Variable-density turbulent mixing in the presence and absence of a constant acceleration field

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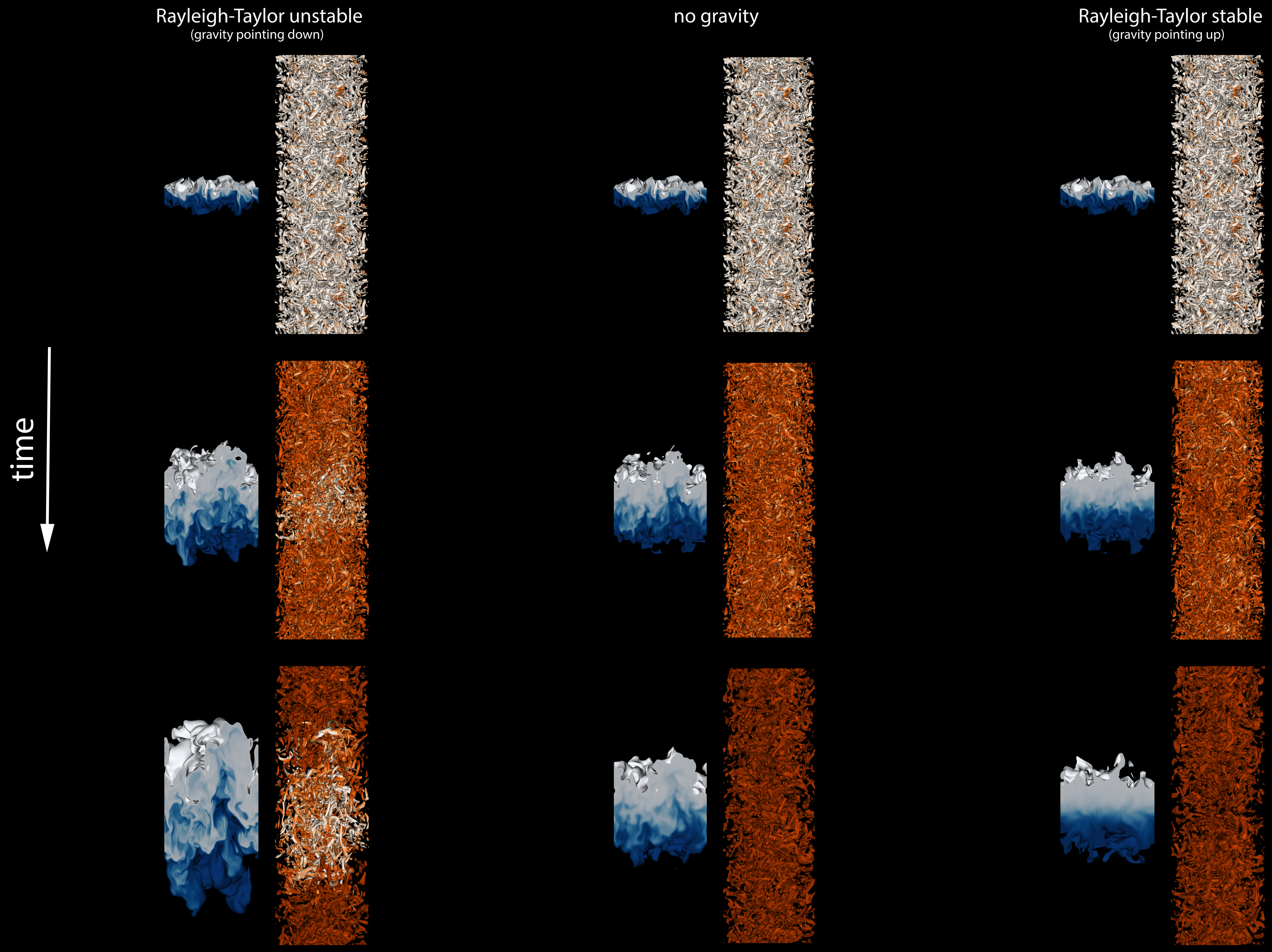
In a variety of problems in atmospheric, oceanic, and astrophysical flows, interfaces are subjected to an acceleration field and evolve to a turbulent mixing region. In this work, we perform direct numerical simulation to investigate the temporal evolution of an unperturbed interface in the presence of an existing isotropic turbulent field. We consider three different set-ups: stably stratified (light over heavy), zero acceleration, and unstably stratified (heavy over light). In the stably stratified set-up (Rayleigh-Taylor stable), buoyancy retards the growth of the mixing region as a portion of the kinetic energy is expended on mixing the two fluids. Vortices become parallel to the plane perpendicular to gravity as the motion in that direction is suppressed. In the absence of gravity, the mixing region grows self-similarly due to turbulent diffusion, with the large-scale density gradient across the mixing region being the only source of anisotropy inside the mixing region. In the unstably stratified set-up (Rayleigh-Taylor unstable), energy is fed into the initially decaying field, thus resulting in a higher growth. The vortices inside the mixing region are more energetic due to the large-scale baroclinic vorticity generation and exhibit a preferred alignment in the direction of gravity.



Isosurfaces of Q-criterion colored with vorticity (white: high, orange: low) and volumetric plots of the mixing region at t/τ= 1 (top), 10 (middle) and 20 (bottom).
The heavy fluid is three times denser than the light fluid in the bottom.