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Mean full-depth circulation and transports in the North Atlantic across 60N in the 2000s

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The 2002–2008 mean state of the full-depth basin-wide summer circulation at the northern periphery of the Atlantic Ocean is assessed by combining satellite altimetry data with the yearly repeat hydrographic measurements at 59.5˚N between Cape Farewell (Greenland) and Scotland.

The mean absolute geostrophic velocities and associated uncertainties at 59.5˚N are obtained from the (i) mean dynamic topography-derived sea-surface velocities provided by CLS, (ii) mean altimetry-derived sea-surface velocity anomalies provided by AVISO, and (iii) mean surface-to-bottom velocity shears calculated from CTD data (7 annual repeats of the section, June–August). The mean Ekman transport across the section was calculated from QuikSCAT monthly wind stress available from CERSAT. The applied approach efficiently filters out transient energetic mesoscale features and hence reveals a velocity field dominated by the prominent mean currents. Based on the obtained velocity pattern, the Meridional Overturning Circulation (MOC) in density (MOCσ=16.5$\pm$2.2 Sv, at σ_0=27.55) and depth (11.2$\pm$1.8 Sv, at 1180 m) coordinates and transports by the upper-ocean, mid-depth and deep currents are quantified. The results are compared with synoptic transports obtained from direct velocity measurements in the region. By incorporating estimates of the Atlantic–Nordic Seas exchange across the Greenland-Scotland Ridge, as available from literature, general features of the large-scale circulation north of 59.5˚N are inferred and schematically visualized.

The meridional circulation across 59.5˚N is comprised principally of the North Atlantic Current in the eastern basin (15.5$\pm$0.8 Sv, $\sigma_0 < 27.55$), the northward Irminger Current in the Irminger Sea (5.6$\pm$0.4 Sv, $\sigma_0 < 27.55$; 6.4$\pm$1.6 Sv, $27.55 < \sigma_0 < 27.80$), the southward Western Boundary Current along the East Greenland slope (the East Greenland / Irminger Current, 21.8$\pm$4.3 Sv, $\sigma_0 < 27.80$ and Deep Western Boundary Current, 10.3$\pm$1.9 Sv, $\sigma_0 > 27.80$) and the deep boundary flow along the eastern slope the Reykjanes Ridge (4.0$\pm$0.8 Sv southward, $\sigma_0 > 27.80$). The MOCσ vertical structure shows clear predominance of the upper-ocean (16.6$\pm$1.0 Sv northward, $\sigma_0 < 27.55$) and deep (13.3$\pm$1.3 Sv southward, $\sigma_0 > 27.80$) net flows in the meridional exchange. The net meridional flow in the mid-depth layer ($27.55 < \sigma_0 < 27.80$) is relatively weak (3.2$\pm$1.4 Sv southward), being the lowest in the density class of the Labrador Sea Water (0.5$\pm$1.0 Sv southward, $27.70 < \sigma_0 < 27.80$). The overall net transport across the section is 0.1$\pm$3.0 Sv northward.

The results can be used as a benchmark for numerical models. From this perspective, the derived multi-year mean transports have an advantage over the synoptic transport estimates from individual sections, which bear the impress of vigorous variability occurring on a variety of spatial and temporal scales. The methodological outcome is that the combined use of the mean dynamic topography, satellite altimetry and repeat full-depth hydrography allows for the multi-year mean circulation and transports in the region to be ‘successfully’ assessed with no a priori constrains and inverse analysis needed.