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Climate of the Past Discussions

Interactive comment on "Nutrient utilisation and weathering inputs in the Peruvian upwelling region since the Little Ice Age" *by* C. Ehlert et al.

Anonymous Referee #1

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In this manuscript, the authors present sediment Nd and Sr isotopes, biogenic silica%, organic nitrogen% and the isotopic composition of biogenic Si and N between 1300 and 2000 AD along the peruvian coast. They found marked environmental changes between the little ice age (LIA) and recent times with higher riverine input and low productivity during the LIA due to "El Nino" like conditions. Furthermore, the author interpret the parallel increase between d30Si and d15N during the transition period as indicating that nutrient relative utilisation is the main process controlling n isotopic composition while denitrification has a relatively marginal influence on the isotopic signal. The author s are using a neat set of proxies to reconstruct past changes in climate and productivity in the study area. The Nd and Sr isotope data are quite compelling. Therefore I would support publication of this paper in Climate of the Past. However, I have issues with the interpretation of the d15N and d30Si data and especially the con-

clusion that d15N responds mostly to changes in utilisation rather than denitrification. Therefore, the authors need to address this before I can fully support publication. First, the authors describe in both cores M771-470 and B0405-6 an increase in d30Si just after the LIA. If you take into account the error bars, only a couple of points in total fall below or above the others. To me the trend is not as marked as the authors describe it. Therefore I would argue that there is at most a 0.2 permil (from 0.7 to 0.9 permil) increase between the LIA and the rest of the record (which is as much as the error bars) and would suggest only a modest increase in silicic acid utilisation. If you use a Raleigh fractionation model you would get something like 12% increase in utilisation. At the same time, the opal % records and valve accumulation rates show a 2 to 3 fold increase depending on the core site. Figure 5 shows a much greater gradient in utilisation between the time slices considered but I believe this is because for the transition period for instance only one d30Si data point is taken into account. I am also wondering whether the authors took into account the fairly low modern d30Si values from core b0405-6 (to me indistinguishable from the LIA values) when they plotted the period-specific relative utilisations on the fractionation curves (Fig 5). Now the d15N records show a much more defined trend with about 2 permil lower values during the LIA compared to modern. That's an increase of about 40% in N utilisation between the LIA and the modern (according to figure 5) if you believe denitrification had only a marginal impact on the d15N signal. The timing of change is very consistent between all core sites while it is not for the d30Si. Therefore, this casts doubt on the assertion that nitrate and silicic acid utilisation increased in parallel during the transition period in response to increased upwelling. Now there is a theoretical problem as well: With increased upwelling, studies have overwhelmingly shown that nitrate utilisation should decrease due to the influx of a great quantity of nitrate to the surface (more nitrate is utilised by the blooming algae but even more is left behind unutilised, hence reducing the recorded relative utilisation (see early papers from Francois and Altabet)). The author of the present paper argue that increasing upwelling and biological production at the end of the LIA resulted in an increase in d15N and d30Si and that it shows that relative utilisation of both nutrients increased together. I have to disagree with this interpretation. To me d15N increased because of increased denitrification promoted by higher organic matter rain rate (higher oxidant demand at depth or in the sediment). D15N indeed increased more than d30Si because it is mostly responding to denitrification and not relative utilisation. The modest and spatially variable increase in d30Si after the LIA does not match the very clear, consistent 2 permil increase in d15n. To me that tells us that both proxies are governed by different processes. It is possible to imagine that Silicic acid was abundant at the sea surface due to increased run off and was also less utilised during the LIA because the conditions where unfavourable to the diatom community (stratification) but that during the transition period they became favourable and hence the diatoms where able to utilised a greater proportion of the available Si (diatom production more than doubled while Si utilisation increased only slightly). I expect in the other hand that nitrate relative utilisation (which depends on diatoms and other planktonic producers) overall decreased or only slightly increased between the LIA and the modern period but the large d15N increase is mostly due to the kick off of denitrification. I also note that the authors use a d15N-nitrate source signal of 4 permil (fig. 5) while today this signal is known to be much higher in this region due to intense denitrification. At least for the reconstruction of the modern nitrate relative utilisation a greater d15N source value should be used.

Minor comments: Line 12 p3360: “this fractionation process is mainly controlled by the availability of Si(OH)4. . .” I believe this is incorrect. I would rephrase this as follow: “Si isotopic fractionation is mainly controlled by the utilisation of silicic acid in the sea surface by the biota”.

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