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Interactive comment on "Pacific Decadal Oscillation and recent oxygen decline in the eastern tropical Pacific Ocean" *by* Olaf Duteil et al.

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We reproduced below the comments of the reviewer in bold and add our replies in black

Reviewer 1 The authors investigate the effect of PDO on the oxygen concentrations in the eastern tropical Pacific. To do this, they used a GCM and carried out several simulations with several atmospheric forcings representing the mean state, PDO positive and negative phases. Their simulation is unique, and the results reveal that the oxygen concentration in the eastern tropical Pacific is decreased due to the shift from the PDO negative to positive phases. The paper is well organized and easy to follow. Below, I list several minor comments for consideration before publication of this paper

We thank the reviewer for her/his positive evaluation

1) The similar paper to theirs has already been published (Deutsch et al., 2011), in which the effect of PDO on oxygen levels in the eastern tropical Pacific was examined using a coarse resolution GCM.

We agree insofar as that the possible role of the PDO was already pointed out in that previous study (Deutsch et al., 2011). However, while Deutsch et al. build their conclusions on a statistical analysis of a single hindcast experiment driven by realistic forcing that includes all modes of variability, our study exclusively addresses effects of the PDO and addresses its impact on marine oxygen levels by a dedicated set of experiments which allow us to explicitly assess the role of the phase of the PDO on the oxygen levels. The work of Deutsch et al. (2011) is acknowledged in the manuscript and similarities and differences will be discussed in more detail in the revised version.

They argued that the respiration in the eastern tropical Pacific in the oxygen deficient zone is decreased during the PDO positive phase, and the dissolved oxygen concentrations tend to increase. The result by Deutsch et al. (2011) seems to be opposite to the result obtained in this study in that the oxygen levels decrease in the PDO positive phase. The authors cited the paper, but did not discuss the difference between their results and those by Deutsch et al. (2011). In this paper, the authors stated that Deutsch et al. (2011) showed that the depth of the thermocline regulates the oxygen levels in the coastal regions of the north eastern subtropical Pacific Ocean. However, to my knowledge, Deutsch et al. (2011) intended to state the effect of PDO on the oxygen levels in the larger spatial scale, i.e., the eastern tropical North Pacific.

Deutsch et al. (2011) indeed focused on the eastern tropical North Pacific. In the revised version we modified the text accordingly:

l531-542: Deutsch et al. (2011, 2014) showed that the depth of the thermocline regulates the oxygen levels in the coastal regions of the north eastern subtropical Pacific

Ocean.

l7269-730: However, we still do not have a clear picture of the impact of the PDO on the suboxic regions and on the oxygen levels of the eastern Pacific Ocean. Indeed, the studies cited above focus either specifically on the suboxic regions of the north eastern tropical Pacific coastal region (Deutsch et al., 2011, 2014) or on the upper thermocline of the tropical Pacific Ocean (Duteil et al., 2014a).

Thus, the comparison between both results should be needed and the discussion about the comparison is also needed.

We concur with the reviewer that a more thorough comparison and discussion would be in order, and we have expanded the manuscript accordingly. We added the following text in the discussion L450 :

"Our study can be compared to the study of Deutsch et al. (2011) (thereafter D2011). Based on a 1959-2005 hindcast experiment, D2011 showed that the global suboxic volume (O2 < 5 mmol.m-3), of which 95

The discussion above is completed by a discussion focusing on the limitations of our modelling framework. Using different biogeochemical parameterisations may indeed impact the points (i) and (ii) above and ultimately the oxygen response to a PDO-induced change.

"While our modelling framework captures the general patterns of primary and export production reasonably well, it does not include an iron cycle and may thus, despite displaying a well-tuned mean state, exhibit systematic errors in the sensitivity to environmental changes. Furthermore, the model's representation of the respiration processes is relatively pragmatic. In particular, our model lacks an explicit nitrogen cycle including anaerobic remineralisation by denitrification under low oxygen conditions (Paulmier et al., 2009). Other limitations include for instance a simplistic parameterization of the attenuation of the flux of particulate organic matter that, in our model, neglects any

dependence on temperature or oxygen (Laufkötter et al., 2017). Also not considered in the model is the diel vertical migration of zooplankton also actively transports material into the deep ocean (Bianchi et al., 2015). Anthropogenic activities impact the global biogeochemical cycles. In particular, atmospheric deposition of anthropogenic nitrogen and iron may partially relax the iron limitation in the tropical Pacific Ocean (Ito et al., 2016). Industrial fishing may affect the mortality rate of the zooplankton and possibly feed back on productivity and respiration (Getzlaff and Oschlies, 2017). Each of these 'missing' processes may modulate respiration rates and possibly being correlated with the state of the PDO. An important result of our study is that the PDO-induced changes in respiration are smaller than the PDO-induced changes in oxygen supply by a few percent in most of the eastern tropical Pacific Ocean. We show that this small imbalance integrated for a few decades results in a significant PDO-driven oxygen anomaly that may explain a large part of the observed oxygen decline over the past decades in this region. Experiments including different biogeochemical parameterisations and processes will need to be performed to better assess the robustness of our results."

References

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dependence of the remineralization of organic matter, Global Biogeochem. Cycles, 31, 1038–1050, doi:10.1002/2017GB005643.

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2) Lines 130-131: I see that the zonal wind speed in WARM increases compared to MEAN in the mid-equatorial Pacific Ocean in Fig. 1b. Please clarify the point.

The sentence L130-131 referring to Fig. 1b is “In WARM the zonal wind speed decreases by about 0.2 to 0.5 ms-1 compared to MEAN in the mid-equatorial Pacific Ocean, where the winds are strongest (at least 8 ms-1) (Fig. 1b). It increases close to the eastern coast by up to 0.3 ms-1, where the winds are weaker (2 to 8 ms-1)”

Figure 1b displays the zonal component of the wind vector with eastward wind velocities having positive values. The zonal wind component is directed westward (negative value). The anomaly WARM – COLD is positive, as the zonal wind component in WARM is “less negative” : the zonal wind speed in WARM decreases (which corresponds to our sentence).

However, the legend of the figure 1 is wrong as “wind speed” should read “wind component (positive eastward)”. The original legend of the Fig. 1b is L643-647 is: “b – average of the zonal 10m wind speed (m.s -1) of the PDO positive (WARM experiment) phase minus PDO negative phase (COLD experiment). Contour : zonal wind speed average (m.s -1) 1948-2007. c – average of the meridional wind speed (m.s -1) of the PDO positive phase (WARM experiment) minus PDO negative phase (COLD experiment). Contour : meridional wind speed average (m.s -1) 1948-2007.”

it should read : “b – average of the zonal 10 m wind component (m.s -1, positive eastward) of the PDO positive (WARM experiment) phase minus PDO negative phase (COLD experiment). Contour : zonal wind component average (m.s -1) 1948-2007. c

– average of the meridional wind component (m.s -1, positive northward) of the PDO positive phase (WARM experiment) minus PDO negative phase (COLD experiment). Contour : meridional wind component average (m.s -1) 1948-2007.”

3) Line 194: COLD is mistaken for WARM?

yes

4) Figs. 1e and 1g: please define the positive and negative values in the barotropic stream function and the meridional overturning.

Fig 1e. The sense of rotation is clockwise for positive values Fig 1g. The sense of rotation is clockwise for positive values

5) Lines 684-685: “COLD minus WARM” is “WARM minus COLD”?

yes

6) Line 702: 10 âŮę W is 10 âŮę S?

yes

7) Line 705: “COLD and WARM” is “WARM and COLD”?

yes

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