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The leading, interdecadal mode of the Atlantic meridional overturning circulation in a hierarchy of ocean and coupled models

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This study focuses on the pronounced interdecadal AMOC variability commonly produced by coupled climate models. To study such variability, as the first step we conduct a stability analysis of a realistic ocean GCM and show the existence of an interdecadal, weakly-damped mode of oscillation (an eigenmode) centered in the northern Atlantic and related to ocean dynamics. The mode period is approximately 24 years and its manifestation is evident in the westward propagation of temperature anomalies in the upper Atlantic ocean. These temperature anomalies affect the ocean density field and hence ocean circulation (especially within the Subpolar Gyre). The most efficient way to excite this mode is via optimal initial perturbations in surface temperature and salinity centered off the east coast of Greenland and Canada. Simple estimates show that moderate changes in surface temperature or salinity in this region can lead to AMOC variations on the order of 10-20%. We show that the excitation of the mode depends on ocean mean convection that allows the deep ocean to feel surface anomalies. Further, we consider the IPSL coupled model that has the same ocean component and exhibits strong AMOC variations with a period close to that of the least-damped mode in the ocean-only GCM. We argue that the mechanism of these variations in the coupled model is the excitation of the exact same oceanic mode by the atmosphere via the optimal perturbation mechanism. The excitation process involves changes in the southward flow through the Denmark Strait that generate salinity anomalies downstream. Finally, we show that these results are relevant to other, broadly used climate models (e.g. CCSM3, CESM, and GFDL CM2.1).