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Climate of the Past Discussions

Interactive comment on "Three exceptionally strong East-Asian summer monsoon events during glacial conditions in the past 470 kyr" *by* D.-D. Rousseau et al.

D.-D. Rousseau et al.

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We would like to thank referee1 for the comments provided on our manuscript Cp-2008-0064 on exceptionally strong E Asian summer monsoon events, and we will reply to the questions raised.

Comment 1 is partially an apparent misunderstanding as we were careful to mention glacial conditions in the title while in the text we only address the record of well marked summer monsoons during glacial times. So we should change "glacial conditions" to "glacial times" in the title in order to better warn the reader about the content of the paper. On the other hand, we never claimed that the magnitude of the events observed and described in glacial times were higher than during interglacials where summer

monsoon is much stronger and dominant in the global climate system. However, we demonstrated in previous papers that glacial times, i.e. MIS 2-4, 6, 8, and 10 recorded intervals during which a summer monsoon signal was preserved in the mollusk record. Moreover we showed for the last climatic cycle that these intervals were fitting with other independent records (pollen, iron content, marine proxy...) available in the literature. The recent published results about Chinese speleothems support even more strongly the occurrence of summer monsoon events during glacial time intervals at least during MIS 2-4 and 6. However the intensity of the signal that we are discussing in our paper is by far much more important and in some way exceptional, as one can notice in the figures provided as we are not yet able to transform our variations in term of amount of precipitation.

Comment 2. Referee 1 is partly correct. Indeed winter conditions are a strong limiting factor as they condition the survival of the individuals, which, if not enduring for example cold temperature, would die. However, some of the species described, named "Orientals" have presently a southern distribution in China, i.e. sub-tropical, that only environmental conditions similar to summer monsoon ones during the period of activity, i.e. spring and summer, would permit their expansion further north. In the other glacials, moist-warm species individuals are found but in much reduced proportions (see Rousseau et al, 1997, 1999; Wu et al., 2001, 2007). We agree with referee 1 that grain size is traditionally taken as a proxy for winter monsoon, the higher the proportion of coarse size fraction, the stronger is the monsoon. This is in that sense that the comparison is proposed. If the proportion of coarse material, characteristic of winter monsoon, is showing lower values, this is interpreted as a reduction in the strength of the monsoon flows over the Chinese Loess Plateau. A new grain size analysis, from Chinese Loess sequence, recently released in Climate of the Past by Guo et al (2008) supports our interpretation. Magnetic susceptibility is an accurate indicator for determining the main lithological and soil variations in the studied sequences, i.e. loess versus paleosols. However, MS do show variations that could be interpreted as signs of summer monsoon impacts, especially in the weathered loess units, noticeable in the

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field, which show signs of pedogenesis. This is available in every loess unit and in the last climatic cycle even more distinct in the interval associated to MIS3.

Comments 3. Referee 1 questions our proposal for an "astronomical configuration" to explain our results especially using insolation. About point 3.1, reviewer 1 is correct when considering the moist sensitive individuals. Indeed there are other occurrences of these species and individuals associated to summer insolation gradient during glacial intervals. We should have mentioned in our text that we already described increase in these particular species but in proportions that have no comparisons with the 3 main events that our paper is discussing. These minors summer monsoon events have been described in Rousseau et al (1997 – Geology, and 1999 – Quat. Res) and in Wu et al.(2001 –J. Geophys. Res, and 2007 – Quat. Sci. Rev.). One must acknowledge that the scale used on figure doesn't favor noticing these minor events, which rather look drawing artifacts while effectively occurring.

Points 3.2 and 3.3 relate again with the record of exceptional counts we obtained and which captured our attention. In its modeling experiment, Masson et al (2000) suggested that the "Indian and African monsoons at 175ka", one of the three events we describe, "were stronger than nowadays…", and that high insolation, from this modeling experiment, could explain such strong summer monsoon signal. This is an interesting support to our observation and remains a modeling result totally independent of our study. Although we didn't intend to do so, referee 1, questioning the intensity of our signal, we are referring to the study of the Sanbao cave located far inland at 110°26'E and 31°40'N, at the southern edge of the Chinese Loess Plateau, were several speleothems provide a complete record of the past 224,000 years (Wang et al. Nature 2008). The δ18O variations recorded have been interpreted as indicative of the strength of the East Asian monsoon during the two last climatic cycles. The authors described strong summer monsoon events interpreted as "Chinese interstadials". Concerning our present record, one can quote Wang et al. (2008) who indicate that " the monsoon peaks corresponding to marine isotope stages (MIS) 5.5 and 7.3

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are relatively low, and the peak at MIS 6.5 is relatively high". Indeed when comparing these variations, one can notice that the δ18O for MIS 6.5 dated at about 175 ka, is indeed higher than during interglacials 5.5 and 7.3, but also indeed is a composite one with 3 identified events thanks to the very high resolution of the record. Thus this independently supports the conclusions of the modeling experiment by Masson et al (2000) that we were quoting, but also our results. Once more the cave is located at the southern edge of the Chinese Loess Plateau. Now considering what we observe during MIS 6 compare to MIS10 and 12 in Luochuan, taking into account these two different and independent data, we can still remain with "exceptional events". However the magnitude of the variations observed, also noticed in another loess sequence, requires particular conditions that we cannot explain without considering the particular configuration of the Earth orbit parameters. Observing such development of moisture sensitive individuals required the northward move of the upper boundary of the East Asian summer monsoon as already observed in MIS 6.5 but still with a configuration allowing these particular developments of populations. Indeed the three events correspond to periods of low eccentricity, especially the two oldest that occurred during periods of the lowest eccentricity values of the past 500,000 years, which reduces the seasonal change anomalies perpetuating favorable conditions for the moist sensitive mollusks. Furthermore during these intervals, summer was at perihelion, thus with summer season longer than winter, with the 6.5 summer even longer when considering the precession values.

Comment 4. We corrected the manuscript using the appropriate term "mean summer insolation" instead of "average summer insolation". Mean summer insolation was calculated using the option provided by "Analyseries" software available and which corresponds to indeed the computation between two positions of the Earth on its orbit or two dates

Comment 5. In the caption of figure 5, we grouped the meaning of red curves into one sentence, which we agree could be confusing. So we changed that to make it more

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readable, only the δ18O curve remaining in red. Same comment about figure 4 as requested for the right hand panel showing both warm species and "oriental" individuals, respectively blue and green curves.

Comment 6. We understand the reviewer's comment as we were mixing the conditions of deposition of the paleodust with the transported. Therefore we put "mainly deposited horizontally" between commas

Comment 7. Referee 1 is correct and we revised the text and figure 5 as follow. As the winter monsoon is originating from the occurrence of the Siberian High at high latitudes, about 65°N, and cooler surface ocean, at about 15°N, in winter directing so the wind circulation. As a first guess we compared the winter mean insolation between 65°N and 15°N and noticed that the peaks of warm sensitive individuals occur when the difference is not maximum. We removed then on figure 5 the plot of summer insolation 65°-35° and replaced it by the plot of winter insolation 65°N-15°N.

Comment 8. Typo errors will be corrected.

Interactive comment on Clim. Past Discuss., 4, 1289, 2008.