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Interactive comment on "On the role of circulation and mixing in the ventilation of oxygen minimum zones with a focus on the eastern tropical North Atlantic" *by* P. Brandt et al.

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Reviewer #2: This overview is an important contribution to the regional and global communities working on the ETNA and especially towards improving the way models reflect the climate sensitivities of the ETNA OMZ. It reflects a very significant and well coordinated effort by the community represented by the authors. The manuscript succeeds in assembling a description and steady state quantification of the oxygen ventilation and consumption processes but it does so in a manner which is dense and hard to read and make the connections. While there is an attempt to "integrate" the processes in Fig 21 the text has the sense of a number of almost standalone parts of

study. One easy gain to simplify the text would be to remove the section on the ETSP which interrupts the coherence of the ETNA focus. It is also not clear how and where this study adds to what was already known. In this respect a focus in the introduction not just on the gaps in the ETNA that this study set out to investigate but also a brief comparison of the Atlantic and Pacific OMZs to put some context to the relatively well ventilated ETNA.

Answer to reviewer #2 (same as answer to reviewer #1): Although removing the ETSP part would shorten the text and keep the focus on the ETNA, we like to keep the comparison of the ETNA OMZ with the ETSP OMZ in the text. The motivation here is similar as for the SFB 754 to compare a hypoxic system, i.e. the ETNA OMZ, with a suboxic system, i.e. the ETSP OMZ. Particularly the observed deoxygenation trend in the hypoxic ETNA OMZ might lead to a shift of the ETNA OMZ to suboxic conditions and hence the comparison of the two systems will lead to a better understanding of differences and similarities of both systems finally to investigate possible consequences of such a possible regime shift in the future. This was not made clear in the earlier text and will be clarified in the revised manuscript. We included in the introduction: "The Atlantic and Pacific OMZs have many similarities particularly regarding OMZ shape and circulation pattern. The ETNA and the eastern tropical South Pacific (ETSP) OMZs (Figs. 1, 2) are both located in the shadow zones of the ventilated thermocline and are ventilated by lateral and vertical mixing as well as by zonal advection in the equatorial band. However, the striking difference between both OMZs is that the ETNA OMZ is hypoxic (oxygen below $\sim$60 to 120 μmol/kg) and the ETSP is suboxic (oxygen below about 10 μmol/kg). Karstensen et al. (2008) concluded that this difference is the result of reduced oxygen levels in the eastward current bands of the Pacific OMZs compared to the Atlantic OMZs, which they argue can be traced back to the larger ratio of the total volume of OMZ layer to the renewal or subduction rate in the Pacific compared to the Atlantic." and "The ETSP OMZ has been studied as well using a reduced observational program. However, the comparison between the hypoxic ETNA and the suboxic ETSP is of particular interest here, as the observed deoxygenation in the ETNA, or future climate change, might lead to a shift from hypoxic to suboxic conditions." At beginning of section 8 we included: "A continuation of the observed deoxygenation in the ETNA would turn the ETNA OMZ suboxic within a century, hence it is worth to look at differences and similarities of the ETNA and the ETSP with regard to a possible shift of a hypoxic system to a suboxic system." In the summary and discussion we included: "The relative importance of the different terms affecting the oxygen budgets of the ETNA und ETSP OMZs appear to be similar. For both OMZs the eastward advection of oxygen-rich waters from the well-ventilated western boundary was found to be a dominant ventilation process. As the zonal currents are of similar strength in the tropical Pacific and Atlantic, the difference in the basin width of both oceans consequently results in lower oxygen concentrations and larger water mass ages in the eastern tropical Pacific (Fig. 20) compared to the eastern tropical Atlantic (Fig. 6)."

Reviewer #2: Much modelling and observational work has been undertaken on the role of planetary wave systems and dynamics to explain O2 variability and trends in the tropical OMZs but this is not really reflected in this study. Given that these dynamics appear to explain a significant part of the variability in the ETSP and the ETSA it seem that the study should explain why these are under-represented in the ETNA.

Answer to reviewer #2: We are not sure, what is exactly meant with the role of planetary wave systems and dynamics. However, we identified an under-representation of the role of remote forcing via equatorial Kelvin and coastal-trapped waves for the variability in the coastal upwelling regions in the previous version of our manuscript. Thus, we included in section 6.1 a paragraph regarding the role of intraseasonal coastal-trapped waves: "Besides the seasonal cycle, the flow variability off Mauretania and Senegal is influenced by intraseasonal coastal-trapped waves partly originating in the equatorial wave-guide (Polo et al., 2008). However, associated sea level anomalies are substantially weaker in the North Atlantic compared to the same latitude band in the South Atlantic. A strong influence of coastal-trapped waves on the oxygen distribution on the shelf of the ETNA as evidenced for the eastern boundary upwelling systems

of the South Pacific and South Atlantic (Gutierrez et al., 2008;Monteiro et al., 2011) could so far not be shown." And in section 8.2 we included "Eddies are mainly generated by coastal flow instabilities that are influenced by remote equatorial forcing via coastal-trapped waves (Belmadani et al., 2012)."

Reviewer #2: The time series data in Figs 8 and 9 indicate that there are seasonal and intra-seasonal modes which warrant consideration in this context.

Answer to reviewer #2: The time series at 5° N show weak annual and semi-annual variability that might be associated with planetary wave propagation on these timescales. Similarly, intraseasonal variability at 5° N might result from Rossby wave propagation associated with the instability of the NECC. We included in section 4 explicitly planetary waves in the list of processes affecting time series shown in Figs. 8 and 9.

Reviewer #2: Given that one of the major scientific benefits of such a synthesis is a better understanding of the climate sensitivities of the ETNA, it would have been useful to see some discussion on where models may look to improve the way they reflect the climate sensitivity of the OMZ.

Answer to reviewer #2: In the summary and discussion, we suggest directions for model improvements: "The increase in resolution of ocean circulation models improves the tropical circulation and associated oxygen distribution in the Atlantic (Duteil et al., 2014) and the Pacific OMZs (Montes et al., 2014), suggesting that model physics largely contribute to the oxygen bias in coarser-resolution models. However, particularly the intermediate circulation (below 250 m) is still underestimated by these high-resolution simulations in realistic settings." "Such a regional pattern is most likely due to changes in the circulation pattern associated with forced ocean dynamics as well as with internal ocean dynamics. [...] Improvements of model ventilation physics by increased resolution and/or improved parameterizations will reduce errors in the simulated mean oxygen distribution and its variability, but at the same time will help to better understand the climate sensitivity of OMZs with regard to anthropogenic climate change."

Reviewer #2: The meridional negative anomaly of the oxygen trend (Fig. 18) between 10 - 30N and 100 - 500m would seem a good basis to examine where the imbalance may be emerging in the proposed budgets Fig. 13 and 14.

Answer to reviewer #2: We are so far not able to conclude from the budget calculation about the trend pattern (Fig. 18). However, we included in Sect. 7: "Changes in the strength and location of the wind-driven gyres are a possible explanation for the long-term oxygen trends observed between 15° and 30° N in Fig. 18."

Reviewer #2: Finally, the summary is again too long and much of the discussion points are repeating the text. Overall, an effort to clarify the objectives and context of the study as well as removal of non critical parts will help further highlight the strengths of this otherwise comprehensive excellent study.

Answer to reviewer #2: We removed repeating parts of the discussion and also streamlined the text in many places in the main body of the manuscript, which hopefully helps to clarify its main points.

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