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Interactive comment on “Multiscale monsoon variability during the last two climatic cycles inferred from Chinese loess and speleothem records” *by* Y. Li et al.

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The authors greatly appreciate the crucial remarks made by the referee.

1. Grain-size data have been widely used as a proxy for changes in winter monsoon strength in paleoclimatic studies of the Chinese Loess Plateau. A lot of sections of grain-size data with high-resolution and sufficient time length have been published, including cited and non-cited in the manuscript. A comparison with other grain-size data from high sedimentation rate and weak pedogenesis loess-paleosol sequences in this region is useful to test local or regional significance of the Gulang section. In particular, the authors should check if the millennial-scale events shown in Fig.6 could

be validated in other loess sections? I suggest drawing a figure to show the nature of replication within the dating uncertainty.

Reply: To check the repeatability, we compare our Gulang mean grain size with the median size variation of a nearby loess section (Shagou section) (Wu et al., 2005). Grain size variations of these two section display high similarity of both glacial-interglacial and millennial scale variability (Fig.1). To verify the regional significance, Gulang grain size variations were also compared with a 249-kyr grain-size stack by Yang and Ding (2014), which includes grain size results of eight loess sections in the northern and western Chinese Loess Plateau (Fig. 1). Our Gulang grain size data show significant glacial-interglacial fluctuations similar to that the grain size stack. To validate the replication of millennial-scale events, we compared the filtered 9-1kyr components of two grain size data sets, and found that the rapid climatic oscillations between these two time series are well aligned over the last two glacial cycles (Fig. 2). In the revised version, we will incorporate these two data set to show the replication. Since only the younger 60 kyr of the Gulang section was dated by OSL method, the OSL dates will be added in the Gulang grain size curve.

2. The composite speleothem data appeared in Fig.2 are problematic. The data sourced from the two references (Wang et al, 2008, Cheng et al, 2009) unlikely produce this figure. I guess that the authors subjectively selected other cave data (for example, a set of the penultmate glacial data published in Cheng et al, Geology, 2006) to replace some intervals of the cited data in the last two climate cycles. Please give an explanation for this replacement.

Reply: We clarified how to generate the composite speleothem data in the revised manuscript. The δ18O time series over the last two glacial cycles are from Sanbao/Hulu caves (0-224kyr, Wang et al., 2008) and Sanbao cave (224-260 kyr, Cheng et al., 2009). As Wang et al did, we plotted Hulu δ18O 1.6‰ more negative as well than Sanbao cave values.

3. A total of 25 D/O events in the NGRIP ice records during the last glacial period are also seen in the Chinese speleothem records (Wang et al, 2008). However, I could not find additional 3 DO events (numbered from 26 to 28 in Fig.6) in the raw speleothem records. I suspect that the decomposing approach would produce illusive/noise signal such as the DO 26-28.

Reply: For comparison with rapid climate changes recorded in speleothem (Wang et al., 2008), we interpolate the raw grain size and the speleothem δ18O data at 0.2 kyr resolution; the high frequency components were decomposed using filtering approach. To confirm whether the data processing can produce noise signal, we also decomposed the raw data into orbital (>9 kyr) and millennial-scale (<9 kyr) components, and calculate the deviation of high-frequency signal relative to background series. We found that most millennial-scale events by Wang et al. (2008) for the last two glacial cycles are more than 1% deviation, which is about two times higher than the analytical error. Based on the 2% error of mean grain size measurement, we use the standard of 4% to pick the rapid climatic events documented in the Gulang loess profile. Note that the DO events from 26-28 can be detected robustly from both speleothem and loess records, implying that these three events are convincible to some extent.

4. The variances of 11 and 16% are too precise to be accepted due to more or less noise added to the climatic signal in the loess and speleothem records. The noise arises from either analytical errors or differences in amplitude of millennial-scale events between the same archives. For example, Fig. 2 shows many differences at millennial-scale changes from the data published in Nature (Wang et al, 2008).

Reply: We re-calculated the variances and uncertainties of millennial-scale signals for both Gulang MGS and speleothem δ18O records, which are 11.1±0.05 % and 15.1±0.05 %, respectively. We admit that the contributions of millennial components are not dominant in both records; however, they truly exist without noises since the variances cannot be changed by simply interpolate and filter the raw data. The validity of the millennial-scale fluctuations of Gulang MGS record is also supported by the

good correlation between original and filtered millennial component (Fig. 3) with similar amplitudes and numbers of evident events.

5. The author should give more detailed explanation for the tie-points in Fig.2. We know that the SPECMAP age model shows 3-5 thousand years younger than the speleothem records at the last three ice terminations.

Reply: In the revised manuscript, we use optically stimulated luminescence ages for the last 60kyr (see Sun et al., 2012). For the lower part, the Gulang MGS series is compared with benthic δ18O record (Lisiecki and Raymo, 2005)ïijŇas it is well accepted that the East Asian winter monsoon variability was dynamically dominated by changes in global ice volume over the last two glacial cycles, and 7 tie-points are selected by matching rapid changes of MGS and δ18O during the major climatic boundaries for the interval of 260-60 kyr. We will add more description on how to select the age controls in the revised version.

6. I wonder why Li et al have not described stratigraphy of the Gulang section (depth, loess-paleosol units). If published elsewhere, please cite it. It seems that parts of the data used in this manuscript have been already published in Catena (2011). However, I do not see the cited reference.

Reply: Grain size data of the upper 20 m were from a 20-m pit near Gulang, which has been published in Nature Geoscience (Sun et al., 2012), we did cite this reference. Grain size of the lower part spanning the last two glacial cycles was used for chronological reconstruction in another paper (which will be likely accepted for publication). We will clarify the source of Gulang grain size data and cite the new reference in the revision. However, in these two papers, multiscale variability of the MGS was not in-depth investigated. Unlike previous loess and speleothem papers, we first decompose multiscale variability recorded in these two proxies, in order to evaluate their relative contributions, similarity and discrepancies as well.

References Cheng, H., Edwards, R. L., Broecker, W. S., Denton, G. H., Kong, X., Wang, Y., Zhang, R., and Wang, X.: Ice age terminations, Science, 326, 248–252, 2009. Lisiecki, L. E. and Raymo, M. E.: A Pliocene-Pleistocene stack of 57 globally distributed benthic δ18O records, Paleoceanography, 20, PA1003, doi:10.1029/2004PA001071, 2005. Sun, Y., Clemens, S. C., Morrill, C., Lin, X.,Wang, X., and An, Z.: Influence of Atlantic meridional overturning circulation on the East Asian winter monsoon, Nat Geosci, 5, 46–49, 2012. Wang, Y., Cheng, H., Edwards, R. L., Kong, X., Shao, X., Chen, S., Wu, J., Jiang, X., Wang, X., and An, Z.: Millennial and orbital-scale changes in the East Asian monsoon over the past 224,000 years, Nature, 451, 1090–1093, 2008. Wu, G., Pan, B., Guan, Q., and Xia, D.: Terminations and their correlation with solar insolation in the Northern Hemisphere: a record from a loess section in Northwest China, Palaeogeogr. Palaeocl., Palaeoecol. 216, 267-277, 2005. Yang, S. and Ding, Z.: A 249 kyr stack of eight loess grain size records from northern China documenting millennial-scale climate variability, Geochem. Geophy. Geosy., 15, 798–814, 2014.

Interactive comment on Clim. Past Discuss., 10, 4623, 2014.

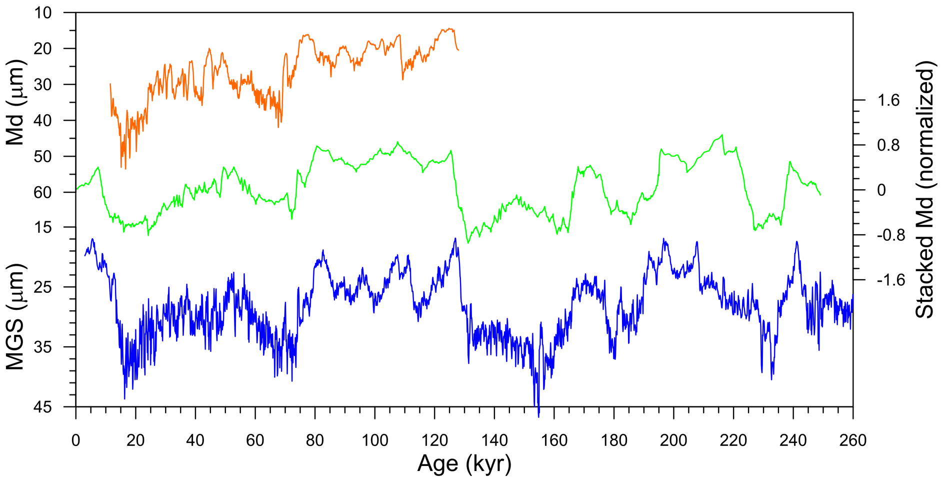

Fig. 1. Fig.1 Comparison of Gulang Mean grain size (MGS, blue) with Shagou median grain size (Md, orange, Wu et al., 2005), and normalized “CHILOMOS” Md (green, Yang and Ding, 2014).

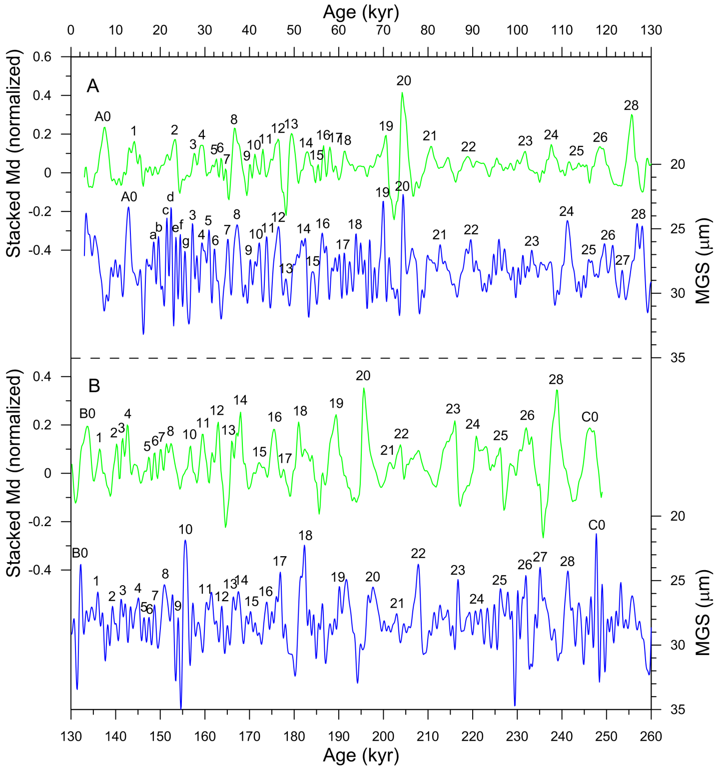

Fig. 2. Fig. 2 Comparison between millennial-scale (filtered 9-1 kyr) variations of Gulang MGS (blue) and the 249kyr grain size stack (green, Yang and Ding, 2014) over the last two glacial-interglacial cycles

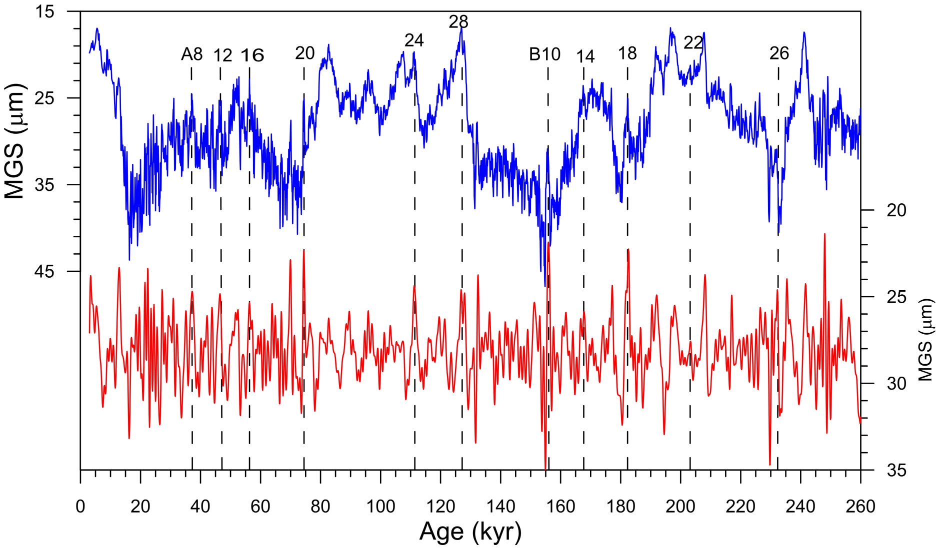

Fig. 3. Fig. 3 Comparison of millennial-scale component (red) with the raw data (blue) of Gulang MGS record. Dashed lines and numbers indicate some interstadials in the Chinese loess.