General:

This generally well-written paper describes a coarse resolution ocean model coupled with an ecological model that resolves nitrogen isotope fractionation, nitrogen fixation as well as denitrification in the sediments and in the water column. The major results include the sensitivity of the model to the benthic denitrification fractionation and to the nitrate utilization in sub-oxic zones. In my analysis, the paper is relevant and new, and worthy of publication after relatively minor revisions.

The model is designed to represent the pre-industrial ocean state, hopefully the authors will consider the question of changing climate or a nitrogen system that is out of steady state in future efforts.

I find the discussion of coastal denitrification a bit cursory. There have been regional studies of nitrogen cycling on coastal shelves that might inform the discussion. E.g. Fennel et al, 2006, GBC. This is particularly important to discuss because the resolution of the global model precludes representation of shelf processes. The tuning process described through which grid cells are subdivided is clever, and seems to match patterns of shelf width for example except perhaps in the Arctic. Also, denitrification is occurring in the middle of the watercolumn effectively but without shelf processes, the coupling between this and the open ocean is likely too strong. It seems likely that shelf denitrification and riverine inputs and primary production are all coupled to produce a net shelf isotope effect that may not be represented in a global model.

Iron limitation is imposed as a mask based on iron deposition rather than as a mask of surface iron concentration. This is likely to lead to overestimation of iron limitation in upwelling regions including equatorial and perhaps open ocean gyre or dome regions (e.g. Cost-Rica Dome). Subramaniam et al, 2013 GRL show high rates of nitrogen fixation in equatorial Atlantic regions.

Sections 2.2.2 and 3.1.2 describe the open ocean denitrification process – which is of course determined by oxygen concentration. The model obviously does a rather poor job of representing low oxygen regions – which should be expected given its resolution. Its clear from figure 2 that low oxygen occurs in the Bay of Bengal rather than the Arabian Sea. In the Pacific, the zones of low O2 are not separated (as expected), and there is low O2 in the Atlantic which is not observed, or at least not to that magnitude. What is the total volume of low O2 water relative to the global ocean? This will affect the budget and rates. How sensitive is the model to this net volume? Is the model representing the low O2 zones in the correct density space?

Line 2, P3137: The discussion of nitrogen fixation states that it occurs downstream of denitrification zones. What is “downstream” for the three denitrification zones in the model? This is an important point in light of the Deutsch et al theory on coupling between denitrification and nitrogen fixation zones. I see no evidence for a link between these zones in the model as presented. Indeed, lowest seafloor 15N values occur in the Atlantic which likely has the lowest open ocean denitrification.

It might be possible to further constrain the model solution based on global distribution of nitrogen to phosphorus ratios – which the model generates. This might help to better constrain the spatial patterns observed in the model.

Specific Comments

Intro:

L10, P3124 is ETSP defined previously?

L14,P3124 Is the first time N is used (N-loss) for nitrogen?

L6, P3125 This discussion might benefit from mention of river and atmospheric canonical 15N numbers.

Line 17, P 3127 Perform better.

Line 15, P3128 Variables are described e.g. D for detritus, but then the chemical formulas are used for oxygen, phosphorus and nitrate, but then elemental ratios are described as N:P which are not defined. This also holds for C. The abbreviations N,P,C should be defined. (Also Fe)

L11,P3132 This should be rewritten more clearly.

L13,P3132 years, not yr

L1, P3139: Dilution is stated as being simulated implicitly in the model. I think this should be explicitly simulated, because you are explicitly representing the spatial heterogeneity in nitrate distributions and thus the mixing effects between high nitrate and low nitrate waters are explicitly resolved, not implicitly parameterized…

L18, P3140 misspelled denitrification

L17, P3143 If they had.

Model equations:

I find the model equations particularly difficult to decode. This is partly due to the overlapping use of P for phytoplankton and phosphorus, and D for detritus and diazotroph. Also, growth terms u and remineralization terms $\boldsymbol{\mu}$ look very similar and are challenging to discriminate.

Specific issues:

Eqn B6 – when is $\boldsymbol{\mu}_P$ used? $\boldsymbol{\mu}_{P0}$ seems to be used instead in eqns A6,7

In contrast, in Eqn B9, $\boldsymbol{\mu}_D$ describes remineralization of detritus as a fn of temperature and depth, and it appears in eqn A9 rather than $\boldsymbol{\mu}_{D0}$

Eqn A5 – Where is the diazotroph fast remineralization?

μ_{D0} – is used twice in Table A1.

Eqn B4 describes a continuous decay of diazotroph growth consistent with text in the model description, but line 15, P3152 states that growth is set to 0 below 15C.

I cannot be confident that I have caught all the errors – if these are errors - because the symbol naming and description is too minimal.

L10, P3153 cite OCMIP protocol and write out acronym.

Figure 1 symbols do not match the equations. μ_{P2} ?