Interactive comment on "Global trends in marine nitrate N isotopes from observations and a neural network-based climatology by Patrick A. Rafter et al.
Anonymous Referee #1
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The original comment is in bold font. The response to the comment is in regular font.

Overview: The paper targets a useful goal – providing a map of 15N-NO3 estimates for the global ocean for use in biogeochemical studies. To do this, it uses a neural network to obtain a relationship between sparse observed 15N-NO3 and World Ocean Atlas (WOA) values of temperature, salinity, oxygen, phosphate and nitrate, and then maps the derived 15N-NO3 estimates. The utility of the approach is assessed via correlation statistics between the estimates and the observations. There are areas where the estimates and observations agree well and others where they agree poorly. The latter are ascribed to temporal offsets between the WOA data collection and the 15N-NO3 observations.
To be clear, our interpretation of the observation-model comparison is that the model estimates the mean values quite well, but does not include temporal variability and therefore will not capture temporal variability.

As far as it goes, the paper is sound, but it doesn't go very far (as an aside it does provide clear and well-constructed descriptions of possible mechanistic causes of the spatial variations in the 15N-NO3 observations, although these do not really derive from or depend on the mapping exercise). It could be improved by addressing the following issues: 1. Is the neural network (NN) approach demonstrably better than a multiple linear regression (MLR) to the same input variables? Assessing this would be useful for two reasons: a. The MLR has the advantage that is provides a simple equation that all can use with their local and future input variable observations [(notably MLR approaches are becoming widely used for nitrate in the context of BGC-Argo observations; Carter et al. 2017, https://doi.org/10.1002/lom3.10232] b. Determining whether and in which parts of the ocean the non-linear NN approach out- performs the linear MLR approach is likely to shed light on the processes that drive 15N-NO3 variations.

Great comment. To address this we built a single global Multiple Linear Regression (MLR) model using all the same predictors used in the Ensemble Array of Neural Networks (EANN). We found that the MLR performs much worse than the EANN at predicting nitrate δ15N. The coefficient of determination for each method and each ocean basin's upper 1000 m is shown in the table below.

	Atlantic	Pacific	Indian	Southern Ocean
MLR R2	0.04	0.49	0.51	0.34
EANN R2	0.53	0.78	0.76	0.68

The reason for this worse performance is likely that the MLR approach assumes the training parameters are independent of each other, but also dependent on nitrate δ15N. This is not the case and so the EANN approach performs noticeably better.

2. Are there other metrics that could assess possible causes of the quality of the matches and mismatches between estimates and observations, to go beyond simply ascribing them to temporal offsets? For example since some of the 15N-NO3 estimates were probably collected synchronously with the WOA data, do these points show closer agreement?

We do not ascribe differences between model and observations to temporal offsets. We suggest that the model predicts an annual climatology of nitrate δ15N, while the observations measure the instantaneous δ15N. There is no temporal component in the EANN. The WOA data that we are using are the annual climatologies – there are no corresponding observations of δ15N.

Can agreement with mechanistic understanding be assessed – for example in regions where single processes largely dominate 15N- NO3 variations (e.g. nitrate assimilation in Southern Ocean surface waters) does the NN approach produce sensible correlations between [nitrate] and 15N-NO3 ?

This is a good suggestion, but we find that adding an additional analysis of the regional model estimates is beyond the scope of this paper. In fact, we are already using the EANN results to examine global nitrate uptake patterns in a current study that will be outlined in a dedicated manuscript.

Details: Line 63: ammonia assimilation is also a significant determinant of the 15N of organic matter.

We revised the manuscript to clarify that these sentences refer to organic matter production by the assimilation of nitrate. Good comment.

Line 370: meaning of sentence beginning "Equivalent processes… was opaque.

The revised manuscript clarifies this sentence. It refers to how the model nitrate δ^{15}N predicts that intermediate water nitrate δ^{15}N in the Indian Ocean has a similar value as the corresponding waters in the Pacific. We argue that this is likely because "equivalent processes" established the pre-formed characteristics of both water masses (i.e., partial nitrate assimilation in the Southern Ocean surface).

Lines 384-395: This discussion of separating nitrification from denitrification influences on deep water 15N-NO3 values would benefit from recognition that relationships with O2 and nitrate have opposite signs.

Good comment. The well-known south-to-north lowering of deep Pacific O2 and increase in nitrate concentrations is consistent with the remineralization of organic matter and not the lateral advection of nitrate from ODZ regions. This will be added to the revised manuscript.

Line 403: The estimate low sinking organic matter d15N estimate of +1.5 should be compared to published results in Lourey et al., 2003, which show good agreement.

We have added and refer to this citation's results in the revised manuscript.