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MIS 7 and MIS 5 glacial inceptions: investigating the asynchronous build-up of Laurentide and Eurasian ice sheets

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During the last glacial cycle, the final volume and extent of the Laurentide ice sheet was larger than over Eurasia. According to ICE-5G multi-proxy and methods reconstruction (Peltier, 2004), the Laurentide ($\sim$ 74 m Sea Level Equivalent, SLE hereafter) was $\sim$ 5 times larger than its Eurasian counterpart ($\sim$ 17 m SLE. The final eustatic sea level drop was $\sim$ -130 m) while a more recent study based on marine δ18O isotope suggests a smaller difference (Bintanja, 2008). On the contrary, during the penultimate glacial cycle ($\sim$245 - 126 kiloyears BP, kyrs BP), the Eurasian ice sheet reached its maximum Quaternary extent (Svendsen et al. 2004). Its volume is estimated to be $\sim$ 60 m SLE based on numerical reconstructions (Lambeck, 2006; Peyaud 2006, Colleoni et al., 2009) implying a smaller ice volume over North America to keep consistent with the eustatic sea level drop of this period ($\sim$ -128 m, Waelbroeck et al. 2002).

The fact that one of those two ice sheets is systematically larger than the other one at the peak glacial of the cycles implies: 1- a substantial amount of time to built it, larger than for the smaller one, 2- an asynchronous built-up of the ice sheets during the cycle. The notion of asynchronous build-ups over North America and Eurasia is supported by recent model estimates of North American and Eurasian ice volume evolution over the last three million years (e.g. Bintanja, 2008). It suggests that a shift in the mean ice volume distribution over the Northern Hemisphere occurred during the penultimate glacial cycle. It also suggests that the Laurentide ice sheet was mostly smaller than the Eurasian one during the older glacial cycles. Indeed, the absence of glacial landscape traces from older glacial cycles in North America suggests that the Laurentide ice sheet reached its largest Quaternary extent during the Last Glacial Maximum, destroying the previous traces of ice dynamics.

What could have caused this change in ice distribution over the Northern Hemisphere? A recent study modelling the last glacial inception ($\sim$115 kyrs) suggests that the growth of the Eurasian ice sheet was delayed by persisting high oceanic heat transport into the high latitudes regions (Born et al., 2010). This supports the idea that the build-up of the Laurentide and the Eurasian ice sheets was asynchronous from the very beginning of the cycle. In this work, we use the CESM climate model (in its fully coupled version) and the GRISLI ice sheet model to simulate the climate and ice distribution of the last two glacial inceptions, MIS 5 ($\sim$ 125 - 115 kyrs BP) and MIS 7 ($\sim$ 236 - 229 kyrs BP). Pseudo transient simulations only accounting for changes in orbitals and greenhouse gas are performed over the periods defined above (vegetation and aeolian dusts are prescribed as their predindustrial distribution). Outputs are then analysed to investigate whether the external forcing alone could be responsible for different ice distributions.