General comments

In their paper, Martin *et al.* present a new global inverse model that represents the distribution of nitrate and nitrite concentrations and isotopes (^{14}N and ^{15}N) in the ocean. The model is novel as it accounts for NO_2^-, a key intermediate in the marine N cycle, which is usually not considered. Overall, the manuscript was well written, easy to follow and the model and results were well discussed. This model will undoubtedly improve our understanding of the global marine N cycling, especially in ODZs. I strongly recommend its publication, after the relatively minor revisions below.

Specific comments
Introduction

Page 3, lines 2-5: How could these differences be reconciled? Could it be that the isotope effect for nitrite oxidation is determined by environment conditions and/or microbial assemblages? The kinetic isotope effect for nitrite oxidation needed in the model is more consistent with the large inverse ε for NO_2^- oxidation of ~ −30 ‰ that has been observed for anammox bacteria in culture (Brunner *et al*., 2013). Other processes, for instance nitrite oxidation with alternate electron acceptors, could also occur with a distinct (and as yet uncharacterized) isotope effect (e.g., Babbin *et al*., 2017).

Methods
Page 4, line 20: I presume that the resolution of this model (2° x 2°) is currently too coarse to capture N-cycling in coastal regions where there is a high spatial (and temporal) heterogeneity, as well as higher turnover rates for most N-species (e.g. Hu *et al*., 2016). Would it be feasible to increase the resolution in future versions of the model to better represent coastal regions?

Page 4, lines 30-32: NH_4^+ significantly accumulates in coastal regions, for instance, concentrations of up to 4 μM were observed off Peru in December 2012 (Hu *et al*., 2016).

Page 5, line 23: Define WOA (World Ocean Atlas) when it is first used.

Pages 5 lines 28-30 and page 6, lines 1-2: Are modeled DON concentrations in surface waters consistent with a mostly recalcitrant DON pool in the ocean? The fast cycling for the labile fraction prevents its accumulation (Knapp *et al*., 2005; Bourbonnais *et al*., 2009). What is their modeled DON distribution?

Page 6, line 9: Are there any newer data for atmospheric N deposition? How well do these modeled estimates match real observations?

Page 6, lines 25-28 and Page 7, lines 1-2: Other organisms (not only *Trichodesmium*) mediate N_2 fixation. For instance, the distribution of unicellular cyanobacteria contrast with that of *Trichodesmium*, and depend on depth, temperature and water column density structure (Moisander *et al*., 2010).

Page 7, lines 12-13: Is N_2 fixation in their model consistent with direct measurements? For instance, while previous models suggested significant N_2 fixation in the ETSP (Deutsch *et al*., 2001), Knapp *et al*., 2016, concluded that N_2 fixation is negligible there based on evidence from direct field measurements.

Page 8, lines 6-7: Is this a reasonable assumption? NO_2^- accumulates significantly between 100 and 200 m depth in the ETSP ODZ (up to about 12 μM) (Bourbonnais *et al*., 2015).

Page 8, lines 30-31: The Martin *et al*. (1997) mineralization curve requires a correction under anoxic condition where observed carbon burial is higher (e.g., Katsev and Crowe, 2015).

Page 10, lines 14-15: What about chemolithoautotrophic denitrification in sulfidic environments (e.g., Lavik *et al*., 2009)?

Page 11, line 1: These thresholds are on the high side compared to the nanomolar ranges suggested by Dalsgaard *et al*., 2014.

Page 11, line 13: "Anammox also produces 0.3 moles of NO_3^-…" Is this always true or it depends on environmental conditions?

Page 12, lines 10-13: Nitrification-denitrification in the sediments produces an efflux of heavier $\delta^{15}N\text{-}NH_4^+$ that would increase $\delta^{15}N\text{-}NO_3^-$ following nitrification (e.g., see Granger *et al.,* 2011).

Page 14, lines 9-10: It is preferable avoiding citing a manuscript in preparation.

Results

Page 15, lines 22-25: Are these relationships significant? It does not seem to be the case for nitrite (Fig. 3, b).

Page 16, lines 17-18: The model also fails to account for the episodic upwelling events in the ETSP and their effects on primary productivity and N-cycling.

Page 16, lines 20-23: N* is also affected by sedimentary processes in anoxic sediments, i.e., preferential release of PO_4^{3-} due to oxyhydroxide dissolution (Noffke *et al.,* 2012).

Page 17, line 2: The model does not reproduce the extreme $\delta^{15}N\text{-}NO_3^-$ values (up to about 70‰ observed in Bourbonnais *et al*., 2015) in the ETSP near the center of an anticyclonic eddy.

Discussion

Page 19, lines 2-3: Is this a reasonable rate?

Page 19, lines 8-21: Another consideration is that the [O_2] data from the WOA were generally measured using Seabird sensors, with typical detection limit in the μM range, while N-loss processes are inhibited at [O_2] in the nM range.

Conclusion

Page 20, lines 12-13: Bourbonnais *et al.* (2015) also calculated an isotope effect of 16‰ for NO_3^- reduction assuming a closed system.

Figure 3: Add r^2 values and degree of significance.

Figure 4: I assume that these are offshore profiles?

Figures 5 and 6: What about NO_2^- and $\delta^{15}N$-NO_2^-?

Technical corrections:

Page 9, line 15: NH_3 appears to be in a different font.

Page 21, line 8: Remove the first "be" in "… given process may ~~be~~ vary, or be expressed …"

Additional references

Babbin, A. R., Peters, B. D., Mordy, C. W., Widner, B., Casciotti, K. L., & Ward, B. B. (2017). Multiple metabolisms constrain the anaerobic nitrite budget in the Eastern Tropical South Pacific. *Global Biogeochemical Cycles*, *31*(2), 258-271.

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Noffke, A., Hensen, C., Sommer, S., Scholz, F., Bohlen, L., Mosch, T., Graco, M., and Wallman, K.: Benthic iron and phosphorus fluxes across the Peruvian oxygen minimum zone, *Limnol. Oceanogr*., 57, 851–867, 2012.