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Does global warming bring the Atlantic MOC closer to a threshold?

J. M. Rodriguez (1), R. Wood (1), R. S. Smith (2), and E. Hawkins (2)

(1) Met Office Hadley Centre, Exeter, United Kingdom , (2) NCAS_Climate, University or Reading, Reading, United Kingdom

Studies with simple models suggest that the Atlantic MOC is non linear and sensitive to changes in freshwater forcings. It may collapse if forcings go beyond a certain threshold. Simulations of green house warming using general circulation models show in general a weakening of the AMOC. The degree of weakening varies between models. However, a systematic study of the MOC stability cannot be done presently with GCMs, due to excessive computational cost. We present here results from a simple model and a low resolution GCM (FAMOUS) to evaluate the position of stability thresholds of the MOC. The simple model is a box model generalised from Stommel's original model to allow for return flow via both warm and cold water paths. All the box model control parameters can be diagnosed from output quantities from any GCM, and in principle also from observations.

We test the box model physics by using it to model the MOC hysteresis structure observed in recent integrations of FAMOUS. The MOC simulated by the box model shows hysteresis behaviour similar to the corresponding one in the GCM. We then estimate the sensitivity of the MOC thresholds under climate change, by re-calibrating the box model to two states taken from FAMOUS run to $4\times CO_2$. Contrary to common belief, we find that the MOC shutdown threshold at $4\times CO_2$ is further away than in the pre-industrial case, and moves further away still as the $4\times CO_2$ state adjusts towards equilibrium. The same result is seen in a second FAMOUS hysteresis run, indicating that the box model is capturing the MOC physics in the increased CO_2 state in FAMOUS. This increased stability behaviour is also observed when the box model is calibrated to $4\times CO_2$ states from other GCM simulations.