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An oscillating Atlantic Meridional Overturning Circulation during the last glacial period

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Abrupt climate changes over the last glacial period (~ 115 to 12 thousand years ago) are often associated with reorganisation of the Atlantic Meridional Overturning Circulation (AMOC). It has been suggested that the AMOC can exist in more than one stable mode, but the mechanisms leading to switches between different regimes are still not understood. It is also unclear how disruptions of the ocean circulation are connected to millennial-scale climate variability, such as Dansgaard-Oeschger events or abrupt transitions during the late last deglaciation.

Most attempts at theorising glacial millennial-scale variability have involved looking at heat and salt transfers between the subtropical and subpolar gyres. This is often referred to as the 'salt oscillator' mechanism, which in turn controlled the intensity of the North Atlantic current. We propose that the salt oscillator is in fact part of a larger motion combining harmonic and stochastic dynamics spanning through all components of the climate system when triggered by an initial excitation. Only under certain combinations of boundary conditions and forcings can multiple stable states coexist, sometimes leading to the activation of a pseudo-oscillating regime for thousands of years.

Based on a new set of last glacial maximum (~21 thousand years ago) simulations that oscillate when forced with snapshots of the early last deglaciation meltwater history, we propose a new way of visualising the stability of the AMOC and its shifts between different stable modes. We provide a detailed analysis of the heat and salinity tendencies in a comprehensive description of the different oscillating modes. Finally, we discuss how the freshwater forcing framework fits into the broader theory of glacial abrupt climate changes.