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A vertically non-local neutral diffusion operator for general coordinate models

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Stirring and mixing by mesoscale eddies lead to a downward cascade of tracer variance that is often parameterized as down-gradient diffusion. Within the stratified ocean interior, the so-called 'neutral direction' of these diffusive fluxes is aligned with surfaces of locally referenced potential density. However, model surfaces are in general not aligned with this neutral direction or, in the case of isopycnal models, are only approximate. The commonly used rotated tensor approach in many models is not positive-definite, leading to new extrema, and may induce diabatic mixing in weakly stratified regions. Here we describe and demonstrate a new operator for neutral diffusion that uses a vertically non-local stencil and calculates fluxes on layers bounded by neutral surfaces. In idealized test cases (implemented in the Modular Ocean Model version 6) the algorithm is demonstrated to be extrema-preserving with minimal dianeutral mixing for both linear and nonlinear equations of state (EOS). We further show that locally linearizing the thermal expansion and haline contraction coefficients is nearly as accurate as using the full nonlinear EOS while leading to significant computational performance.

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No

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