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# On the reversibility and symmetry of the climate system's response to anthropogenic and natural forcing

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The question of reversibility and symmetry of changes in the climate system is not only interesting from an academic point of view, but is also important since new RCP scenarios with a peak in $CO_2$ emissions around 2020 and a decrease afterwards are proposed. Analogues for such forcing changes can be found in past climate history. In this study, we first investigate whether the climate system can return to its initial state after $CO_2$ concentrations have raised to high levels and subsequently decreased back to their initial concentrations. Results show that during the warming phase, changes in the hydrological cycle and surface heat fluxes cause the Atlantic Meridional Overturning Circulation (AMOC) to weaken. When $CO_2$ concentrations are reduced again, depending on the length of the period of stabilization at high $CO_2$ levels, the AMOC either recovers and overshoots or remains weak for centuries, a behaviour not seen in other modern climate models. The delayed recovery of the AMOC in the latter case could reveal similar mechanisms as the Bolling-Allerod event.
The question of symmetry of the climate response is further investigated with idealised solar forcing increase and decrease of the same intensity. Results show that the climate system does not behave symmetrically, partly due to oceanic circulation but also due to the state dependance of the climate feedbacks. These results can be related to the Last Glacial Maximum.
The idealised simulations presented in this study can be useful to understand past climate change but are also relevant for impact studies on long time scale changes in the future.