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Role of the Ocean-Atmosphere interactions for the Atlantic Multidecadal Variability in an idealized coupled model

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The role of the ocean-atmosphere interactions in the multidecadal variability of the Atlantic Meridional Overturning Circulation (AMOC) is investigated in an idealized coupled configuration of the MIT General Circulation Model. The flat-bottom ocean, composed of an Atlantic-like small basin, a Pacific-like large basin, and an unblocked Antarctic-like circumpolar channel, is coupled to a global atmospheric model (SPEEDY). In order to better represent the atmospheric dynamics and its interactions with the ocean, three set-ups, with horizontal resolution of about 4°, 2° and 1° (at the equator) in both the ocean and atmosphere models, are compared. They show a linearly increasing North Atlantic Oscillation-like variability.
At all resolutions, the AMOC undergoes a spontaneous variability on multidecadal time scales between 30-40 yr, with an additional higher frequency in the highest resolution set-up. The AMOC variability responds to temperature anomalies along the western boundary through the thermal wind relationship. These temperature anomalies result from the propagation of large-scale baroclinic Rossby waves across the small basin. The unstable region responsible for the growth of Rossby waves through baroclinic instability, diagnosed using a temperature variance budget, shifts from the eastern boundary at coarse resolution (4°) to the western boundary at higher resolution (2° and 1°). An earlier study, performed with the same coarse resolution set-up (4°), has shown that the AMOC does not participate to the growth of Rossby waves, but passively reacts to these waves. The AMOC being mainly connected to the western boundary dynamics, its role in setting large scale baroclinic Rossby waves might be different between the coarse resolution set-ups (4°) and the higher resolution set-ups (2° and 1°).
The ocean-atmosphere interactions are strongly enhanced in the highest resolution set-up (1°), with the development of a significant correlation of about 0.4 between the NAO and the AMOC variability, the former partially influences the latter with a 2 yr lag. At high resolution (1°), an ocean-only simulation forced by constant atmospheric fluxes shows more regular AMOC variability at multidecadal time scales, such that the ocean-atmosphere fluxes variations have a disruptive effect on the AMOC variability. These fluxes partially inhibit the propagation of large-scale baroclinic Rossby waves across the small basin. They perturb the regularity of the AMOC variability rather than participating to it.
In conclusion, the AMOC variability in our idealized coupled model at various horizontal resolutions is essentially an intrinsic oceanic process. However, the resolutions involved in this study do not explicitly resolve oceanic mesoscale eddies.