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On the role of eddies in the heat transport and overturning circulation in the Nordic Seas

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The factors that determine the heat transport and overturning circulation in marginal seas subject to heat loss to the atmosphere are explored using a combination of a high resolution ocean circulation model and a simple conceptual model. The study is motivated by the exchange between the subpolar North Atlantic Ocean and the Nordic Seas, a region that is of central importance to the oceanic thermohaline circulation. It is shown that mesoscale eddies formed in the marginal sea play a major role in determining the mean meridional heat transport and meridional overturning circulation across the sill. The balance between the oceanic eddy heat flux and atmospheric cooling, as characterized by a nondimensional number, is shown to be the primary factor in determining the properties of the exchange. Results from a series of eddy-resolving primitive equation model calculations for the meridional heat transport, overturning circulation, density of convective waters, and density of exported waters compare well with predictions from the conceptual model over a wide range of parameter space. These results imply that one must accurately resolve or parameterize eddy fluxes in order to properly represent the mean exchange between the North Atlantic and the Nordic Seas, and thus between the Nordic Seas and the atmosphere, in climate models.