Possible role of the snow/ice covered Tibetan plateau on the ice- age cycles

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Although the role of orbital forcing on glacial cycles has been widely recognized, the issue of how the insolation cycle triggers glaciation in the northern hemisphere is still under much debate. Most theories are based on the reasoning that reduced solar insolation during the northern hemisphere summer preserves snow or ice over the northern Hudson Bay area into the next season, thus facilitating the accumulation of large snow mass over an extended period of time. The emergence of continental ice-sheets is suspected to accompany a large anticyclone over the ice-sheet and a bifurcation of the jet-stream.

On the other hand, the Tibetan plateau, which is believed to have elevated around 8 million years ago has a strong effect on the climate system, including the onset of the Asian summer monsoon and intensification of the Asian winter monsoon, along with increased aridity in northern China. It is also suggested that the intensification of ice-age cycle around 3.6-2.5 million years ago coincides with the uplift of the Tibetan plateau. Because of its large area of high-latitude mountains located in the mid-latitudes, it is hypothesized that the change in the surface condition over the plateau has a profound effect towards the northern hemisphere climate. However, until now the role of the Tibetan plateau under different orbital parameters and surface conditions has not been addressed fully.

Here, we present an ancillary view of the role of Tibetan plateau under the orbital forcing using a coupled atmosphere-ocean general circulation model (AOGCM) MRI-CGCM2.3.2 developed by the Meteorological Research Institute. We conduct two types of model simulation, with the orbital parameter set at 115 kya b.p. and 125 kya b.p. where the summer insolation over the northern hemisphere was at its minimum, or maximum respectively. The greenhouse gas (GHG) concentration was fixed at pre-industrial level for ease of comparison. A large cooling of 5-10 degrees celcius in the atmospheric surface temperature appears over the Eurasian and northern American continent. Enhanced precipitation along the storm track over north Pacific and north Atlantic is also visible, and a southern shift in the the climatological snow line is located in the northern Hudson Bay. To clarify the role of the Tibetan plateau, we conduct another set of simulation for each orbital parameters with the tibetan pleateau completely covered by snow/ice. The model result shows that for both orbital parameters, the existance of large ice-mass on the Tibetan plateau weakens the Asian monsoon substantially, and the temperature over the mid to high latitudes is cooled by 2-3 degrees celcius. Additional precipitation was visible along the major storm tracks which may have enhanced the formation of continental ice-sheets. Another implication is that through enhanced accumulation of snow and/or fresh water supply over the north Atlantic, the formation of North Atlantic Deep Water circulation may have weakened substantially.