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Integrating model and data over the Southern Ocean at the Last Glacial Maximum to better understand the sea-ice cover

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At the interface of the atmosphere and the oceans, sea ice is a thin and reactive layer which depends on the surface temperatures of the two and with significant impact on both. In this vein, sea ice affects the regional energy budget due to its high albedo, modulates the transfer of gas and energy at the ocean-atmosphere by its simple presence and modifies the water column vertical structure through brine rejection during freezing and freshwater input during melting. As the densification of surface waters can lead to deep water formation, sea ice has an impact on deep ocean circulation (Ferrari et al. [2014], Marzocchi et al. [2019]).

Around 21,000 years ago, the glacial period called the LGM was marked by extensive ice sheets in the Northern Hemisphere, a consequent lower sea-level, and lower atmospheric CO_2 concentrations than today's. However, the processes driving these lower atmospheric CO_2 concentrations are still not fully understood. Paleotracer data (Curry and Oppo [2005]) suggest that the Antarctic Bottom Water was a poorly ventilated and voluminous water mass, therefore efficiently trapping carbon. Proxies also allow for the reconstruction of LGM sea ice (de Vernal et al. [2013]), and their studies have indicated both an extended Southern Ocean sea ice and an enhanced seasonality (Gersonde et al. [2005], Allen et al. [2011], Benz et al. [2016]).

Models are very helpful to investigate the potentially complex response of the climate system to any perturbation. The Paleoclimate Modelling Intercomparison Project (now in phase 4) has proposed standardized LGM boundary conditions which notably allows for an evaluation of the model performance under cold conditions. During past PMIP phases, the simulation of the LGM deep ocean circulation has proven to be challenging (Otto-Bliesner et al. [2007], Muglia and Schmittner [2015]), which could be linked – at least partially – to the limitations in modelling past sea-ice changes (Goosse et al. [2013], Roche et al. [2012]).

In this study, the iLOVECLIM model – of intermediate complexity – (Goosse et al. [2010]) is used under the PMIP4 experimental design with both the ICE-6G-C and GLAC-1D topographies. The simulated sea ice is compared with a recent compilation of proxy data (Crosta, pers. com.). We

look for potential sources of the observed model-data discrepancies using different model configurations. We examine in particular the simulated SSTs compared to MARGO [2009] data and show a regional and seasonal model-data disagreement that is quite consistent with the sea-ice model-data comparison.