Biogeosciences

Discussions

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comment

Interactive comment on "Biogeochemical evidence of heterotrophic N$_2$ fixation in the Gulf of Aqaba (Israel), Red Sea" *by* Angela M. Kuhn et al.

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The study by Kuhn et al. investigates the role of heterotrophic nitrogen fixers in the Gulf of Aqaba. To do so, they develop the first ocean model of heterotrophic nitrogen fixers in a 1D setting which also includes other main types of nitrogen fixers. They optimise their model parameters with time series observations of this region and then validate their model's results looking at different model's version (with/without heterotrophic N2 fixers, with/without explicit N2 fixation . . .) to look at the sensitivity of the different types of nitrogen fixers on the ocean biogeochemistry. They find that heterotrophic N2 fixers are key in representing observed concentration of nitrate and oxygen in the deep ocean.

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Discussion paper

This is an important study as the first model study to include heterotrophic nitrogen fixers, a model which has been carefully optimised and validated with an extensive time series. The paper is very well-written, clear, concise, and presents well-designed modelling experiments. I thus strongly encourage its publication. My only concern is on the conclusion in relation to N* as the model doesn't capture very well the observations (see main comments below).

Main comments

N* model reproduction While the model (H3 in particular) does a very good job at representing NO3 and O2 observed concentrations, the model seems to be quite off from the N* data. This is not well enough highlighted in the paper which currently presents heterotrophic nitrogen fixers being key on reproducing the N* values. Because the model (even H3) is not able to capture most of the observed variability in N*, I don't think the model results support well enough this conclusion. I wonder what could be missing in the model and if you have thought about the role of preferential P remineralisation on N*. I wrote a paper in 2012 investigating the role of preferential remineralisation of P on the distribution of N* in the North Atlantic. In that region, this mechanism is necessary to reproduce the observed sub-surface maximum of N*. Here your model seems to have too small values in PO4 and NO3 at depth. Would it possible to test in your model the effect of preferential remineralisation of P to see if that helps reproducing the observed N* variability? If not, at least mention it. In our 2012 model, preferential remineralisation of P helped to get higher concentration of P, enhanced nitrogen fixation and then resulted in higher N* value at depth (as N* increases after the remineralisation of diazotrophic matter).

Monteiro, F. M., & Follows, M. J. (2012). On nitrogen fixation and preferential remineralization of phosphorus. Geophysical Research Letters, 39(6).

Minor comments

P2, Line 1: Need to mention about atmospheric N sources

P3, Line 5: Need to justify in the introduction why the Gulf of Aqaba is an interesting region to study nitrogen fixation.

P3, Lines 21-23: Sentence not clear. Can you amend?

P5, Line 16: The model description is confusing on if/how H0 and H0' represent N2 fixation. Here you say "without explicit N2 fixation . . . and follows the model equations described in Fennel et al. (2006, 2013)", which would mean that there is a non explicit representation of N2 fixation in the model. If so, replace with "with non-explicit N2 fixation representation" and then describe briefly how it is done in Fennel's papers. But later on there are many references to "with no N2 fixation" (P5/Line 18, Figure 4, P10 Line 5, P14 Line 20, . . .). Can you amend accordingly?

P6, Line 5: Isn't there any evidence of DDA in this region or atmospheric source of N? Please add comments as they can be potential important sources of N.

P7, Line 2: I could not find how denitrification is represented in the model. Can you make sure it is described?

P9, Line 10: Need to comment on the model performance for PO4. Especially for 100-600 m where H3 matches well observations for NO3, still cannot get PO4 right.

P9, Line 11-12: Can you refer to Figure 3 here?

P9, Lines 20-24: This paragraph does not add much so I would be inclined to remove it.

P10, Line 9: It would be good to add a statement on why heterotrophic N2 fixers improve the representation of deep oxygen as a key result of your paper.

P10, Line 18-20: Need to comment on potential reasons why H3 accumulates NO3 over time.

P11, Line 3-8: Need to add comments on why H3 and H2 have much higher N2 fixation rate than observations between 0-DCM in the Summer 2010 .

P11, Line 17-18: I would be more subtle about the models' abilities to replicate N* as it is still quite far from the observations (see my main comments above).

P12, Lines 17-32: While this is an interesting section about the contribution of N2 fixation on PP, why include results from H3a which is not as realistic as H3?

P13, Section 5.3: One of the main points of the paper is to highlight the important role of heterotrophic nitrogen fixers. I feel this section could then be a lot stronger highlighting all the effect of heterotrophic N2 fixers on the ocean biogeochemistry of this region. Here for instance I would mention that heterotrophic N2 fixers improve the NO3 and O2 concentrations at depth, as well as the contribution of heterotrophic bacteria to total N2 fixation. Also, would it be possible to plot the model difference between H2 and H3 to show the impact of heterotrophic N2 fixation?

Figure 10 is not mentioned in the main text. It looks interesting so probably worse describing it at some point.