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Safeguarding the North Atlantic thermohaline circulation: a sensitivity analysis using the dimrise model

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The fully coupled integrated assessment model dimrise (dynamic integrated model of regular climate change impacts and singular events) has been designed to investigate the stability of the North Atlantic thermohaline circulation (THC). The THC module employs a dynamic four-box interhemispheric extension of the classic Stommel model. The free parameters of this box-model are calibrated to reproduce the THC behavior as shown by CLIMBER-2, a climate model of intermediate complexity developed at the Potsdam Institute for Climate Impact Research. The THC module is driven by the ICLIPS multi-gas climate module, a computationally efficient globally aggregated model that is able to mimic the response of sophisticated carbon cycle and atmosphere-ocean general circulation models. In order to estimate the monetary cost of avoiding a THC breakdown, the THC and climate modules are coupled with a globally aggregated Ramsey-type optimal growth model of the world economy.

dimrise is able to derive cost-effective emissions paths that comply with prescribed bounds on admissible THC weakening, duly imposed in order to avoid an irrevocable break-down. In addition, emissions corridors can be calculated within the framework of the tolerable windows approach. These emissions corridors delineate the sets of all emissions paths that (1) do not endanger the stability of the THC and (2) do not transgress prescribed welfare losses associated with the emission mitigation efforts that are necessary to achieve that goal.

Applications of a conservatively calibrated dimrise model variant reveal that the point

of no return for a future break-down of the THC could be crossed within two decades if a business-as-usual emissions path is followed. This vulnerable behavior can be readily explained by taking into account both (1) the considerable time-lag between greenhouse gas emissions, associated temperature change, and the resulting response of the ocean circulation, and (2) the cumulative emissions that would arise from two decades of inaction together with the restricted capacity of the world economy to rapidly reduce greenhouse gas emissions thereafter.