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Direct and indirect pathways of convected water masses and their impacts on the overturning dynamics of the Labrador Sea

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The dense waters formed by wintertime convection in the Labrador Sea play a key role in setting the properties of the deep Atlantic Ocean. To understand how variability in their production might affect the Atlantic Meridional Overturning Circulation (AMOC) variability, it is essential to determine pathways and associated timescales of their export. In this study, we analyze the trajectories of Argo floats and of Lagrangian particles launched at 53°N in the boundary current and traced backwards in time in a high-resolution model, to identify and quantify the importance of upstream pathways. We find that 85% of the transport carried by the particles at 53°N originates from Cape Farewell, and it is split between a direct route that follows the boundary current and an indirect route involving boundary-interior exchanges. Although both routes contribute roughly equally to the maximum overturning, the indirect route governs its signal in denser layers. This indirect route has two branches: part of the convected water is exported rapidly on the Labrador side of the basin, and part follows a longer route towards Greenland and is then carried with the boundary current. Export timescales of these two branches typically differ by 2.5 years. This study thus shows that boundary-interior exchanges are important for the pathways and the properties of water masses arriving at 53°N. It reveals a complex three-dimensional view of the convected water export, with implications for the arrival time of signals of variability therein at 53°N and thus for our understanding of the AMOC.