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Biogeosciences Discussions

Interactive comment on "Spatial variation in N_2-fixation rate and diazotroph activity in the Tropical Atlantic" *by* J. P. Montoya et al.

J. P. Montoya et al.

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We have made a number of changes in the manuscript to clarify the issues of concern to Reviewer 2. Our changes and other responses are in bold face type below.

Abstract Line 4: change "novel" to something else like "unpublished"? Lines 5 and 6: I suggest stating what the two groups of diazotrophs are somewhere in the abstract
Done

Page 1743 and 1744: Are the results a mix of the 2 methods (15N2 versus ARA)? Or were Trichodesmium N2 fixation rates estimated using ARA and unicells with 15N2. The authors indicate that the methods may not measure the same thing and so this may be a bias.
The data include results of both ARA and 15N2 incubations. We have carried

out extensive intercomparisons of the two methods for Trichodesmium, but are unable to do so for small diazotrophs because the ARA method is generally not sensitive enough to measure N2 fixation rates in unconcentrated water. These comparisons will require pure or enrichment cultures of small diazotrophs to provide sufficient signal for the ARA method. We discuss this potential bias in section 4.1 and note that we currently have no evidence for systematic bias in either method and no reason not to compare rates from the two methods.

How were the depth integrated N2 fixation (areal rates) calculated for the two groups? Were there depth profiles for abundance and rates (or just one or the other)? For the unicellular group it is unclear how one goes from volumetric to areal rates unless one knows the basis for that calculation. For Trichodesmium, the abundance of this group with depth is highly variable.

In almost all cases, areal rates were calculated by integrating rate and biomass measurements from several depths spanning the upper water column. The methods used for Trichodesmium and for whole water incubations on cruise ME55 are described in detail elsewhere. We have added a paragraph to the methods section to make this point more clearly and to discuss the few stations where we had to extrapolate from a single depth.

What was the basis for integrating N* through the upper 300m and 750m? Are these meaningful for diazotrophy?

These depth horizons were chosen to represent roughly the core and lower boundaries of the subtropical mode water in the western basin, which contains a strongly positive N* signature. We have added a sentence clarifying this.

Given the assertions that the authors make, I think that more clarifications are warranted.

Discussion: For Trichodesmium, the authors need an abundance estimate to get colony-specific N2 fixation rates to volumetric rates. Were these done? Was a sin-

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gle rate applied to some abundance over some depth to arrive at the areal rate? It seems that there might be a large bias associated with this calculation based on the depth integration. Was colony size accounted for when converting per colony rates to volumetric rates? Are areal rates appropriate for small diazotrophs because it seems that we know little about their vertical distribution (Langlois et al. found depth horizons).
The methods used to calculate areal N2 fixation rates for Trichodesmium are described in detail by Capone et al. (2005). In general, the areal rates for small diazotrophs reflect integration of rate measurements carried out at discrete depths in the upper water column. We have added text to the methods section to make this clear.

Page 1745: I don't understand the significance of the ANOVA (nor see the need for Table 2). Is this a geographical comparison? Were rates simply similar at the time of the cruises? Was this specific to Trichodesmium? If so, does this mean that colony-specific rates were similar?
The ANOVA provides a quantitative test of whether it's appropriate to combine Trichodesmium data from multiple cruises for comparison with the data on small diazotrophs. It is not strictly a geographical comparison, but rather a comparison of rates measured in a defined region of the ocean. Although we could simply report the outcome, Table 2 explicitly shows the partitioning of error and is usually shown in more statistically-oriented studies (e.g., in the ecological literature).

The result of this ANOVA is that there is at least one significant pairwise difference among our cruises. Closer examination showed that this difference reflects the absence of high outliers in the data from cruise MP03. Including this cruise in the combined data set will tend to reduce the overall mean N2 fixation rate in the composite data set, which will in turn produce a conservative test of difference between the Trichodesmium and small diazotroph rates. We present these considerations fully in the manuscript and believe that our discussion is sufficient

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for anyone versed in statistics and interested in our treatment of the data.

This ANOVA is focused specifically on areal rates of N2 fixation by Trichodesmium and includes no information on colony- or trichome-specific rates.

Again, I think the assumptions that are made in deriving the areal rates need to be laid out given that a primary goal is comparing areal rates for the two groups of diazotrophs.
See above.

Page 1746, Lines 15-23: This seems to bring into question the results of the ANOVA and the depth integration exercise. How were the vertical differences in distribution of the two groups accounted for in the depth integration? Was it measured or were there assumptions made?
The ANOVA tested for differences among Trichodesmium N2 fixation rates measured on different cruises. The whole point of the ANOVA was to verify that we could combine the Trichodesmium rates measured on different cruises for comparison with the rates measured for small diazotrophs. This section focuses on the bulk-water experiments, not Trichodesmium incubations

See above for details on the depth integration.

Page 1747, lines 3-5: I'm not sure that I understand the meaning of this and am not sure I agree because of the lack of experimental details.
The ANOVA provides quantitative justification for combining three of the four sets of Trichodesmium rate measurements. We justified adding the fourth cruise to the composite data set because doing so will make the comparison with rates measured in bulk water (small diazotrophs) more conservative.

Page 1748: It sounds like the authors are saying that there is a biogeography to diazotrophic groups and that Trichodesmium N2 fixation may be superimposed on some background N2 fixation rate by more cosmopolitan unicellular diazotrophs. Is this correct?

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Not quite – we're saying that the activity of the two groups shows significant spatial variation (biogeography) and that the two groups show opposite zonal trends in activity: Trichodesmium activity declines to the east while small diazotrophs show increased activity to the east.

Page 1749, line 4: At the end of the line add "s" to diazotroph.
Done

Page 1749, last 2 lines to Line 2 on Page 1750: Why wouldn't Trichodesmium N2 fixation then increase too? Why would input of N result in increases in N2 fixation in the east?
It's not at all clear why Trichodesmium and the small diazotrophs show different spatial patterns of activity – we believe that this is one of the pressing questions that should be addressed through additional field and laboratory efforts.

We have corrected the error (N in place of Fe) that appeared in the phrase "Ĕ impact of inputs of Fe and P entering the surface ocean in the form of African dustĔ"

Fig 2.: Is this ARA data or 15N2? Lateral offset in Fig 2A is confusing. Are both panels really necessary?
All Trichodesmium rates are based on the acetylene reduction assay. We have noted this explicitly in the methods section.

The lateral offset in Fig 2A is simply to prevent overlap from obscuring the data points.

The two panels show different aspects of the data distribution and are both relevant to the discussion.

Fig 3: Are these 15N2 or ARA data? I think it important to specify
Done

Fig 5: Are there just no data for some of the longitudes (Panel A to the east and Panel

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B to the west)? There appear to be some gaps.
The "gaps" reflect absence of data.

Interactive comment on Biogeosciences Discuss., 3, 1739, 2006.