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Climate of the Past Discussions

Interactive comment on "Relative impact of insolation and Warm Pool surface temperature on the East Asia Summer Monsoon during the MIS-13 interglacial" *by* Q. Z. Yin et al.

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We thank reviewer 1 for his/her constructive and interesting comments, and give our answers hereunder.

Reviewer Comment 1: Most of Asia summer monsoon in modern climate are driven by southern Indian ocean latent heat transport and the moisture source of Asian monsoon precipitation is from the indian Ocean. While this study attempted to prescribe more warming in WPWP surface and try to find a linkage between stronger monsoon and WPWP warming, the lack of modified Indian surface ocean needs more explanation. It's worthy to mention that if any modified Indian ocean SST may change significantly

the results of modeling output.

Author reply 1:

In our experiment of enhanced SST, SST is actually increased over the Indo-Pacific Warm Pool (the so called Great Warm Pool) region, a region extending from the eastern equatorial Indian Ocean to the western tropical Pacific. For clarity, we have added in the revised manuscript a figure (see Figure 1 attached) showing the region of this Indo-Pacific Warm Pool. We also explained more in Section 2 by telling " . . ., the modified SST is obtained by adding 1oC to the reference SST from March to July at each grid point of the Indo-Pacific Warm Pool region (where SST$\geq$28oC) which extends from the eastern equatorial Indian Ocean to the western tropical Pacific (Figure 1)."

Moreover, we added in Section 3.2 some discussion related to the impact of Indian Ocean surface temperature:

"Many studies have used modern observational data or proxy reconstructions to discuss the relationship between SST and the precipitation in China, but the interpretations based on data are much more diverse than based on modelling results. Zhao et al (2000) found that increased SST in the western Pacific Warm Pool corresponds to less rainfall in northern China and more rainfall in southern China. Zhang et al (2009) studied the correlation between the western Pacific warm pool SST and the East China precipitation during the past 360 years. They found that this correlation has strong regional diversity, but it is only over the Yellow River and Huaihe River basin in northern China that this correlation (negative) is significant. Yang and Lau (2004) found that the interannual variation of the summer precipitation over central eastern China and over southern coastal China is correlated with a north-south dipole mode of SST anomalies over the western North Pacific, the tropical Indian Ocean and the warm pool: when SSTs are abnormally warm over the warm pool and northern Indian Ocean and are abnormally cold over the western North Pacific, summer precipitation tends to be heavier than usual in central eastern China but to be less in southern coastal China. Lee et al

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(2008) found that the north EASM precipitation is negatively correlated with the tropical western Pacific SST and is positively correlated to the tropical Indian Ocean SST, and that the south EASM precipitation is positively correlated with the western North Pacific SST but has no obvious correlation with the Indian Ocean SST. However, also based on observational data, Saji and Yamagata (2003) found that the precipitation over India and southern China is enhanced during the positive IOD (Indian Ocean Dipole) event, an event which is characterized by anomalous cooling in the eastern equatorial Indian Ocean and anomalous warming in the western equatorial Indian Ocean.

The different findings from these studies might be related to different data sets or different analytical techniques which have been used. Nevertheless, these studies tend to show that the summer precipitation in northern China is negatively correlated with the SST in the western Pacific Warm Pool, which is in agreement with our model results. The conclusions are more controversial for southern China. Among them, Zhao et al (2000) found a positive correlation between southern China precipitation and the SST of western Pacific Warm Pool. This, at a first glance, seems to be contrary to our results, but actually it is not because it is not appropriate to compare the finding of Zhao et al (2000) with our results. In our experiment the SST is indeed enhanced not only over the western Pacific warm pool but also over the Indian Ocean Warm Pool, a region extending from the tropical western Pacific to the eastern equatorial Indian Ocean (Fig.1). It means that in our simulation the precipitation in southern China responds to changes in SST not only in the western Pacific Warm Pool but also in the Indian Ocean Warm Pool. In our experiment, due to the SST increase in the eastern equatorial Indian Ocean, a negative "IOD-like" event is created. Presumably opposite to the positive IOD situation as in Saji and Yamagata (2003), a negative IOD might be associated with reduced precipitation over India and southern China, which is indeed the case in our simulation (Figure 4b)."

Reviewer Comment 2: Evidence exists to suggest El Nino like condition in the equatorial Pacific coincident with MIS 13 warm and humid in the Euro-Asia (Mohtadi et al.,

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2006), which implies a more extensive warming extending eastward to the central Pacific during MIS 13. More discussion is needed on what impacts maybe generated if the models incorporate more widespread warming in the equatorial Pacific;

Author reply 2:

ENSO indeed plays an important role on the East Asian monsoon and should not be forgotten in explaining the paleo-monsoon dynamics. However, due to lack of robust oceanic reconstruction during the MIS-13 interglacial, we did not have a justification to increase the SST in a more widespread region extending up to the central Pacific. Mohtadi et al (2006) indeed mentioned El Nino-like pattern during MIS-13, but as they clearly claimed, this is only a hypothesis which is not necessarily true. Based on the simulations with two AOGCMs, Karami et al (2014,accepted in Climate Dynamics) demonstrated that a La Niña-like mean climatic state exists during MIS-13. It is worth to mention that both models simulate a larger SST gradient between the cold tongue and the western tropical Pacific in MIS-13 but a decreased SST difference between the easternmost and western tropical Pacific Ocean. This is important to consider when interpreting proxy SST records from the tropical Pacific.

Following the suggestion of Reviewer 1, we have added the following lines in the last paragraph of conclusion:

"As the insolation of MIS-13 has not been found exceptional as compared to other interglacials (Yin and Berger, 2012), we need to seek for other explanations for the exceptional EASM in northern China. This requires a better constraint of the spatio-temporal characteristics of the MIS-13 climate from geological records. The sea surface conditions over the Indian-Pacific Oceans must be paid more attention because of their importance on the EASM and also because of many reconstruction uncertainties over these regions. For example, Mohtadi et al (2006) hypothesized El Niño–like conditions during MIS-13, conditions which have been found in modern time associated with less summer rainfall in both southern and northern parts of China, and more

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summer rainfall in central China, around the lower reaches of the Yangtze River and the Huaihe River valleys (Zhang et al., 1999). By contrast, climate simulations show that MIS-13 was subject to a La Niña-like mean climatic state (Karami et al., 2014). More SST reconstructions from the tropical Pacific would help to understand better the ENSO situation during MIS-13 and its possible role on the EASM."

Reviewer Comment 3: The proposed change of Northern Hemisphere ice sheet extent during MIS 13 is intriguing and may be one of the reasons in interpreting relatively warm winter climate in northern Asia. I suggest that the authors present existing evidence (for example, Chinese loess) that clearly indicated relatively weak winter monsoon in northern China to increase the readability of this paper.

Author reply 3:

Thanks for this suggestion. We have added some lines in the conclusion to remind this winter monsoon issue:

". . ..In the mean time, the loess grain size data from northern China indicate that MIS-13 had the weakest winter monsoon among the last nine interglacials (Guo et al., 2009). Therefore, the impact of a smaller Greenland ice sheet might be investigated in the future to see if it helps to explain the exceptional EASM precipitation in northern China as well as the weakened winter monsoon during MIS-13."

As the focus of this manuscript is on the impact of SST on the EASM, a detailed investigation and an extensive discussion about the impact of a reduced Greenland ice sheet on the East Asian winter climate will be made in the future.

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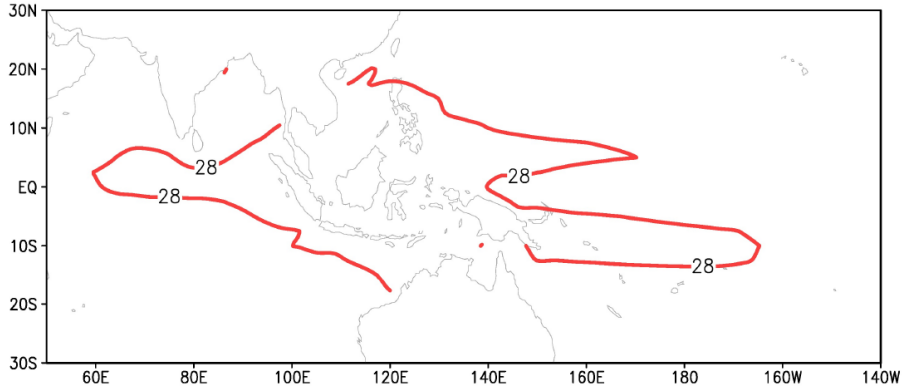

Figure 1. Area of the Indo-Pacific Warm Pool surrounded by 28˚C isotherm line.
Annual mean SST values are provided by the HadCM3 simulation for MIS-13 (Muri et al., 2013).

Fig. 1.

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