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Interactive comment on "Oceanic N_2O emissions in the 21st century" *by* J. Martinez-Rey et al.

Anonymous Referee #3

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This paper presents a model simulation of oceanic N2O emissions under an enhanced CO2 level 'business as usual' future climate scenario. Their results suggest a decrease in future N2O emissions may occur due to a reduction in export primary production and mixing between the surface and deep N2O reservoirs. This decrease in mixing (increased stratification) would also lead to an increase in N2O concentration in the deep ocean. They consider two model parameterizations of N2O production, with one parameterization also including N2O consumption at low O2. Given the predominance of a high-O2 production pathway, the differences between the parameterizations are relatively small. In fact, without an estimate of uncertainty, it's not even clear whether they are significant.

One of the conclusions that they make is that we need to better understand the processes leading to N2O production under low oxygen conditions. I agree with this statement, but I do think we know more about N2O production than is represented in their

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parameterization. The low-O2 parameterization used here is derived from a Goreau et al., (1981) study based on experiments with nitrifying bacteria. It's pretty clear that denitrification is linked to organic matter supply, and more sophisticated model could include denitrification explicitly, allowing N2O to be both produced and consumed by this process.

Moreover, it is not clear to what extent they tested their assumptions about the N2O initial condition and production parameterization. A range of values is possible for the N2O yields for low and high O2 proceses, and I'm curious how the values used here were chosen. Would tuning of these parameters lead to an improvement in the model? As it currently stands, the model/data agreement could be better (Figures 1-3), and that leads me to question the results of the future simulations. In addition, it would be helpful to have an estimate of uncertainty in the model results, with which to gauge whether the simulated decrease in oceanic N2O emissions is significant.

Finally, I wonder what are the implications of the model spin-up procedure (only letting the N2O model run for 150 years before perturbing the system) and proscribed initial conditions (20 nM everywhere) for the results. How do we know that the 'future scenario' is not simply the model N2O field continuing to evolve from the proscribed initial conditions? It seems like these changes should be evaluated relative to a control simulation in which the forcing is kept constant through 2100.

p. 16711: The choice of 75% of N2O production in the P.OMZ simulation via the high-O2 pathway seems rather arbitrary. It would be helpful to know how sensitive the model results are to this assumption.

p. 16711-12: What are the implications of the model drift for model results described here? Were such drifts corrected for in some way? A model spin-up time of 150 years is probably too short to come to equilibrium.

p. 16712: "close to the subsurface" is awkward phrasing. p. 16714: How was the global average profile of N2O estimated? Why not this distribution to initialize the model?

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p. 16714: “does not fully reproduce neither. . .” is a double negative.

p. 16715: It seems relatively easy to parameterize the high O2 process and get distributions correct outside the OMZ, but the real trick is to get it right in the OMZ. How much tuning went into this model fit?

p. 16717, first paragraph: This discussion seems circular. They are seeing a model manifestation of what they parameterized it to look like. They parameterized N2O production to primarily track O2 consumption responding to organic matter export, and that is what it does. Would some other combination of parameters simulate the N2O distributions and fluxes equally well, or even better?

p. 16719: Again, “close to the subsurface” is awkward.

p. 16719: It’s not clear to me from Figure 7 that all relevant changes occur in low-latitude regions? Could you please be more specific or quantitative in this statement? The changes appear to be fairly evenly spread.

p. 16723: Constant atmospheric N2OâĂŤwhat is the sensitivity to this assumption and the choice of atmospheric N2O concentration?

Figures: In general, the text in the figures is very small and an increased font size would improve readability.

Figure 1: What is the reason for the mismatch between model results and observations from Nevison et al (1995)? It looks like the model simulations underestimate N2O emission from the ocean in several regions of the ocean (Figure 1d).

Figure 8 legend: I assume these are the box model results, but it is not clear what is being shown.

Interactive comment on Biogeosciences Discuss., 11, 16703, 2014.