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Identification and quantification of the North Atlantic Deep Water pathways

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The North Atlantic Deep Water (NADW) flows equatorward along the Deep Western Boundary Current (DWBC) as well as interior pathways and is a critical part of the Atlantic Meridional Overturning Circulation. Its upper layer, the Labrador Sea Water (LSW), is formed by open-ocean deep convection in the Labrador and Irminger Seas while its lower layers, the Iceland–Scotland Overflow Water (ISOW) and the Denmark Strait Overflow Water (DSOW), are formed north of the Greenland–Iceland–Scotland Ridge.

In recent years, more than two hundred acoustically-tracked subsurface floats have been deployed in the deep waters of the North Atlantic. Studies to date have highlighted water mass pathways from launch locations, but due to limited float trajectory lengths, these studies have been unable to identify pathways connecting remote regions.

This work presents a framework to explore deep water pathways from their respective sources in the North Atlantic using Markov Chain (MC) modeling and Transition Path Theory (TPT). Using observational trajectories released as part of OSNAP and the Argo projects, we constructed two MCs that approximate the lower and upper layers of the NADW Lagrangian dynamics. The reactive NADW pathways—directly connecting NADW sources with a target at 53°N—are obtained from these MCs using TPT.

Preliminary results show that twenty percent more pathways of the upper layer(LSW) reach the ocean interior compared to the lower layer (ISOW, DSOW), which mostly flows along the DWBC in the subpolar North Atlantic. Also identified are the Labrador Sea recirculation pathways to the Irminger Sea and the direct connections from the Reykjanes Ridge to the eastern flank of the Mid–Atlantic Ridge, both previously observed. Furthermore, we quantified the eastern spread of the LSW to the area surrounding the Charlie–Gibbs Fracture Zone and compared it with previous analysis. Finally, the residence time of the upper and lower layers are assessed and compared to previous observations.