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A re-examination of the gradient Richardson number criterion for the instability of stratified fluids

The gradient Richardson number is perhaps the aspect of classical hydrodynamic stability theory with the farthest reach in the natural sciences. This is because the so-called Richardson number criterion is often used as both a proxy for instability and mixing in the natural environment, as well as in parametrizations in large scale ocean and atmosphere models. Yet at the same time, it is well know that the Richardson number less than 0.25 is a necessary, and not sufficient, criterion for instability of stratified, parallel shear flow. Moreover, examples exist in the published literature of the inadequacy of the Richardson number in determining whether a flow remains stable, or undergoes instability and transition to turbulence. In this talk I will begin by reviewing several relevant examples from the literature related to the Richardson number. I will then present results of relatively simple simulations of the stratified adjustment process. These reveal the complex manner in which long waves, such as internal solitary waves, coexist with short wave instabilities in situations for which the Richardson number of the background state remains higher than 0.25. The initial perturbation acts to dynamically modify the background state, leading to significant short wave activity, and for long times, the breakdown of some of the internal solitary waves present.