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Analysis of the entropy budget at stable stratification using LF Richardson's notion of the intrinsic energy

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The second law of thermodynamics requires positive internal entropy production rates. All subgrid scale processes in our models have to be described to be irreversible. A naive analysis of the heat flux parameterization at stable stratification reveals however, that the second law is violated by our usually applied methods. It will be explained that, when counting the TKE flux as a sort if heat flux additionally to the classical sensible heat flux, their sum must be downgradient the temperature. In fact, this flux sum is then nearly zero, since the subgrid scale processes describe nearly adiabatic motions where TKE and TPE are continuously transformed into each other. Hence, at stable stratification the shear production is the main dissipation rate. Parameterization developers have to check their code with respect to the second law constraint. Unfortunately, the usually applied Boussinesq approximated equations hide the problem. Those equations may not be formulated in accordance to the Gibbs fundamental equation from which the entropy budget follows.

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