

Interactive comment on “The OMZ and nutrients features as a signature of interannual and low frequency variability off the peruvian upwelling system” by M. Graco et al.

Anonymous Referee #2

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The paper addresses an interesting topic of physical-chemical coupling in the northern Humboldt System. This region is particularly attractive because of its strong connection with equatorial dynamics, high biological productivity, as well as a shallow and intense oxygen minimum zone that influences nitrogen cycling and biological dynamics. The study examines the temporal and vertical variability of relevant physical and chemical variables during the period 1996-2009, covering the strong El Niño 1997-98 and subsequent La Niña 1998-99, as well as period with relatively neutral or weak ENSO conditions after 2002. The authors conclude that most of the physical-chemical variability off Peru is linked to equatorially originating remote forcing. They also suggest enhanced physical-chemical intraseasonal variability after 2002, associated with

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a change in the intraseasonal equatorial Kelvin wave (IEKW) activity. None of those statements is well supported in the paper. Three aspects could be argued against the conclusions. First, since the local forcing (e.g. coastal winds, heat fluxes) was not examined, it is not possible to conclude that remote forcing is the dominant forcing. Second, the coastal time series have monthly resolution that precludes a proper characterization of the dominant 40-60 day intraseasonal variability off Peru, making difficult to connect the physical-chemical changes off Callao to the IEKW variability. Third, the characterization is strongly dependent on El Niño 1997-98 and subsequent La Niña disturbances. It is not clear for me if a really novel scenario exists after 2002.

The paper has the potential to address a very interesting topic, as the interannual to intraseasonal variability of chemical variables remains not well documented off Peru. However, there are many aspects that need revision, including goals and methodological issues. The paper structure and writing need substantial improvement.

Specific issues that need revision:

1. Introduction

The introduction is weak. I suggest be more concise and define better the paper goals. The sentence “in order to infer potential biogeochemical scenarios in connection with equatorial variability” appears to me too vague.

2. Methods 2.1 Sentences from lines 8 to 13 are not needed in this section.

2.2 The instruments to measure temperature and salinity changed in 2002. Could that explain the apparent change in the physical-chemical coupling after 2002? Do you have a period with overlapping observations of thermometer, salinometer, and CTD to check the measurements consistency?

2.3 Is the EOF analysis really needed? Only the PC time series were shown, what about the spatial pattern?

3. Results

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I suggest Figure 2 be a 8 panels figure, with the time-depth diagrams of temperature, salinity, density, and oxygen in the left panels, and the corresponding monthly climatological mean in the right panels. In that way you could eliminate Figs. 3 and 4, and you do not need to go back and forward in the figure's citation.

3.1 Page 8 Line 17: Year 2008 is not El Nino according to El Nino 3.4 index. Lines 22-24: How do you support the $Z_{15^{\circ}\text{C}}$ - ENSO connection?

3.2 Page 9 Line 21-23. I do not think it is possible to discriminate properly the intraseasonal from the seasonal variability with monthly observations.

Why R-square instead of r when reporting correlation coefficients? That appears to be a conceptual error

3.3 Page 10 Line 10-12. Maximum NO_3 in winter could be linked to decreased plankton uptake due to light-limitation (Echevin et al., 2004)

Why phosphate is not limiting? Need to support it

Page 11 The connection between PC2 and the intraseasonal variability is not clear for me. Could you quantify the connection?

3.4 Is it possible to include numerical model outputs in the analysis? Several regional model efforts have been done in the region that might be useful to interpret better the observations.

I do not understand why do you use only the global wavelet spectrum. Examining wavelets in the time-frequency domain is more informative, especially to see temporal changes in the IEKW activity.

Where is Section 3.5? Cited three times in the text

4. Discussion

Overall the discussion needs a better integration of biogeochemical processes influ-

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encing the observed vertical profiles of oxygen and nutrients.

Page 16 The statement that 84% of variability could be remotely forced is totally unsupported. You get those percentages from the EOF analysis, but the link between equatorial variability and El Callao series was not quantified. What about local winds? Wind stress curl?

Same thing, that the leading EOF of the chemical components explains 50% does not mean that 50% of the variability is linked to remote forcing.

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