Preface

This volume contains the 2011 annual research briefs of the students, postdoctoral fellows, research staff and senior visitors of the Center for Turbulence Research (CTR). Thirty scholars from around the world had residence at CTR and contributed to its program in broad areas of fluid mechanics.

The volume begins with twelve articles on development, validation and applications of large eddy simulation (LES) to complex multi-physics flows. These include calculation of supersonic jet from complex nozzles with chevrons used to mitigate noise, subgrid scale modeling for primary atomization of liquid jets, wall modeling for subsonic and supersonic flows with shock waves, and prediction of laminar/turbulent transition. With exponential growth in supercomputer resources, LES has become a viable tool for prediction and better understanding of complex turbulent flows of practical interest. However, proper development and use of LES requires an interdisciplinary approach integrating numerical analysis, computer science and physics-based modeling. The CTR environment has been conducive to bringing together scholars in various pertinent areas to develop the LES technology for engineering analysis. This development has been a key goal of CTR since its founding twenty-five years ago.

Quantification of uncertainties in the output of numerical simulations has been at the core of the predictive science program at CTR which is supported by the National Nuclear Security Administration. Among various possible sources of uncertainties, the most difficult to tackle are epistemic uncertainties due to turbulence model form, a natural fit and challenge for CTR. Two of the featured reports are concerned with epistemic uncertainty quantification with a particular emphasis on turbulent mixing models and reaction rates of chemical mechanisms.

Prediction of turbulent combustion is a pacing item for high fidelity numerical simulations, and continues to be a major component of research and method development at CTR. Liquid fuel atomization, Lagrangian drop tracking, models for break-up, coalescence and evaporation of drops, and reduced order models for the chemistry remain all outstanding problems in this field. The papers that follow report on the supersonic and subsonic turbulent combustion efforts at CTR and include novel experimental studies for model validation.

The next group of reports concerns development of accurate and efficient numerical methods for compressible and multi-phase flows. In particular, the large number of runs required for gathering statistical samples for the uncertainty quantification effort has led to renewed demand for ever more efficient numerical methods. We have also formed a new study group at CTR to address persistent numerical challenges in simulation of multi-phase flows.

We thank Deborah Michael for her day to day management of CTR. The CTR roster for 2011 is provided in the Appendix. This volume is available at the CTR site on the worldwide web (`http://ctr.stanford.edu`).

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