

Author responses to Anonymous Referee #2:

I have read the manuscript together with the previous referee comments and the authors' responses. The revision has addressed most of the issues raised in the first round, and the manuscript is now considerably clearer. I find the study suitable for publication after minor revision. My remaining comments mainly concern the strength of the orbital-scale interpretation.

Reply: We thank the reviewer for the careful evaluation of our revised manuscript and for the constructive suggestions.

1. I think a clearer distinction is still needed between sampling resolution and chronological resolution. The ~ 4 kyr value describes the average spacing of the samples in the age domain, whereas the uncertainty between paleomagnetic tie points may be appreciably larger. This matters particularly for interpretation of the 20- and 40-kyr components. I suggest providing the paleomagnetic tie points and the corresponding age-depth relationship, at least as supplementary material, together with a brief indication of sedimentation-rate changes and their possible effect on the shorter orbital bands.

Reply: We agree with the reviewer that sampling resolution and chronological resolution should be clearly distinguished. In the revised manuscript, we have clarified that the ~ 4 kyr value describes the average temporal spacing between samples, rather than the chronological resolution or precision of the paleomagnetic age model. Following the reviewer's suggestion, we have added the paleomagnetic tie points and

the corresponding age-depth relationship as Supplementary Table S1 and Supplementary Figure S1a. The sedimentation rates between adjacent paleomagnetic tie points are listed in Supplementary Table S1 and illustrated in Supplementary Fig. S1b. We have also added a statement noting that, because ages between adjacent tie points were obtained by linear interpolation, chronological uncertainty between tie points may exceed the average sample spacing and may have a greater influence on the interpretation of the shorter 20- and 40-kyr components than on eccentricity-scale variability.

Lines 199-207: The average temporal spacing between samples is ~4 kyr for the ~3.6-3.3 Ma interval and ~18 kyr for the 2.95-~1.8 Ma interval. These values describe the spacing of the analyzed samples, rather than the chronological resolution or precision of the paleomagnetic age model. Because ages between adjacent paleomagnetic tie points were obtained by linear interpolation, chronological uncertainty between tie points may exceed the average sample spacing and may have a greater influence on the interpretation of the shorter 20- and 40-kyr components than on eccentricity-scale variability. Therefore, the spectral analysis was focused mainly on the densely sampled ~3.6-3.3 Ma interval.

2. About describing the ~3.6–3.3 Ma interval as showing a well-defined 100-kyr cycle. The interval is only about 300 kyr long and therefore contains approximately three eccentricity-scale cycles. In addition, the strongest peaks in the two proxies are not identical, with χ_{fd} /HIRM close to 100 kyr and median grain size closer to 125 kyr. Given the limited record length, it may be more appropriate to refer to “eccentricity-

scale (~100–125 kyr) variability” unless the authors can demonstrate that these frequencies can be reliably distinguished.

Reply: We agree with the reviewer’s suggestion. We have revised the relevant text by replacing “100-kyr cycles” with “eccentricity-scale (~100–125-kyr) variability” where appropriate.

3. The records were interpolated from an average sampling resolution of ~4 kyr to a 1-kyr time step before REDFIT analysis. The rationale for this interpolation should be stated. Since interpolation does not add independent temporal information, it would also be useful to confirm that the main eccentricity-scale spectral result is not sensitive to this processing step.

Reply: We agree that the rationale for interpolation should be stated more clearly. In the revised manuscript, we explain that the 1-kyr interpolation was used only to obtain evenly spaced time series for spectral analysis and band-pass filtering, and that this procedure does not add independent temporal information to the records. To evaluate whether the main spectral result was sensitive to this processing step, we repeated the spectral analysis using a 2-kyr interpolation time step. The results show that the main eccentricity-scale (~100–125-kyr) variability remains evident in both proxy records, indicating that this feature is not an artifact of the 1-kyr interpolation. We have added this clarification to the Methods section and provided the sensitivity test as Supplementary Fig. S2.

Lines 210-212: The 1-kyr interpolation was used only to regularize the time spacing of the records for spectral analysis and band-pass filtering, and does not add

independent temporal information.

Lines 216-221: To test whether the main eccentricity-scale spectral result was sensitive to the interpolation procedure, we repeated the REDFIT analysis using a 2-kyr interpolation time step. The eccentricity-scale (~100-125-kyr) variability remained evident in both proxy records, indicating that this feature is not an artifact of the 1-kyr interpolation (Supplementary Fig. S2).

Lines 269-272: A sensitivity test based on a 2-kyr interpolation time step yielded similar eccentricity-scale spectral peaks in both proxy records, further supporting that the main eccentricity-scale variability is not caused by the 1-kyr interpolation procedure (Supplementary Fig. S2).

4. The manuscript continues to use the term “phase relationship” when comparing band-pass-filtered records. It is not clear whether phase and coherence were actually quantified. If the comparison is based primarily on the visual alignment of filtered curves, wording such as “broad correspondence” or “similar filtered variations” would be more appropriate. This is especially relevant at the 20- and 40-kyr bands, where modest age uncertainty could affect the apparent alignment between records.

Reply: Thanks for the suggestion and we have replaced “phase relationship” with more cautious expressions such as “broad correspondence” and “similar filtered variations” where appropriate. We have also softened the interpretation of the 20- and 40-kyr bands in the revised manuscript.

5. The revised discussion of χ_{fd}/HIRM is more convincing, but would slightly

soften the final statement. Preservation of magnetite-bearing remanence does not necessarily rule out selective alteration of the fine magnetic fraction, and relatively uniform lithology does not completely exclude smaller provenance changes. These considerations do not invalidate the use of χ_{fd}/HIRM as a precipitation-sensitive proxy, but minor sedimentological or post-depositional influences cannot be entirely excluded.

Reply: Thank you for this helpful comment. We have softened the final statement on the χ_{fd}/HIRM proxy interpretation. The revised text now states that χ_{fd}/HIRM primarily reflects precipitation variations in the GS section, while acknowledging that minor sedimentological or post-depositional influences cannot be entirely excluded.

Lines 336-340: These considerations support the use of χ_{fd}/HIRM as a precipitation-sensitive proxy in the GS section, although minor sedimentological or post-depositional influences, including selective alteration of fine magnetic particles, evaporite dilution, and small provenance changes, cannot be entirely excluded.