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Interdecadal modes of variability through a hierarchy of ocean models

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A hierarchy of ocean models from quasigeostrophic (QG) to primitive equations is used to investigate the fundamental mechanisms of interdecadal variability of the thermohaline circulation. In idealized geometry, this variability is shown to occur under constant forcing and hence does not rely on so-called mixed boundary conditions. In more realistic settings, it may require stochastic noise in the atmospheric forcing to be triggered. In any case, linear stability analysis shows it appears through an unstable or weakly damped linear mode. We track this mode through a hierarchy of ocean models, from the weakly damped Rossby basin modes in barorotropic QG models, to the deformed and recirculating baroclinic modes when a mean gyre circulation is included, to the unstable modes when large-scale baroclinic instability is enabled. Finally, we extend these analysis to more realistic ocean basins and forcing to provide this interdecadal thermohaline mode signature in the North Atlantic.