

Review of *'Isotopic constraints on the pre-industrial oceanic nitrogen budget'* by C. J. Somes et al. (MS No. bg-2013-6, in *Biogeosciences Discuss.*, 10, 3121-3175, 2013, doi:10.5194/bgd-10-3121-2013)

General Comments

This article is excellent in its scientific significance, scientific quality, and presentation. Somes et al. clearly and elegantly describe a dual-model (MOBI and 1-box model, '0D') analysis of the preindustrial global oceanic nitrogen budget. This analysis presents the first (to my knowledge) global ocean model N-isotope results. These results, combined with the suite of sensitivity analyses performed, provide a high level of mechanistic insight into the relative importance of modeled N-isotope fractionation processes occurring during N₂ fixation, and denitrification in the water column and within sediments. The authors identify both nitrate utilization in suboxic zones and the net benthic denitrification fractionation factor as having particularly large impacts. The model-data comparison employs a new benthic sediment d¹⁵N dataset, which serves as a useful model target. Using the model simulation that best reproduces the observational dataset, Somes et al. provide new estimates of preindustrial N₂ fixation, water column denitrification and benthic denitrification. The level of background information throughout this well-written article achieves the ideal balance of informing those unfamiliar with oceanic nitrogen cycling, while asking and addressing the cutting-edge scientific questions motivating this research.

Specific Comments

1. As this study presents a new approach to estimating N₂ fixation, it could be useful to include a brief review here of the "historical" non-model-based methods that have been used to measure N₂ fixation (and have been found to produce underestimates). (P 3123 L 17)
2. In the text, diazotrophs' growth rate is described to be no longer set to zero below 15C (P 3129 L 8-11), but Appendix B contradicts this (P 3151 L 17). Please update Appendix B.
3. There is an inconsistency between the original range of global water column denitrification estimates given at P 3124 L 26 (50-150 Tg N yr⁻¹), and what is given in the water column denitrification model experiments section at P 3132 L 20 (70-150 Tg N yr⁻¹).
4. Can you briefly clarify in the text (P 3135 L 21-26) that model seawater d¹⁵N is not being simultaneously adjusted when the d¹⁵N of PON reaching the seafloor is enriched by 0.9‰ km⁻¹ to account for diagenesis. It would be good to make clear that the adjustment of sediment d¹⁵N does not affect isotope conservation and is done expressly for model-data comparison.
5. Given the range of recently reported high ε_{BD} values (=4-8‰), I wondered why the authors chose to not perform an additional sensitivity experiment well within this range (for example, ε_{BD} = 6‰). This is indirectly addressed in the discussion section (P 3142 L 16-29), and at that point it is clear that

the 0D model was run using $\epsilon_{BD} = 6\text{‰}$. Unfortunately, these results are not shown. Please address this choice in the text.

Technical corrections:

1. P 3123 L 19-20: the word “to” missing from “estimated to be”
2. P 3124 L 10: ETSP has not been defined – change to Eastern Tropical South Pacific (ETSP)
3. P 3124 L 17-19: the sentence starting “Estimates for N₂ fixation...” is awkward – at minimum change “predicting” to “predict”
4. P 3124 L 21 – change to “found to underestimate”
5. P 3127 L 17 – ‘...implicit in the model simulations that perform superior with respect to observed...’ should be replaced with ‘...implicit in the model results that most closely simulate observed...’
6. P 3127, L 20 – remove ‘used’
7. P 3129 L 24 – change ‘to’ to ‘by’
8. P 3130 L 22 – change ‘hits’ to ‘reaches’ or ‘arrives at’
9. P 3130 L 26 – here the word ‘parameter’ is used twice – after the O₂* equation, remove ‘parameter of oxygen and nitrate concentrations’
10. P 3132 L 10 – insert equal signs before ‘~5‰’ and ‘~30.8 μM’
11. P 3132 L13 – insert ‘section(s),’ before ‘annual mean results’
12. P 3132 L 18 – remove ‘given’ before ‘nitrate thresholds’
13. P 3135 L 22 – change ‘hitting’ to ‘reaching’ or ‘arriving at’
14. P 3137 L 4 – at ‘with greater’, change ‘with’ to ‘of’
15. P 3153 L19 – First, why introduce here the labile carbon flux term F_c if it’s not used in the following equation, and second, please define the RRPOC term (as in Bohlen et al. (2012): “rain rate of POC to the sea floor”). You could additionally introduce RRPOC on P 3130 L 19 after “organic carbon rain rate”.
16. P 3140 L 18 – in ‘nitrification-denitrification loop’, denitrification is misspelled
17. P 3142 L 1 – remove ‘both’ (a double instance)
18. P 3143 L 27 – suggested rewrite: “The fact that MOBI is directly comparable to d15N observations in regions where denitrification occurs in the water column and sediments allows better validation of the various isotope effects.”
19. P 3144 L 4 – first usage of ETNP – spell out or define acronym earlier
20. P 3144 L 10 – change ‘levels’ to ‘level’
21. P 3145 L 17 – change ‘is likely’ to ‘are likely’

Technical corrections – Tables and Figures:

1. Table 3 – The percent symbols should be changed to per mille symbols for categories ‘Sinking PON full mean (‰)’. Also, please add to the caption that observational estimates, where available, are given in parentheses (as in Table 2).

2. Figure 1 – the caption should include definitions of terms used in the schematic, as well as the Somes et al. (2010b) reference.
3. Figure 4 – add units to the y-axis (‰)
4. Figure B1 – revise the x-axis label from ‘threshold value’ to ‘NO₃⁻ threshold value (μM)’