Exploring the Dynamical Connections between GM and Redi Mixing Coefficients

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The Gent-McWilliams (GM) and Redi eddy parameterizations are essential features to ocean climate models. GM helps to maintain stratification, balancing the steepening of isopycnals by Ekman forcing and convection, with a relaxation that dissipates potential energy adiabatically. The Redi parametrization represents unresolved isopycnal mixing of tracers, while keeping diabatic mixing small. Due to its direct impact on the simulated circulation, research has focused more on theories for the GM than Redi coefficient, the latter typically being set equal to the former without justification.When tuned to values of O(500) m2/s, GM-based simulations are able to reproduce observed ocean stratification. By contrast, observational estimates of along-isopycnal mesoscale diffusivity (the Redi part) are typically an order of magnitude larger. Setting the Redi coefficient to the too-small GM value results in serious errors in biogeochemical tracers like oxygen and carbon (Gnanadesikan et al. 2013, 2015).

Here we investigate this idea using a high-resolution MITgcm simulation of an idealized channel with a topographic ridge. Ten independent passive tracers are advected by the flow, and linear restored to target states that effectively maintain mean gradients in each direction, at each point. The eddy fluxes and mean gradients of these tracers are used to solve an inverse problem, resulting in an estimate of an eddy diffusivity matrix. Notably, the mean is defined as a combined time-average and spatial coarse- graining, resulting in a 3D estimate. The estimated eddy diffusivity tensor shows exceptional skill at reconstructing tracer fluxes, for both passive tracers and active tracers (buoyancy and PV). GM and Redi diffusivities are extracted from the tensor, and are shown to be consistent with a relationship expected from QG theory.