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Is the work of expansion/contraction really negligible in weakly compressible turbulent stratified flows?

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One of the most popular approximation in the study of turbulent stratified fluids is the incompressible Boussinesq approximation, which is often done both in the oceans and in the atmosphere. The textbook justification usually states that such an approximation is valid if density fluctuations remain small relative to the total density of fluid. Moreover, the arguments used are usually reliant on scaling arguments, and the use of a single length and time scale to estimate the relative magnitude of the terms involved. Turbulent stratified fluids, however, are arguably composed a continuous spectrum of interacting scales that go all the way to the molecular diffusive scales at which compressibility effects can be shown to be very large. The purpose of this work will be to revisit the classical analysis of compressible effects in turbulent stratified fluids by using a global energetics approach that remains valid for a strongly interacting spectrum of scales ranging from large-scales to microscopic ones. The main conclusion is that such an approach reveals that although compressible effects are most effective at the smallest diffusive scales, they are nevertheless associated with leading order energy conversions which may be associated with significant non-viscous dissipation of kinetic energy. The dependence of these effects on the equation of state will be discussed, as the effects appear to be significantly different in dry air and seawater.