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Variability and predictability of the Atlantic meridional overturning circulation from generalized stability theory

L. Zanna (1,2), E. Tziperman (1), P. Heimbach (3), and A.M. Moore (4)

(1) Harvard University, Earth & Planetary Sciences, Cambridge, MA, United States (zanna@fas.harvard.edu), (2) Oxford University, Atmospheric, Oceanic and Planetary Physics, Oxford, OX1, UK, (3) MIT, Earth, Atmospheric and Planetary Sciences, Cambridge, MA, United States , (4) UC Santa Cruz, Ocean Sciences, Santa Cruz, CA, United States

To explore the predictability and variability of the Atlantic meridional overturning circulation (MOC), we use generalized stability theory to study the fastest growing perturbations arising from the non-normal dynamics in an ocean general circulation model. Even though the system is linearly stable, small temperature and salinity perturbations can generate large MOC anomalies on timescales of years to decades.

The transient growth of MOC anomalies due to the interaction of several non-orthogonal eigenmodes can be partially understood by examining the time evolution of zonal density gradients (related to the MOC via the thermal wind relation). The speed of the propagation of density anomalies, which depends on the mean flow and the mean density gradient, determines the growth timescale of the MOC anomalies and therefore the MOC predictability timescale.

Our results suggest that a large transient amplification of the MOC anomalies due to the non-normal ocean dynamics may be an efficient way to excite ocean variability on interannual timescale and may limit the predictability timescale of the Atlantic ocean circulation.