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Does MIS-13 originate from Northern Hemisphere or from Southern Hemisphere summer at perihelion?

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The deep-sea records show that MIS-13 is among the most glaciated interglacials and therefore most probably among the coolest ones over the last one million years. The most important interstadial of MIS-13 is MIS-13.1 with the δ18O peak located in SPECMAP at 501 ka BP and in LR04 at 491 ka BP. Assuming a lag of a few thousands of years, the hypothesis can be tested that the astronomical forcings at 506 ka BP and at 495 ka BP are responsible for the climate at 501 ka BP and at 491 ka BP, respectively. At 506 ka BP, Northern Hemisphere (NH) summer occurs at perihelion, whereas at 495 ka BP, it occurs at aphelion or equivalently Southern Hemisphere summer occurs at perihelion. It happens therefore that the astronomical configuration 495 ka ago does not correspond to the traditional NH Milankovitch hypothesis for which it would lead to a cold climate rather than to a warm one. To try discriminating between the two dates, an Earth system model of intermediate (LOVECLIM) is used for analysing the climate response to the astronomical forcing at 506 ka BP and 495 ka BP through both snapshot and transient simulations.

Snapshot simulations using only the astronomical forcing show that the Earth is globally warmer at 506 than at 495 ka BP, underling the importance of the NH response and associated feedbacks at the global scale. However, in response to the astronomical forcing alone, transient simulations covering the period from 511 ka BP to 481 ka BP leads to two peaks about equivalent in magnitude. One is located at 503 ka BP and another at 488 ka BP. The second simulation where CO2 forcing is also taken into account leads to the similar result except that the most recent peak is attracted towards the CO2 peak. In the third simulation where the ice sheets forcing which are estimated from the LR04 δ18O stack are added, the recent peak is reinforced and displaced toward 491ka BP. Results of the last 2 simulations are therefore strongly influenced by the dates of CO2 and δ18O. As a conclusion, we see that snapshot simulations lead to the peak of MIS-13 at 501 ka BP, which is not seen in the recent LR04 δ18O data. If transient simulations are considered, there are two peaks during MIS-13 among which the most significant is consistent with the proxy data (either CO2 or LR04 δ18O) but strongly influence by their dating. As a consequence, discussion must go on to try to conciliate the modeling results and the proxy data. An appropriate model with fully coupled ice sheet and carbon cycle, and/or independent time scales for CO2 and ice volume (sea level) are also therefore urgently needed to decide whether the traditional NH astronomical hypothesis has to be revised (transformed into SH hypothesis) or the data corrected.