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Probabilistic projections of the Atlantic Meridional Overturning Circulation for the 21st century

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To assess the possible impacts of future climate change, not only mean projections but also associated uncertainty ranges have to be identified. This is particularly important for circulations of global scale and impact like the Atlantic Meridional Overturning Circulation (AMOC). The AMOC is a key component of the climate system and has undergone rapid changes during past glacial cycles. Most climate models agree in projecting an AMOC weakening as a consequence of global warming over the 21st century, however the magnitude of this weakening is highly uncertain. Ensemble simulations are needed to confine this uncertainty, which is costly to perform with computational intensive complex coupled Atmosphere-Ocean Circulation models (AOGCMs).

Here, we use linear response theory to derive a functional relationship between AMOC strength and global mean temperature (GMT) change. We find a simple one-dimensional diffusion equation with two free parameters to be sufficient to reproduce the model dependent AMOC evolution over the 21st century for an ensemble of 8 AOGCMs of the Coupled Model Intercomparison Project (CMIP5). Under ongoing global warming, the AMOC weakening for the RCP26, RCP45 and RCP85 scenarios can be emulated with one model specific parameter set. Additionally, also the AMOC recovery exhibited by several models under the RCP26 and RCP45 scenarios over the second half of the 21st century is reproduced.

By combining our linear response theory approach with probabilistic GMT projections provided by the MAGICC6 model, we can derive probabilistic projections of the AMOC evolution over the 21st century. Based on these projections, impacts of a changing AMOC, like regional sea-level rise at the North American Atlantic coastline, can be assessed with greater confidence.