Author's response

De Vleeschouwer et al. – cp-2021-151

Dear Prof. McClymont,

First of all, we want to thank you for granting us the necessary time to include some additional repeated measurements to answer some concerns raised by reviewer #3 on clumped isotopes statistics. Second, we thank all three reviewers for their assessment of our paper. We adapted the manuscript as described in the detailed replies to the three reviewers' comments (uploaded on February 15th 2022).

In this document, we include an overview of all relevant changes made to the manuscript in response to the reviewers' concerns.

1. **Leeuwin Current intensity on secular timescales**

Two important changes were made to the manuscript in order to improve the presentation of one of our main take-home messages:

a. First, we made changes to the text of paragraph §4.2. to emphasize the observation that the 3.7 – 3.1 Ma interval is characterized by isotopic gradients that are equally steep as the early Pleistocene interval between 2.6 – 2.2 Ma. This is important, as it illustrates that the 3.7 – 3.1 Ma interval is marked by a "weaker-than-expected" Leeuwin Current.
b. Second, we highlight the fact that the SST records in the Agulhas/Benguela region exhibit similar behavior on secular timescales: These records also reflect late Pliocene cooling between 3.7 – 3.1 Ma. This is now emphasized by means of grey rectangles on Figures 7 and 8. Contrary to what was written in the answer to the reviewers, we did not adopt cross-spectral analysis for this purpose because the records under investigation were of too low temporal resolution. But we believe that our visual approach in Figure 7 and 8 gets the message across.

These two changes help in bringing across a key message: The latitudinal isotopic gradient is a proxy for Leeuwin Current strength, and we observe a *stronger-than-expected* gradient (*weaker-than-expected* Leeuwin Current) in the late Pliocene. This time interval is then interpreted in terms of changing oceanography and southern hemisphere climate.

2. **Comments on temperature reconstructions**

Changes to the manuscript (especially in §3.2) were carried out as described in the answer to Reviewer 1.

3. **The impact of diagenesis on stable isotope results**

Changes to the manuscript (especially §4.1) were carried out as described in the answer to Reviewer 2. Section §4.1 now contains an explicit discussion of the potential effects of dolomitization and recrystallisation, and it provides an overview of all the actions and checks we adopted to minimize their effects on the clumped isotope and stable isotope results.

4. **Comments on the reliability of isotopic gradients for the reconstruction of Leeuwin Current strength**

Changes to the manuscript (especially §4.2) were carried out as described in the answer to Reviewer 2. A new supplementary figure (Fig. D1) is also provided in response to the reviewer's comment. This new figure contains a comparison of the TEX_{86} gradient between Sites U1461 and U1459 (as in Figure 3C in He et al, 2021), and the isotopic gradient from this study. Importantly: these two gradients are completely independent of each other, as they were calculated from completely different proxies. Yet, they show similar patterns throughout the Plio-Pleistocene, corroborating the assumption that TEX_{86} and isotopic gradients along the Leeuwin Current pathway are temperature-driven, and thus can serve as a proxy for Leeuwin Current intensity.

5. **TEX86 vs. clumped temperatures**

The seasonal warm-bias on TEX86 is now more explicitly considered as an important part of the proxy-discrepancy in the manuscript.

6. **Isotopic gradients**

Changes to the manuscript (especially in §3.2 and §4.2) were carried out as described in the answer to Reviewer 3.

7. **Clumped isotopes statistics.**

Additional measurements were carried out and appropriate changes to the manuscript were carried out. All the Reviewer #3 suggestions with respect to clumped isotope statistics were followed.

8. **Recalculated clumped isotope calibration**

The new paper by Peral et al. is still not accepted by *Geochemica Cosmochemica Acta*. In case *Climate of the Past* accepts our manuscript earlier than *Geochemica Cosmochemica Acta* accepts Peral et al. (2022), we can cite a pre-print of the paper by Peral et al., hosted on EarthArXive: https://doi.org/10.31223/X5VK82. This pre-print has already been cited in the current submitted version of our paper.

Kind regards,

David De Vleeschouwer and co-authors.