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Interpretation of Isopycnal Layer Thickness Advection in Terms of Eddy-Topography Interaction

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Spatially varying amplitude of the eddy isopycnal layer thickness diffusivity Kgm and the layer thickness advection Kgmskew of the modified Gent and McWilliams parameterization are estimated using two different approaches: the adjoint estimation from a global data assimilation system and the inversion calculation according to divergent buoyancy eddy flux-mean buoyancy gradient relation using results from idealized eddy resolving numerical models with various bottom topographies. This work focuses on the properties of Kgmskew. From the adjoint estimation, large Kgmskew values are found along meandering currents and predominantly positive (negative) over the deep ocean and negative (positive) over seamounts in the southern (northern) hemisphere, implying close relation to the 'Neptune effect" parameterization by Holloway in which the eddy induced mean velocity stream function is represented by –fHL, where H is the bottom depth, f the Coriolis parameter and L a length scale. In the inversion calculation, divergent buoyancy eddy fluxes are obtained by removing the rotational components from the total buoyancy eddy fluxes through Helmholtz-Hodge decomposition. Though subject to topographic length scale, the inversed Kgmskew reveals characteristics of both f and H, and interactions with the mean current, inter-confirming the adjoint estimation results. Applying this parameterization for Kgmskew in the general circulation model produces cold domes and anti-cyclonic circulations over seamounts, which reduces common model biases there. By construction, the original thickness advection Kgmskew redistributes potential energy and the original "Neptune effect" parameterization improves potential vorticity conservation, applying the latter into the former as suggested in the present study thus more correctly reproduces the potential vorticity structure over a sloping topography while conserving the total potential energy.