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Climate of the Past
Discussions

Interactive comment on "Oxygen isotopic analyses of individual planktic foraminifera species: implications for seasonality in the western Arabian Sea" *by* P. D. Naidu et al.

Anonymous Referee #2

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The manuscript focuses on the seasonality of an ODP core-site in the western Arabian Sea for the past 22kya through the oxygen isotope analysis of individuals of two species of planktonic foraminifera (G. sacculifer and N. dutertrei). Through previous work, the temperature component of this foraminiferal calcite was removed allowing for the calculation of salinity, the authors have chosen to discuss this in terms of the changes in evaporation and precipitation in the region. Such evaluation of downcore seasonal variability in the western Arabian Sea (sections 6.2 onwards) with respect to global climate and the Greenland-Monsoonal teleconnection demonstrates the importance of, and the need for, such single specimen oxygen isotope studies. The methodology is clever, in that assigning the extremes a distinct temperature value al-

lows for the recontruction of salinity and/or d18O-seawater. The major problem is that the extreme values are assigned either a Winter or Summer temperature value from a previously published Artifical Neural Network (ANN) of faunal data, despite the obvious complexities with the monsoonal system. Without an independent check the relatively small seasonal temperature range assigned appears to cause an overestimation of the other components. Therefore regretfully in its present form I would have to recommend rejection, other points are explained below. I agree with the points of Referee 1 and therefore have tried to not repeat what has already been mentioned.

1/ Selection of species and sample size: There is the potential for extreme events, or events outside of a single species temperture tolerance, to be missed if a single species is measured (N. dutertrei is measured for the thermocline and so an additional surface dweller would be required). It is possible that G. sacculifer like G. ruber in Ganssen et al., (2011) is not sufficient to quantify both extremes, a 'colder' species is required to ensure that the extreme events are sufficiently sampled. As ODP 723A is affected by upwelling conditions it is unlikely that the lower temperature extremes are sufficiently sampled by the species used here.

Naidu et al. state that the both G. sacculifer and N. dutertrei occur all year round, however it is hard to evaluate this statement as the referred to paper, Curry et al. (1992– referred to on L2 P3665), does not present the results for G.sacculifer in their paper. Curry et al. (1992) does mention that there is a marked difference in abundance of G. sacculifer between the NE and SW Monsoon in the 'CAST' trap. If this is similar to the location around ODP 723A then the limited sample size, as Referee 1 pointed out, may mean that the d18O values may be biased toward the period of greatest flux (i.e. during the period of greatest productivity). However, if G. sacculifer does occur all year round then the seasonal difference in Fig. 7 does not make any sense. Assuming that the sample that represents 0.5ka had the same conditions as present then the range (1 per mil or assuming that 1°C is 0.2 per mil then approx. 4°C) in single specimens of G.sacculifer is consistent with the difference between the minimum and maximum temperatures (approx. 5°C), found as per Fig. 1 from the WOA of Levitus (1994) between the SW Monsoon and the inter-Monsoon. However, the SST range calculated in Fig. 7 for 0.5ka is smaller than what would be expected for a year round species. This is the major problem of the paper as indicated by Fig.1 the greatest temperature difference may occur outside of Summer or Winter, therefore assigning the isotope value a temperature may drastically overestimate the role of d18Osw/salinity. A point of note is that Curry et al. (1992) does clearly show that N. dutertrei is absent at WAST during the early part of the year contrary to the statement presented in the manuscript that "both these species live throughout the year".

2/ Size fraction utilised (500-600 μm): I would guess that the low number of specimens analyzed is the result of there being fewer specimens in the size fraction used in this study, especially for N. dutertrei. Was using this size fraction due to analytical limitations (i.e a by-product of the mass spectrometer, to gain sufficient mass to produce a signal)? There is some attempt at justification for the choice of such a large size fraction given, because "the effect of stable isotope variation in depth of calcification would not affect our results because the size range >500um will not influence ontogenetic effect". However it would be helpful to elaborate on this unpublished work, given that previous work such as Berger (1978) has shown that coeval specimens of different sizes from different core depths have a large offset. By selecting such a size fraction how does this bias the estimation of seasonal range? Are all sizes likely to be found at all times in the year? Is the depth habitat and therefore likely exposure to the highest temperature ranges similar between all size fractions, as larger planktonic foraminifera are generally considered to have calcified down to a deeper depth (where seasonal temperature ranges are lower)? Although there is some suggestion in the literature that larger specimens of G. sacculifer are more indicative of surface conditions then smaller specimens, as growth or at least size is highly influenced by the symbionts (see the early culture studies of Bé; Spero etc.).

3/ Equation 1: I do not believe that using a rearranged form of the low light equation

(cultured Orbulina universa) of Bemis et al. (1998) to calculate the δ18Osw from the end-members was sufficiently justified. First why was the low –light equation used? As pointed out if larger specimens of G. sacculifer do represent shallower forms then a high light equation would make more sense. And secondly, given the differences between species temperature equations, why wasn't a more species-specific equation used? Mulitza et al. (2003)'s in-situ equation is not only the same species (G. sacculifer) but also represents a larger calibration temperature range (16-31°C) than that of Bemis et al. (1998). Alternatively there is the equation of Spero et al. (2003 – see Pearson, 2012 for an unpublished equation) from G. sacculifer in culture.

4/ Outliers: Counterintuitively, in the context of calculating salinity this dataset should be screened for outliers given that it is impossible to assign distinct years for each individual d18o value and a single datapoint at the extremes may not represent the 'normal' pattern of seasonality but something akin to a one in a hundred year event. This is all the more important when anchoring the isotope value to a fixed temperature value (as opposed to reconstructing the temperature via combining individual d18o with single shell Mg/Ca), especially as temperature reconstructions based upon the assemblage is highly unlikely to give the full seasonal range but an average summer/winter SST value This is evident from the (four) d18O G. sacculifer datapoints at 18ka that give the sample such a large range. If bioturbation or expatriation can be excluded, then the large spread between individual datapoints (0.2-0.5) on the high temperature/negative d18O end would suggest to me that these represent 'rare' events, and the isotope value assigned to the ANN temperature would be 1.5 per mil too light.

Other points:

I had thought that most labs had stopped using the discontinued Solnhofen limestone standard NBS20 for calibration as it was too finely ground which was thought to lead to exchange with the atmosphere that altered the standards d18O value. I also agree with Referee 1 that the uncertainty appears remarkably low, from personal experience the uncertainty of the standards we utilise increases when the masses of the standard are similar to those of the lightest foraminifera we analyse (5μg), as the result of grain heterogeneities (see Ishimura et al., 2008).

Much of the focus, given the context of reconstructing the seasonality, has been on the extreme/end-members which means that most of the data (lying between the end-members) is largely left uninterrupted/statistically untreated. For instance between 10-14 ka (Fig. 3) there appears to be a split in the middle, is this two populations? The interpretation/discussion of the data of N. dutertrei should be expanded, for instance it would be interesting to plot or to show the differences between the two species given their respective depth habitats.

References

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