Preface

This volume contains the 2003 Annual Progress Reports of the postdoctoral fellows and visiting scholars of the Center for Turbulence Research. In 2003 CTR sponsored 19 resident Postdoctoral Fellows, 5 Senior visiting scholars, 4 doctoral students and hosted 9 Research Associates. The volume contains progress reports on a wide range of subjects reflecting the impact of the dynamic subgrid scale model on new application areas, and the close association of CTR with efforts funded at Stanford University by the Department of Energy, the Air Force Office of Scientific Research and the U.S Office of Naval Research. The development of core technology for gas turbine application remains the largest component of CTR's effort. This reflects the support received by CTR from NASA's Ultra Efficient Engine Technology Program in turbulent combustion research. Close coordination with the efforts supported by DOE's ASCI program at Stanford enables rapid transfer of progress in fundamental understanding and modeling to realistic aircraft engine simulations. Several reports show progress in simulation of multiphase flows in general, and sprays in particular. Level set methods have been developed to model the primary breakup of sprays, and adaptive level set methods have been applied to study three-dimensional breakup of drops. A new Eulerian-Lagrangian formation shows great potential for the extension of particle methods to the dense regime in sprays. Advances in multiphase flow simulation enabled new studies in other problems such as the Richtmyer-Meshkov instability. Major progress has been made in transferring the multiphase technology to the unstructured LES code being developed to simulate realistic gas turbine combustors. Simulation of the flow in turbine blade cooling passages shows the power of the immersed boundary technique in enabling realistic simulations in complex geometry, and is a good example of the continuing and indispensable research at CTR on numerical methods. The increased number of reports on geophysical and astrophysical applications reflects an active effort at CTR to contribute to all of NASA's enterprises. Close collaborations with scientists from NASA's Solar Dynamics Observatory (SDO) project have been established. New macroscopic models of radiative transfer are being developed for application to the soot problem in combustion and to atmospheric and solar simulations. The application of improved sub-grid scale models in cloud simulations show great potential in improving the predictive capability of atmospheric codes. Early indications point to a similar success in improving simulations of the sun interior. New transport equations for sparse particle systems such as clouds, have been derived and will be applied to cloud seeding by aircraft contrails. Ocean modeling is becoming of increased importance to NASA in support of its mission to understand and protect our home planet. Efforts in this area have focused on simulating regional ocean patterns. Other efforts show continued support by CTR of fundamental studies in turbulence and other multiscale phenomena. These theoretical efforts have been the seed of new ideas and will continue to be of interest to CTR.

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