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Biogeosciences Discussions

Interactive comment on "Physical and biogeochemical forcing of oxygen changes in the tropical eastern South Pacific along 86° W: 1993 versus 2009" *by* P. J. Llanillo et al.

Anonymous Referee #1

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General comments

The paper by Llanillo et al. compares two cruises in the tropical eastern South Pacific, one in 1993 during a warm "El Nino" period and one in 2009 during a cold "La Nina" period. Using the extended OMP analysis, the authors explain the physical and biogeochemical forcing that are responsible for the oxygen changes observed during these two periods into a region well known as one of the most important OMZ. Nowadays is becoming of extreme importance to increase our knowledge about the oxygen changes in general, and in particular within these areas (the OMZs), since several studies have shown a consistent expansion of the OMZ and decrease of oxygen over

the last decades.

The paper is well written, however I have some specific questions that I would like the authors to address.

Specific comments:

1) I can understand the choice of computing the changes along depth coordinates, since depth coordinates are more familiar for most of the readers. However, the authors should have done also the analysis on isopycnals coordinates. Isopycnals analysis tends to reduce the changes due to isopycnal heaves for all parameters (see for example Johnson and Gruber, 2007). Moreover, the discussion of the paper focuses on water mass mixing, and water tends to mix along isopycnals. It has been demonstrated that if you average along isobaric coordinates you may encounter into the problem of producing artificial water masses (see Lozier et al. 1994, Fratantoni and McCartney 2010, and how for example the WOCE hydrographic climatology has been gridded). I guess that performing the difference of two hydrographic cruise that are interpolated along depth lever can bring to a similar problem.

2) P. 17588 from L. 16: I'm not completely sure whether the authors have done the interpolation before or after applying the OMP method. On my opinion the first option is not completely correct, it is better to do first the OMP and then interpolate the data. Indeed, the interpolation adds some artifact that you want to have as latest as possible in your results, even if, as the authors stated, the interpolated bottles data reproduces well the CTD data.

3) Maybe I missed that but I don't see anywhere in the text the definition of the depth range of the OMZ, where is it laying in the region analyzed? Maybe a figure that shows the oxygen section from the two cruises would help.

4) What is the accuracy of the data? The authors should mention that in the data and methods. If you compute the changes in oxygen and nitrate all results that are lower

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than the accuracy should not be considered.

5) P. 17588 from L. 20: Which kind of data at the end it is used for your analysis? Interpolated bottle data for nutrients and CTD data for temperature, salinity and oxygen or only interpolated bottle data? This part should be better explained.

6) P. 17590 from L. 3: As the authors wrote in this paragraph, the OMP analysis is based on the assumption that the source waters are time-invariant. What happens if the water mass changes over time? Do you have an estimation of the uncertainties or can you say something about how much your results would change if some of the water mass were subject to interannual or decadal changes?

7) P. 17590 from L. 14: It would be nice to have some estimation, like when the authors write in L. 14 "Characterized by a subsurface salinity maximum [. . .]" how much is it this maximum? Or in L. 20, "Not to be confused with the salinity minimum of AAIW" which is about? Or, is the salinity around 34.0 the minimum of the SAAW? P. 17591 L. 7: "a broad silicate maximum". . .of?

8) P. 17597: Similar to the previous comment. The authors have done a qualitative analysis about the changes observed in this region, but it would be nice to have also some quantitative analysis. For example, when the changes in the oxygen and nitrate contents are described, can you quantify a bit these changes? How much is the oxygen increase/decrease in μmol/kg and how much is the nitrate increase/decrease within the OMZ?

9) L. 26 of P. 17599 until L. 4 of P. 17600: I am a bit puzzled about what it is described and what it is shown in Fig. 9. What I understood from the explanation, Fig. 9a represents the oxygen changes due to advection, Fig. 9b the oxygen changes due to respiration and so on. So if you observe an increase in the respired oxygen in Fig. 9b, it means that the respiration rate is reduced since you have less oxygen advected in the region, which is available for the respiration. However, in P. 17600 L. 4, the authors wrote that in the upper 300 m there is a general decrease in the advected

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oxygen and gained in the advected nitrate (which I agree), but then it is said that this is accompanied by a reduction in the oxygen respired, while Fig. 9b shows an increase. Did you maybe mean that what is reduced is the respiration rate, since there is less oxygen available for the respiration, which reflects in the apparent gain of the oxygen in Fig. 9b? Also, P. 17599 L. 27, the authors said that a significant advective gain of oxygen is observed between 300 and 600 m depth. This is not completely true, since from Fig. 9a within that depth range the oxygen increases in the southern part but decreases in the northern part between 300 and 400 m. Then the authors said that this is partially compensated by an increase in the respiration rate (so reduction in the respired oxygen), but that again is not everywhere. First of all, I suggest describing the observed changes a bit more accurate, pointing to changes within particular regions in depth and along latitudes. Second to describe a bit better what the figures are really showing compare to what you are describing.

10) P. 17600 L. 19: Again the same problem as above but for the denitrified nitrate. You said that in the upper 250 m south of 10°S there is an increase in denitrification. If you look at Fig. 9e you observe negative denitrified nitrate. I guess again if you have an increase in the denitrification rate you observe a decrease in the denitrified nitrate. If this is what you mean, it is confusing to follow your argument when the direction of the changes plotted is on the opposite sign. So you should probably explain better what is shown in the figures, you could also for example invert the color bar so that it follows the direction of your description.

Regarding figures and tables, overall they are justified and clear. However I have some comment:

11) In table 1 the equation from Weiss (1970) it is used to calculate the oxygen saturation. This equation is obsolete, while a better equation is proposed by Garcia and Gordon (1992) based on the values of Benson and Krause. This equation has been used for calculating the oxygen saturation in well-known datasets like GLODAP and in the ATLAS09 (and all previous versions).

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12) In Fig. 1 I suggest to make the line track of the Meteor cruise in white since black is not well visible with the dark blue color on the background. Also I would consider to add (maybe on the same figure on another panel if this one is already too crowded) a schematic of the water masses and currents in the region (with arrows for examples indicating the pathway of the water masses), since it will help the reader that is not familiar with the circulation in the Pacific Ocean, to identify all the water masses that are described in the paper.

13) I would also consider inverting the order of Figs. 3, 4 and 5 since in the text the description of the figures starts with the 5 and continues with the 4 and then with the 3.

14) Fig. 6, why don't you use an absolute values? It can be more intuitive for readers.

Technical comments:

15) P. 17588, L. 10: The cruise P19 also has bottle-data station. Specifying that you use bottle-data station only for the M77 cruise, seems to imply that other kind of data were used for the P19 cruise.

16) P. 17593, L. 25: ITCZ is not defined.

17) P. 17594 from L. 5 on: Beside the suggestion to invert the order of Figs. 3, 4 and 5 (already mentioned in comment 13) I suggest also to refer to the figure the authors are describing in the text. For example: "SAAW has the highest percentage (>20%) in the western part of the 14°S transect (Fig. . . .)" and so on.

18) P. 17595, L. 1: "through" instead of "trough"

19) P. 17601, L. 11: remove "waters" after STW.

References:

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Interactive comment on Biogeosciences Discuss., 9, 17583, 2012.