Biogeosciences Discuss., 5, S1718–S1723, 2008
www.biogeosciences-discuss.net/5/S1718/2008/

Biogeosciences Discussions

BGD

5, S1718–S1723, 2008

Interactive Comment

Interactive comment on "North Pacific-wide spreading of isotopically heavy nitrogen from intensifieddenitrification during the Bølling/Allerød and post-youngerdryas periods: evidence from the Western Pacific" *by* S. J. Kao et al.

S. J. Kao et al.

Received and published: 17 September 2008

4-A. General comments: 4-A-1. In their paper Kao et al. present an interesting sediment record of glacial to Holocene changes in nitrogen isotopic composition from the Okinawa Trough in the West Pacific. This record is particularly interesting because to date not many records exist from sites distant from the regions of water column denitrification in the major oxygen minimum zones. In order to understand the effect of glacial-interglacial changes in the strength of water column denitrification on the global nitrogen budget and ultimately on climate, records from outside those regions are crucial. Therefore, this paper is in general well suited for publication in Biogeosciences and the well-dated d15N record presented here will be an important contribution to the growing global data set of d15N records. In my opinion the structure of the paper needs to be improved and the discussion needs to be expanded, however. The way the authors interpret their data as reflecting water column denitrification in the Eastern Tropical North Pacific (ETNP) is one possible way to explain the record, but as nitrogen isotope records are inherently complicated, the other potential influences need to be discussed in more detail. Finally, the authors should work on improving language and grammar in their manuscript.

As mentioned earlier, we revised the manuscript thoroughly.

4-B. Specific comments: 4-B-1. In the discussion of the record with regard to water column denitrification in the ETNP it should be made clearer how the authors think their data will help to resolve open questions.

We added more data to discuss and separate local and long-range signal from ETNP. Reasons for the signal propagated from ETNP have been strengthened and implications were highlighted.

4-B-2. The sentence on p. 1019, l. 16-17 ("Such synchronicity between the western and eastern North Pacific allows us to infer enhanced production ...") is unclear; it is already known from the East Pacific records that water column denitrification varied. Do the authors mean that the fact that the same signal is seen in the West Pacific (and its magnitude) allows reconstructing the magnitude of water column denitrification (in a modeling approach)? Furthermore, the authors should state whether they interpret the 15N variations at their site as a signal that is directly imported by advection of heavy nitrate, or whether they think their data reflects changes in the global mean isotopic composition of nitrate (see Deutsch et al. 2004). Both are plausible and should be discussed. To this end, a more detailed discussion of North Pacific water masses and

BGD

5, S1718–S1723, 2008

Interactive Comment

currents at the relevant water depths would be helpful (e.g., what is the connection between Eastern and Western North Pacific, how are KIW and NPIW linked, ...).

We applied the model results by Deutsch et al. (2004) for more discussion. An extra possibility of the deglacial increase in d15N was provided and discussed in this version. The mechanism is related to deepwater ventilation in the North Pacific. We also added new information in Figure 1a to illustrate the global distribution of denitrification signal and the circulation as well.

4-B-3. Concerning mean ocean nitrate 15N, it is important that only water column denitrification has a strong fractionation effect on nitrate isotopic composition, whereas sedimentary denitrification leaves little signal (the authors should always state which kind of denitrification they refer to).

We now clearly identify water column denitrification (WCD) throughout the manuscript.

4-B-4. The relative extent to which global denitrification occurs in the water column is therefore an important influence on global mean nitrate 15N (Brandes and Devol, 2002). For example, a deglacial peak in mean ocean nitrate 15N would be expected if water column denitrification increased earlier than sedimentary denitrification during deglaciation (Deutsch et al. 2004). Other influences on sedimentary 15N are only partly discussed in the current version of the manuscript. This discussion should be expanded and structured more systematically, for example by discussing each factor separately and stating the arguments for or against a significant influence. 1) Terrigenous N: It would be helpful to plot the 13C data discussed in the paper and to investigate whether there are correlations with 15N. As terrigenous input is a very local effect, the fact that this influence has been ruled out for the South China Sea (Kienast 2000) does not imply that it is not relevant at the study site. Neither is the small magnitude of 13C change, since the magnitude of change in 15N is also small. Do the authors have C/N ratios for their data?

Data for d13C for two cores were added and effects of terrestrial input on d15N were

BGD

5, S1718–S1723, 2008

discussed. Both d13C and d15N show consistent result that the core MD012403 is influenced by terrestrial inputs.

4-B-5. 2) Local water column denitrification: The authors use previously published total sulfur (%TS) data to infer more stagnant conditions at their site during glacial times. Hence, during these times local water column denitrification might have occurred, as the authors discuss. They also point out that the timing of changes in %TS and 15N make a large influence on 15N unlikely, but it is also important to discuss how this signal would have been transported (e.g., upwelling) and how transport could have changed. Are there any other indications for changes in ventilation, e.g. lamination of the sediment in glacial intervals?

We did not find laminated sediments in our core. Ventilation changes were discussed in this version by using both cores in southern and middle Okinawa Trough. Extra information reported previously for the core in the southern Trough was also indicated.

4-B-5. 3) N2 fixation: As the authors point out, the low 15N values they observe in their core suggests that N2 fixation is influencing the signal. This N2 fixation could be local, regional (Kuroshio area), or even widespread in the North Pacific (see Deutsch et al. 2007). Changes in N2 fixation could be due to changes in nutrient composition (feedback to denitrification; Redfield et al. 1963, Haug et al. 1998, Galbraith et al. 2004, Meckler et al. 2007) or to changes in dust (iron) input, or both. Since the Asian monsoon system changed strongly during the deglacial events discussed in this paper, it is likely that winds blowing dust off the continent also changed considerably.

Iron doest not limit N2-fixation in the North Pacific due to strong riverine inputs. In this version, we attributed the lower d15N in NO3 in the Kuroshio Current to regional N2-fixation basing on previous study. Related references are added.

4-B-6. 4) Diagenetic alteration: It is typically observed that d15N is altered during diagenesis in well ventilated, open ocean settings. This may not be a problem at this site, but the authors should explicitly state why. What is the sedimentation rate here?

BGD

5, S1718–S1723, 2008

We added more discussions on diagenetic effect on sedimentary d15N in this version. The mass accumulation rate was now shown in Figure 2 and 3 for reference.

4-B-7. 5) Relative nutrient consumption: The authors should point out that they assume nutrient consumption has always been complete (and why).

References and reasonings were given in this version. The assumption is based on previous study.

Further specific comments: 4-B-8. p. 1019, l. 6-11: The records of both Kienast (2000) and Higginson et al. (2003) show variations on d15N of up around 1 permil during the deglaciation, which is not so different from the magnitude seen in this study. The authors should examine possible covariations. For glacial data up to 16 ka, those records do not agree (Kienast et al. 2005) and should therefore be interpreted with caution.

As suggested, we referred to Kienast et al. (2005) and gave more discussions about the inconsistency in d15N in cores taken from the same site at the northern South China Sea. Terrestrial inputs from different source area were discussed.

4-B-9. p. 1021: It is confusing to start the results section with a discussion of the local setting.

We added a new section for study area. All related materials for local setting were moved into the new section.

4-B-10. p. 1023, l. 5-6: The relationship with precession is not discussed further and does not seem important for the arguments of the paper; I would suggest omitting this comparison.

As replied above, we eliminated the precession curve.

4-B-11. p. 1024, l. 19-21: I do not see a clear signal in d15N in either of the discussed cores during Heinrich events I and II (the JPC56 record is not long enough, site 893 does not show a change, and the signal in MD01-2404 is very weak).

We rewrote the paragraph not mentioning those insignificant drops. By contrast, we compared d15N values with accumulation rates during the three event periods.

4-B-12. p. 1024, l. 21-22: A similar mid-Holocene decrease in d15N has also been observed in Cariaco Basin (Altabet 2007, Meckler et al. 2007), and was attributed to increasing N2 fixation in the latter study.

Thanks for reviewer's suggestion. We referred to the two papers and made statements for the similarity.

Minor comments: 4-B-13. Title: The title is rather long; I would suggest changing "during the Bolling/Allerod and post-Younger Dryas period" to "during deglaciation".

Modified as suggested.

4-B-14. p. 1018, l. 2-5: The first sentence in the abstract does not make sense; maybe part of it got lost?

Yes. We rewrote the sentence.

4-B-15. p. 1019, l. 2: N isotopic composition of organic matter buried in sediments ...

Now the sentence is "Sedimentary nitrogen isotope (d15N) record under oligotrophic waters".

4-B-16. p. 1025, l. 8-10: This sentence could be misunderstood as "... the scale of OMZ intensification ... is likely North Pacific-wide ...", which is probably not what the authors want to say.

We rewrote the sentence. Now it is "..that the signal of enriched 15N due to enhanced denitrification in ETNP might have broadcasted to the western North Pacific during the last deglaciation".

Interactive comment on Biogeosciences Discuss., 5, 1017, 2008.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper