

# **Why and How did the Middle Pleistocene Transition occurred?**

## **~Modelling challenge of the ice sheet change in both hemispheres**

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Wax and Wane of large Northern Hemisphere ice sheet occurred in the past few million years, characterized by a transition from a period of 40 thousand years cycle with small amplitude of ice sheet change to 100 thousand year cycle with a large amplitude, known as the Middle Pleistocene transition. Although the characteristics of the glacial cycle is well observed, the mechanism what determines the occurrence of 100ka/40ka cycle and what controls the terminations are still under debate. Here we show the pattern of the growth and retreat of the ice sheets during a glacial cycle follows the hysteresis (multiple steady states) structure of North American ice sheet versus insolation by modelling the three dimensional ice sheet together with a climate model (MIROC). The 100 ka termination is punctuated by Northern American ice sheet responding basically to the precession cycle and summer insolation through its delayed bedrock depression and the large scale calving. Terminations occur when the summer insolation increases after a minimum eccentricity even under constant CO<sub>2</sub> level. Obliquity modifies the role of precession and becomes important for a glacial cycle especially when the eccentricity is small. The North American ice sheet is slightly more favorable for faster growth than Eurasian ice sheet when the ice sheet expands over Labrador and Hudson Bay, where is relatively cool in summer. It is As a result, the North American ice sheet can have affected the hemispheric climate and punctuated the ice sheet change in Eurasia and in Antarctica through CO<sub>2</sub> and sea level change. Furthur we show that a cooling due to, for example, the draw down of long term CO<sub>2</sub> level of 20ppm or so at most from 240ppm to 220ppm is enough for a switch from 40 ka cycle response to 100 ka cycle response of Northern Hemisphere ice sheet. If MPT ocured with a change in some kind of forcing equivalent to this 20 ppm CO<sub>2</sub> change, this means the system at this time is very sensitive to small change in external forcing. In the talk, we discuss the furthur influence of MPT on Antarctica as well as the modeling problems of Antarctica ice sheet.