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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. The authors should confirm the results shown in Fig. 3, by applying at least another spectral technique not based on Fourier method. I suggest to use the Singular Spectrum Analysis (SSA, toolkit available online), which is well suited also for series affected by a high-noise level. SSA required equally-spaced data and therefore an interpolation is required.

Reply: We performed SSA on the loess grain size records, and found that the spectrum by Redfit and SSA are highly comparable (Fig. 1), confirming the reliability of our

spectral results. In the revised version, we will incorporate the spectral results derived from both REDFIT and SSA methods to confirm the dominant frequencies at orbital and millennial bands.

2. Regarding the reconstruction of the variability components (Fig. 4, 5 and 6), the choice of the boundaries of the frequency bands C1, C2, : : :, C5 is somewhat arbitrary and the shape of the components reconstructed in Fig. 4 can depend on this choice. The arbitrariness in the choice of frequency bands can be overcome by extracting the components using SSA. A Monte Carlo test (more specific in respect to that corresponding to the red curves of Fig.3) is associated with SSA. By applying it, discrimination among the many components identified as significant in the C4 and C5 bands, should be possible.

Reply: We agree that the choice of the boundaries of the frequency bands is not absolutely objective, but the widely accepted frequencies in paleocommunity were considered in decomposing the loess grain size series. We noticed many significant periods exist at millennial bands (Fig.1), we divided millennial signals into C4 (9-3 kyr) and C5 (3-1 kyr) components to possibly correspond, respectively, to the Heinrich (∼6 kyr) rhythm and the D-O cycles (∼1.5 kyr).

As the referee suggested, we applied SSA method to decompose our Gulang MGS data and found that the low-frequency signals on orbital scale are similar to those based on our division and spectral results (Fig. 2). However, more than 10 components at millennial bands were decomposed from the original data. We also used Empirical Mode Decomposition (EMD) to extract the "intrinsic mode functions" (IMF) of Gulang MGS data. Since the EMD method is based on the local characteristic time scale of the data, can avoid the arbitrariness in the choice of frequency band as well. Based on EMD results, 6 IMFs are obtained on the orbital-to-millennial scale with respective periodicity of ∼100 (IMF1), ∼41 (IMF2), ∼23 (IMF3), ∼15 (IMF4), ∼3-7 (IMF5), and ∼1-3 kyr (IMF6). IMF3 and IMF4 are combined together to be regarded as the precessional signal. Only two millennial components were decomposed and corresponded well to rhythms of Heinrich and D-O events, respectively.

We compared our results with decomposed components by both of SSA and EMD on orbital scale; but only compared our results with IMFs on millennial scale as too many high-frequency signals are decomposed by SSA. As shown in Fig. 2, the SSA and EMD components are comparable to those based on our divisions, both in terms of variability and dominant frequencies (Fig.2), indicating that our choice is reasonable. In the revised manuscript, we will adopt the EMD method to further demonstrate the multi-scale features of East Asian monsoon variability.

3. It is not clear if the variances of the components in Fig. 4 are a percentage of the two raw series total variance. If the case, the corresponding components of the two series may contain different noise levels, thus distorting the comparison.

Reply: Yes, the variances are calculated on the raw time series. Noises of these two records were from the analytical errors, which are about 2% and 0.1% for the loess mean grain size and speleothem δ18O, respectively. However, the variances of orbital-to-millennial components (>10%) are significantly higher than the analytical errors, and thus can be used for proxy-to-proxy comparison and further addressing different sensitivity of loess and speleothem proxies to orbital and glacial forcings.

4. Please clarify if the loess measurements presented here are totally or partially new.

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.

5. I suggest to put in more evidence the new results presented in this work in respect to those previously obtained. I suggest to add a section briefly explaining the spectral methods used, the Monte Carlo procedure used to calculate the red curves in Fig. 3 and the applied filtering approach.

Reply: Thank you for these suggestions. We aware that East Asian monsoon variability and dynamics indeed have been extensively studied at various timescales using loess grain size and speleothem δ18O. Unlike previous works, the main objectives of our studies are twofold. First, we tried to evaluate the relative contributions of orbital and millennial signals in these two widely accepted monsoon proxies using spectral analysis and decomposing approaches. Second, we want to emphasize the glacial-interglacial discrepancy and millennial similarity between loess and speleothem records by comparison of the decomposed components of these two proxies. Our results confirmed that the extracted millennial-scale climatic events are almost identical in these two archives, which is very important of further evaluating the coupling between millennial-scale winter and summer monsoon variability. We will clearly clarify our motivations in the revision. In addition, we'll apply different spectral (SSA) and decomposing (EMD) methods with detailed descriptions in the revised manuscript to confirm the spectral and decomposing results.

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

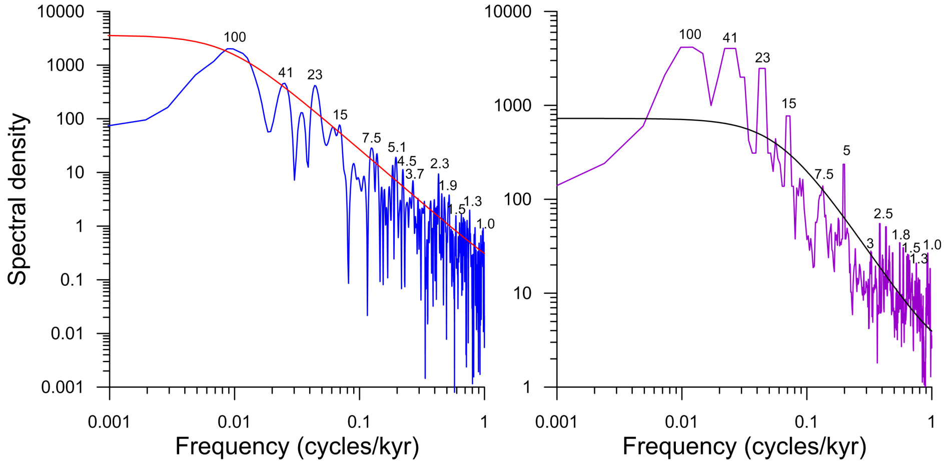

Fig. 1. Spectral results of Gulang MGS record by applying Redfit (left) and SSA (red) with 80% (red) and 90% (black) confidence levels, respectively. The black numbers are identified periods in kyr.

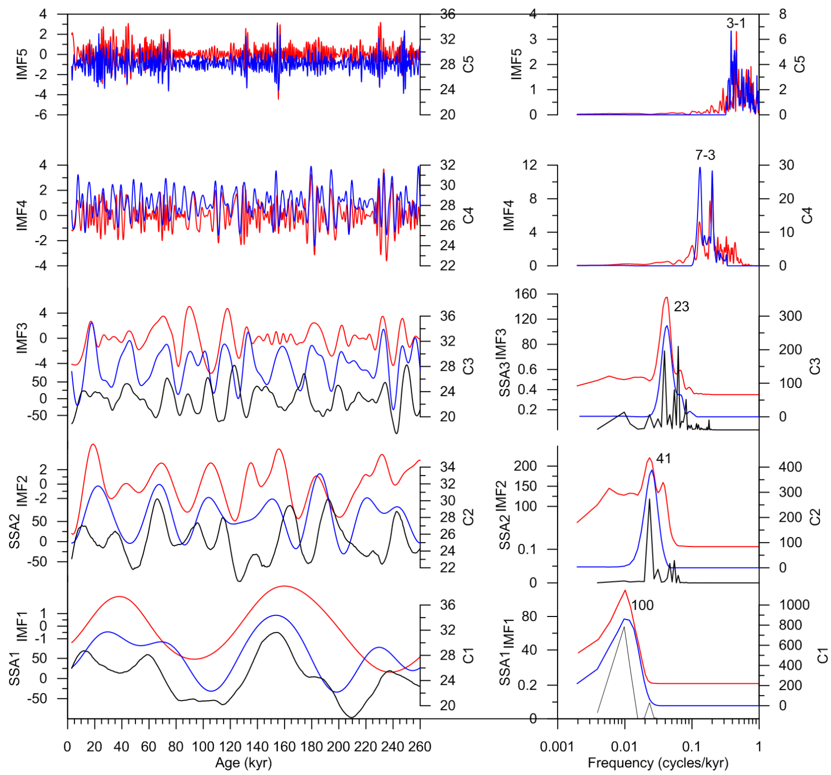

Fig. 2. Variations of decomposed components (left) and their corresponding spectral results (right) using SSA (black), EMD (red), and filtering (blue) method. Black numbers indicate the identified periods.