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Biogeosciences Discussions

Interactive comment on "Following the N_2O consumption at the Oxygen Minimum Zone in the eastern South Pacific" *by* M. Cornejo and L. Farías

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We really appreciate the contributions of the reviewers, who made contributions to this ms. and helped us to improve and precise several points conducing to misinterpretations. Below are the comments and responses to each point. Major Comments 1. N2O production/consumption rates As the reviewer mentioned, we provided a parametrization of the ïĄĎN2O in the OMZ of the ESP. We rewrote and changed this phrase in order to depict in a better way our work. 2. Uncertainty about N2O consumption within the denitrifying domain of the OMZ. In order to reduce the uncertainty of N2O concentrations, and then the estimated apparent N2O production, we corrected all our equilibrium and ïĄĎN2O concentrations according to the age of the water mass below the mixed layer as was suggested by the reviewer #1. It was made considering the

CFC-11 and CFC-12 concentration came from the WOCE stations located on the study area. (see the answer to reviewer #1). Also, the error of the analytical measurements of N2O is now included in the method section. 3. End-member mixing analysis. We understand that the mixing analysis is a useful tool to accurately determine the effects of the mixing in the gases concentration. Our analysis is mostly descriptive about a relationship between two nitrogen species, NO2- and N2O, which had been observed for many years ago, not only in the ESP, but also in other OMZs. We believe that the found relationship help to understand the N2O behavior under O2 stress, but using nitrite as a dependent variable. We present new arguments to illustrate the risk associated with the use of oxygen measured with standard methods. As most of the N2O undersaturations are observed in the core of the OMZ, we assume there is no mixing in the water mass. This is a reasonable assumption taking into consideration the strong stratification observed in the study due to the presence of the minimum saline layer above OMZ. Other evidence with Argo float showed no such ventilation events as a common phenomenon in the zone (Whitmire et al 2009, Pizarro et al, submitted). Whitmire, A. L., R. M. Letelier, V. Villagrán& O. Ulloa. Autonomous observations of in vivo fluorescence and particle backscattering in an oceanic oxygen minimum zone. Optics Express, 17, 21992-22004, 2009. 4. Insight on the cycling of N2O in the OMZ. a. Based on experiments, and isotopic and isotoperic compositions, Farías et al 2009 and Dalsgaard et al. (accepted) revealed the importance and magnitude of total denitrification as a process driving N loss in the OMZ's ESP. Also, N2O mass balance in the subsurface layer indicated that only a small amount of the gas could be effluxed to the atmosphere and that most N2O is used as an electron acceptor during denitrification at rates higher than those measured for anammox. As a result as well, Castro & Farías (2004) stated that the proportion of N2O consumption relative to its production increases as O2 decreases towards the OMZ core. In the present study, we are showing another important factor in the ongoing denitrification in the core of the OMZ in a wide latitudinal range, as also the relationship between two nitrogen species involved in denitrification, NO2- and N2O. Farías, L., M. Castro-González, M. Cornejo, J.

Charpentier, J. Faúndez, N. Boontanon& N. Yoshida. Denitrification and nitrous oxide cycling within the upper oxycline of the oxygen minimum zone off the eastern tropical South Pacific. Limnology and Oceanography, 54, 132-144, 2009. Castro-González M., & L. Farías. N2O cycling at the core of oxygen minimum zone off northern Chile.Marine EcologyProgress Series, 280, 1-11, 2004. Dalsgaard, T,B. Thamdrup, L. Farías& N. P. Revsbech (2012). Anammox and denitrification in the oxygen minimum zone of the Eastern Tropical South Pacific.Limnol&Oceanogr. (accepted) b. Correlations between ïĄĎN2O and N*. Distinguish between production and consumption regimen. In order to give a notion about the N* picture in our study region, we are now included the N* plot in figure 1, as also included a description in the text. Briefly, OMZ was characterized by strong negative N* (Deutsch et al 2001), as a consequence, negative ïĄĎN2O were always associated with negative N*. However, there was no observed any correlation between both variables (r2=0.04; p=0.05) c. Comparison with Nevison's model As it is mentioned in the text, our utilization of the Nevison's equations looks for demonstrates the importance of denitrification and then N2O consumption in the core of our OMZ. We are certain that Nevison does not include consumption by denitrification. In this ms we demonstrate that N2O consumption (negative apparent N2O production) proceed in the ESP. On the other hand, we think that the water mass mixing is an important issue but it did not initially refer our work. Indeed, recent works indicate that ventilation events are transient and could be an interannual frequency (Pizarro et al submitted). d. Oxygen threshold 4 to 8 μM and nitrite threshold 0.75 μM. Based on mentioned Bonin experiments (1987), the oxygen threshold for the ongoing N2O consumption was 8 μM. Also, based on observed data, NO2- threshold of 0.75 μM was chosen, which show an onset of negative ïĄĎN2O in nitrite concentrations higher than this (Figure 1, here). As for oxygen approximation, NO2- concentrations higher than 0.75 μM were observed only in waters with O2 lower than 8 μM. This is relatively good agreeing with the Thamdrup et al (2012) results, which show NO2- accumulation (higher than 0.5 μM) by only in nanomolar O2 levels waters. The sensitivity of the O2 methods would be the explanation for this difference. This is now discussed in the text.

Figure 1.Number of samples with negative ïĄĎN2O. The line indicates the 0.75 μM of nitrite Minor points. 1. P2697, L.19-20. Equation and empirical values from Nevison's work was included. 2. P2699, L.2. Changed 3. P2699, L16. We mentioned that the relationship between ïĄĎN2O and NO2- looks like an exponential function (Figure 2). In order to obtain a linear function, we related the ïĄĎN2O with the inverse of the NO2- concentrations.

Figure 2.ïĄĎN2O vs. NO2- concentrations in the core of the OMZ from the study area. 4. P2699. Equation 2 gives another parametrization of ïĄĎN2O in the OMZ. It's correct that there is a huge oceanic O2 database compared with NO2-. However, as it is discussed in the text, and also is noted in other works (Jensen et al 2008; Revsbech et al 2009; Thamdrup et al 2012) regular samples of O2 have poor analytical resolution at low O2 concentrations. Furthermore, the found relationship between NO2- and ïĄĎN2O is insights about two nitrogen species are closely related. 5. P2700. The profile showed is just an example. The total observed (black points) and estimated (red points) ïĄĎN2O are showed in figure 3b. 6. Figure 2. Lines are the linear fit of the points. This and the R2 and number of points, are indicated in the figure. Technical points and tipos 1. P2692, L.12. Changed 2. P2692, L.13. Removed 3. P2693, L.13-18. Phrase re-wrote 4. P2694, L.1-5. Phrase re-wrote 5. P2694, L.9. Removed 6. P2699, L.23. Changed 7. P2699, L.11. Changed 8. P2699, L.17. Changed 9. P2699 equation 2. [NO] changed by [NO2-]. $\pm$8 is the error. Now, the constant coefficient has also its error. 10. P2700, L.1. Changed 11. P2700, L.5. Changed 12. P2700, L.11. Changed 13. P2700, L.18. Iron availability has been associated to the secondary NO2- maximum in the OMZ from Arabian Sea (Moffet et al 2007). An explanation is the onset of the denitrification, which has high Fe requirements. This is now have a briefly discussion in the text. 14. P2700, L.22. Changed 15. Figure 1.b-e. We change the contouring method in order to improve the images 16. Figure 2a. Labels and contour lines have been added. 17. Figure 2 and 3. Changed. 18. Figure 3. "," in the x label changed to ".". 19. Page 2694 to 2697. References changed.

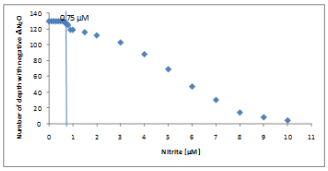

Figure 1.Number of samples with negative ΔN2O. The line indicates the 0.75 µM of nitrite

Fig. 1.

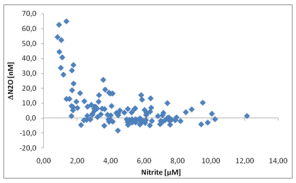

Figure 2. ΔN2O vs. NO2- concentrations in the core of the OMZ from the study area

Fig. 2.