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Multi-model assessment of the deglacial climatic evolution at high southern latitudes

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The quaternary climate is characterised by glacial-interglacial cycles, with the most recent transition from the last glacial maximum to the present interglacial (the last deglaciation) occurring between ~ 21 and 9 ka. While the deglacial warming at southern high latitudes is mostly in phase with atmospheric CO2 concentrations, some proxy records have suggested that the onset of the warming occurred before the CO2 increase. In addition, southern high latitudes exhibit a cooling event in the middle of the deglaciation (15–13 ka) known as the Antarctic Cold Reversal (ACR). In this study, we analyse transient simulations of the last deglaciation performed by six different climate models as part of the 4th phase of the Paleoclimate Modelling Intercomparison Project (PMIP4) to understand the processes driving southern high latitude surface temperature changes. While proxy records from West Antarctica and the Pacific sector of the Southern Ocean suggest the presence of an early warming before 18 ka, only half the models show a significant warming (~1 °C or ~10 % of the total deglacial warming). All models simulate a major warming during Heinrich stadial 1 (HS1, 18–15 ka), greater than the early warming, in response to the CO2 increase. Moreover, simulations in which the AMOC weakens show a more significant warming during HS1 as a result. During the ACR, simulations with an abrupt increase in the AMOC exhibit a cooling in southern high latitudes, while those with a reduction in the AMOC in response to rapid meltwater exhibit warming. We find that all climate models simulate a southern high latitude

cooling in response to an AMOC increase with a response timescale of several hundred years, suggesting the model's sensitivity of AMOC to meltwater, and the meltwater forcing in the North Atlantic and Southern Ocean affect southern high latitudes temperature changes. Thus, further work needs to be carried out to understand the deglacial AMOC evolution with the uncertainties in meltwater history. Finally, we do not find substantial changes in simulated Southern Hemisphere westerlies nor in the Southern Ocean meridional circulation during deglaciation, suggesting the need to better understand the processes leading to changes in southern high latitude atmospheric and oceanic circulation as well as the processes leading to the deglacial atmospheric CO2 increase.