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# Lagrangian Ocean Ventilation: Improved Subgrid-Scale Dispersion on Neutral Surfaces

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Mesoscale eddies play a major role in ocean ventilation by stirring ocean tracers, such as carbon, along sloping surfaces of neutral buoyancy. To capture the effects of these turbulent eddies, coarse resolution ocean models resort to tracer diffusion parameterizations that take into account neutral surface slopes. Likewise, when studying tracer pathways in a Lagrangian framework, the effect of eddy dispersion needs to be parameterized when coarse models are used.

Dispersion in Lagrangian simulations is traditionally parameterized by random walks, equivalent to diffusion in Eulerian models. Beyond random walks, there is a hierarchy of stochastic parameterizations, where stochastic perturbations are added to Lagrangian particle velocities, accelerations, or hyper-accelerations. These parameterizations are referred to as the 1$^{st}$, 2$^{nd}$ and 3$^{rd}$ order 'Markov models' (Markov-N*)* respectively. Most previous studies investigate these parameterizations in two-dimensional setups, often restricted to the ocean surface. The few studies that investigated Lagrangian dispersion parameterizations on three-dimensional neutral surfaces have focused only on random walk (Markov-0) dispersion.

Here, we present a three-dimensional isoneutral formulation of the Markov-1 model. We also implement an anisotropic, shear-dependent formulation of Lagrangian random walk dispersion, originally formulated as a Eulerian diffusion parameterization by Le Sommer et al (2011). Random walk dispersion and Markov-1 are compared using an idealized setup as well as more realistic coarse and coarsened (50 km) ocean model output. While random walk dispersion and Markov-1 produce similar particle distributions over time, Markov-1 yields more realistic Lagrangian trajectories and leads to a smaller spurious dianeutral flux.