wind stress curl is weak or do you mean that the alongshore variability of meridional wind stress is weak?
We mean that the meridional variability in wind stress curl is weak. This will be clarified (see General Comment #4).

Figure 2 c : this is labelled as upwelling intensity (vertical velocity at the bottom). For upwelling intensity, it would be better to use vertical velocity at the base of the Ekman layer (your 100 m depth of the boxes is probably too deep?).

In this paper, we are interested in the primary productivity. In consequence, we designed boxes extending vertically from the free surface down to 100m depth to encompass the euphotic layer where light is available for phytoplankton photosynthesis and primary production. We then consider the upwelling-induced nutrient flux at the base of the boxes (100m depth) since the nutrients that enter this layer are susceptible to be consumed for primary production.

Page 8, line 24: remove 'inversely' **OK**

Page 8, line 32: '...associated to...' should be '...associated with...' **OK**

Page 9, line 11: 'does not translate in...' should be 'does not translate into....' **OK**

Page 9, line 14: 'Noteworthy, the phytoplankton biomass is found maximum off Cape Blanc and the South Saharan Bank contrasting with minimum upwelling-induced nitrate supplies (Fig. 3a).

rather:

'It is noteworthy that maximum phytoplankton biomass is found off Cape Blanc and the South Saharan Bank despite the fact that upwelling-induced nitrate supplies are at a minimum at those locations (Fig. 3a).' **OK**

Section 3.1.3: laborious

According to the referee's suggestion (shared with referee #1), numbers in Sections 3.1.3 will be removed from the text. The Results Section will be generally clarified to highlight the major features of the study region shown in the figures.

page 10, line 6: 'sinks' should be 'sink' **OK**

page 11, line 12: 'enlightened' is very archaic in this context. Replacing it with 'euphotic zone' would be better. **OK**

Page 11, line 14: 'explicit' cannot be used as a verb and whole sentence is unclear. **OK**

Page 11, line 17: 'Alternatively' since you're not offering an alternative to a previous statement, something like 'On the other hand' works better. **OK**

Page 11, line 22: 'Noteworthy, at the western...', change to 'It is noteworthy that at western boundaries velocities are...' **OK**

Page 11, line 23: replace 'happen to be' with 'are' **OK**

Page 11, line 29: replace '..falls in the same order of magnitude than diffusion...' with '..is the same order of magnitude as diffusion...' **OK**

Page 11, line 31: replace 'Noteworthy...' with 'It is noteworthy that vertical nitrate supply...' **OK**

Page 12, line 10: In the text it states that Fig. 10 is annual mean, but the figure caption says Spring mean. **OK**

Page 12, line 18: replace '....., in less manner,....' with '..., less so,...' **OK**

Page 13, line 2: In the text it states that fig 12 shows the annual mean source and sink terms but the figure caption says it is the spring mean. **OK**

Discussion

Page 14, line 9: 'in relation with the...', should be 'in relation to the...' **OK**

Page 14, line 10: 'Finally, we will seek to explicit...' should be 'Finally, we will seek to identify...' **OK**

Page 14, line 13: 'In our simulation, the meridional variability of coastal upwelling is not correlated to the local variability of wind-driven Ekman transport and Ekman pumping. This result questions the estimation of vertical velocities based on local wind forcing that were commonly used in EBUS'. **OK**

- two points on this statement: 'were' should be 'are' **OK**

The estimation of upwelling using alongshore wind stress is for vertical velocities at the base of the Ekman layer. Your level of 100m, or the bottom in places shallower than 100 m, may be too deep.

We agree and the sentence will be modified as follows : « In our simulation, the meridional variability of vertical velocities at 100m depth (which roughly corresponds roughly to the euphotic layer) is not correlated to that of upwelling-favourable winds and Ekman pumping. This result questions the estimation of upwelling-induced nutrient inputs in the euphotic layer based on the wind-driven Ekman transport and the nutrient concentrations in upwelling source waters, a method commonly used in EBUS (Gruber et al., 2011; Messié et al., 2009; Messié and Chavez, 2014). »

Page 14, line 16: You state that the large scale transport could be a factor explaining the mismatch in upwelling intensity and Ekman transport. With the model output you can calculate it directly to verify your statement.

The mismatch between Ekman transport and upwelling intensity off Cape Blanc implies that other mechanisms than the Ekman transport play against coastal upwelling to create downward vertical velocities. These can be internal waves, mesoscale processes (like fronts and eddies) or the convergence of water masses. We clearly show that downward vertical velocities in the coastal box off Cape Blanc from May to July co-occur with alongshore velocities at both the northern and southern boundaries directed inward, which demonstrates that the convergence of water masses is the most plausible explanation for this mismatch.

Page 14, line 22: '...explicit...', can't be used as a verb. You could use 'identify' **OK**

Page 14, line 23 and figure 14: you use the bottom velocity to assess the sensitivity of coastal upwelling to wind forcing. You should rather use vertical velocity at the base of the Ekman layer.

The point here is to investigate the sensitivity to wind forcing of the vertical velocities at 100m depth (attributed to the coastal upwelling) that participate to the vertical nutrient fluxes in the euphotic layer where nutrients are consumed for primary production (see our response to the comment in Section Results « Figure 2 c »).

Page 14, line 26: 'lead' should be 'leads' **OK**

Page 15, line 18: instead of 'Albeit' use 'Although'. **OK**

Page 16, line 31: sentence starting with 'This points a gap...' is confusing **OK**

Page 17, line 13: 'the coast, the wind stress curl...' should be 'the coast, (ii) the wind stress curl...' **OK**

Page 17, line 14: 'hypothesis' should be 'hypotheses' **OK**

Page 17, line 15: 'explicit' should be 'identify' **OK**

Page 17, line 20: 'associated to' should be 'associated with' **OK**

Page 17, line 22: 'Our results indicate downward and upward wind-induced Ekman pumping of respectively north and south of Cape Blanc' should be 'Our results indicate downward and upward wind-induced Ekman pumping north and south of Cape Blanc respectively' **OK**

Page 18, line 1: 'participate' should be 'help' **OK**

Page 18, line 8: '2ZOTLathuliere2008' - a latex referencing bug? **OK**

Page 18, line 10: 'thatfilaments' should be 'filaments' **OK**

Conclusion

Page 18, line 21: 'of the primary production spatial distribution in' should be 'of the spatial distribution of primary production' **OK**

Page 18, line 25: ' production in' should be 'production with' **OK**

Page 18, line 31: 'excepted' should be 'except' **OK**

Figures

Figure 1: include the box labels that you use in the text and in other figures **OK**

Figures 1-4: in some you include just the abbreviations of the box areas, in others you have the full name. When you don't have the full names in the legend, you could include them in the caption **OK**

Figure 6: label x-axis with latitude as well, or at least show where north is **OK**

Figure 10 and 12: the captions dont agree with the text (Annual vs. Spring mean) **OK**

Figure 14: it is not clear how these averages are calculated (in the caption or in the text). In the caption you state: 'within and at the boundaries of coastal boxes'. Is it an average of meridional wind, bottom velocity, cross-shore velocity and alongshore velocity within the entire coastal strip? If so, does this make sense, given that your interest is the meridional variability of primary productivity

In the text, it will be modified as : « For this latter purpose, we further analyze the seasonal cycles of meridional wind versus vertical and horizontal velocities averaged within and over each edge of the coastal boxes (i.e. North, South, West and bottom), respectively (Fig. 14). »

The caption will also be modified as follows : « Figure 14: Seasonal climatology of (a) wind intensity (negative is upwelling-favourable, m s^{-1}), (b) bottom vertical velocity (m s^{-1}), (c) zonal velocities (m s^{-1}) and (d) meridional velocities (m s^{-1}) averaged within and over each edge of the coastal boxes (i.e. North, South, West and bottom ; defined positive inward, so vertically upward), respectively. Each color corresponds to a box (see legends in Fig. 2). In (d), a solid (dashed) line represents a velocity at a northern (southern) edge of a box, respectively. »