On Simple Global Extrapolations of Topography-Catalyzed Mixing Estimates.

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3. Abstract

Stratification in the deep ocean is maintained by a combination of ventilation at isopycnal outcrops and in situ diapycnal mixing. For the abyssal interior at mid-to-low latitudes, diapycnal mixing is believed by many to be the dominant process maintaining the deep stratification against the influx of very cold water injected into the deep ocean at polar latitudes (e.g., Munk and Wunsch, 1998). Yet, direct measurements and inferred estimates of turbulence in the ocean's interior are well below what is required by the simple advection-diffusion models for maintenance of the stratification. This fact has re-kindled interest in the idea that diapycnal mixing occurs primarily at water-earth boundaries, with the mixed products (but not the turbulence) being stirred into the ocean interior along isopycnals. Intense localized mixing has been observed at boundaries during the past decade but whether it is sufficient to significantly influence basin-averaged diffusivities remains an open question. This work examines how the extrapolation of the intense near-boundary mixing to basin-average diffusivities depends on the resolution of the bathymetry used and the structure function employed for the diffusivity.

Firstly, a geometrical scaling argument (Armi, 1979) to estimate basin-average diffusivities is re-examined in light of the higher resolution, more accurate bathymetric products available now (ETOPO5 versus Smith & Sandwell and swath bathymetry). Secondly, the effect of a more carefully prescribed decay structure of mixing in both the horizontal and vertical distances from topography is investigated. The structure functions investigated are the simple step-function employed by Armi, 1979 versus an exponential decay with both a horizontal and vertical dependence. Lastly, a parameterization based on fine- and microstructure data from various geographic regions and bathymetric roughness is developed. This parameterization takes the form of a power law with a weak dependence on seafloor roughness. Both the step-function and exponential decay are shown to be inadequate descriptions of the mean vertical structure of diapycnal mixing.

It is found that it is plausible that boundary-induced mixing plays an important role in the maintenance of the observed abyssal stratification at least as shallow as three kilometers of depth but is unlikely to result in basin-average diffusivities on the order of the $10^{-4}\text{m}^2\text{s}^{-1}$ at shallower depths. Furthermore, the total dissipation is shown to be highly dependent on the maximum near-boundary diffusivities.