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Interactive Comment

Interactive comment on "Influence of orbital forcing on the seasonality and regionality of the Asian Summer monsoon precipitation" *by* M. E. Hori et al.

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1 On the role of the orbital parameters in the changes in insolation distribution at 115 and 125 ka BP.

In their paper, Hori et al. (2008) state that: "The absolute value of cooling (heating) anomaly in the 115 kya (125 kya) during boreal summer is mostly a result of smaller (larger) obliquity angle of the earth's rotation axis. On the other hand, the slant of the anomaly extending from the boreal summer to autumn corresponds to a shift in seasonality of the incoming radiation and is a result of the precession of the earth?s rotating axis". In this comment, I wanted to show that the obliquity does not have an as strong role as claimed by the authors. I will show the importance of each of the orbital parameters in the changes in insolation distribution at 115 and 125 ka BP.

Insolation value at a given latitude and time in the year is relatively easy to compute. Indeed, it is mostly a function of three orbital parameters, i.e. eccentricity (e), obliquity (ε) and climatic precession ($e \sin \varpi$). However the interpretation of the changes in insolation through time is not so easy. Here, three periods are taken into account, i.e. present-day, 115 ka BP and 125 ka BP. The comparison of seasonal and latitudinal insolation distribution can then serve as the basis for the discussion of changes in Asian summer monsoon between these periods. As preliminary remark, let me remind that there are two major ways in identifying the time in the year at which the insolation is computed (Berger, 1978). Indeed, time in the year can be identified according to the 'traditional' calendar or according to an astronomical calendar, which gives the angular position of the Earth on its orbit around the Sun (true longitude). As clearly stated by Joussaume and Braconnot (1997), using one or the other can yields 'artificial' leads and lags. Although not clearly stated, Hori et al (2008) used the calendar date in their paper. I will do the same in this comment. The orbital features of the three periods under consideration are given in Table 1 in Loutre (2008) (Berger and Loutre, 1991).

The deviation from present-day values of the insolation computed for these selected periods is displayed in Figure 1 in Loutre (2008). The solar constant is taken to be 1365 Wm^{-2}. The vernal equinox, i.e. the origin of time, is supposed to be March 21 for the three periods. Figure 1 in Loutre (2008) corresponds to Fig. 1 of Hori et al (2008).

Some features were pointed out in Hori et al (2008) paper. There is a cooling anomaly at 115 ka BP during boreal summer. This anomaly extends to a negative anomaly in the Southern Hemisphere during the austral spring. On the other hand, a reverse anomaly (i.e. positive anomaly during boreal summer and austral spring) is displayed at 125 ka BP (Fig. 1 in Hori et al (2008) and Figure 1 in Loutre (2008)). Obviously the changes in orbital parameters are responsible for this anomaly. However, it is not easy to disentangle properly the contribution of each of them. In order to do so, the values

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of the orbital parameter will be changed one at a time from their present-day value to their past value (either 115 or 125 ka BP). The three sensitivity experiments are described in Table 1 in Loutre (2008). In XOB1, eccentricity and longitude of perihelion are kept to their present-day values while only the obliquity is changed to its value at 115 ka BP. In PRE2, eccentricity and obliquity are kept to their present-day values while only the longitude of perihelion is changed to its value at 125 ka BP. At last, in ECC1, longitude of perihelion and obliquity are kept to their present-day values while only the eccentricity is changed to its value at 115 ka BP.

A decrease in the obliquity (e.g. 115 ka BP compared to present) yields a decrease in local summer insolation at all latitudes and an increase in local winter insolation at all latitudes. However, the amplitude of the insolation anomalies related to obliquity alone are rather small, i.e. less than 30 Wm^{-2} in the high latitudes when only the obliquity decreases from its present-day values to its value at 115 ka BP (Figure 2 in Loutre (2008) - left). It is even less at 125 ka BP. Therefore, the obliquity alone cannot account for the negative anomaly in the insolation at 115 ka BP. Moreover, in the Southern Hemisphere the negative anomaly at 115 ka BP is the largest in early spring (October) while the (much smaller) anomaly related to obliquity change alone is maximum at the summer solstice (December).

The present-day precession corresponds to perihelion in early January (boreal winter). It is almost the same situation at 115 ka BP while at 125 ka BP perihelion occurs in early July, as acknowledged by Hori et al. (2008). This latest situation means that the Earth is closer to the Sun in July at 125 ka BP than at present at all latitudes; it induces a positive anomaly in the insolation, for all latitudes from March to September. This can clearly be seen on Figure 2 in Loutre (2008) (right), where only climatic precession is changed from the present-day value. A similar anomaly, although with larger amplitude is also displayed on the deviation from present-day value of the insolation distribution at 125 ka BP (Figure 1 in Loutre (2008) - right).

The last orbital parameter to take into account for explaining the changes in insolation

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distribution is the eccentricity. The eccentricity is much larger at both 115 and 125 ka BP than at present. Moreover, longitude of perihelion has similar value at 115 ka BP and at present, which induces a change in climatic precession. Indeed climatic precession is defined as eccentricity times the sine of longitude of perihelion. Therefore, the increase in eccentricity strongly reinforces the effect of the climatic precession on the Earth-Sun distance. Earth is further away from the Sun in boreal summer at 115 ka BP than at present (for all latitude) and it is closer in boreal winter (for all latitudes). Consequently, there is a negative anomaly in March to September for almost all latitudes at 115 ka BP. In other words, it is the increased eccentricity that explains most of the anomaly pattern in insolation at 115 ka BP. Moreover, the large eccentricity at 125 ka BP strengthens the amplitude of the anomaly due to the change in the longitude of perihelion.

As a conclusion, the anomaly pattern of insolation at 115 ka BP can be explained mostly by the change in eccentricity. Climatic precession has the largest contribution in the change in insolation distribution at 125 ka BP compared to the present.

Hori et al (2008) mentioned that the insolation anomaly pattern is showing a slanted behaviour. Figure 4 in Loutre (2008) (bottom) shows that this behaviour is related to the use of calendar date. Indeed the only difference between on the one hand Figure 4 and, on the other hand, Figure 1, Figure 2 and Figure 3 in Loutre (2008) is the use of an astronomical calendar in the first series of figures.

2 About the seasonality in the tropics

In their paper, Hori et al. (2008) state that: “There is also a notable change in seasonality of incoming radiation in the tropical area. During the 115 kya period, the tropics experiences an early anomalous heating in excess of 30 Wm^{-2}, which rapidly diminishes towards summer and autumn. The situation is reversed in the 125 kya period where the tropical region experiences a decreased solar radiation of over 50 Wm^{-2} in the boreal winter and during the following spring, which rapidly changes to a positive

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anomaly in the summer. Such change in seasonality exists mostly in the tropical area, with the mid-latitudes sharing only a part of this anomaly”. The question of seasonality in the region between the tropics is not an easy one and I will try to explain why I partly disagree with the statement by Hori et al (2008). Indeed, as pointed out by Berger et al. (2006) and Ashkenazy and Gildor (2008), each latitude of this region experiences the passage of the Sun overhead twice a year, in contrast with the extra-tropical latitudes, which exhibits a simple maximum of insolation each year. This feature is the basis for the seasonality and its changes described in Hori et al (2008). The authors pointed out drastic changes in seasonality between 115 and 125 ka BP. It is true but subtler when looking at each latitude individually instead of zonal averages. At 115 ka BP (Figure 5 in Loutre (2008) - left), the equator experiences two maxima of insolation; the largest one occurs end of February while the other one occurs in November. The minimum value takes place during boreal summer. For the latitudes north of the equator, the absolute maximum is displayed around the March equinox and the absolute minimum is moving from the June solstice to December solstice as we travel from the equator to the tropic of Cancer. In the Southern Hemisphere, tropical region, the minimum of insolation is reached around the June Solstice for all latitudes, and the maximum is reached in the first months in the year. This is much more complex than the behaviour described in Hori et al (2008). Moreover the statement provided by Hori et al (2008) may be misleading. Indeed "the maximum in solar radiation occurs in the early spring" must be read as "boreal spring" and "the solar radiation takes a minimum value in the boreal summer" is only valid for the Southern Hemisphere. The strongly contrasted seasonality in 125 ka BP (Hori et al, 2008) displays a complex behaviour when looking at each latitude of the tropical region. Like at 115 ka BP, the equator experiences two maxima of insolation; however, at 125 ka BP (Figure 5 in Loutre (2008) - right), the largest one occurs end of August while the other one occurs end of April. The minimum value takes place during boreal winter. Moving from the equator to the tropic of Capricorn, the absolute minimum turns out around the June equinox, and the absolute maximum, between August and October, according to the latitude. In the

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Northern Hemisphere, going from the equator to the north, the maximum of insolation moves from end of August to July, while the minimum in the annual cycle remains in December.

To conclude, let me quote Ashkenazy and Gildor (2008): "The Sun crosses the equator twice a year, at the autumnal and vernal equinoxes. Thus, during these dates the equatorial insolation is expected to be maximal, ... Owing to changes in the Earth?s precession, sometimes the Earth is closest to the Sun at the vernal equinox, leading to annual maximum equatorial insolation at that time, and sometimes at the autumnal equinox, leading to annual maximum equatorial insolation then."

References

Ashkenazy, Y. and Gildor, H.: Timing and significance of maximum and minimum equatorial insolation. Paleoceanography, 23, pa1206, doi:10.1029/2007pa001436, 2008.

Berger, A.: Long-term variations of daily insolation and Quaternary Climatic Changes. Journal of Atmospheric Science, 35(12), 2362-2367, 1978.

Berger, A. and Loutre, M.F.: Insolation values for the climate of the last 10 million years. Quaternary Science Reviews, 10, 297-317, 1991.

Berger, A., Loutre, M.F. and Mélice, J.-L.: Equatorial insolation: from precession harmonics to eccentricity frequencies. Clim. Past, 2, 131?136, 2006.

Hori, M. E., Abe, M., Yasunari, T. and Kitoh, A.: Influence of orbital forcing on the seasonality and regionality of the Asian Summer monsoon precipitation. Clim. Past Discuss., 4, 719?740, 2008.

Joussaume, S and Braconnot, P.: Sensitivity of paleoclimate simulation results to season definitions Journal of Geophysical Research (atmospheres), 102(D2), 1943-1956, 1997.

Loutre, M.F.: Some features of the insolation at 115 and 125 ka BP, www.climate.be/231766, 2008.

Interactive comment on Clim. Past Discuss., 4, 719, 2008.

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4, S265–S271, 2008

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