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Towards Greenland Glaciation: cumulative or abrupt transition?

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During the mid-Pliocene warming period (3-3.3 Ma BP), the global annual mean temperatures inferred by data and model studies were 2-3° warmer than pre-industrial values. Accordingly, Greenland ice sheet volume is supposed to reach at the most, only half of that of present-day [Haywood et al. 2010]. Around 2.7-2.6 Ma BP, just $\sim$ 500 kyr after the warming peak of mid-Pliocene, the Greenland ice sheet has reached its full size [Lunt et al. 2008]. A crucial question concerns the evolution of the Greenland ice sheet from half to full size during the 3 – 2.5 Ma period. Data show a decreasing trend of atmospheric CO_2 concentration from 3 Ma to 2.5 Ma [Seki et al.2010; Bartoli et al. 2011; Martinez et al. 2015]. However, a recent study [Contoux et al. 2015] suggests that a lowering of CO_2 is not sufficient to initiate a perennial glaciation on Greenland and must be combined with low summer insolation to preserve the ice sheet during insolation maxima. This suggests rather a cumulative process than an abrupt event. In order to diagnose the evolution of the ice sheet build-up, we carry on, for the first time, a transient simulation of climate and ice sheet evolutions from 3 Ma to 2.5 Ma. This strategy enables us to investigate the waxing and waning of the ice sheet during several orbital cycles. We use a tri-dimensional interpolation method designed by Ladant et al. (2014), which allows the evolution of CO_2 concentration and of orbital parameters, and the evolution of the Greenland ice sheet size to be taken into account. By interpolating climatic snapshot simulations ran with various possible combinations of CO_2, orbits and ice sheet sizes, we can build a continuous climatic forcing that is then used to provide 500 kyrs-long ice sheet simulations. With such a tool, we may offer a physically based answer to different CO_2 reconstructions scenarios and analyse which one is the most consistent with Greenland ice sheet buildup.