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Symmetric and Baroclinic Instability in Dense Shelf Overflows

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We revisit the problem of rotating, stratified dense overflow dynamics by performing numerical simulations of dense water formation on a shelf and transport down a slope using the nonhydrostatic MITgcm. Grid resolutions are 5-20m in the vertical and 25-100m in the horizontal, allowing a wide spectrum of submesoscale variability to be captured. We examine 2- and 3-dimensional cases and find the submesoscale range of both to be dominated by symmetric instability (SI). SI leads to the onset of secondary shear instability, dissipation of geostrophic energy, and water mass modification. Rotating dense overflows are characterized by an initial geostrophic adjustment phase, which creates a bottom-intensified (and compensating surface-intensified) jet. In 2D, Ekman drainage leads to downslope descent of the geostrophic jet, forming a highly dense alongslope front. Beams of negative Ertel potential vorticity develop parallel to the slope, initiating SI and vigorous mixing in the overflow. In 3D, baroclinic eddies are responsible for cross-isobath dense water transport but SI again develops along the slope and at eddy edges. Through two different dynamics the 2D SI-dominated case and 3D eddy-dominated case attain roughly the same final water mass distribution, highlighting the potential role of SI in driving mixing within certain regimes of dense overflows. In the second part of this study we perform analogous simulations using the GFDL-MOM6 hydrostatic model, employing both z* and layered isopycnal vertical coordinate systems. We explore the impact of vertical coordinate, horizontal resolution, and parameterizations of shear-driven mixing and mesoscale eddies on the representation of the water mass transformation processes observed in the high-resolution cases.