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Land-ice melting causes strong multi-century slowdown of Atlantic circulation even under 2×CO_2 stabilisation

D. Swingedouw, P. Braconnot, P. Delecluse, E. Guilyardi, O. Marti
Laboratoire des Sciences du Climat et de l'Environnement, Gif-sur-Yvette, France

The response of the Atlantic Meridional Overturning Circulation (AMOC) to an increase in atmospheric CO2 concentration is analyzed using the IPSL-CM4 coupled ocean atmosphere model. Two scenarios are integrated for 70 years with 1%/yr increase in CO_2 concentration, up to doubling, and are then stabilized for another 430 years. The first scenario takes into account a simple parameterization of the land-ice melting that leads to a strong freshwater input of about 0.13 Sv at high latitude for a warm climate. In this case the AMOC shutdowns. The other simulation does not consider this land-ice melting and there, the AMOC recovers after 200 years. This discrepancy shows that this model is close to an AMOC shutdown threshold under global warming conditions, due to continuous input of land-ice melting.

The analysis of the origin of the density changes in the Northern Hemisphere convection sites allows to identify the origin of the changes in the AMOC. The processes that decrease the AMOC is the reduction of surface cooling because air-sea temperature is smaller as the atmosphere warms and the local freshening of the convection sites due to the increase of local freshwater forcings. On the other hand, two processes are controling its recovery: the northward advection of positive salinity anomalies from the tropics and the decrease of sea-ice transport through the Fram Strait in the convection sites. The quantification of the AMOC related feedbacks shows that the most important feedback is related to salinity transport, temperature related feedback remaining small because of the compensation between heat transport and surface heat flux in the coupled system.