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Response of the meridional overturning circulation to a cooling: can we understand the difference between simulations of the LGM?

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Simulations performed with coupled atmosphere-ocean climate models for the Last Glacial Maximum display a wide range of response of the Meridional Overturning Circulation (MOC). Some of them show an increase in the maximum of the MOC compared to pre-industrial conditions, some others a decrease, while in some of them the value of the maximum is nearly unchanged but still a reorganization of the MOC is present. In order to understand the causes of those very different behaviors, an idealized experiment has been performed with the coupled climate model of intermediate complexity LOVECLIM in which the total solar irradiance (TSI) has been very slowly decreased to obtain a quasi-equilibrium response of the model to cooling of different magnitudes. For modest reduction on the TSI, the maximum of the MOC increases slightly. For a larger cooling, convection is shifted southward in the Norwegian Sea and the magnitude of maximum of the MOC increases until convection moved southward of the latitude of Iceland. If the cooling continues on, the intensity of the MOC decreases, convection becomes much shallower until a total collapse of the MOC for very large cooling. We argue that the difference between the results of models for LGM is due to this non-linear response of the system to a cooling. Because of their different climate sensitivities, the models simulate cooling of different magnitude for the LGM. Furthermore, the cooling associated with the maximum in the MOC is certainly model-dependant. As a consequence, for some models, the cooling at LGM is not large enough to induce a reduction of the MOC. Besides, for some others, it is strong enough to shift the convection southward of Iceland and induces a reduction in the intensity of the MOC.