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Irminger Sea as a key site for the Atlantic Meridional Overturning Circulation

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Intense cooling of the upper-ocean waters in the Nordic Seas produces cold dense overflows to the North Atlantic thereby driving the Atlantic Meridional Overturning Circulation (MOC) – an important element of the climate system. Observations and models consistently show that the direct contribution of the Nordic overflows (∼6 Sv) to the MOC is modest when compared to the MOC strength (∼16 Sv) at the Subpolar Gyre southern margin and that the exchange across the Greenland-Scotland Ridge (GSR) is remarkably stable relative to the MOC variability south of the GSR. Therefore, it is reasonable to expect that the MOC low-frequency variability is associated for the most part with variability of the light-to-dense water conversion within the Subpolar Gyre. Localization of the key sites of this conversion is thus essential.

By combining repeat hydrography (7 annual summer snapshots) with altimetry, we estimated the 2002–2008 mean absolute transports across the 59.5˚N transatlantic section between Cape Farewell (Greenland) and Scotland. The obtained MOCσ – maximum in southward transport accumulated from the bottom in density coordinates – is 16.5±2.2 Sv (at σ_0 = 27.55), in agreement with the MOCσ estimates (16.3±2 Sv, $\sigma_0 \approx 27.55$) based on direct velocity measurements in summer 2002 and 2004 at the OVIDE Cape Farewell-to-Portugal section. In the next step, we used the obtained mean transports at 59.5˚N along with fluxes across the GSR, as available from literature, to estimate the overturning rate in the GSR–59.5˚N region by applying a simple box model. The results provide the following conceptual view of the gyre / overturning circulation at the northern periphery of the Atlantic Ocean.

The North Atlantic Current / Irminger Current (NAC/IC) carries 21.1±1 Sv of warm upper-ocean waters across 59.5˚N northwards within the MOCσ upper limb ($\sigma_0 < 27.55$). 40% of this flow forms the Atlantic Inflow to the Nordic Seas (8.4±1 Sv), and 60% (12.7±1.4 Sv) recirculates westwards in the Subpolar Gyre northern branch south of Iceland to feed the Western Boundary Current (WBC) in the Irminger Sea. Only 20% (2.4±1.2 Sv) of the recirculating NAC/IC-derived waters exits the Irminger Sea in the WBC at shallow levels ($\sigma_0 < 27.55$), while 80% (10.2±1.7 Sv, ∼50% of the initial NAC/IC flow at 59.5˚N) loses enough heat to gain density of $\sigma_0 > 27.55$ and contributes to the MOCσ lower limb. The resulting MOCσ rate at the latitude of Cape Farewell is ∼16.5 Sv, of which 62% (∼10.2 Sv) / 38% (∼6.3 Sv) are due to light-to-dense water conversion south / north of the GSR. As no dense-to-light water re-conversion occurs in the Subpolar Gyre, the recirculating NAC/IC waters entering the MOCσ lower limb in the Irminger Sea eventually contribute to the MOCz lower limb (11.2±1.8 Sv at 59.5˚N) at the exit of the WBC from the subpolar region (∼48˚N), where the MOCσ and MOCz are known to be close in magnitude. Given the "observed and modelled stability of the overflows" on a decadal time scale, variability of the overturning rate in the Irminger Sea is very likely to be one of the key underlying mechanisms of the Atlantic MOC decadal variability.