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Where does the AMOC peak? Assesssing regional variations in North Atlantic Overturning from GLORYS12

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The Atlantic Meridional Overturning Circulation (AMOC) transports vast amounts of heat to high latitudes, and is largely responsible for Western Europe's relatively mild climate. Climate models project the AMOC will weaken substantially over the 21st century, which impacts weather, climate, sea level and the oceanic carbon cycle. In many studies, the AMOC state is described in a condensed two-dimensional view or even by means of a single metric, which leaves many aspects of its complex 3D-structure underexposed. By revealing the sharp contrast in overturning strength between the western and eastern subpolar gyre (SPG), the recent OSNAP observations emphasized the importance of considering the AMOC in 3D.

In this study, we explore this further by analyzing the characteristics of the overturning in density space in the North Atlantic SPG on a regional scale, and over time periods ranging from seasons to decades. For this, we use model data from the high-resolution GLORYS12 reanalysis, spanning the period 1993-2020. Following the approach applied in OSNAP, the overturning is assessed from alongstream changes in boundary current transport in specific density classes. This analysis is performed for the entire SPG, for its major basins (Iceland Basin, Irminger Sea, and Labrador Sea) and for smaller segments along the boundary currents, thus providing detailed insights in variations of the overturning varies along the entire SPG boundary.

The mean overturning from GLORYS12 for 1993-2020 is 23.8 Sv, distributed as 41%, 29%, and 30% for the Iceland Basin, Irminger Sea, and Labrador Sea respectively, and peaking at increasingly higher densities in alongstream direction. Within each basin, a pronounced seasonal cycle can be identified, with the maximum overturning occurring in March and the minimum in September. Over the entire reanalysis period, the overturning strength in both the Iceland Basin and Irminger Sea exhibits a weak decreasing trend, whereas the Labrador Sea displays a weak increasing trend.

The subdivision in shorter segments reveals large spatial differences in overturning, both with regard to its overall strength and its distribution over density classes. However, these outcomes are less robust than the analyses on the scale of the major basins, as the flow is highly variable and numerical uncertainties associated with offline overturning calculations become more prominent.

Further research is needed to properly interpret these regional variations, and thereby improve our understanding of the AMOC dynamics and its sensitivity to changing oceanic and atmospheric

forcing conditions. Linking them to local processes known to govern the overturning (i.e., formation of dense waters in the interior of marginal seas and their export, formation of dense waters within the boundary current system itself and the exchange of waters via overflows) seems a viable route.