Coarse Grained Simulation and Turbulent Mixing

Small-scale turbulent flow dynamics is traditionally viewed as universal and as enslaved to that of larger scales. In coarse grained simulation (CGS), large energy-containing structures are resolved, smaller structures are spatially filtered out, and unresolved subgrid scale effects are modeled. *Coarse Grained Simulation and Turbulent Mixing* reviews our understanding of CGS. Beginning with an introduction to the fundamental theory, the discussion then moves to the crucial challenges of predictability. Next, it addresses verification and validation, the primary means of assessing accuracy and reliability of numerical simulation. The final part reports on the progress made in addressing difficult nonequilibrium applications of timely current interest involving variable density turbulent mixing.

The book will be of fundamental interest to graduate students, research scientists, and professionals involved in the design and analysis of complex turbulent flows.

Fernando F. Grinstein is a scientist at the X-Computational Physics Division of the Los Alamos National Laboratory. He is a world leader in issues of large eddy simulation (LES) of turbulent material mixing physics in complex multidisciplinary applications. He has led integration efforts of the pioneers of the implicit LES techniques in workshops and special meetings worldwide, and in the first comprehensive description of the methodology, *Implicit LES: Computing Turbulent Flow Dynamics*, written with Len Margolin and William Rider.

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To
Julia and Frederic,
and to the many contributors to this volume.

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Preface

The small scale turbulent flow dynamics is traditionally viewed as universal and enslaved to that of larger scales. In coarse grained simulation (CGS) large energy containing structures are resolved, smaller structures are spatially filtered out, and unresolved subgrid scale (SGS) effects are modeled. CGS includes classical large eddy simulation (LES) strategies focusing on explicit SGS models, implicit LES (ILES) relying on SGS modeling and filtering provided by physics capturing numerical algorithms, and, more generally, LES combining mixed explicit/implicit SGS modeling. The CGS strategy of separating resolved/unresolved physics constitutes the viable approach to address complex transition, unsteady flow, and multiphysics in practical geometries.

The validity of the scale separation assumptions in CGS needs to be carefully tested when potentially important SGS flow physics is involved, specifically, for turbulent material mixing – the underlying focus of the book. Fundamental CGS issues receiving special dedicated attention, include: (1) coupling convectively driven flow with relevant other physics – for example, with material mixing and combustion; (2) inherent sensitivities of turbulent flow to initial conditions; and (3) capturing complex turbulent mixing consequences. The book reviews our understanding of CGS, its theoretical basis, verification, validation, predictability aspects, and reports progress in difficult nonequilibrium applications of timely current interest involving variable density turbulent mixing.

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