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The contribution of melt ponds to enhanced Arctic sea-ice melt during the Last Interglacial

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HadGEM3 is the first coupled climate model to simulate an ice-free Arctic during the Last Interglacial (LIG), 127 000 years ago. This simulation appears to yield accurate Arctic surface temperatures during the summer season. Here, we investigate the causes and impacts of this extreme simulated ice loss. We find that the summer ice melt is predominantly driven by thermodynamic processes: atmospheric and ocean circulation changes do not significantly contribute to the ice loss. We demonstrate these thermodynamic processes are significantly impacted by melt ponds, which form on average 8 days earlier during the LIG than during the pre-industrial control (PI) simulation. This relatively small difference significantly changes the LIG surface energy balance, and strengthens the albedo feedback. Compared to the PI simulation: in mid-June, of the absorbed flux at the surface over ice-covered cells (ice concentration>0.15), ponds account for 45-50%, open water 45%, and bare ice and snow 5-10%. We show that the simulated ice loss leads to large Arctic sea surface salinity and temperature changes. The sea surface temperature and salinity signals we identify here provide a means to verify, in marine observations, if and when an ice-free Arctic occurred during the LIG. Strong LIG correlations between spring melt pond and summer ice area indicate that, as Arctic ice continues to thin in future, the spring melt pond area will likely become an increasingly reliable predictor of the September sea-ice area. Finally, we note that models with explicitly modelled melt ponds seem to simulate particularly low LIG sea-ice extent. These results show that models with explicit (as opposed to parameterised) melt ponds can simulate very different sea-ice behaviour under forcings other than the present-day. This is of concern for future projections of sea-ice loss.