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Sensitivity of the Atlantic Meridional Overturning Circulation to Northern glacier melting in scenarios

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A weakening of the Atlantic Meridional Overturning Circulation (AMOC) in the next century occurs in most state-of-the-art coupled models (IPCC 2001), despite large differences in the magnitude of this weakening. However, almost none of these models account for land-ice melting due to the global warming. This melting is likely to amplify the AMOC weakening. The discharge of this freshwater could also have some local effects in the Arctic.

Here we evaluate the impact of this melting on the climate using the IPSL coupled model. For this purpose we use two different versions of the model, one with a crude land-ice melting parameterization, and the other without. Experiments using a 1 %/year increase of CO_2 have been realized with the two versions of this model. The AMOC is reduced by 47 % when melting of land-ice is considered. In this simulation, the land-ice melting represents 0.1 Sv at $2*CO_2$, to 0.2 Sv at $4*CO_2$, which is in the upper range of northern glacier melting projections. This contributes to increasing the stratification of the North Atlantic, and limits deep-water formation. When land-ice melting is not considered the AMOC reduction is only of 19 %.

When land-ice melts, the associated AMOC decrease leads to a reduction of the northward heat transport in the Atlantic. As a result, the ice cover remains about 23 % larger than in the simulation without land-ice melting. The local effects of the freshwater discharge on sea-ice cover appear to be of second order. Thus, the sea-ice albedo feedback decreases when the AMOC weakens. This in turn limits the water vapor feedback. As a result, the warming north of 30˚N is reduced by 1.1˚C in the simulation with the land-ice melting, which represents a 8 % difference in global climate sensitivity at $4*CO_2$.