Preface

This volume contains the 2012 annual research briefs of the students, postdoctoral fellows, research staff and senior visitors of the Center for Turbulence Research (CTR). Twenty-nine scholars from around the world had residence at CTR and contributed to its program in broad areas of fluid mechanics. In addition to its ongoing research activities, this year CTR sponsored its fourteenth biennial Summer Program, with ninety-one participants. The proceedings of the Summer Program are published in a separate volume.

This volume begins with modeling and simulation of turbulent combustion, a highly non-linear, multi-scale phenomenon. In the context of the Predictive Science Academic Alliance Program (PSAAP) at Stanford, the first two briefs develop and apply a model for uncertainty quantification (UQ) of high-speed turbulent combustion in a scramjet engine. In particular, it is shown that an uncertainty-aware flamelet progress-variable approach can serve as a dimensionality-reducing gate when analyzing uncertainties.

The UQ theme continues through the next group of briefs, starting with an integrated multi-fidelity investigation of uncertainties associated with shock/boundary layer interaction, a phenomenon important to scramjet combustors. In addition to aleatory uncertainties in inflow conditions and geometry, epistemic uncertainties associated with assumptions underlying turbulence models were also considered. Details of the method used to quantify epistemic uncertainties are provided in a following brief. Other briefs in this group address the challenge of applying UQ to flows containing sharp features, such as shocks.

The next group of briefs focuses upon reduced-order modeling, and the first in this group provides a link between this topic and UQ. Dynamical reduced-order models are also essential to efficient flow control, motivating the development of sparsity-promoting and low-rank versions of the dynamic mode decomposition (DMD). Related to reduced-order modeling, stability analysis is important to understanding the key dynamics underlying many flows, and is addressed by two briefs.

Similar to turbulent combustion, simulation of multi-phase turbulent flows is challenging because of the new length scales and physics introduced by the phase interface. The next group of briefs study simulation techniques ranging from the level set method to Eulerian representation of polydisperse flows, and assess their predictive power.

The next group of briefs addresses the development and application of large eddy simulation (LES) as a predictive tool for complex turbulent flows. Accurate and efficient sub-grid scale models for wall-bounded turbulent and transitioning flows is a topic of several briefs in this group. Exponential increase in computer power enables increasing numbers of inter-disciplinary applications of LES, ranging from simulation of a full scramjet engine to an investigation of crackling supersonic jets to solar convection.

We thank Rika Bosmans for her day to day management of CTR and Marlene Lomuljo-Bautista for her continued support of postdoctoral scholars at CTR. The CTR roster for 2012 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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