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Compressibility effects in nearly incompressible turbulent stratified fluids: Do they matter or do they not?

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Molecular diffusion of temperature in turbulent stratified fluids causes local heating and cooling anomalies, which in turn induce positive and negative pressure and specific volume anomalies; ultimately, these cause an internal energy transfer between internal energy and mechanical energy (i.e. kinetic energy and/or gravitational potential energy) mediated by the compressible work of expansion/contraction. Because the magnitude of the local heating/cooling anomalies due to molecular diffusion increases with the strength of the stratification and turbulence, a legitimate question is whether the compressible effects that they induce may sometimes become dynamically important in turbulent stratified fluids. Until now, the role of compressible effects in nearly incompressible turbulent stratified fluids has remained very unclear, owing to such fluids being in general systematically studied in the context of the incompressible Boussinesq approximation.
The purpose of this work will be: 1) To show that the incompressible Boussinesq approximation, despite its "incompressible" label, actually explicitly represents a large fraction of the compressible effects due to molecular diffusion, which can be formally identified with the changes of gravitational potential energy caused by changes in mass due to diabatic effects; 2) To show that a large fraction of the compressible work is actually dynamically passive, as merely involved in moving irreversibly the centre of gravity of the background stratification; 3) Discuss the potential dynamical importance of the remaining compressible effects not captured by the incompressible Boussinesq approximation, and not involved in effect 2), by using exact methods based on combining the entropy and potential enthalpy budgets in the context of mechanically-stirred (or not) horizontal convection.