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The Atlantic Meridional Overturning Circulation's Response to Variable Buoyancy Forcing

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The Meridional Overturning Circulation (MOC) is a large-scale global circulation of water (and heat) throughout the world's ocean. It is an integral part of the climate system, responsible for significant anomalous warming of the North Atlantic region. Much of our current understanding of the MOC is based on equilibrium theories. However, the MOC is not a steady circulation and exhibits variability across a broad range of timescales. We examine the transient response of global ocean overturning, with particular emphasis on the Atlantic MOC (AMOC), to periodic variations in the North Atlantic meridional density gradient on decadal, centennial, and millennial timescales within the Nucleus for European Modelling of the Ocean (NEMO) model framework. We use the ORCA2 global ocean configuration of NEMO (with realistic topography and a horizontal resolution of 2°) and impose periodic variations in air temperature over the North Atlantic. In response, we see large oscillations in the strength of the AMOC which peak in magnitude at 128-year timescales. A scaling relationship of the form $\Psi \sim \Delta\rho H^2$ (in which $\Delta\rho$ is a measure of meridional density gradient and H is the depth scale of maximal overturning) is found to hold for the AMOC in these transient simulations with strongest correlations observed at centennial timescales. We explore the validity of this scaling relationship across a broad range of spatial and temporal scales and discuss its validity in a global context.