Review of Buchanan et al. (2025):

"Oceanic enrichment of ammonium and its impacts on phytoplankton community composition under a high-emissions scenario"

Summary

In their study, Buchanan and coauthors use an ocean biogeochemistry model forced by output from a climate model to investigate the impact of changes in nitrogen speciation on phytoplankton community structure. They find a shift towards more ammonium under a future climate, which is accompanied by a shift towards non-diatom phytoplankton and mostly driven by changes in ocean circulation.

We would also hasten to add that the shift in phytoplankton community composition is also primarily driven by a metabolic stimulation by warming (see Fig 5).

Overall, the presentation of the results is clear, and this paper will be a valuable addition to literature assessing the response of phytoplankton to future climate change. Besides the new scientific findings, the authors compiled existing data related to nitrogen cycling from the literature for this paper; all these datasets are already made publicly available by the authors, which is valuable in itself.

We sincerely thank the reviewer for their careful and constructive feedback of our research.

However, before publication of the manuscript, the presentation of the methods in the main text could be improved in my opinion, to provide readers with all information necessary to understand the results, i.e., by providing a more thorough description of how the model simulates the oceanic nitrogen cycle. Further, the description of the model sensitivity experiments should be revised to enhance clarity on what processes are (not) included in each experiment.

We have acknowledged and addressed the reviewer's suggestions by incorporating more information in the methods section. This has involved the addition of a new methods section as well as more text in the description of our experiments.

I have no doubt that these issues can be addressed by the authors during the revisions, after which the study will be suitable for publication in *Biogeosciences*.

We again sincerely thank the reviewer for their positive recommendation.

Please see the detailed explanation of all major and minor points below.

Major comments

My only somewhat major comment concerns the description of the methods, in particular the description of nitrogen cycling in the model:

The authors have made modifications to the model code describing nitrification, which is now a two-step process in their model. They currently fully describe these modifications in the supplementary information, but since any change done to the representation of the nitrogen cycle in their model is of relevance to the study at hand, I suggest adding the changes to the main text for full transparency.

For brevity and readability, we originally opted to place this description in the supplement. As per the reviewers request, we added this information into the main text within the methods. However, on adding this information, we saw that this would be distracting to many readers of the paper because a full description of nitrification within the methods would dedicate 3 paragraphs and 8 equations. Adding a full description of nitrification was an important step in the technical developments needed to pursue this research, but the focus of this research is on diatoms response to increased NH_4^+ concentrations, which we show is driven by circulation and a warming-induced stimulation of phytoplankton metabolism, and nitrification therefore does not feature as a critical process, with the exception of its reponse to ocean acidification, but this effect is negligible on phytoplankton community composition (see Fig. 5).

However, the reviewer is right to want more clarity and descriptions of the model and the experiments. To accommodate the reviewer's request, we extend our initial description of the nitrogen cycle within the methods section but also maintain detailed information in the supplementary text for the interested reader. We also expand substantially on the N limitation parameterisation (see more in our answers below).

Lines 103 – 131:

"2.1 The biogeochemical model

The biogeochemical model is the Pelagic Interactions Scheme for Carbon and Ecosystem Studies version 2 (PISCES-v2), which is detailed and assessed in Aumont et al. (2015). This model is embedded within version 4.0 of the Nucleus for European Modelling of the Ocean (NEMO-v4.0). We chose a 2° nominal horizontal resolution with 31 vertical levels with thicknesses ranging from 10 meters in the upper 100 meters to 500 meters below 2000 meters. Due to the curvilinear grid, horizontal resolution increases to 0.5° at the equator and to near 1° poleward of 50°N and 50°S.

We updated the standard PISCES-v2 (Aumont et al., 2015) for the purposes of this study, specifically by adding NO_2^- as a new tracer. The PISCESv2 biogeochemical model already resolved the pools of NH_4^+, NO_3^-, dissolved oxygen, the carbon system, dissolved iron, phosphate, two kinds of phytoplankton biomass (nanophytoplankton and diatoms), two kinds of zooplankton biomass (micro- and meso-zooplankton), small and large pools of particulate organic matter, and dissolved organic matter (Aumont et al., 2015). While the model does not strictly represent picophytoplankton, implicit variations in the average cell size of the nanophytoplankton type affect nutrient uptake dynamics and may therefore encompass some functionality of picophytoplankton in oligotrophic systems (Aumont et al., 2015). The addition of NO_2^- necessitated breaking full nitrification ($NH_4^+ \rightarrow NO_3^-$) into its two steps of

ammonia (NH_4^+ → NO_2^-) and nitrite oxidation (NO_2^- → NO_3^-). Both steps were simulated implicitly by multiplying a maximum growth rate by the concentration of substrate and limitation terms representing the effect of environmental conditions to return the realized rate. For ammonia oxidation, limitations due to substrate availability, light and pH determined the realised rate. For nitrite oxidation, limitations due to substrate availability and light affected the realised rate. All parameter choices were informed by field and laboratory studies and a detailed description is provided in the Supplementary Text S1.

New nitrogen is added to the ocean via biological nitrogen fixation, riverine fluxes, and atmospheric deposition. Nitrogen fixation and static riverine additions are equivalent to that presented in Aumont et al. (2015) and atmospheric deposition is maintained at preindustrial rates according to Hauglustaine et al. (2014) and applied as in Buchanan et al. (2021). Nitrogen is removed from the ocean via denitrification, anaerobic ammonium oxidation (anammox) and burial. The internal cycling of nitrogen involves assimilation by phytoplankton in particulate organic matter, grazing and excretion by zooplankton, solubilization of particulates to dissolved organics, ammonification of dissolved organic matter to NH_4^+, followed by nitrification of NH_4^+ and NO_2^- via ammonia oxidation and nitrite oxidation (Supplementary Text S1).”

I acknowledge that the authors already briefly mention the updates in the main text (L. 96), but I would encourage the authors to reconsider the location of the detailed description of code changes, as bringing those to the main text would give any reader a much better overview of how nitrogen is cycled through their modeled ocean.

We agree with the reviewer that a complete description of the oceanic nitrogen cycle within the main text would benefit the interested reader. However, for readability and to not distract from the main focus of the paper, which is about the response of the phytoplankton community composition to changes in the NH_4^+:DIN ratio, which itself is dependent on circulation changes and phytoplankton’s response to warming (Fig. 5), we therefore opt to not distract too much from this narrative by focussing on details related to nitrogen fixation, denitrification, etc. We do, however, respectfully extend our simplified description of the nitrogen cycle (please see our response above) and provide an entirely new section within the methods that is dedicated to the nitrogen limitation routines of phytoplankton growth.

Further, I think it would help readers to see the modeled distributions of ammonium and its ratio to total dissolved inorganic nitrogen from the preindustrial control simulation in the main text. Especially in light of the changes the authors have made to the code, I think it would help readers, who aren’t experts on modeling marine nitrogen cycling, to first demonstrate good performance of the new version of the model (by comparison with observations) and to show the baseline state in the main text before any sensitivity simulations or future projections are presented.

We fully agree with the reviewer and have brought the model assessment into the main text as the first results section. The new section is called:

“3.1 Assessment of modelled NH_4^+ and NH_4^+:DIN”

and reads as:

Lines 345 – 373:

"Concentrations of 0.1 µM NH_4^+ or greater exist over continental shelves and in regions of strong mixing with high rates of primary production and subsequent heterotrophy. This accumulation of NH_4^+ in productive regions is reproduced by our model (Fig. 3a). In these eutrophic systems, high NH_4^+ co-occurs with high NO_3^- concentrations, so NH_4^+ makes a small contribution to total DIN (Fig. 3b). These regions include the eastern tropical Pacific, eastern boundary upwelling systems, the northwest Indian Ocean, the subpolar gyres and the Southern Ocean (although we note that the model underestimates NH_4^+ concentrations in the Southern Ocean). In contrast, low NH_4^+ concentrations of less than 0.05 µM pervade the oligotrophic gyres of the lower latitudes. As these regions also display very low NO_3^- concentrations, NH_4^+ makes up a much higher fraction of total DIN in both the observations and our model, with the NH_4^+ peak occurring deeper in the water column (Fig. S1).

Eutrophic upwelling systems and oligotrophic waters differed in the major sinks of NH_4^+ (Fig. 3c), consistent with available observations and constraints from theory. In eutrophic waters (here defined by surface nitrate > 1 µM), ammonia oxidation represented 49 ± 29 % (mean ± standard deviation) of NH_4^+ sinks, but this dropped to 32 ± 9 % in oligotrophic systems. Measured rates of ammonia oxidation showed a positive relationship with surface NO_3^- concentrations and this was reproduced by the model (Fig. S2), indicating that ammonia oxidation was indeed a greater proportion of the overall NH_4^+ budget in eutrophic regions. In agreement, isotopic methods have shown that the bulk of nitrogen assimilated by phytoplankton in oligotrophic waters is recycled (Eppley and Peterson, 1979; Fawcett et al., 2011; Klawonn et al., 2019; Van Oostende et al., 2017; Wan et al., 2021), implying that most nitrogen cycling occurs without ammonia oxidation. Our model reproduces this feature of oligotrophic systems (Fig. 3c). Overall, the model shows good fidelity to the available observations of NH_4^+ concentrations, NH_4^+:DIN ratios, and rates of NH_4^+ cycling that we compiled for this study (Fig. 3; Fig. S2-S3)."

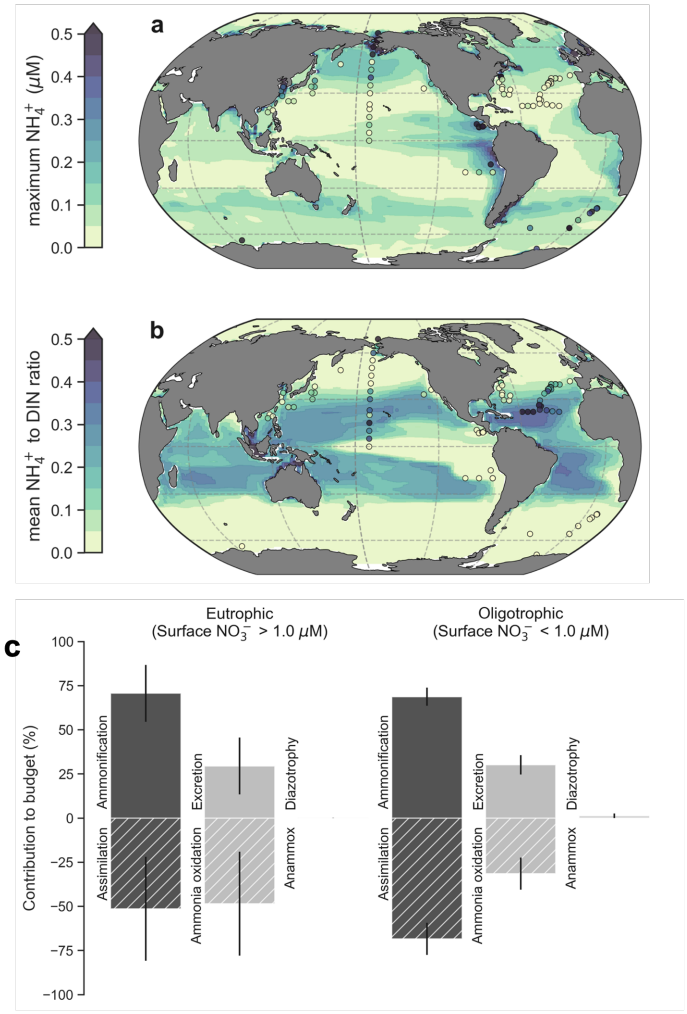

Figure 3. Global patterns of NH_4^+ concentrations, its contribution to DIN in the euphotic zone, and NH_4^+ budgets. (a) The simulated maximum NH_4^+ concentration within the euphotic zone. The maximum was chosen to emphasise basin-scale variations. (b) Average values of the NH_4^+:DIN ratio. Modelled values are annual averages of the preindustrial control simulation between years 2081-2100. Observed values following linear interpolation between the surface and 200 metres depth are overlaid as coloured markers. Only those profiles with at least 3 data points within the upper 200 metres are shown. (c) Global mean ± standard deviations of NH_4^+ fluxes separated into eutrophic and oligotrophic regions. Sources of NH_4^+ are represented by positive values and sinks by negative values.

Currently, the main text only shows relative changes for many properties (see Fig. 2, but also true for other figures), which makes it more difficult (than it has to be) for the reader to quickly evaluate what changes should be considered substantial.

We agree with the reviewer that additional panels to our figures showing the absolute changes would be very helpful and informative. To address this, we have added Section 3.1 "Assessment of modelled NH_4^+ and NH_4^+:DIN", which now refers to Figure 3 that shows the maximum NH_4^+ concentration and the mean NH_4^+:DIN ratios in the global upper ocean. In particularly, the mean NH_4^+:DIN ratios (Fig. 3b) can be easily compared with the change in NH_4^+:DIN ratios (Fig. 4a).

We also expanded Figure 5 (previously Figure 3) to include two new panels that show the absolute changes in diatom concentrations and now reference these additional panels in the

text. The new figure 5 is:

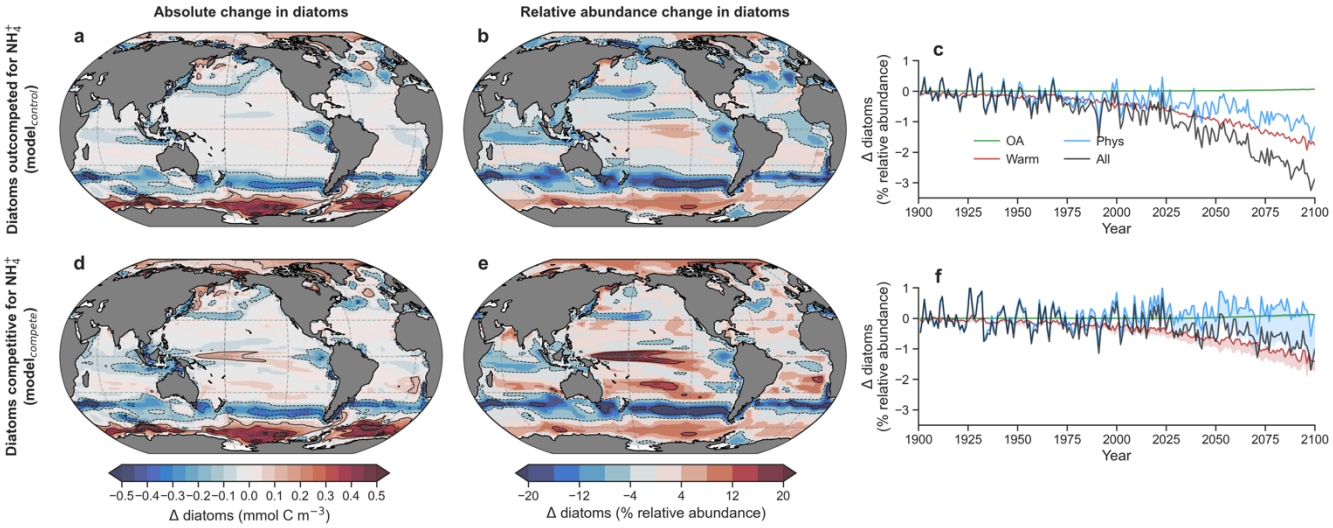

Figure 5. Impact of NH_4^+ enrichment within DIN on diatoms. (a), Mean change (Δ) in the absolute concentration of diatoms and (b) relative abundance of diatoms (%) by the end of the 21st century (2081-2100) as predicted by the control run of the ocean-biogeochemical model ($model_{control}$) under the RCP8.5 scenario and averaged over the euphotic zone. (c), Global mean change in diatom relative abundance due to physical (circulation + light) changes (blue), warming effects on metabolic rates (red), ocean acidification effect on ammonia oxidation (green) and all stressors (black) for $model_{control}$. (d), The same as in (a), but for $model_{compete}$, where the NH_4^+ growth limitation of the diatom PFT was made equal to the nanophytoplankton PFT. (e), The same as in (b), but for $model_{compete}$. (f), The same as in (c), but for $model_{compete}$. The shading shows the change between $model_{control}$ and $model_{compete}$.

In addition, I think it should be stated in more detail in the method section:

- How biological nitrogen fixation is modeled,
- How atmospheric nitrogen deposition is treated,
- How the two phytoplankton types differ in their affinity for different nitrogen species.

Some of this information can be found scattered throughout the manuscript, but it would be more logical to have it presented together in the method section for easier findability.

We have expanded on ammonia oxidation and nitrite oxidation in the methods (see response above and lines 110 – 131).

We have also added an entirely new section to the methods called "Isolating the effect of competition for NH_4^+", which reads as follows:

Lines 189 – 245:

"2.2.2 Isolating the effect of competition for NH_4^+

A unique aspect of the PISCESv2 biogeochemical model is that it weights uptake of NH_4^+ over NO_3^- when both substrates are low, but as NO_3^- becomes abundant, the community switches towards using NO_3^- as a primary fuel (Fig. 2). This is achieved via

$$L_{PFT}^{NH_4^+} = \frac{[NH_4^+]}{[NH_4^+] + K_{PFT}^N} \quad (1)$$

$$l_{PFT}^{NO_x^-} = \frac{[NO_2^-] + [NO_3^-]}{[NO_2^-] + [NO_3^-] + K_{PFT}^N} \quad (2)$$

$$l_{PFT}^{DIN} = \frac{[NH_4^+] + [NO_2^-] + [NO_3^-]}{[NH_4^+] + [NO_2^-] + [NO_3^-] + K_{PFT}^N} \quad (3)$$

$$L_{PFT}^{NH_4^+} = \frac{5 \cdot l_{PFT}^{DIN} \cdot l_{PFT}^{NH_4^+}}{l_{PFT}^{NO_3^-} + 5 \cdot l_{PFT}^{NH_4^+}} \quad (4)$$

$$L_{PFT}^{NO_x^-} = \frac{l_{PFT}^{DIN} \cdot l_{PFT}^{NO_x^-}}{l_{PFT}^{NO_3^-} + 5 \cdot l_{PFT}^{NH_4^+}} \quad (5)$$

Where K_{PFT}^N is the prescribed half-saturation coefficient for uptake of inorganic nitrogen for a given phytoplankton functional type (PFT); $[NH_4^+]$, $[NO_2^-]$, and $[NO_3^-]$ are the molar concentrations of ammonium, nitrite and nitrate; $l_{PFT}^{NH_4^+}$, $l_{PFT}^{NO_x^-}$ and l_{PFT}^{DIN} are the michaelis-menten uptake terms for NH_4^+, inorganic oxidised nitrogen (the sum of NO_2^- and NO_3^-), and DIN; and $L_{PFT}^{NH_4^+}$ and $L_{PFT}^{NO_x^-}$ are the growth limitation factors on NH_4^+ and inorganic oxidised nitrogen. In the above, the resulting $L_{PFT}^{NH_4^+}$ and $L_{PFT}^{NO_x^-}$ terms (Eqs. 4-5) are influenced by a factor 5 that is applied to $l_{PFT}^{NH_4^+}$. This assumes that NH_4^+ uptake is weighted five times more than oxidised inorganic nitrogen, which represents the well-established preference for growth on NH_4^+ (Dortch, 1990). However, as oxidised nitrogen (hereafter NO_3^-) becomes more abundant than NH_4^+, the $L_{PFT}^{NO_x^-}$ term exceeds $L_{PFT}^{NH_4^+}$, meaning that phytoplankton switch to new production over regenerated production (see cross over points between solid and dashed lines in Fig. 2).

These dynamics are common to both PFTs: nanophytoplankton and diatoms (Fig. 2). However, a key difference is that the K_{PFT}^N of diatoms is prescribed as 3-fold greater than that of nanophytoplankton, reflecting their greater average size. As a result, diatoms are always less competitive than nanophytoplankton for NH_4^+ and are less competitive for NO_3^- when NO_3^- is scarce. However, a low $l_{PFT}^{NH_4^+}$ for diatoms also results in a higher $L_{PFT}^{NO_x^-}$ as NO_3^- concentrations rise. This is evident in Figure 2, where growth by diatoms on NO_3^- (black solid line) overtakes growth by nanophytoplankton on NO_3^- (green solid line) as NO_3^- becomes abundant. As a result, the model gives diatoms a competitive advantage over nanophytoplankton that accords with theorized growth advantages under high NO_3^- (Glibert et al., 2016a; Lomas and Glibert, 1999; Parker and Armbrust, 2005). Additionally, the switch from regenerated to new primary production occurs at much lower concentrations of NO_3^- for diatoms, aligning with fields studies that identify diatoms as responsible for the majority of NO_3^- uptake in the nitracline (Fawcett et al., 2011).

We sought to isolate the impact of competition for NH_4^+ and thus target the causative relationship between NH_4^+:DIN and variations in PFT relative abundance. To do so, we repeated the set of experiments described above (All, Phys, Warm, OA and the preindustrial control) from years 1850 to 2100 but with an alternative parameterization where diatoms were made to have the same growth limitation on NH_4^+ as other phytoplankton, so that there was zero competitive advantage or disadvantage for NH_4^+ between these groups (i.e., making the dashed black and green lines in Figure 2 the same under all conditions). These simulations were completed with "$model_{compete}$" and were initialised from the same conditions as those done with the default parameterisation, which we call "$model_{control}$". All other traits remained unchanged. Importantly, this included the competitive advantage of diatoms at high NO_3^- but also their competitive disadvantage at low NO_3^- (Fig. 2). In other words, when DIN

was low, diatoms were equally competitive for NH_4^+, but still suffered their unique limitations associated with NO_3^-, light, silicate, phosphate, and iron availability, as well as grazing pressure, and this isolated the direct effect of competition for NH_4^+.

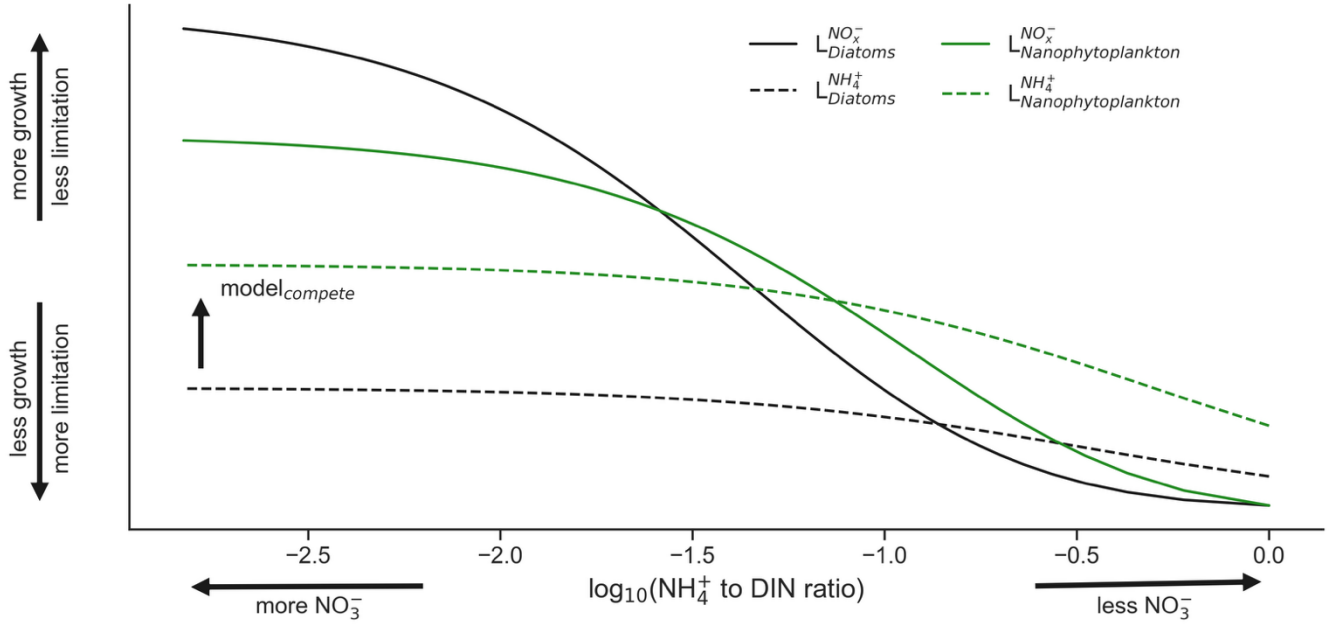

Figure 2. *Limitation of the diatom (black) and nanophytoplankton (green) phytoplankton functional types (PFT) in the ocean-biogeochemical model by NO_3^- (solid lines) and NH_4^+ (dashed lines) as a function of the NH_4^+:DIN ratio on a $\log_{10}$ scale. Note that the nanophytoplankton PFT is always more competitive for NH_4^+ and is more competitive for NO_3^- when NO_3^- is low, while diatoms become more competitive for NO_3^- when NO_3^- is high.*

While we agree with the reviewer that a more complete description of the updates to the nitrogen cycle is important, we note that nitrogen fixation has not been altered from its default in this version of PISCESv2 and a description can be found at Aumont et al (2015). Nitrogen deposition, meanwhile, can be found at Buchanan et al. (2021) and we now point the reader to this paper. We also note that both nitrogen fixation and deposition have extremely small fluxes compared with primary production and nitrification, so their importance to the nitrogen cycle is negligible in the context of our study. Our quantification of the fluxes in the nitrogen cycle in what is now Figure 3c attests to this.

Minor comments

- **L. 27**: Typo - "an a potentially underestimated"
  Corrected.
- **L. 30**: Typo - "fundamental in for the growth"
  Corrected.
- **L. 67/68**: Please add references to support the statement "numerous studies that showcase [...]"
  Added.

- **L. 100**: How is biological nitrogen fixation parametrized?
  We point the interested reader to Aumont et al. (2015).
- **L. 101**: Please elaborate on atmospheric deposition of nitrogen — assumptions for future experiments?
  We have elaborated.
  Lines 124-126:
  "New nitrogen is added to the ocean via biological nitrogen fixation, riverine fluxes, and atmospheric deposition. Nitrogen fixation and static riverine additions are equivalent to that presented in Aumont et al. (2015) and atmospheric deposition is maintained at preindustrial rates according to Hauglustaine et al. (2014) and applied as in Buchanan et al. (2021)."
- **L. 112**: Suggest rephrasing and specifying which IPSL model output variables were used; justify why monthly forcing was used.
  Specified that the physical outputs used to force the BGC model are temperature, salinity, transports, short wave radiation and wind speeds.
- **L. 122**: Be specific about which fields were varied/held constant in sensitivity experiments.
  We have expanded to give more information.
  Lines 168-177:
  "Experiment "Phys", for example, involved changing the ocean's circulation, temperature and salinity, and the resulting effects to light associated with sea-ice extent changes, but the ecosystem component of the model experienced only the preindustrial temperature, and atmospheric CO_2 was held at a preindustrial concentration of 284 ppm. In contrast, experiment "Warm" maintained the preindustrial climatological ocean state and atmospheric CO_2 at 284 ppm, but ensured that the ecosystem component saw increasing temperatures (T in ºC) according to the RCP8.5 scenario, which scaled growth of phytoplankton types according to 1.066^T and heterotrophic activity (grazing and remineralisation) according to 1.079^T (Aumont et al., 2015). Experiment "OA" held the circulation and temperature effects on metabolism constant but involved the historical and future projected increase in atmospheric CO_2. This decreased pH and negatively affected rates of ammonia oxidation at a rate consistent with field measurements (Beman et al., 2011; Huesemann et al., 2002; Kitidis et al., 2011), specifically a loss of ~20% per 0.1 unit decrease in pH below 8.0 (Fig. S1)."
- **L. 129**: Why define euphotic zone with a nutrient threshold rather than a light threshold? Clarify.
  Changed to *"upper ocean where primary production was active"*.
- **L. 141/142**: Clarify how ignoring nitrite in calculations impacts evaluation of ammonium.
  This will have negligible effects since NO_2^- is of trace concentrations outside of the secondary nitrite maximum, which exists in low oxygen zones and beneath the euphotic zone.
- **L. 146**: Quantify what "broad agreement" means — subjective otherwise.
  Lines 256-257: "Measured ammonia oxidation rates (N=696; nM day^{-1}) were also used for model-data assessment and showed an acceleration of rates from oligotrophic to eutrophic regions in agreement with the model (Fig. S3)."
- **L. 179**: Clarify whether the statistical model was built only with model output.
  This is clarified in the text. We refer the reviewer to:
  Lines 308-313:
  "Mixed layer depth, phosphate and silicate was measured in situ at the sample

locations of Tara Oceans, while dissolved iron and NH_4^+:DIN ratios were provided by the model at the same location and month of sampling, since measurements of these properties are scarce. In addition, phosphate and silicate concentrations were available as interpolated products from the World Ocean Atlas (Garcia et al., 2019). An alternative estimate of NH_4^+:DIN ratios was provided by the Darwin model (Follows et al., 2007). Predictor variables from models and World Ocean Atlas were extracted at the locations and months of sampling and different combinations of in situ and modelled variables were used to build GAMs."

- **L. 183**: Alpha is missing in the equation.
  corrected.
- **L. 188**: Explain why NH4:DIN ratio is taken from another model but not iron fields.
  We note that any number of properties could be taken from any number of models. The focus of this study is on DIN, and PISCES is well known to perform well with dissolved Fe in the upper ocean, so we opt to not include additional representations of dissolved Fe.
- **L. 194**: Explain what values below 3 mean (context missing).
  Context added.
  Line 332:
  "All covariate VIFs were < 3, which indicates minimal multicollinearity."
- **L. 208–213**: Suggest removing redundant information.
  Removed.
- **L. 213–215**: Consider moving model evaluation figures into the main text.
  Moved what was supplementary Figure S1 to main text, which is now Figure 3.
- **L. 217**: Clarify what "+- 6%" refers to.
  standard deviation. Clarified in the text.
- **L. 246**: The conclusion about linearity of drivers seems too strong — consider rewording or running multi-driver sensitivity tests.
  Reworded.
  Lines 407 – 410:
  "Altogether, the individual contributions of physical change, acidification and stimulated metabolism diagnosed via our sensitivity experiments explained 93% of the full change in NH_4^+:DIN, indicating that the different drivers had small interactive effects that drove NH_4^+:DIN only slightly higher than their linear combination."
  Respectfully, the results do show that the linear combination amounts to 93% of the full response.
- **L. 258**: How does present-day phytoplankton distribution compare with observations?
  This is showcased and assessed in Aumont et al. (2015) for the PISCESv2 ocean biogeochemical model. We refer the interested reader to this publication for additional model details:
  Lines 104-105:
  "The biogeochemical model is the Pelagic Interactions Scheme for Carbon and Ecosystem Studies version 2 (PISCES-v2), which is detailed and assessed in Aumont et al. (2015)."
- **Fig. 3**: Define contours clearly in caption; introduce "model_control" and "model_compete" in methods.
  Complete.
- **L. 263**: Clarify language suggesting exact additive behavior of sensitivities.
  Clarified.
  Lines 479 – 482:
  "Our sensitivity experiments enabled an attribution of the major drivers, at least in a

coarse-grained sense. At a global scale, the loss of diatom representation within marine communities in our model was driven by a combination of stimulated microbial metabolism (60% of full response in experiment "All") and physical changes (40% of full response in experiment "All"), while ocean acidification had negligible effects (Figure 5c; Fig. S7)."

- **L. 269**: Clarify phrasing "in some ways."
  Changed to *"at least indirectly"*
- **L. 271**: Early note that most ocean models differentiate NO3 and NH4 (provides better context).
  We agree that many models do this, and that they are therefore well positioned to explore these competitive dynamics, but have yet to do so in a focussed way, which we have attempted herein.
  Lines 495 – 496:
  "However, explicitly representing competition for NH_4^+ can provide a more nuanced view of why a decline in NO_3^- might cause a decline in diatom relative abundance or shifts in any phytoplankton taxa for that matter."

- **L. 280**: Some descriptions of model processes should move earlier (to methods).
  This has been moved earlier with a dedicated methods section.
- **L. 286**: Clarify whether zooplankton grazing is temperature-dependent.
  It is. Clarified.
- **L. 289**: Typo - "thids" should be corrected.
  Corrected.
- **L. 296–304**: Information could be moved to the method section.
- **L. 307**: Clarify what 70% refers to.
  Clarified.
- **L. 308**: Typo - "whom" usage check.
  Corrected.
- **L. 365**: Specify which model data shown (preindustrial control?).
  Clarified in the Figure legend.
- **L. 368**: Clarify "higher affinities than NO3."
  Clarifed.
- **L. 388–393**: Consider deleting redundant description.
  Deleted. We have removed this paragraph and extended the previous paragraph to be:

  Lines 752 – 761:
  "Next, we search for evidence of a relationship between NH_4^+:DIN ratios and phytoplankton community composition in the global ocean. While evidence from many localized studies in freshwater, brackish and marine environments suggests that increasing NH_4^+:DIN ratios should have an effect on phytoplankton community composition, namely a negative effect on diatom relative abundance and a positive effect on cyanobacterial relative abundance (Berg et al., 2003; Carter et al., 2005; Donald et al., 2013; Fawcett et al., 2011; Klawonn et al., 2019; Van Oostende et al., 2017; Selph et al., 2021; Tungaraza et al., 2003; Wan et al., 2018), evidence for this relationship across the large-scale of the global ocean is lacking. We used two proxies of phytoplankton relative abundance from the Tara Oceans global survey, 18S rRNA gene metabarcodes (de Vargas et al., 2015) and psbO gene counts (Pierella Karlusich et al., 2023), combined with NH_4^+:DIN as predicted by our global ocean-biogeochemical model, to predict relative abundances of major phytoplankton taxa

via Generalized Additive Models (GAMs; see Methods).”

- **Fig. 5**: Comment on curve differences between model and Tara dataset fits — could data sparsity cause shape mismatch?
  Yes it absolutely could. Tara Oceans has 144 data points to cover the entire globe, while the model on its native grid has 16638 surface grid cells, which is 115-fold more data points than the Tara Oceans dataset. This means that, simply due to data sparsity, different relationships may emerge.
  To accommodate this information, we have added to the Figure legend the number of data points for both the model and Tara Oceans data.
- **L. 463**: Circulation changes not shown; suggest adding supplemental info.
  Amended here to include a reference to the supplementary Figure 5.
- **L. 493**: Typo - "albiet" → "albeit"
  Corrected.
- **L. 496**: Typo - "elaboratuing"
  Corrected.
- **L. 511**: Typo - "strong" → "strongly"
  Corrected.
- **Text S1**: Equation typo — it should be [NO2^-] → [NO3^-].
  Corrected.