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Biogeosciences
Discussions

Interactive comment on "What controls biological productivity in coastal upwelling systems? Insights from a comparative modeling study" *by* Z. Lachkar and N. Gruber

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General comment :

This paper propose a comparative modeling study between the California Current System and the Canary Current System. The authors take advantage of the modeling approach to test hypothesis explaining the observed difference in primary production between the two ecosystems. Although the study is elegant and the results are attractive, some major mechanism for primary production were not discussed. Thus, in order to improve the discussion of the paper I suggest the points listed below should be addressed.

Specific comments :

1 - Limitation for phytoplankton growth: In the biogeochemical model used, the only possible nutrient limitation to primary production is the nitrate. However, a number of studies have shown or suggested the importance of iron or other micro-nutrients as limiting factors for primary productivity in EBUS (eg : Echevin et al., 2008; Chavez and Messié, 2009; etc...). Furthermore, it is well known in the Canary CS that Saharan dust events, carrying in particular iron over the ocean, can generate phytoplankton bloom independently from upwelling enrichment (Rijkenberg et al., 2008; Ohde and Siegel, 2010; etc...). Iron limitation was also suggested in California CS (Hutching et al., 1998). Then, if atmospheric enrichment is a specificity of the Canary CS, this should be at least discussed in your paper as another possible explanation for the more efficient use of the nutrients in the Canary CS.

2 - Effect of eddies: Why should eddies reduce plankton residence time in the upwelling area? This non-intuitive result should be explained more in details. No doubt that eddies will increase the mixing of upwelled water with oceanic water, but the implication on plankton retention is not straightforward. In the literature, observations frequently report eddies as retention areas (e.g. Heywood and Priddle, 1987; see Rodriguez et al. 2004 for a review). The main source of offshore transport in the Canary CS comes from the upwelling filament structures, which generate an offshore transport significantly larger than Ekman transport (Kostianoy and Zatsepin, 1996; Navarro-PéÌĄrez and Barton, 1998, Pelegri et al., 2005a, Pelegri et al.. 2005b). Upwelling filaments are not eddies, but their westward movement is linked to vorticity conservation and then by removing the non-linear term in the momentum equation you may lose them as well. This experiment deserves much more description and analysis to be well understood by the reader. I suppose it is done in Gruber et al. (2011) but I could not find this reference, is it published yet? Furthermore, the effect of eddy on primary production is not neutral, and it is different between cyclonic and anticyclonic eddies (local enrichment, concentration,... e.g. Falkowski et al., 1991, Oschlies et Garçon, 1998, etc...). This

effect might be more complex than just changing the plankton residence time in a given area, and this should be mentioned in your paper. See also Roughan et al. (2006) for a discussion on how mesoscale activity in the California CS impacts the retention of plankton inshore.

3 – Seasonality: The inter-regional comparison analysis was done between static states corresponding to the mean annual primary production. However, the upwelling seasonality is very strong in the Californian CS: during the winter the upwelling stops and a northward current, the Davidson Current, develops at the surface from the shore to 100 km offshore (Carr et al. 2008). Conversely, in the Canary CS the upwelling is permanent north of Cape Blanc (21°N) (Machu et al. 2009). Comparing the annual average primary production between two regions with different upwelling seasonality can potentially lead to misinterpretation of the underlying mechanism. For example, the higher annual mean productivity in the Canary CS compared to California CS could be a consequence of its longer upwelling season. A few sentences are needed to clarify this point.

Technical corrections : P5623 line 24 : please give the range for euphotique depth in Canary and Californian CS. P5637 : Chavez and Messié (2009) is in your reference list but I didn't find it in the text.

References cited in this comment :

Carr, S.D., Capet, X.J., McWilliams, J.C., Pennington, J., Chavez, F.P., 2008. The influence of diel vertical migration on zooplankton transport and recruitment in an upwelling region: estimates from a coupled behavioral-physical model. Fisheries Oceanography 17, 1-15.

Echevin, V., Aumont, O., Ledesma, J., Flores, G., 2008. The seasonal cycle of surface chlorophyll in the Peruvian upwelling system: A modelling study. Progress in Oceanography 79, 167-176.

Falkowski, P.G., Ziemann, D., Kolber, Z., Bienfang, P.K., 1991. Role of eddy pumping in enhancing primary production in the ocean. Nature 352, 55-58.

Heywood, R.B., Priddle, J., 1987. Retention of phytoplankton by an eddy. Continental Shelf Research 7, 937-955. Hutchins, D.A., DiTullio, G.R., Zhang, Y., Bruland, K.W., 1998. An Iron Limitation Mosaic in the California Upwelling Regime. Limnology and Oceanography 43, 1037-1054.

Machu, E., Ettahiri, O., Kifani, S., Benazzouz, A., Makaoui, A., Demarcq, H., 2009. Modeling the environment of Sardina pilchardus over the Saharan Bank to investigate the collapse of the stock in 1997. Fisheries Oceanography 18, 287–300.

Ohde, T., Siegel, H., 2010. Biological response to coastal upwelling and dust deposition in the area off Northwest Africa. Continental Shelf Research 30, 1108-1119.

Oschlies, A., Garçon, V., 1998. Eddy-induced enhancement of primary production in a model of the North Atlantic Ocean. Nature 394, 266–269.

Pelegrí, J.L., Marrero-Dìaz, A., Ratsimandresy, A., Antoranz, A., Cisneros-Aguirre, J., Gordo, C., Grisolìa, D., Hernández-Guerra, A., Láiz, I., Mart'Äśnez, A., Parilla, G., Pérez-Rodr'Äśguez, P., Rodrìguez-Santana, A., Sangrà, P., 2005. Hydrographic cruises off northwest Africa: the Canary Current and the Cape Ghir region. Journal of Marine Systems 54, 39-63.

Pelegrí, J.L., Arístegui, J., Cana, L., Gonzalez-Davila, M., Hernandez-Guerra, A., Hernández-León, S., Marrero-Díaz, A., Montero, M.F., Sangra, P., Santana-Casiano, M., 2005. Coupling between the open ocean and the coastal upwelling region off northwest Africa: water recirculation and offshore pumping of organic matter. Journal of Marine Systems 54, 3-37.

Rijkenberg, M.J.A., Powell, C.F., Dall'Osto, M., Nielsdottir, M.C., Patey, M.D., Hill, P.G., Baker, A.R., Jickells, T.D., Harrison, R.M., Achterberg, E.P., 2008. Changes in iron speciation following a Saharan dust event in the tropical North Atlantic Ocean. Marine

Chemistry 110, 56-67.

Rodríguez, J.M., Barton, E.D., Hernández-León, S., Arìstegui, J., 2004. The influence of mesoscale physical processes on the larval fish community in the Canaries CTZ, in summer. Progress in Oceanography 62, 171-188.

Roughan, M., Garfield, N., Largier, J., Dever, E., Dorman, C., Peterson, D., Dorman, J., 2006. Transport and retention in an upwelling region: The role of across-shelf structure. Deep Sea Research Part II: Topical Studies in Oceanography 53, 2931-2955.

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