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Two climatic states and thermohaline circulation stability in the MPM-2

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The McGill Paleoclimate Model-2 (MPM-2) is employed to study climate-thermohaline circulation (THC) interactions in a pre-industrial climate, with a special focus on the feedbacks on the THC from other climate system components. The MPM-2, a new version of the MPM, has an extended model domain from 90S to 90N, active winds and no oceanic heat and freshwater flux adjustments. By slowly adding freshwater water into or slowly extracting freshwater from the North Atlantic in the latitude band 20-50N, the hysteresis diagram of the Atlantic Meridional Overturning Circulation (MOC) intensity is derived. There are mainly two modes for the Atlantic MOC under the "present-day" forcing (present-day solar forcing and the pre-industrial atmospheric CO2 level of 280 ppm). The 'on' mode has an active North Atlantic deep water formation, while the 'off' mode has no such deep water formation. By comparing the 'off' mode climate state with its 'on' mode analogue, we find that there exist many large differences between the two climate states, which originate from large changes in the oceanic meridional heat transports. By suppressing or isolating each process associated with a continental ice sheet over North America, sea ice, the atmospheric hydrological cycle and vegetation, feedbacks from these components on the Atlantic MOC are investigated. Sensitivity studies investigating the role of varying continental ice growth and sea ice meridional transport in the resumption of a collapsed Atlantic MOC are also carried out. The results show that a fast ice sheet growth and an enhanced southward sea ice transport significantly favor the resumption of a collapsed Atlantic MOC in the MPM-2. In contrast to this, the feedback from the atmospheric hydrological cycle is a weak positive one. The vegetation-albedo feedback could enhance continental ice sheet growth and is thus a negative feedback on a collapsed Atlantic MOC. However, before the shut down of the Atlantic MOC, feedbacks from

these components on the Atlantic MOC are very weak.