Under-resolved turbulent mixing

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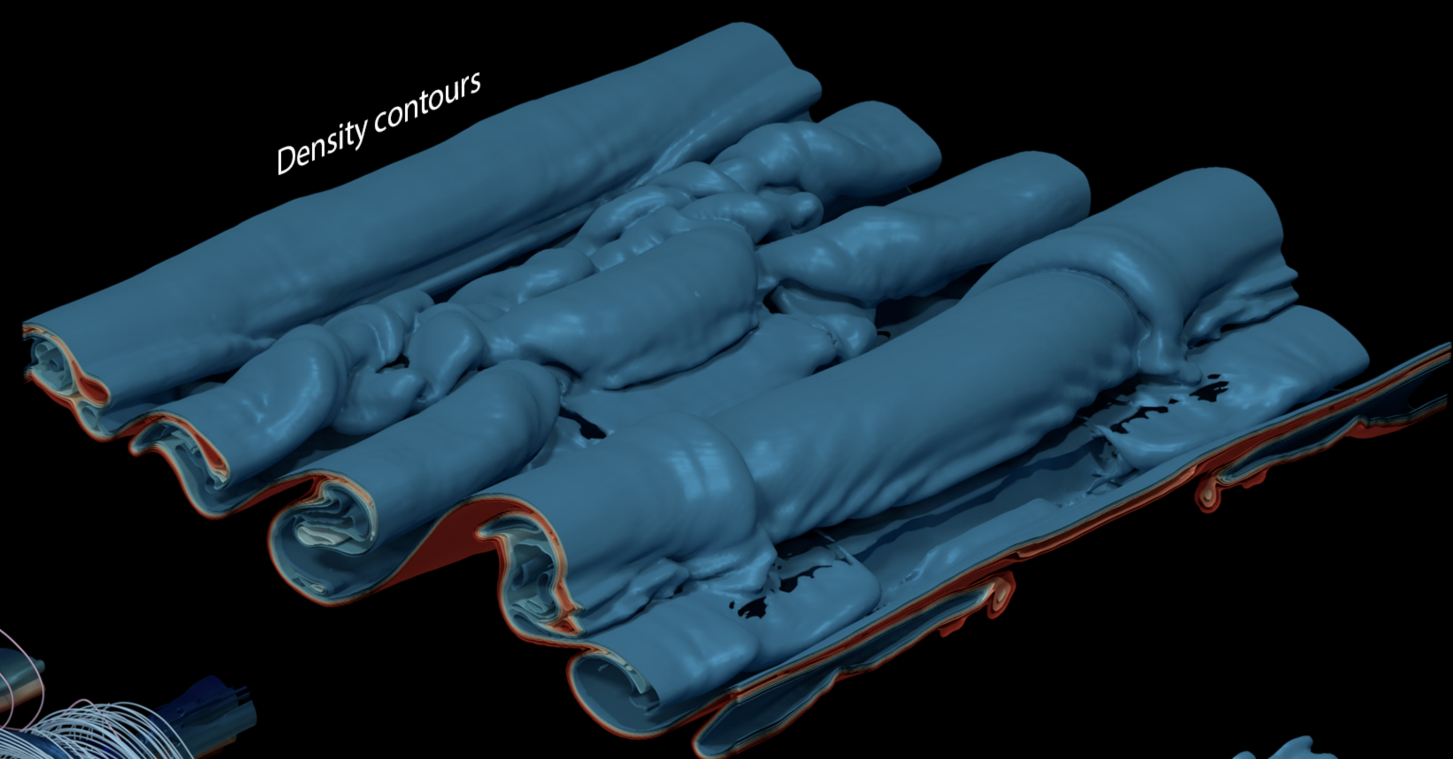

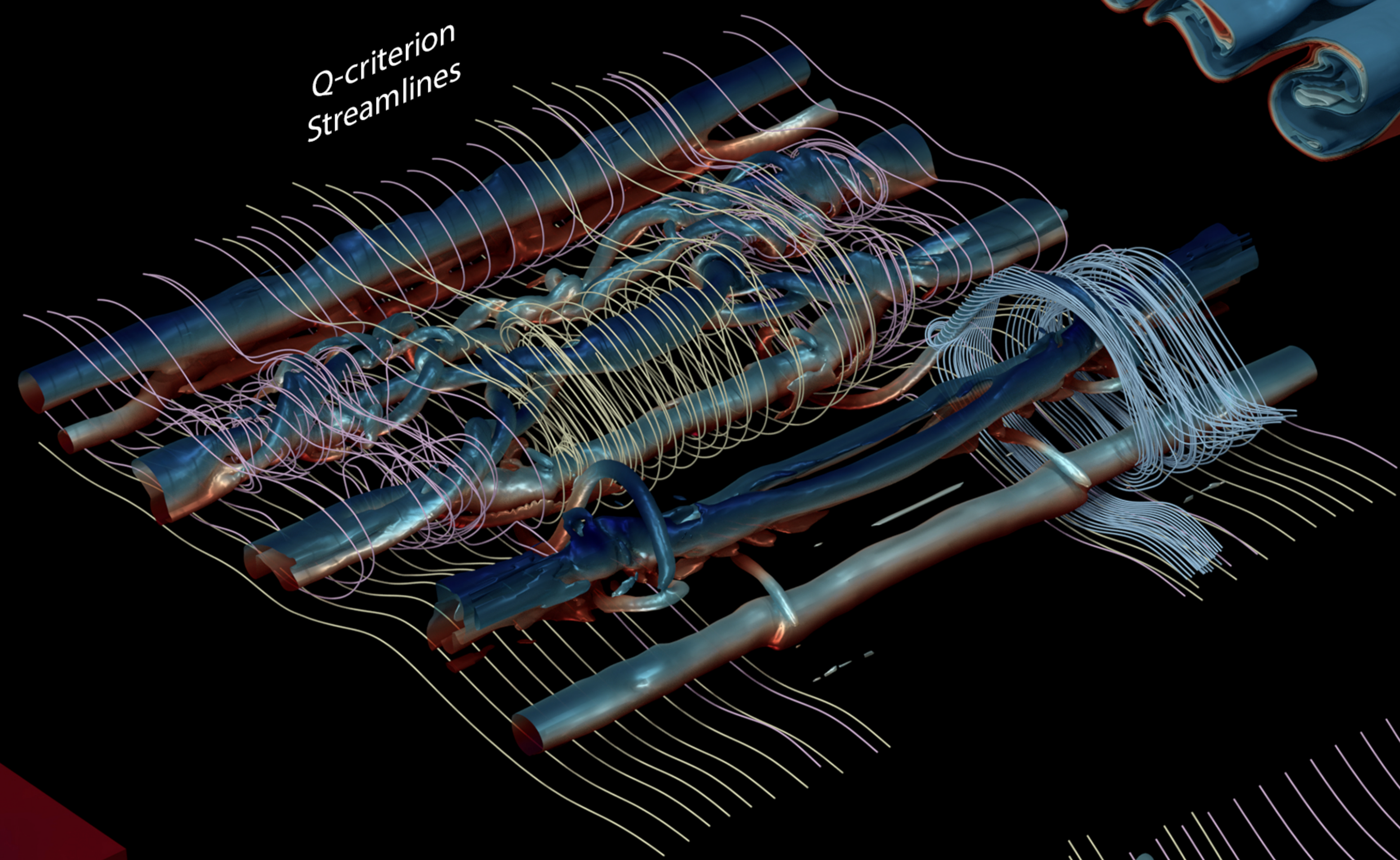

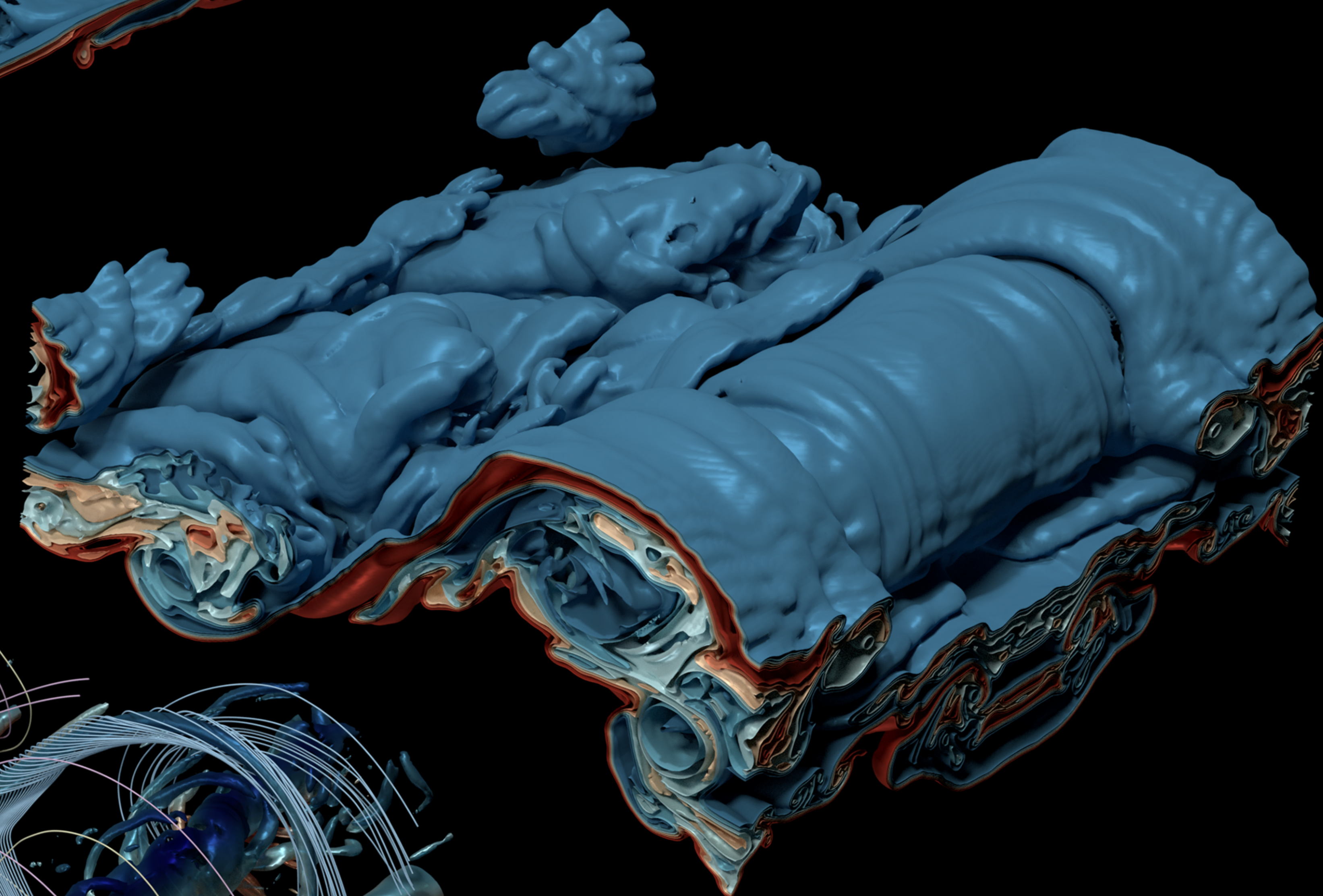

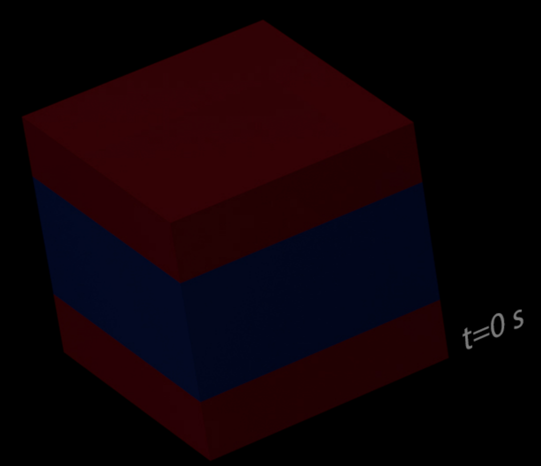

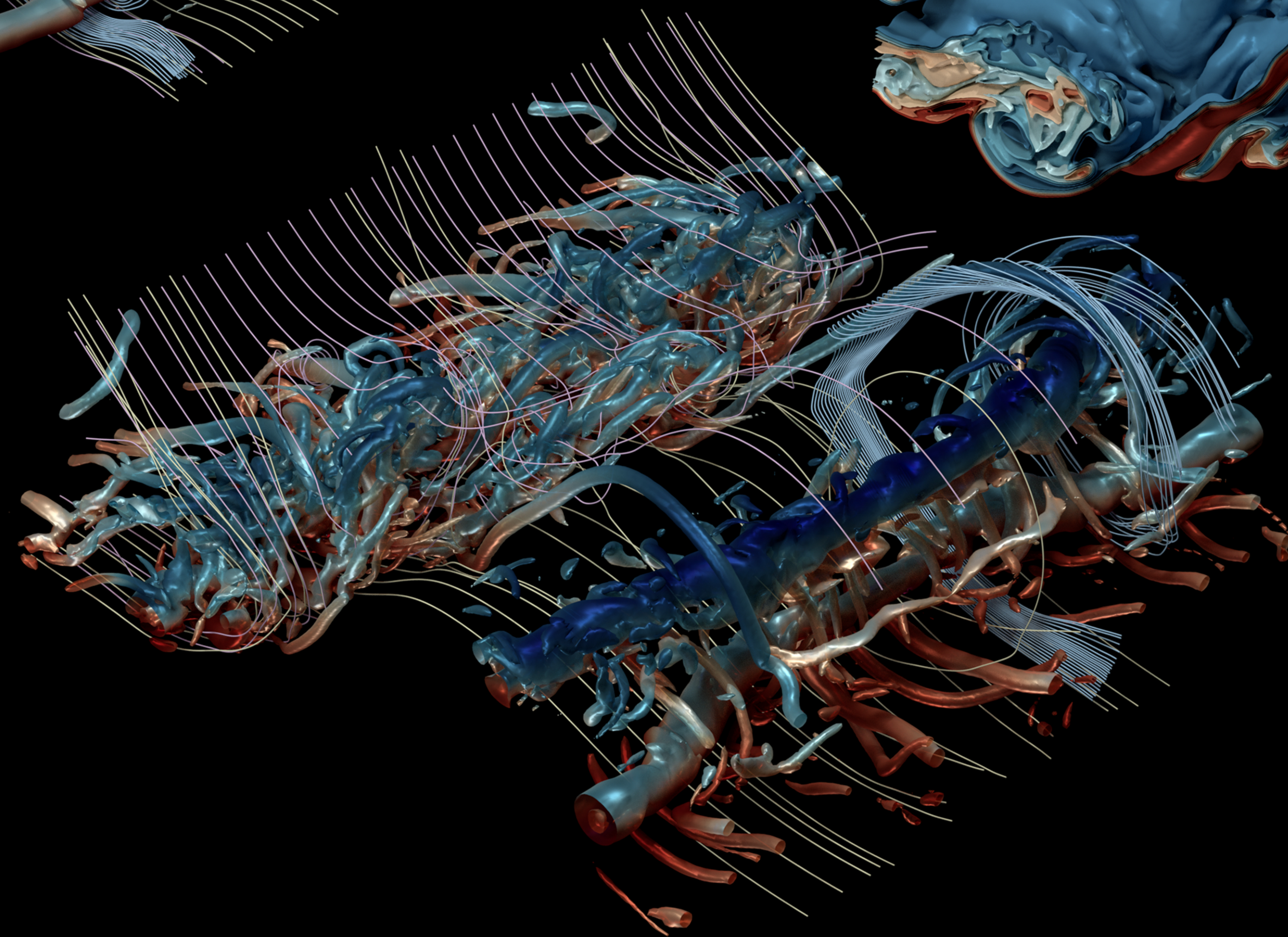

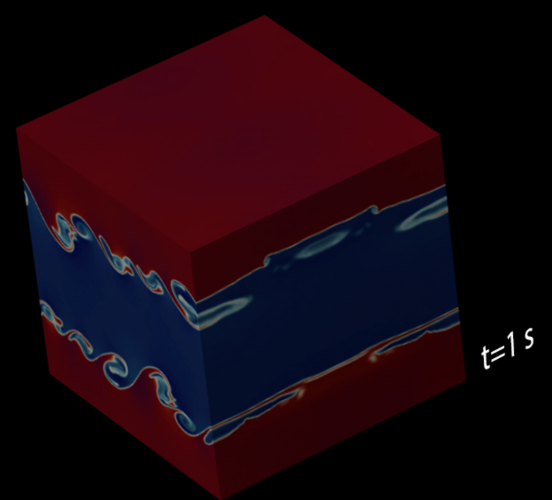

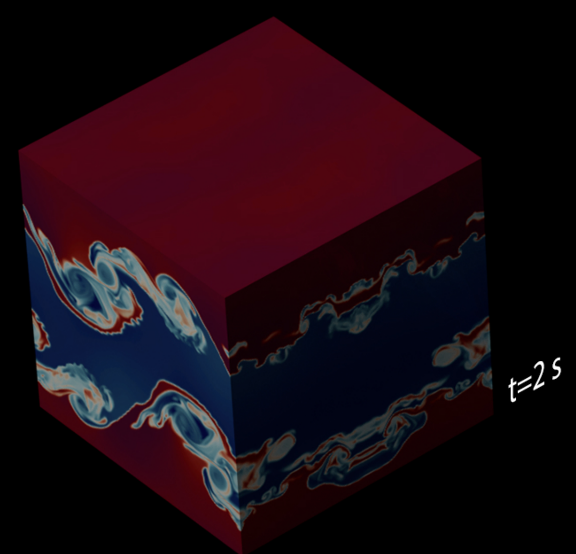

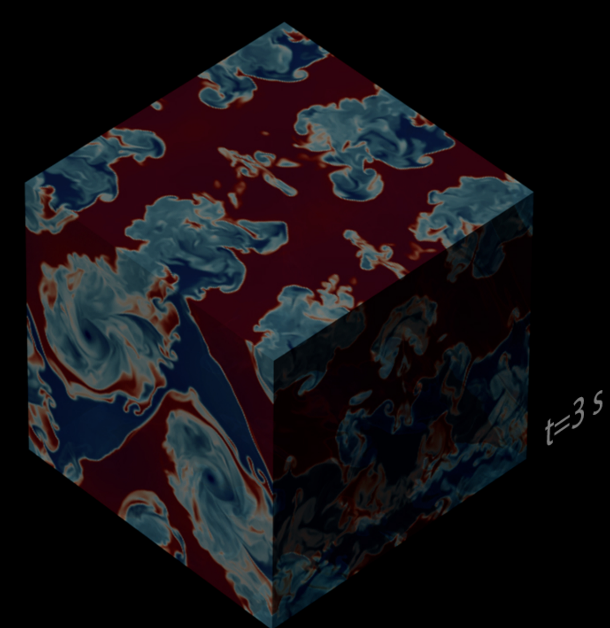

Compressible turbulence is a highly nonlinear multiscale phenomenon. It has become one of the most challenging problems in computational physics.

Turbulent flows can be numerically reproduced by means of hydrodynamic solvers. A common approach is the use of the Euler equations in combination with a suitable numerical discretization method. When the numerical diffusion inherent to the discretization method mimics the physical dissipation of the unresolved turbulent motion, the approach is called Implicit Large Eddy Simulation (ILES).

ILES methods accurately reproduce the statistical behavior of turbulent flows. The truncation errors of the scheme play the role of the common sub-grid scale filters used in traditional LES methods. High-fidelity simulations can be achieved when using this approach.

A 7-th order ILES solver is used to compute a Kelvin-Helmholtz instability inside a periodic box with 256^3 cells. The initial condition is configured as a stratified shear layer with an initial sinusoidal perturbation.

The figures show two snapshots of the flow field in the lower half of the box at t=1 s and t=2 s. They show the fundamental essence of turbulence as a physical phenomenon. Due to the initial perturbation, large vortex tubes are formed and are then rolled-up and twisted (t=1 s) to form small-scale 3D turbulent structures (t=2 s). Such structures are then converted into even smaller vortices, which are eventually dissipated.

The vortical structures are depicted using the Q-criterion and are coloured by the velocity magnitude, allowing to show the strong shear suffered by the vortex sheets.