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Glacial climate sensitivity to different states of the Atlantic Meridional Overturning Circulation: results from the IPSL model

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Abstract. Paleorecords from distant locations on the globe show rapid and large amplitude climate variations during the last glacial period. Here we study the global climatic response to different states of the Atlantic Meridional Overturning Circulation (AMOC) as a potential explanation for these climate variations and their possible connections. We analyse three glacial simulations obtained with an atmosphere-ocean coupled general circulation model and characterised by different AMOC strengths (18, 15 and 2 Sv) resulting from successive ~0.1 Sv freshwater perturbations in the North Atlantic. These AMOC states suggest the existence of a freshwater threshold for which the AMOC collapses. A weak (18 to 15 Sv) AMOC decrease results in a North Atlantic and European cooling. This cooling is not homogeneous, with even a slight warming over the Norwegian Sea. Convection in this area is active in both experiments, but surprisingly stronger in the 15 Sv simulation, which appears to be related to interactions with the atmospheric circulation and sea-ice cover. Far from the North Atlantic, the climatic response is not significant. The climate differences for an AMOC collapse (15 to 2 Sv) are much larger and of global extent. The timing of the climate response to this AMOC collapse suggests teleconnection mechanisms. Our analyses focus on the North Atlantic and surrounding regions, the tropical Atlantic and the Indian monsoon region. The North Atlantic cooling associated with the AMOC collapse induces a cyclonic atmospheric circulation anomaly centred over this region, which modulates the eastward advection of cold air over the Eurasian continent. This can explain why the cooling is not as strong over western Europe as over the North Atlantic. In the Tropics, the southward shift of the Inter-Tropical Convergence Zone appears to be strongest over the Atlantic and Eastern Pacific and results from an adjustment of the atmospheric and oceanic heat transports. Finally, the Indian monsoon weakening appears to be connected to the North Atlantic cooling via that of the troposphere over Eurasia. Such an understanding of these teleconnections and their timing could be useful for paleodata interpretation.

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