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Seasonal and weekly variability of Atlantic inflow into the northern North Sea

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Quantifying the variability of Atlantic inflow is necessary for managing the North Sea ecosystem and for producing accurate models for forecasting, for example, oil spill trajectories. The JONSIS hydrographic section (2.23°W to 0° at 59.28°N) crosses the path of the main inflow of Atlantic water into the northwestern North Sea. 122 occupations between 1989 and 2015 are examined to determine the annual cycle of thermohaline-driven volume transport into the North Sea. Thermohaline transport is at a minimum (0.1 Sv) during winter when it is driven by a horizontal salinity gradient across a zonal bottom front; it is at a maximum (0.35 Sv) in early autumn when it is driven by a horizontal temperature gradient that develops across the same front. The amplitude of the annual cycle of temperature-driven transport (0.15 Sv) is bigger than the amplitude of the annual cycle of salinity-driven transport (0.025 Sv). The annual cycles are approximately six months out of phase. Our quantitative results are the first to be based on a long-term dataset, and we advance previous understanding by identifying a salinity-driven flow in winter. Week-to-week variability of the Atlantic inflow is examined from ten Seaglider occupations of the JONSIS section in October and November 2013. Tidal ellipses produced from glider dive-average current observations are in good agreement with ellipses produced from tide model predictions. Total transport is derived by referencing geostrophic shear to dive-average-current observations once the tidal component of the flow has been removed. Total transport through the section during the deployment (0.5–1 Sv) is bigger than the thermohaline component (0.1–0.2 Sv), suggesting non-thermohaline forcings (e.g. wind forcing) are important at that time of year. Thermohaline transport during the glider deployment is in agreement with the annual cycle derived from the long-term observations. The addition of the glider-derived barotropic current permits a more accurate estimate of the transport than is possible from long-term hydrographic monitoring, and enables the separation of barotropic and depth-varying components. These results refine our understanding of the variability of Atlantic inflow into the North Sea on key timescales, and of the contribution of frontal flow to shelf sea circulation.