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Spatial localization and mesoscale modulation of mixing and transformation of the Denmark Strait Overflow

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The Denmark Strait Overflow (DSO) is a major export route for dense waters from the Nordic Seas forming the North Atlantic Deep Water, an important element of the climate system. Mixing processes in the Irminger Basin determine volume transport and properties of the DSO but are poorly resolved by sparse observations which hinders development of DSO mixing parameterizations in global circulation models (GCMs).

We employ a high resolution circulation model (horizontal grid spacing of 2km and 210 levels in the vertical) to investigate transformation and mixing in the DSO in the Irminger Basin and quantify the effect of mesoscale (10-100km) flows unresolved by GCMs. Both the warming rate derived from model Lagrangian particles and the Eulerian eddy temperature flux divergence show elevated values in about a 200km long and 50km wide corridor downstream of the Denmark Strait sill and between the shelf break and the 2000m isobath. In this region, the DSO warms by about 1K, which constitutes most of the transformation along the entire 700km pathway in the Irminger Basin.

The horizontal and vertical mixing is modulated by dense water boluses and overlying cyclonic eddies that propagate together through the Irminger Basin ('beddies'). The passage of beddies increase the squared vertical shear of horizontal velocity by a factor of 3, correspond to increase in the vertical velocity by ten times and double the eddy heat flux divergence leading to a warming of the bottom (densest) waters and a cooling of the interface layer of the overflow plume and the ambient water above. There is a clear correlation between the speed in the nose of the plume, the eddy kinetic energy and the vertical shear in the horizontal flow. The modulation of mixing by the mesoscale variability and the attendant mixing localization should be included in future overflow parameterizations in global circulation models. A targeted field campaign to empirically test these conjectures is another high priority.