Preface

This volume contains the 2022 Annual Research Briefs that summarize the research activities at the Center for Turbulence Research (CTR). In addition to the studies reported in this volume, CTR sponsored its eighteenth biennial Summer Program earlier this year. A volume documenting the findings from the Summer Program is published separately.

The central objectives of CTR are the investigation and understanding of fundamental aspects of turbulent flows, and the development of physics-based models and computational tools for multi-scale analysis and prediction of engineering systems. The eighteen reports contained in this volume are arranged as follows. The first seven reports are focused on fundamental studies and development of predictive models for engineering applications of wall-modeled large-eddy simulation (WMLES) for high-speed aerodynamics. These include development and evaluation of a near-wall model which accounts for comprehensibility and heat transfer effects, and application of LES to transonic flows with shock-induced flow separation. A novel application of WMLES reported in this group is a study of effects of icing on aircraft aerodynamic loads.

The next three reports are devoted to deepening the intersection of turbulence studies with computer and data science tools. The first two reports in this group include the development of a task-based parallel framework to facilitate complex workflows of ensemble simulations and in situ data analysis, and its application to online training of a neural-network for sensing and inference. The third report offers a critical assessment of the use of neural networks in LES. The subjects of the first two reports are motivated by a central goal of the Stanford PSAAP-III Center to perform integrated exascale simulations of laser-based ignition of a model rocket combustor.

Two-phase and reacting flows, and numerical methods are the focus of the rest of this volume. Topics here include the development of a phase-field method for unstructured grids, assessment of material interface capturing numerical schemes, modeling of scalar-transport, and analysis of boundary condition for modeling contact lines. The remaining three reports are respectively focused on a strategy for direct numerical simulation of shock-turbulence interaction in high-enthalpy nonequilbrium flows, reduced-order modeling of non-premixed flame for analysis of thermoacoustic instabilities, and the effect of imposed boundary conditions on the global mode analysis of the receptivity process in high-speed external aerodynamics.

The investigations reported in this volume have been supported by the Department of Energy (DOE) through the Advanced Simulation and Computing (ASC) Program, the National Aeronautics and Space Administration (NASA), and the Boeing company. Many high-fidelity simulations reported in this volume used resources of the Oak Ridge Leadership Computing Facility at the Oak Ridge National Laboratory, which is supported by the Office of Science of DOE.

The CTR roster for 2022 is provided in the Appendix. Also listed are the members of the CTR Steering Committee, which has met quarterly to act on fellowship applications.

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`http://ctr.stanford.edu`

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