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Biogeosciences Discussions

Interactive comment on "Production and consumption mechanisms of N_2O in the Southern Ocean revealed from its isotopomer ratios" *by* N. Boontanon et al.

Anonymous Referee #2

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This paper presents three depth profiles of N2O and its isotopomers from the Southern Ocean from 61 to 66S. The dataset is woven into a theory for N2O production and consumption and air-sea flux dynamics in the Southern Ocean. The dataset is new and interesting and the theory is potentially insightful, but the present write-up is difficult to follow. In particular, the discussion in sections 4.1 and 4.2 seems to be led by preconceived ideas, which are eventually, and sometimes only loosely, related to the actual data. A main idea, which needs to be stated more clearly, is that N2O is produced by nitrification in the upper ∼200m, as suggested by isotopically light N2O, and then is consumed by denitrification below the N2O maximum, as suggested by declining N2O and enrichment in 15N, 18O and site preference. This hypothesis is supported by the

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data, but the patterns are weak compared to other profiles in the ETNP or western Pacific. It would be helpful to discuss whether the interpretation presented is the only one possible and, if not, to acknowledge alternative explanations. Another point of confusion is that the isotopic values are frequently discussed relative to mean tropospheric N2O or subsurface nitrate, but these reference values are not presented in an easily digestible manner. It would be good to have them all in one convenient place, such as in a table. In addition, there is considerable structure in 15N alpha, beta and site preference that is not adequately discussed or explained. The paper eventually may be suitable for publication, but it would be more effective if it were rewritten in a more coherent fashion.

Some other comments: p.8, 1st paragraph, discussion of alpha inv/ev. Please wrap up this discussion by relating it to the actual data. What value of alpha is estimated from the Southern Ocean data?

Abstract: Please mention the latitude range as well as the longitude of the measurements

Methods: Please give uncertainty in nM of the N2O concentration measurements (keeping in mind that the surface undersaturation of $\sim$6% corresponds to slightly less than 1nM at these temperatures). Is 2-decimal point precision (e.g., p 7) warranted?

Figure 2. Please cite in the text when this figure is first presented. It would also be good to show DO or AOU in the same figure as DN2O. It is hard to see the DO minimum or to match it up to the DN2O maximum in the current set of figures.

Section 4.1, line 4. Please replace “another ocean” with the name of the appropriate ocean (Indian?).

p.6, line4, the statement that excess N2O increased significantly toward continental margins seems inconsistent with smaller undersaturation of 1nM at 66S vs. 2nM at 61S

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Section 4.1, lines 8-9. Please define or give a reference for Feb-Mar temperature stability. A change of 1.5 deg C could give rise to a 1nM change in N2Osat.

Finally, with respect to section 4.3, the discussion is problematic for a number of reasons. First, it is unclear what the northern extent of the Southern Ocean is, as defined in this manuscript. Please give the latitude bounds of the estimated Southern Ocean area of 37 e12 mˆ2. Second, the discussion implies that the escape of subsurface N2O, which is supersaturated by 8nM (about 50% at 0 deg. C), is diffusion limited. This may be true in the summer or perhaps in the continental margin due to ice sheet dynamics, but this is not true year-round in the Antarctic Circumpolar Current. When the mixed layer breaks down in fall and winter, it is reasonable to expect to excess N2O to escape to the atmosphere. Diffusion across a stratified subsurface layer will not be the limiting factor. Third, the Southern Ocean N2O flux estimate in Mg N/day is an ambiguous measurement unit. Readers may be tempted to multiply by 365 to estimate the annual flux, but the Southern Ocean N2O source is probably highly seasonal, with the largest net flux to the atmosphere occurring during winter when the mixed layer breaks down and enriched deepwater is ventilated. During seasons when the ocean is stratified, e.g., February, the flux is probably governed by changes in windspeed, as discussed in Section 4.1, or by solubility effects, such as warming or cooling of surface waters or freshening due to ice melt. Extrapolating fluxes resulting from temporary disequilibrium due to wind or solubility effects over the entire year is unlikely to give an accurate estimate of the annual source.

Interactive comment on Biogeosciences Discuss., 7, 7821, 2010.