Why is the AMOC mono-stable in Coupled General Circulation Models?

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Abstract

This question we attempt to address is : why do Coupled General Circulation Models (CGCM) seem to be biased towards a mono-stable AMOC? We first review observational evidence and suggest that the AMOC is likely to be bi-stable in the real world in the past and present. We then study the stability of the AMOC in the NCAR CCSM3 by comparing the present day control simulation (without flux adjustment) with a sensitivity experiment with flux adjustment. It is found that the mono-stable AMOC in the control simulation is altered to a bi-stable AMOC in the flux adjustment experiment because a reduction of the surface salinity biases in the tropical and northern North Atlantic leads to a reduction of the bias of freshwater transport in the Atlantic. In particular, the tropical bias associated with the double ITCZ reduces salinity in the upper South Atlantic ocean and, in turn, the AMOC freshwater export, which tends to over-stabilize the AMOC and therefore biases the AMOC from bi-stable towards mono-stable. This conclusion is consistent with the stability indicator of IPCC AR4 CGCMs: models without flux adjustment are all mono-stable, while models with flux adjustment tend to be bi-stable. We propose that the surface climate bias, notably the tropical bias in the Atlantic, may contribute significantly to the mono-stability of AMOC behavior in current CGCMs.