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Interactive comment on “Low-latitude climate variability in the Heinrich frequency band of the Late Cretaceous Greenhouse world” *by* N. J. de Winter et al.

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General Comments

The study by de Winter et al. investigates the expression of sub-Milankovitch periodicities in various paleoclimatic records of the Late Cretaceous deep-sea Site 516F. Using Blackman-Tukey spectral analysis and Gaussian bandpass filtering of these records, they highlight eccentricity and precession cycles over a ∼700 kyr-long interval in the Early Campanian as well as two other distinct significant periodicities at ∼10 and ∼7kyr in a limited subset of this interval. Based on the expression of their filters, they conclude that the periodicity at ∼10 kyr is an artifact reflecting a harmonic of the preces-

sion whereas the ∼7kyr cycle represents an actual sub-Milankovitch climatic process, possibly associated with a nonlinear response of the Earth’s climate system to orbital forcing, originating at low latitudes and similar to the process responsible today for Heinrich events.

The results of this study are promising but overall, the paper is hypothetical contribution with statements that are poorly constrained by the actual data.

I have three major criticisms: (1) There is no stratigraphic constraints over the entire studied interval. Not a single stratigraphic data is presented in the text or in the illustrations. (2) There is no assessment of the actual significance of the frequency peaks delineated in the Blackman-Tukey spectral analysis. It is therefore not possible to test the noise-to-signal ratio in their records which makes the interpretation of these results very speculative. (3) The length of the record analysed for the identification of sub-Milankovitch cycles is very short (potentially less than two 100 kyr cycles) and thus does not offer the possibility to test other useful cyclostratigraphic methods. For example, spectral analysis of the amplitude modulations of sub-Milankovitch frequencies would be quite useful to test whether or not these sub-Milankovitch cycles are linked to the precession.

For these reasons, I recommend major revisions for this work to be accepted for publication. In detail, it is necessary that the interval of study is extended and I would recommend at least a ∼1.2 Myr-long record. It is necessary to provide a cyclostratigraphic method which allows assessment of the significance of observed frequency peaks. Additional methods such as wavelet analysis, amplitude spectrograms or Fast Fourier transforms would help assessing potential changes in sedimentation rates over the studied interval. Filtering of the frequencies should be used by the authors to tune their record into the time domain. A new cyclostratigraphic analysis of the tuned signal in time would also make the results more sound. Finally, it is necessary and fundamental to add the available biostratigraphic and magnetostratigraphic informations of the studied interval of Site 516F.

Detailed comments

Title :

Heinrich events are originally defined by the finding of ice rafted debris in sediment cores spanning the last glacial. No evidence for glaciation has been found in the early Campanian. Possible glaciations and growth of a small ephemerous Antartic ice cap have been inferred only for the Maastrichtian, not for the Campanian (Barrera and savin, 1999). I understand in the discussion of the paper that the origin of the Heinrich climatic variability may actually be at tropical latitudes. However, I would avoid the use of “Heinrich frequency band” in the title, because this term is directly related to the presence of an ice-sheet and it may cause confusion to the reader with regards to Campanian climate. Replace it by “sub-Milankovitch”.

Results:

One of the major issues of this paper is the complete lack of stratigraphic constraints provided for the studied interval. I don’t think anyone will be convinced by this study without any stratigraphic informations. There is not a single illustration with age, sub-stage and biostratigraphic zonations allowing an age estimation or a duration of the studied interval. The argument based on similar sedimentation rates between this study and Park et al. (1983) is insufficient because the paper of Park et al. suffers from the exact same issue with respect to stratigraphic constraints. I understand that leg 72 was drilled and studied a long time ago but there are available biostratigraphic and magnetostratigraphic data that should allow the authors to make at least a rough estimate of an average sedimentation rate in their studied interval or adjacent intervals. For instance, magnetochron C33n lies above the studied interval, spanning cores 110 to 104. The nannofossil biostratigraphy is not provided in detail for leg 72 but the planktic foraminifer biozonation is available in Weiss (1983). Therefore, it should be indicated on the illustrations : (1) that the studied interval lies within C33r (Berggren et al., 1983), (2) the position of the first occurrence of Globotruncana arca (in the lower part of core

114 after Weiss, 1983) and the corresponding foraminifer biozone spanning the studied interval, (3) Stage and sub-stage.

Issues with the cyclostratigraphic methods:

- The method chosen to assess the expression of frequencies in the signal (Blackman-Tukey power spectra, Figs 2 and 4) does not provide any significance levels or statistical tests. I think it is necessary to provide either a red noise model and associated significance levels or a F-test to any of those power spectra.

- The interpreted 100 kyr eccentricity at 2.5 m in L* has a very low power in the Blackman-Tukey of Fig. 2.

- The interpreted precession in L* is actually expressed by two peaks centered respectively at 0.53 and ca. 0.43 m on Fig. 2. A similar peak is recorded in a* at 0.43 (maybe 0.45 m). However, the chosen filter of L* is centered at 50 cm without justification. The bandpass of the Gaussian filters is never provided, neither in the illustrations or in the text. The exact parameters chosen for bandpass filtering should be systematically provided with justification by the results of the power spectra (centered frequency or period and total width of the band in frequency or m unit).

- Wavelet analysis, Fast Fourier transforms or amplitude spectrograms are important complementary informations for L* and a*

- The interval chosen for the analysis of the sub-Milankovitch periodicities is way too short (from 1152 to 1156 m, i.e. 4m). This is equivalent to less than 2 eccentricity cycles, 9 precession cycles and thus ∼19 of the 22 cm cycles. To my opinion, the only way to understand the true nature of those sub-Milankovitch periodicities is to run high-resolution data over a much longer interval of at least 1.2 Myr, to filter them and to extract the amplitude modulations of the filter. If those cycles are semi-precessional in nature and a precessional harmonic expression, then the amplitude modulations should show significant frequency peaks in the eccentricity band, as expected from eccentricity-modulated precession cycles. This test must be performed before any further interpretation of the results. It is very hard to currently assess this because of the too short length of the analysed signal. However, it actually seems like the 22 cm filter shows 2 well-expressed amplitude modulations which would correspond well to the eccentricity whereas the 16 cm filter is different and seems to show 4 to 5 amplitude modulations (Fig. 5). Therefore, I would actually tend to support the authors' interpretation on the different nature of those two cycles but with the lack of stratigraphic constraints, the lack of statistical methods for the significance of the peaks in the power spectra, and the very short length of the interval analysed, I think it is unfortunately not possible to build a strong case out of this study. However, I actually think that the study is very promising and I strongly encourage the authors to push it further.MS measurements seem to show well these periodicities, are cheap and relatively fast to perform, therefore, I would strongly advise the authors to perform such analysis over a longer interval in order to make this promising study more solid.

- In order to assess a more precise expression and duration of their sub-Milankovitch cycles, I would also recommend the authors to perform a depth-to-time tuning of their longer record based on the filtering of a stable frequency component in L* and a* (such as the obliquity at 90 cm ?). Cyclostratigraphic analysis should then be performed in the time domain on the tuned signal.

Additional remarks on the text:

Page 4478, line 6: They have also been found in the Late Jurassic (Rodriguez-Tovar and Pardo-Iguzquiqua, 2003; Boulila et al., 2010), in the Triassic (Zühlke et al., 2003; Wu et al., 2012) and in the Devonian (DeVleeschouwer et al., 2012).

Page 4478, lines 19-20. Use of "whereas": there is no contradiction/opposition in this sentence. Similar paleolatitudes and basin configurations for Sicily and the early Campanian South Atlantic Site 516F. This is actually a good argument for expecting similar behaviors, not a counter-argument

Page 4478, line 21: "Moreover": delete, this is not an additional counter-argument since there was actually no contradiction in the previous sentence. It is the first counter-argument.

Page 4478, line 24: I suggest "Here, we use. . ."

Page 4479, line 4: rephrase, one word is missing after drilled.

Page 4479, lines 1-5: please precise the base and top of the sampled interval in mcd.

Illustrations:

This manuscript is well-written but it is hard to follow because there is no indication of the interpretation of filtered Milankovitch cycles on Figures 1, 3, 5, A1 and of the identified peaks on power spectra of Figure 2 and Figure 4. Please indicate precession, obliquity and eccentricity. Please precise what the drawn lines indicate on figures 3, 5 and A1. The meaning of *pma is only explained in the text. It should be explained as well in all figure captions.

References

Barrera, E., Savin, S.M., 1999. Evolution of Campanian–Maastrichtian marine climates and oceans. In: Barrera, E., Johnson, C.C. (Eds.), Evolution of the Cretaceous Ocean-Climate System: Spec. Publ. Geol. Soc. Am., 332, pp. 245–282.

Berggren et al. (1983) available at http://www.deepseadrilling.org/72/volume/dsdp72_49.pdf

Boulila, S., B. Galbrun, L. A. Hinnov, P.-Y. Collin, J. G. Ogg, D. Fortwengler, and D. Marchand (2010), Milankovitch and sub-Milankovitch forcing of the Oxfordian (Late Jurassic) Terres Noires Formation (SE France) and global implications: Milankovitch and sub-Milankovitch forcing of the Oxfordian, Basin Research, 22(5), 717–732, doi:10.1111/j.1365-2117.2009.00429.x.

De Vleeschouwer, D., A. C. Da Silva, F. Boulvain, M. Crucifix, and P. Claeys (2012), Precessional and half-precessional climate forcing of Mid-Devonian monsoon-like dynamics, Climate of the Past, 8(1), 337–351, doi:10.5194/cp-8-337-2012.

Rodriguez-Tovar, F. J., and E. Pardo-Iguzquiza (2003), Strong evidence of high-frequency (sub-Milankovitch) orbital forcing by amplitude modulation of Milankovitch signals, Earth and Planetary Science Letters, 210(1-2), 179–189, doi:10.1016/S0012-821X(03)00131-6.

Weiss, 1983, available at http://www.deepseadrilling.org/72/volume/dsdp72_31.pdf

Wu, H., S. Zhang, Q. Feng, G. Jiang, H. Li, and T. Yang (2012), Milankovitch and sub-Milankovitch cycles of the early Triassic Daye Formation, South China and their geochronological and paleoclimatic implications, Gondwana Research, 22(2), 748–759, doi:10.1016/j.gr.2011.12.003.

Zuhlke, R., T. Bechstadt, and R. Mundil (2003), Sub-Milankovitch and Milankovitch forcing on a model Mesozoic carbonate platform - the Latemar (Middle Triassic, Italy), Terra Nova, 15(2), 69–80, doi:10.1046/j.1365-3121.2003.00366.x.

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