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Climate of the Past Discussions

# *Interactive comment on* "Distinct responses of East Asian summer and winter monsoons to orbital forcing" *by* Z. Shi et al.

**Z. Shi et al.**

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We thank Dr. A. L. Berger and the anonymous referee for their constructive comments. A detailed response to the issues raised by anonymous referee #1 is given below.

Zhengguo Shi

On behalf of all authors

Comments: This paper explores the responses of East Asian summer and winter monsoons to the orbital forcing. Although all the monsoon proxies were already published and the model outputs were from Kutzbach et al (2007), the paper brought some new insights about the mechanisms of monsoon changes, particularly for the East Asian winter monsoon. Both geological records and model outputs likely support a predomi-



nant role of the obliquity forcing (40 ka period) on the East Asian winter monsoon. The authors further propose that the obliquity forcing exerts a more significant effect on the evolution of the East Asian winter monsoon than 'expected before', probably through controlling the meridional insolation difference.

Re: Thanks for the referee's comments.

I detected a few points that I feel deserve more supports and explanation.

It sounds necessary to add a paragraph in the Introduction Section on what were 'expected before' about the obliquity signals in the winter monsoon evolution, as the authors stated at the end of the abstract (p 944 line 13).

Re: As far as we know, previous studies on Asian monsoon (mostly on summer monsoon) basically concentrate on the precession scale (e.g., the phase differences between monsoon response and insolation). The winter monsoon proxies are always linked to the changes of global ice sheets, at least for the grain-sizes in the Chinese loess records. Although the importance of obliquity is getting more attention in recent years (Tuenter et al., 2005; Wyrwoll et al., 2007), there are still very few people who have put their focus on the relative importance of precession and obliquity in Asian monsoon evolution. In common opinions, precession should be of greater importance in the low-latitude climate systems due to its dominance on daily insolation. That is why our study is proposing a significant role of obliquity (not expected before) in the winter monsoon. Following the referee's suggestion, we add some statements in the introduction in order to clarify our goal of this study (P945, L18).

"Owing to its dominant role in the daily insolation variation (Berger, 1978; Berger, 1988), precession has been widely emphasized as the key factor in the monsoon evolution (Clemens et al. 2003; Wang et al., 2008) and "less-important" obliquity is often neglected. However, obliquity can control the total irradiation over a period of time during the year (Berger et al., 2010) and large-scale meridional gradient of insolation in the summer hemisphere (Tricot and Berger, 1988). Thus, how the astronomical parameters affect the EAM, especially the relative importance on these two bands, still needs to be clarified."

The authors consider that the used stalagmite delta 18O (as a proxy of summer monsoon) varied synchronously with precession, and hence, is supportive to the hypothesis of Kutzbach et al (1981) that the subtropical summer monsoon systems respond directly to precession-dominated changes in NH insolation. However, a recent work (Paleoceanography, 25, PA4207, doi:10.1029/2010PA001926, 2010) stated for a phase difference of several thousand years between stalagmite d18O and the precession. The authors should conduct a phase analysis and provide a figure for clarifying this point, because it seems to be crucial point for the statements about the summer monsoon (e.g. the statement on p950 lines 14-15).

Re: Yes, the referee is right. The used stalagmite delta 18O has a phase lag of about 45 degree (correspondingly 2.9kyr) with the precession minima (NH June insolation). However, this record can still be considered as a direct evidence of Kutzbach's hypothesis, as said in the original paper (Wang et al., 2008). Actually, the "zero phase" is merely an approximate and one can not expect the monsoon proxies are exactly in phase with NH June insolation, primarily due to the thermal inertia and various processes/feedbacks. Even in the Paleoceanography 2010 paper, the stalagmite records can also be considered as supportive for the NH-controlled Asian monsoon. And that is why Clemens et al. argued that the stalagmite delta 18O can not be a pure proxy of monsoon precipitation. More importantly, Kutzbach's and Clemens's hypothesis are long-term existing debate, one we do not actually discuss in our study. Our focus is merely the different dominant cycles (not the phase difference) in the summer and winter monsoons. Thus, we do not add a phase analysis in the new manuscript (the result of Clemens et al., 2010 is valid and we needn't repeat), however, we have revised the discussions (P948, L8-12) in order to avoid the readers' misunderstanding.

"During the past 224ka, the stalagmite delta18O values, considered as the proxy of the summer monsoonal precipitation, change nearly synchronously with precession,



revealing an obvious 20-ka periodicity (Fig.2a). Although a phase lag of 2.9ka between precession and this monsoon proxy is proposed (Clemens et al., 2010), the approximate in-phase relation still supports the hypothesis that the subtropical summer monsoon systems respond directly to precession-dominated changes in NH insolation and the phase lag might be primarily resulted from the thermal inertia of climate system"

The paper suggests that a 'large-scale cross-equatorial circulation, which is resulted from the inter-hemisphere meridional insolation contrast, also play an important role on the Asian winter monsoon' besides the local insolation forcing. This is the most significant statement of the paper, but remains speculative. This large-scale crossequatorial circulation should be observable in the used model outputs. The authors should add a figure of wind vectors to show the circulation. The model could also analyze the sensitivity of this circulation to the inter-hemisphere meridional insolation contrast.

Re: The varied meridional circulation intensity responded to the Obliquity forcing can be seen in the simulation results. Compared to the TL case, the TH-composite omega field indicates that the global meridional circulation is intensified due to the increased thermal contrast and an enhanced downward current is observed over the Siberian region (Fig. 1). We add this figure in the revised manuscript (P952, L6) to support our viewpoint that obliquity controls the meridional circulation and thus Siberian High.

"In the modeling results, we can also observe a significant response of meridional circulation in the obliquity composites (Fig. 9). In the TH composite, the cross-equatorial circulation with a downward airstream over Siberian region is intensified than the TL composite, supporting that our explanations should be reasonable."

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Interactive comment on Clim. Past Discuss., 7, 943, 2011.

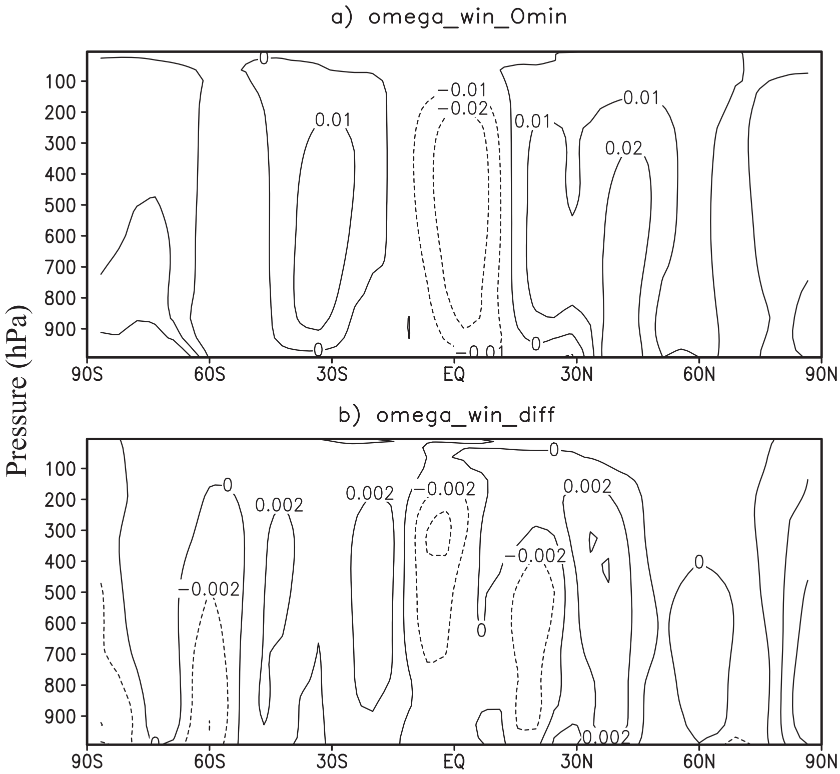


**Fig. 1.** The TL composite of vertical velocity (Pa/s) in boreal winter averaged for 80-150E (a) and the difference between TH and TL (b).