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## How did Marine Isotope Stage 3 and Last Glacial Maximum climates differ? – Perspectives from equilibrium simulations

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**Abstract.** Dansgaard-Oeschger events occurred frequently during Marine Isotope Stage 3 (MIS3), as opposed to the following MIS2 period, which included the Last Glacial Maximum (LGM). Transient climate model simulations suggest that these abrupt warming events in Greenland and the North Atlantic region are associated with a resumption of the Thermohaline Circulation (THC) from a weak state during stadials to a relatively strong state during interstadials. However, those models were run with LGM, rather than MIS3 boundary conditions. To quantify the influence of different boundary conditions on the climates of MIS3 and LGM, we perform two equilibrium climate simulations with the three-dimensional earth system model LOVECLIM, one for stadial, the other for interstadial conditions. We compare them to the LGM state simulated with the same model. Both climate states are globally 2°C warmer than LGM. A striking feature of our MIS3 simulations is the enhanced Northern Hemisphere seasonality, July surface air temperatures being 4°C warmer than in LGM. Also, despite some modification in the location of North Atlantic deep water formation, deep water export to the South Atlantic remains unaffected. To study specifically the effect of orbital forcing, we perform two additional sensitivity experiments spun up from our stadial simulation. The insolation difference between MIS3 and LGM causes half of the 30–60° N July temperature anomaly (+6°C). In a third simulation additional freshwater forcing halts the Atlantic THC, yielding a much colder North Atlantic region (–7°C). Comparing our simulation with proxy data, we find that the MIS3 climate with collapsed THC mimics stadials over the North Atlantic better than both control experiments, which might crudely estimate interstadial climate. These results suggest that freshwater forcing is necessary to return climate from warm interstadials to cold stadials during MIS3. This changes our perspective, making the stadial climate a perturbed climate state rather than a typical, near-equilibrium MIS3 climate.

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