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Rayleigh–Taylor Turbulent Mixing: Synergy Between Simulations, Experiments, and Modeling (Invited)

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Recent work by the author and collaborators on simulation, experiments, and modeling of Rayleigh–Taylor turbulent mixing is reviewed. Specifically, it is shown how the synergy between increasingly sophisticated direct numerical simulation (DNS) of Rayleigh–Taylor instability-induced turbulence and recent experiments has led to a more advanced understanding of modeling such turbulence using Reynolds-averaged Navier–Stokes (RANS) simulation. A DNS inspired by detailed measurements of the initial stages and subsequent evolution of Rayleigh–Taylor mixing in small Atwood number water channel experiments conducted at Texas A&M University is described. Data from the simulation is used to gain both fundamental insights into the flow and to provide an *a priori* validation of a four-equation RANS model based on mechanical and scalar turbulent evolution. The model is also validated *a posteriori* against the DNS data and against data from experiments at small and large Schmidt numbers. A similar study conducted using an intermediate Atwood number, large Reynolds number DNS dataset is also discussed. A similar four-equation RANS model is validated *a priori* using the data. The analysis of both RANS models includes a study of the model coefficients that give the best fit to the respective DNS data. The implications of these studies for the development of state-of-the-art RANS models of Rayleigh–Taylor turbulent mixing are discussed.

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