Effects of large density contrasts in Unstably Stratified Homogeneous Turbulence

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In this work, we investigate numerically the effects of large density contrasts on the dynamics of buoyancy-driven turbulence, commonly encountered in geophysical and astrophysical flows. To this aim, we use the Variable Density equations[1,2], extending the Boussinesq approximation to large Atwood number flows. In particular, we consider the framework of Unstably Stratified Homogeneous Turbulence (USHT)[3], which is a paradigm of Rayleigh-Taylor mixing layers with a constant vertical density gradient (an example of density field is shown on Figure 1). In this study, we focus on the dynamics of large eddies[4], emphasizing the growth rate of turbulent kinetic energy, on the anisotropy of the density structures and on the small-scale mixing. More thoroughly, we establish the scale-by-scale kinetic energy budget and analyze how it is modified, by comparison with the Boussinesq framework. To address these different topics, highly resolved Direct Numerical Simulations of Variable Density and Boussinesq USHT have been performed with the 3D pseudo-spectral code STRATOSPEC[5].

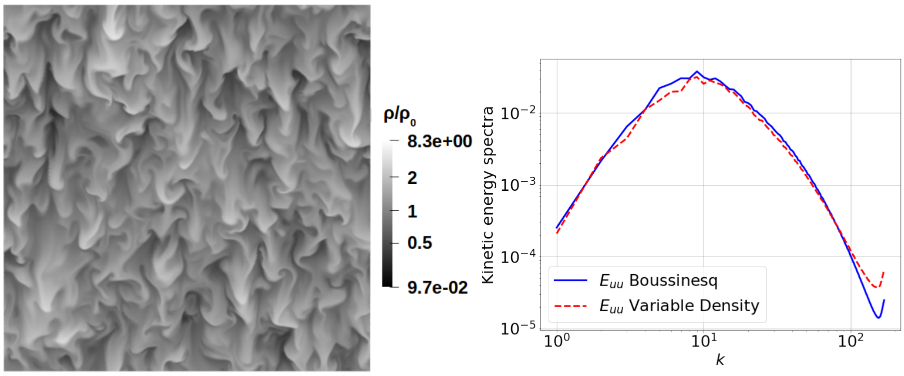

Figure 1: Left: 2D-slice of the normalized density field ρ/ρ_0, from a Variable Density USHT simulation at an early time. Even though the non-Boussinesq effects are weak, large density contrasts can be observed. Right: turbulent kinetic energy spectra at the same time. The turbulent energy gap at small scales is due to steeper density gradients in Variable Density USHT.

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