



Abyssal recipes revisited: A new physically-based approach to quantify the vertical diapycnal diffusion profile required to balance water masses formation by surface heat and freshwater fluxes with error bars.

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We revisit the calculation of the diapycnal mixing required to equilibrate the formation of deep water made by Munk and Wunsch 1998 (MW). Our calculation is made possible by a new physically-based density variable, called thermodynamic neutral density, recently introduced by Tailleux 2016, which accurately approximates Jackett and McDougall 1997 empirical neutral density. Unlike neutral density, however, thermodynamic neutral density is a materially conserved variable. As a result, it can only change as the result of diabatic molecular diffusive effects by heat and salt, and is therefore more suitable for studying ocean mixing than neutral density, since the latter can also change as the result of non-material effects unrelated to mixing processes. Climatological temperature and salinity data are used along with heat and freshwater surface fluxes to estimate the diapycnal mean fluxes using a framework stemming from Walin 1982 ideas. The mean fluxes values are estimated to range between $0.2e-4$ m^2/s and $5e-4$ m^2/s for the densest waters and between $0.025e-4$ m^2/s and $0.1e-4$ m^2/s for middepth and surface waters. These values contrast with the previous values of $1e-4$ m^2/s first obtained by Munk 1966 and then by MW, and appear much closer to observational estimates of diapycnal mixing obtained by tracer release or microstructure measurements. We further show that the range of uncertainty in the above values is due to the nonlinearities of the equation of state for density.