IMPLICIT LARGE EDDY SIMULATION

The numerical simulation of turbulent flows is a subject of great practical importance to scientists and engineers. The difficulty in achieving predictive simulations is perhaps best illustrated by the wide range of approaches that have been developed and are still being used by the turbulence modeling community. In this book the authors describe one of these approaches: implicit large eddy simulation (ILES). ILES is a relatively new approach that combines generality and computational efficiency with documented success in many areas of complex fluid flow. This book synthesizes the current understanding of the theoretical basis of the ILES methodology and reviews its accomplishments. Here ILES pioneers and lead researchers combine their experience to present the first comprehensive description of the methodology. This book should be of fundamental interest to graduate students, basic research scientists, and professionals involved in the design and analysis of complex turbulent flows.

Fernando F. Grinstein and Len G. Margolin are theoretical and computational physicists in the Applied Physics Division of Los Alamos National Laboratory.

William J. Rider is theoretical and computational physicist in the Computational Physics Research and Development Department of Sandia National Laboratories.
To our parents,
our wives, Julia, Holly, and Felicia,
our children, Frederic, Rachel, and Jackson,
and the many contributors to this volume.
Implicit Large Eddy Simulation

COMPUTING TURBULENT FLUID DYNAMICS

Edited by

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Preface

This book represents the combined efforts of many sponsors. Most of the basic planning and organization was carried out while one of us (F. F. Grinstein) was the 2003–2004 Orson Anderson Distinguished Visiting Scholar at the Institute for Geophysics and Planetary Physics (IGPP) at Los Alamos National Laboratory (LANL). It is very important that we acknowledge the critical role played by the implicit large eddy simulation (ILES) workshops at LANL in January and November of 2004. These workshops took place under the auspices of IGPP and with partial support from the Center for Nonlinear Studies at LANL. They provided us with an ideal forum to meet and exchange ILES views and experiences, and to extensively discuss their integration within the book project. At the personal level, special thanks go to IGPP’s Gary Geernaert and to the U.S. Naval Research Laboratory’s (NRL’s) Jay Boris and Elaine Oran for their continued encouragement and support. Last but not least, continued support of F. F. Grinstein’s research on ILES during his tenure at NRL from the U.S. Office of Naval Research through NRL and from the U.S. Department of Defense High-Performance Computing Modernization Program is also greatly appreciated.

This book has evolved far beyond the early plan of merely putting together a collection of review papers on ILES authored by the lead researchers in the area. Several very useful collaborations have quite spontaneously occurred in the process of integrating the material, and we now have an active ILES working group that is focusing on a variety of timely research projects.

Much of the work on ILES reported here was accomplished despite the lack of acceptance and support of the turbulence modeling community. We hope that our readers will recognize the quality of these results and will be encouraged to do their own experiments and evaluations.

Fernando F. Grinstein, Len G. Margolin, and William J. Rider
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<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>ALE</td>
<td>Arbitrary Lagrangian Eulerian</td>
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<tr>
<td>AMR</td>
<td>Adaptive Mesh Refinement</td>
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<td>BBC</td>
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<tr>
<td>CFD</td>
<td>Computational Fluid Dynamics</td>
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<td>CV</td>
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<td>DES</td>
<td>Detached Eddy Simulation</td>
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<tr>
<td>DNS</td>
<td>Direct Numerical Simulation</td>
</tr>
<tr>
<td>ENO</td>
<td>Essentially Non-Oscillatory</td>
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<tr>
<td>ENZO</td>
<td>code name</td>
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<td>EULAG</td>
<td>code name</td>
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<td>EV</td>
<td>Eddy Viscosity</td>
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<tr>
<td>FCT</td>
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<td>code name</td>
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<td>Fluid in Cell</td>
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<td>FV</td>
<td>Finite Volume</td>
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<td>ILES</td>
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<td>KH</td>
<td>Kelvin-Helmholtz</td>
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<td>code name</td>
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<td>LES</td>
<td>Large-Eddy Simulation</td>
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<td>MEA</td>
<td>Modified Equation Analysis</td>
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<td>MILES</td>
<td>Monotone (or Monotonically) Integrated LES</td>
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<td>MM</td>
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