Self-similarity of a Rayleigh-Taylor mixing layer at low Atwood number with a multimode initial perturbation

BRANDON MORGAN, BRITTON OLSON, Lawrence Livermore National Laboratory, JUSTIN WHITE, JACOB MCFARLAND, Department of Mechanical and Aerospace Engineering, University of Missouri — High-fidelity large eddy simulation (LES) of a low-Atwood number ($A = 0.05$) Rayleigh-Taylor mixing layer is performed using the tenth-order compact difference code Miranda. An initial multimode perturbation spectrum is specified in Fourier space as a function of mesh resolution such that a database of results is obtained in which each successive level of increased grid resolution corresponds approximately to one additional doubling of the mixing layer width, or generation. The database is then analyzed to determine approximate requirements for self-similarity, and a new metric is proposed to quantify how far a given simulation is from the limit of self-similarity. It is determined that the present database reaches a high degree of self-similarity after approximately 4.5 generations. Finally, self-similar turbulence profiles from the LES database are compared with one-dimensional simulations using the $k-L-a$ and BHR-2 Reynolds-averaged Navier-Stokes (RANS) models. The $k-L-a$ model, which is calibrated to reproduce a quadratic turbulence kinetic energy profile for a self-similar mixing layer, is found to be in better agreement with the LES than BHR-2 results.

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