Bounds on Mixing in Stratified Shear Flows

Dr. Colm P. Caulfield

Environmental Engineering Group, Mechanical and Aerospace Engineering,
Jacobs School of Engineering, University of California, San Diego

Flows where both the velocity and density vary with height (i.e. stably stratified shear flows) are ubiquitous in nature. Of crucial importance to appropriate description of the redistribution of heat, momentum and chemical species within such flows is a detailed understanding both of the fundamental processes that trigger transition to turbulence and also the mixing characteristics of the ensuing turbulence. Significant progress towards addressing this problem has been made through the relatively recent advent of adequately resolved three-dimensional simulations. When combined with innovative theoretical, experimental, and observational results, a detailed picture is beginning to emerge of the qualitative and quantitative aspects of the time-dependent reversible mixing associated with small-scale disordered motion within such flows.

Of particular interest is the efficiency of the mixing, i.e. the proportion of the kinetic energy that is lost by the underlying shear flow that leads to irreversible increases in the potential energy of the system. In this talk, I will review the characteristics of mixing within a range of stratified shear flows. I will also present theoretical arguments and numerical evidence that point towards the existence of a well-defined bound on the attainable maximum intensity of mixing within a stratified shear flow. It appears that, over a sufficiently long-time average in a turbulent flow, no more than half the kinetic energy lost by the shear can be converted irreversibly into potential energy; the rest must be lost through viscous dissipation, thus constraining significantly the extent to which shear-driven turbulence can drive irreversible mixing.

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