

Interactive comment on “Two distinct decadal and centennial cyclicities forced marine upwelling intensity and precipitation during the late Early Miocene in Central Europe” by G. Auer et al.

G. Auer et al.

gerald.auer@uni-graz.at

Received and published: 28 July 2014

The comment of Referee 2 deals largely with the sedimentary aspect of the interpretation, as well as the contamination of "autochthonous taxa" with allochthonous specimens, while raising some concerns with the applied ecological parameters. These are all valid points to be made in the scope of this work and thus will be addressed accordingly by us.

However, the form, in which the comment was submitted, makes answering point-by-point arguments tricky. A certain amount of paraphrasing of the statements in the comment will be necessary to address them in a meaningful way. We also would like

C1152

to direct Referee 2 to our reply submitted to the comment of Referee 1, since it deals with similar issues.

Argument1: *Amounts of allochthonous specimens are likely (stated as a personal observation of the Referee) to be the major contributing factor to the assemblage, largely masking any autochthonous signal with 'noise', especially of long lasting taxa (i.e. *Coccolithus pelagicus*, *Cyclicargolithus floridanus* and *Reticulofenestra minuta*). The reviewer then suggests that Paleogene and Cretaceous components of the allochthonous assemblage should be treated separately.*

This is quite easily (although not quickly) answered: Within the scope of this work 9 REDFIT analyses have been performed (and supplemented by Wavelet spectra). If the argument of the Referee actually were true, these spectral analyses should conceivably all show the same periodicities (or lack thereof). Especially the results of *Coccolithus pelagicus* and *Cyclicargolithus floridanus* clearly show no correlation in the cyclic patterns with the also studied amount of allochthonous material in the samples. If these two taxa actually were contaminated by significant amounts of Paleogene specimens, they should either match the cyclic patterns found for the allochthonous taxa, or (more likely) show no patterns at all, especially not one that clearly correlate with unrelated geochemical proxies.

Of course, correlation coefficients were also calculated (but not included in the final manuscript, as they actually have no statistical value when comparing percentage data: based on the ubiquitous, but diligently ignored or misunderstood "closed sum problem").

We also did not further deal with the issue, since we think that the results of the REDFIT analyses amply demonstrate the effective unrelatedness of the signal in long lasting taxa with allochthonous taxa, despite undeniable contamination. Nevertheless, for the sake of completeness we chose to append them to this reply (Table 1).

To summarize the results: All long lasting taxa show at most a weak negative (c. -0.4)

C1153

correlation with the total amount of allochthonous taxa, which is just a result of how percentages actually work (i.e. the closed sum problem). The problems arising from using percent-data were dealt with extensively by the use of transformations during the analyses. The amount of Paleogene taxa, which has of course has been recorded separately, but was, for the sake of brevity, lumped together with the Cretaceous taxa, for the interpretation. They actually show no significant linear correlation at all, with any of the long ranging taxa. Also, the amount of Paleogene taxa is comparably low when compared to the amount of cretaceous taxa in the assemblage. The voracity of the actual ecological signal (despite indefinable amounts of reworking) was also tested with multivariate statistics in a previous study. Based on these results the primary ecological trends and signals do not appear to be noticeably masked by reworked specimens (Auer et al., 2014).

As a final note, REDFIT analysis actually is specifically developed to deal with random noise (white and red noise) in particular. Since it is safe to assume that the amount of platelets of specific allochthonous taxa will always be equivalent to random noise, even if the total amount displays cyclic patterns, these methods actually are able to deal with a considerable amount of 'contamination'. I strongly refer the Referee to the works of Weedon (2003) and Schulz and Mudelsee (2002) for further information on spectral analysis methods and REDFIT, in particular.

Finally, based on the concept of random populations in a cyclic signal, it is also largely useless to only consider Paleogene reworked taxa, since they are, per definition, always a random component (via extensive mixing during transport) within the total population of allochthonous material.

Argument 2: *allochthonous taxa are 'clay-sized' grains and thus act as indicators of variable sedimentation rates caused by varying terrigenous input, proving that sedimentation rates are not stable. This poses major problems in the detection of periodic cycles.*

C1154

First of all, most coccoliths are of 'silt-size' when considering them as sedimentary grains. Secondly, no sedimentation can ever be considered to be a perfect constant. While we agree that passages in the manuscript need to be revised in order to more accurately reflect this, we do, however, not see a significant problem. Spectral analysis methods are actually quite robust when dealing with minor (non linear) changes in sedimentation rate. Spikes in the abundance of allochthonous taxa thus represent wetter, more terrigenous input rich, episodes that are caused by cyclic variations in climate, and are likewise expressed as cycles in the related proxy-records.

To further ameliorate this problem, we incorporated the layer thicknesses in our datasets to gain information about changes in sedimentation rate (=layer thickness). REDFIT analysis was also specifically developed to deal with this kind of unevenly spaced 'noisy' (in the sense signal processing) data. Furthermore, Wavelet analysis, with its continuous plot of all recorded frequencies and their powers over the total thickness of the sampled interval (see Weedon, 2003), actually allows to check for changes in sedimentation rate when regular cycles are assumed to be present. This approach was used in this particular work, and also discussed when dealing with the single frequency filters.

Argument 3: *there is still a lack of clear data on the ecological preferences of the taxa used for the interpretation.*

We agree that deep understanding of the ecological behavior of coccolithophores is still lacking. Nevertheless general inferences can be made about their ecological behavior, without overstating the present knowledge. Generally, we think that modern analogues, while arguably very useful, should only be applied very broadly in terms of environmental preferences for the encountered taxa, as we think was done in this work.

Also, there is already a published study, on which the present work is built, that deals extensively with both the ecological parameters, as well as the possible contamination

C1155

of the autochthonous assemblage with allochthonous material by using multivariate statistics and integrated proxy records (Auer et al., 2014).

References

Auer, G., Piller, W. E. and Harzhauser, M.: High-resolution calcareous nannoplankton palaeoecology as a proxy for small-scale environmental changes in the Early Miocene, *Mar. Micropaleontol.*, 111(0), 53–65, doi:10.1016/j.marmicro.2014.06.005, 2014.

Schulz, M. and Mudelsee, M.: REDFIT: estimating red-noise spectra directly from unevenly spaced paleoclimatic time series, *Comput. Geosci.*, 28(3), 421–426, doi:10.1016/S0098-3004(01)00044-9, 2002.

Weedon, G. P.: *Time-Series Analysis and Cyclostratigraphy: Examining Stratigraphic Records of Environmental Cycles*, 1st ed., Cambridge University Press, Cambridge, 2003.

Interactive comment on *Clim. Past Discuss.*, 10, 1223, 2014.

C1156

Table 1: Table showing the correlation coefficients of the five dominant "autochthonous taxa" with the amount of total allochthonous material and the amount of Paleogene allochthonous material. The Cretaceous taxon *Watznaueria barnesiae* was used as a reference and unsurprisingly shows a positive correlation with the total amount of allochthonous taxa.

	correlation coefficients	
	total allochthonous taxa	Paleogene taxa
<i>Coccolithus pelagicus</i>	-0.45	-0.01
<i>Cyclicargolithus floridanus</i>	-0.44	0.13
<i>Reticulofenestra haqii</i>	-0.40	-0.08
<i>Reticulofenestra minuta</i>	-0.21	-0.24
<i>Reticulofenestra pseudoumbilicus</i>	0.16	-0.24
<i>Watznaueria barnesiae</i>	0.53	-0.24

Fig. 1.

C1157