Molecular control of turbulent diapycnal mixing in the ocean thermocline

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Turbulent diapycnal mixing is a key process in the ocean that is essential to close the heat and energy budgets. The Cox number C, defined as the ratio of the turbulent diapycnal diffusivity over the background molecular diffusivity, is often used to measure the intensity of turbulent diapycnal mixing. In contrast to the laboratory, where turbulent mixing with a wide range of Cox numbers can be generated, turbulent mixing in the strongly stratified ocean thermocline exhibits Cox numbers that rarely depart from the canonical value $C = O(100)$. Recently, a new synthesis of available turbulent mixing data by [1] suggests that turbulent mixing in the ocean depends on the molecular Prandtl number Pr, and hence may be rate-limited by molecular diffusion. The purpose of this talk is to propose a new physical mechanism that is able to explain how molecular diffusion of heat and molecular viscous dissipation may concur to limit the rate of turbulent diapycnal mixing in strongly stratified environments characterising the ocean thermocline. To that end, [2]'s conceptual framework to study diapycnal mixing is used to rigorously separate the adiabatic stirring effects from the diabatic effects associated with irreverible mixing. Until now, the separation between diabatic and adiabatic effects has been mostly limited to separating the total potential energy into available potential energy and background potential energy. In this work, we show that this separation can be further extended to vertical transport, thus providing a decomposition of the buoyancy flux into adiabatic reversible and irreversible diabatic components. Scaling of the diabatic velocity field yields a scaling for the Cox number $C = O(P_r^2)$. Since $P_r = O(10)$ in the ocean, the theory yields $C = O(100)$, which is roughly in agreement with observed Cox numbers.

References

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