Book review

IMPLICIT LARGE EDDY SIMULATION: COMPUTING TURBULENT FLUID DYNAMICS

Fernando F Grinstein, Len G Margolin and William J Rider.
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9780521869829, £60, 560 pp.

The authors present a coherent view of implicit large eddy simulation (ILES), one of many approaches of computational fluid dynamics for the simulation of turbulence flow in complex boundary conditions. The 18 chapters are written by 34 specialists under four sections: motivation; capturing physics with numeric; verification and validation; and frontier flow.

The opening section summarises the early history in chapter 1 and proposes a rationale for the approach in chapter 2. Section two develops the idea of building physics into numerical methods. Several concepts that lead to non-oscillatory finite volume approximation are described and the relationships between ILES and more conventional subgrid-scale models are explored in chapter 3. The basic ideas of capturing physics with numeric are expanded in a sequence of physical basis, mathematical properties, fundamental performance and algorithms. Various algorithms for ILES are presented in chapter 4 including limiting algorithms, the piecewise parabolic method compressible scheme, the Lagrangian remap method and the multidimensional positive definite advection transport algorithm. The numerical analysis of implicit subgrid models using numerical regularisation is given in chapter 5. Approximate deconvolution associated with modern high-resolution methods is described in chapter 6, providing a bridge across many explicit-LES and a broad family of implicit-LES. The verification and validation of ILES includes chapters 7 to 13 by comparing with analytic models of idealised turbulence, with full numerical simulation of simple flows and with laboratory studies. The section begins by application of ILES to homogeneous turbulence for canonical and simple flows and comparison with full numerical simulation, theoretic results and high-quality laboratory data. Chapters 8 on vortex dynamics and transition in free shear flows and 9 on symmetry bifurcation and instabilities discuss some new insights generated in ILES studies of the dynamics of high Reynolds number flows driven by Kelvin–Helmholtz instabilities. The application to the study of wall-bounded flows is addressed in chapters 10 on incompressible wall bounded flows and 11 on compressible turbulent shear flows. Fully developed turbulent channel flow, flow over a cylinder,

flow over a sudden expansion, flow over a surface-mounted cube and flow past a prolate spheroid at different angles of attack are studied in chapter 10. The extension of the techniques to general compressible bounded shear flows is discussed in chapter 11 and examples on supersonic base flow are presented. Studies based on vorticity confinement are given in chapter 12 and Rayleigh–Taylor and Richtmye–Meshkov mixing is studied in detail in chapter 13, constituting an essential tool for construction and validation of engineering models for application to complex real applications.

The frontier flow section discusses the extremely complex flows of geophysics, astrophysics and engineering. The section begins with chapter 14 on studies of geophysics. In this chapter, the authors demonstrate the ability of ILES to meet the challenge of modelling the dynamics of the global ocean and atmosphere compounded by the broad range of significant length scales and by the relative smallness of the vertical height in comparison with their horizontal extent. In chapter 15, studies of astrophysics represented by homogeneous decaying and driven compressible turbulence, local area models of stellar convection, global models of red giant stars are examined. Complex engineering turbulent flows are studied in chapter 16. Cases included are the flow around a model-scale submarine, multi-swirl combustion flows, solid rocket motor flows and the flow and wave pattern around a modern surface combatant with transom stern. Large-scale urban simulations are given in chapter 17. After discussion of available tools such as Gaussian plume models, computational fluid dynamics (CFD) approach, standard CFD simulations and the LES approach for contaminant transport, the authors start to present the monotone integrated LES for urban-scale simulations including the solar heat effects, tree effects, turbulent stochastic backscatter, geometric specification, wall boundary conditions and urban street crossing. Validation with wind-tunnel urban model data, convergence issues and sensitivity are discussed with available data. Finally, some outlook and open research issues are given in chapter 18.

The book provides a comprehensive account of implicit large-eddy simulation and is written in simple mathematics that readers with an undergraduate level of scientific knowledge should be able to follow. The text is very valuable for practising wind scientists, engineers and architects. It is particularly useful for those who wish to produce a computer package on the topic for commercial use.

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