

Review of „Seasonal Variability of the Oxygen Minimum Zone off Peru in a high-resolution regional coupled model“ by O. Vergara, B. Dewitte, I. Montes, V. Garçon, M. Ramos, A. Paulmier, and O. Pizarro.

The study focuses on the seasonal oxygen variability and the oxygen budget of the South Pacific Oxygen Minimum Zone (OMZ). It reports interesting and new results regarding important tropical ocean variability. The manuscript is largely based on a high-resolution physical/biochemical model simulation that are very well validated against available observations. With this model simulation the oxygen budget on seasonal timescales is evaluated, particularly focusing on the role of physical and of biogeochemical processes for the seasonal oxygen changes. The authors are able to define and calculate the relative importance of physical and biogeochemical processes in different regions and water depths, which represents an important result for our understanding of the annual cycle of oxygen. The manuscript is in general well written and represents a very valuable contribution to the existing literature. However, part of the analysis and particularly figures and its captions must be clearer to be completely understandable. I will give some suggestions and hints for consideration.

General Points:

The term mixing used throughout the paper is not well defined from the beginning. Does it refer to lateral (eddy-induced) or diapycnal mixing or both. Or does it correspond to the 3rd term of the rhs of equation 1? Please clarify. Also the lateral mixing term in equation 1 (2nd term rhs) is not well defined. Does it describe the subgrid-scale diffusivity? What is K_h in the model? Is it evaluated as part of the oxygen budget? Is it not important?

Fig. 12 seems to be a main result, but is very difficult to understand. It shows on the one hand the mean oxygen and energy flux resulting from the propagation of annual ETRW (Fig. 12a,b) and on the other hand the annual cycle of the DO eddy flux. It would be good to separate these 2 topics and discuss them separately. In this way you could add also phase information in a new panel to Fig. 12c, which would make the annual cycle of DO eddy flux better understandable.

Specific points:

P2, L16: “... DO eddy flux dominates over the mean seasonal DO flux ...”

It is not so clear what is meant: DO eddy flux includes a mean and a seasonal cycle; mean seasonal DO flux (is also not defined and difficult to understand) can also include a mean and a seasonal cycle. What “dominates” refer to?

P2, L19: what is “mean eddy flux” here?

P2, L22: Implications of the results ...

P3, L5: presently

P3, L8: “climatic gases” sounds awkward and not correct: better “greenhouse gases”?

P3, L9: “sequestration ocean role”, please reformulate

P5, L6: reduce ... the offshore transport (of what?)

P5, L7 also P5, L20: “eddy-induced” instead of “eddies-induced”

P5, L10-12: mesoscale activity can only be a ventilation process if the higher oxygen is found at the coast, which might be present during some time of the year. What are OMZ properties? Typically, I would assume that OMZ properties refer to minimum oxygen; the transport of it would not represent a ventilation of the offshore OMZ. Please clarify.

P8, L4: “OMZ equilibrium is reached”: water mass ages are typically much older in OMZs compared to the length of the used simulation. Thus the equilibrium is probably not reached. However, the simulation can still be quite stable and drifting not much away from the initial conditions, which should be good for the used application of the model.

P8, L20/21: something is missing like “obtained “ or similar

P9, L1 and L9: avoid the repetition

P10, L5: Here you have to define exactly the used terms: e.g., mean seasonal DO flux (also mentioned in the abstract), DO flux obtained from annual harmonics (Fig. 12), etc.; please be careful and use the defined terms throughout the manuscript. What is a mean flux and what is a seasonally varying flux?

P10, L5: I am not sure to what “latter” refers to.

P10, L8: How is the departure from monthly mean calculated? Just subtracting from the time series monthly means during each month would result in step-like functions. Do you use a running mean or any other kind of interpolation?

P10, L13: How is K_z and K_h defined in the model.

P10, L16: How large is K_h ? Is the horizontal diffusion further used in the oxygen budget, e.g. Fig 11b? What is mixing in Fig. 11b (on P5, L7 and L20 you use the term mixing for eddy-induced mixing)? What represents the residual in Fig. 11b?

P11, L3-6: Please clarify here, why do you need baroclinic mode decomposition to derive WKB ray paths. According to Ramos et al. (2008), in the long wave approximation the WKB ray path depend on the local vertical wave number. Such vertical wavenumber could be derived from the vertical distribution of the annual harmonic amplitude and phase. Please explain, why do you use instead phase speed values from different baroclinic modes and how this is in agreement with the WKB assumptions?

P11, L15: With the given normalization it is difficult to understand the amplitude of the annual harmonic. It would help to also see the harmonic amplitude without normalization.

P12, L4: at this stage it is not clear what is meant with advection and mixing. What is about eddy fluxes, and horizontal diffusion?

P13, L19: What does (deoxygenated) mean in brackets next to oxygen?

P14, L6: What is mixing here?

P14, L27-30: What is the constant input of low oxygen waters? This should be mean advection. Please clarify or reformulate.

P16, L11: Mean seasonal flux: My understanding is that Fig 12a shows a contribution of annual oscillations to the mean oxygen budget as it is averaged over time. This is very different from the remaining part of the section "Mean seasonal flux". Fig12c shows the annual oscillation of the DO eddy flux. Please clarify why these two terms are discussed together?

P16, L13: Is the seasonal DO flux maximum below 400 m? It is difficult to see as in Fig 12a as DO is normalized by the variance of its climatology. How does it compare to the contribution of the DO eddy flux to the mean budget?

P16, L17: "annual energy flux vector". Please be consistent throughout the manuscript with the use of "annual" and "seasonal". Here (Fig. 12b) annual is used, while for Fig. 12a seasonal is used. Annual is typical used for annual harmonics, while seasonal might be used for the mean seasonal cycle.

P17, L3: "thus" seems awkward at the beginning of a new section.

P17, L4,5: Offshore transport of DO also depends on the DO gradient, which can be directed onshore or offshore (see e.g. Fig. 2c) and might vary on seasonal time scales.

P19, L17: latitudinal variability: variability of what? I am not sure what is meant: variability of meridional velocity?

P19, L18,19: I don't see the connection: Why indicate the existence of eddies that they can remove DO from the OMZ, which represents a up gradient flux? Can the DO eddy flux become negative or only anomalous weak?

P19, L24: "DO exhibits ... amplitude" seems not to be correct. I would suggest: ... regions with enhanced amplitude or specific propagation characteristics, suggesting ...

P20, L8: upper 300 m.

P21, L6: suggestion: ...Anticyclone, and the peak in the seasonal DO eddy flux coincides with the reported ...

P21, L9: Similar processes were discussed in Qiu et al. (2013, JPO).

P21, L20: please specify the range of frequency that you have in mind

P31, Figure 1 and following figures: if used term „depth“ in contour labels or at the axes it should be always positive

P32, L32: mean zonal speed

P34, L5: what is total? Please define.

P36, phase figure could be in color to better see the different regions/phase propagation

P36, L4-5: “ray paths for a baroclinic mode” seems not correct, as a single baroclinic mode cannot produce a ray path.

P36, L6: oxygen not capital

P38, L38: nice figure

P39, caption: Solid white lines (c) denote

P40: Is horizontal diffusion from equation 1 included in one of these terms or is it neglected?

P41, L5,6: It is not clear, how to reconstruct the original fields from the EOF pattern, the principle components and RMS. Which terms are dimensional, which are non-dimensional, how is the RMS calculated, has the RMS units?

P41, L6: definition (region, width of the band along the coast, etc.) of alongshore winds, coastal sea level, Chl- a and MLD are required.

P42, Fig. 12: This figure is very difficult to understand and addresses different topics (so far I can understand). From the given formulas, I would assume that Figs. 12a and b represent mean fluxes. Fig. 12a represents a contribution to the mean oxygen budget (however, the importance of such a term relative to other terms of the budget is unknown). Fig. 12c represents the annual cycle of the DO eddy flux corresponding to an annually oscillating on- and offshore DO flux (is this correct?). Why are these terms together in one figure? Other points regarding this Figure: a) units are not given, taken into account the normalization, it should be m/s. Is this correct? b) why is the unit m^2/s , how is it calculated? Arrows indicate vector direction and strength. For Fig. 12c a phase information would be helpful.

P42, L11: What is DO: O_2' or O_2^{1yr} . It is not clear, how the normalization is performed. I would suggest to be consistent throughout the manuscript in using either DO, O_2 , oxygen concentration etc.

P43, L6: delete “average profile”?

P44, L5: direction and strength

P44, L5: include “mean oxygen values”

P45, L5: denote mean oxygen

P46, figure caption: very difficult to understand. Please clarify and better specify what is shown. Be consistent “dominant EOF” and “first EOF”. L6: “running variance of currents (dominant EOF mode)”: I am not sure what is meant. L7: “... section (blue line in Fig. 14)”. L13: “Dispersion” is very unusual term and I would suggest to find a better description of it. Are the spatial pattern normalized before calculating RMS and standard deviation.

P47, Fig. 17: Why is the oxygen flux from the coastal boundary into the OMZ not back and forth as the eddy fluxes at the northern-southern boundaries? Fig. 12c would suggest this. L7: The position ... at which depth? Please also explain the green line, where it is calculated. Again, this schematic seems to mix mean and seasonally varying fluxes. Is this the aim?

