RC2: Anonymous Referee #2

Referee comment in black
Author answer in blue

We thank the Referee #2 for his/her comments. We will address those comments in detail in the revised version of our manuscript. We detail below how we will address them point by point.

This is a review of the manuscript by Lichterfeld et al., submitted for consideration for publication in Past Climate. The manuscript investigates seasonal and interannual climate variability and its potential expression in the oxygen isotopic composition (δ18O) of individual surface- and thermocline-dwelling planktonic foraminifera. The authors present new and published single-specimen δ18O data from Globigerinoides ruber and Neogloboquadrina dutertrei collected at four sites across the tropical Indian Ocean and compare these observations with forward-model simulations.

As currently presented, however, the manuscript makes only a limited contribution to our understanding of how seasonal and interannual climate variability is recorded by individual planktonic foraminifera. This is primarily due to the lack of key observational datasets, as outlined below. With the addition of data that could likely be generated within a reasonable timeframe, the manuscript would be substantially strengthened.

Major comments

1. *The modeled data are compared with late Holocene (0–3.6 kyr BP) individual-foraminifer δ18O data (Fig. 8). In Section 5.3.4, the authors discuss several possible explanations for the discrepancies between modeled and observed data, including temporal integration, sedimentation rates, and the age of the core-top samples. Restricting the comparison to well-dated core-top samples that are younger than approximately 500–700 years would considerably reduce these uncertainties and limit the need for speculative explanations.*

The dating of the MD96-2060 core-top (0-1cm) is clearly affected by bioturbation and/or core-top poor recovery with the old CALYPSO piston device, which makes the core-top mean age of planktonic foraminifera older than those from other cores we compare. This is a major source of uncertainties in studies attempting to calibrate a method using core-top that are not contemporaneous.

Yet the core location, situated in a warm and stratified ocean location poorly affected by changes in seasonality and interannual variability nowadays as compared to other locations is key to have an equatorial background for how modern hydrological parameters will imprint in the isotopic composition of IFA in the warm and low-saline western equatorial region of the Indian Ocean.

In contrast, regions where cores were collected South or North of our site (i.e. the eddy-driven surface circulation of the Mozambique channel and the Somalian upwelling, respectively) are affected by an upper ocean dynamic much more active than in MD96-2060. We are aware of another sediment piston core situated offshore with analogous hydrological parameters (MD96-2062), but the onboard preliminary analysis (core description, magnetic susceptibility and sedimentary reflectance) indicates a sedimentary gap at around 4 meters depth (https://doi.org/10.17600/96200060).

We stated at length in the article that the real core-top is not modern, but other downcore measurements of geochemical parameters indicate as well that the core is mostly unaffected by other sedimentary problems downcore (https://www.seanoe.org/data/01016/112750/). As the Holocene $\delta^{18}O$ values of *G. ruber* are mostly constant in more dynamical sites situated North (Ganssen et al., 2011) and South (Wang et al., 2013) we have confidence in the core-top IFA values as reliable anchors while testing the applicability of IFA for past different climate backgrounds (see below).

2. *A major weakness of the manuscript is the absence of measured (observational) individual-foraminifer δ18O data from climatic intervals other than the late Holocene. For example, generating comparable datasets for the Last Glacial Maximum (LGM) from sites MD06-2060 and SO189-39KL and directly comparing the LGM and Holocene records would provide a valuable test of the sensitivity and broader applicability of the proposed approach. Such a comparison would substantially strengthen the manuscript.*

Indeed, a following article precisely targeting the LGM is almost ready for submission. As the interpretation in terms of LGM Indian Ocean variability is a long story on its own, we decided to publish that calibration exercise in advance to ease the discussion of the second paper that needs this first paper to be published. We are happy to see that the reviewer is willing to read the paleo-story IFA, that will be submitted as soon as this article is in press.

Minor comments

- *The assumed habitat depth of 0.5 m for G. ruber is not supported by several observational studies.*

We already addressed this point in detail in our response to Referee #1. We agree that a fixed calcification depth of 0.5 m is a simplification of the habitat depth range of *G. ruber*. To assess this, we turned to stratified plankton-net data from the FORCIS database (Chaabane et al., 2023) which show that *G. ruber* consistently stays concentrated within the upper 50 m of the water column. This supports a near-surface calcification depth overall, though we recognize that 0.5 m itself is still a simplification rather than a tightly constrained ecological depth. We also tested the sensitivity of our forward model comparing simulations run at a fixed depth versus over a fixed 0–50 m layer. The two approaches yield no significant difference in standard deviation

(ΔSD < 0.065‰ at most sites), showing that our results hold up well against this simplification. We will clarify and discuss this point further in the revised manuscript.

- *What is the basis for the assumption that an individual foraminifer records monthly averaged environmental conditions?*

This assumption is justified by the assumed 2–4-week lifespan of both *G. ruber* and *N. dutertrei* (Spero, 1998; Schiebel and Hemleben, 2017), which is consistent with lunar-period cycle reproduction (Bijma et al., 1990). Moreover, this lifespan is shorter than or comparable to the monthly resolution of the ORAS5 reanalysis used for the forward-modelling such that each individual is considered to calcify within a single monthly interval. We have added this clarification in the revised manuscript (Section 3.1.2).

- *Page 10 (line 265): Dissolution is discussed and largely dismissed as a possible explanation for the observed δ18O variability. SEM images documenting shell preservation would strengthen this conclusion.*

Other cores collected further South in more regions prone to calcite dissolution because of higher surface productivity indicate SEM images with pristine calcite, with clearly apparent foraminifera spines (Wang et al., 2013). We are aware of only two records where dissolution affect significantly the oxygen isotopes, one in the much more corrosive Pacific Ocean (Wu & Berger, 1989) and North of the productive Somali Basin (Schmiedl & Mackensen, 2006), despite the fact that the Pacific Ocean is probably affected by biologically-mediated calcite dissolution (Schulte & Bard, 2003). Of course, SEM images would be an additional argument to discard dissolution as a potential artifact, but foraminifera were hand-picked and very good preservation was already observed, with limited foraminifera fragments (Adebayo et al., 2025) showing a very low fragmentation index (3%) at MD96-2060, among the best-preserved core-tops of their dataset. We will hence probably not invest in further SEM for that analysis.

- *Figure 5: The standard deviation values are incorrectly formatted. Replace commas with decimal points (e.g., 0.276 instead of 0,276).*

It will be done in the revised manuscript.

- *Page 17 (line 448): Based on the figure, I estimate a temperature amplitude of approximately 6 °C rather than the 8.5 °C reported in the text. Please verify this value.*

It will be done in the revised manuscript. We checked using the ORAS5 monthly SST reanalysis (1958–2018) at this site and confirm that the value in the text conflated the total range of the monthly time series, which includes interannual variability (ΔSST = 8.7 °C), with the seasonal SST amplitude shown in Fig. 3 (mean monthly cycle only), which is 5.6 °C consistent with the referee's estimate. We have corrected the text to report the seasonal amplitude of 5.6 °C.

- *Figure 7: For improved readability, use more distinct colors to differentiate decreasing salinity from decreasing temperature. The same recommendation applies to increasing salinity and increasing temperature.*

It will be done in the revised manuscript.

References:

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Wang, Y. V., et al. (2013). Northern and southern hemisphere controls on seasonal sea surface temperatures in the Indian Ocean during the last deglaciation. *Paleoceanography*, 28(4), 619–632. https://doi.org/10.1002/palo.20053

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