

The importance of the western Transition Zone in decadal AMOC variability

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Currently there is no accepted mechanism for decadal AMOC variability and little background theory on which the community agrees. Insights about mechanism have largely come from models, but the magnitude and time scale of AMOC variability varies markedly across models and model formulations. Despite this, there are three robust features of AMOC variability that may inform mechanisms of decadal variability. (1) Observations and models suggest that buoyancy anomalies on the western boundary are key to understanding low-frequency AMOC variability. (2) A pacemaker region for decadal AMOC variability appears to be located along the boundary between the subtropical and subpolar gyres. (3) Meridionally coherent decadal AMOC anomalies are communicated southward from this pacemaker region. We use these three robust features to argue that the region near the Grand Banks where the Gulf Stream/North Atlantic Current (NAC) and the deep western boundary current cross over, henceforth called the Transition Zone, is a key region influencing large-scale decadal AMOC variability. It is here that we observe the Mann eddy, an intense anticyclone swirling to the southeast of the NAC. Variability in this key region is implicitly reflected in the AMOC indices commonly utilized by the modeling community. Processes that are important in creating buoyancy anomalies in the Transition Zone are expected to play an important role in AMOC variability. Such processes include local atmospheric forcing, advection of anomalies by mean currents, westward propagating (wind or buoyancy forced) baroclinic Rossby waves, anomalies resulting from large-scale ocean circulation changes (such as shifts of the Gulf Stream path), and anomalies advected/propagated from high latitudes. The complex ocean dynamics in transition zone likely explain why AMOC variability is so sensitive to model formulation, both between models and in the same model when changes are made to its resolution, overflow parameterizations, etc.

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