88b Large-Eddy Simulation of Turbulent Reactive Flows

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Numerical computation of turbulent reacting flows is a vital tool in the design and analysis of chemical processes. The wide range of length and time scales and their complex interaction that occur in such flows, pose a formidable computational challenge. In the recent past, large-eddy simulation (LES) has emerged as a reliable computational tool for modeling turbulent flows. LES resolves all large-scales of the flow and models the unresolved small scale features which are assumed to be universal in non-reacting turbulent flows. However, fast chemical reactions occur at the smallest length scales and need to be modeled exclusively. In this work, we detail the development of the hybrid LES-filtered-density-function (LES-FDF) approach for the simulation of turbulent reacting flows. LES is a deterministic method while solution to the high-dimensional FDF transport equation requires a Lagrangian Monte-Carlo method. Several modeling and algorithmic issues regarding such coupling are addressed. Using this new algorithm, for the first time, a series of experimental flames are computed with detailed chemistry. Such a rigorous test shows the feasibility, robustness and adaptability of the LES-FDF methodology. Extensions to multi-phase reacting flows are also discussed.