J. Fluid Mech. (2007), *vol.* 593, *pp.* 505–507.
Printed in the United Kingdom

BOOK REVIEW

Large-Eddy Simulation for Acoustics. Edited by C. Wagner, T. Hüttl & P. Sagaut. Cambridge University Press, 2007. 441 pp. ISBN 978 0521 871440. £65.

J. Fluid Mech. (2007), *vol.* 593, doi:10.1017/S0022112007008725

This book has the advantage that it involves a good lineup of international experts, many highly eminent in their fields. Hence, it is up-to-date, presenting the state of the art, and is an excellent information source. The downside of having 34 different authors is that the book cannot express a coherent viewpoint, is disjointed in places and in many instances repetitive. More aggressive editing would have helped, but to an extent the editor's hands were tied. The book's framework precludes free movement of paragraphs and sections – contributions comprise distinct sections preceded by author names. Hence, for example, Tables 3.4 and 5.4 are duplicated, the latter also being then externally referenced to Saguat – a book editor and contributor. Also, in pp. 208–214 there is much overlap with the LES and the hybrid Reynolds-averaged Navier–Stokes (RANS)–LES chapter. Furthermore, around p. 215, boundary conditions are discussed, followed by a brief final remarks section, suggesting the chapter's finish. However, this is then followed by an acoustics boundary conditions section having much information relevant to basic LES boundary conditions. There is then a three page interlude before another section on boundary conditions opens up, again containing a substantial overlap with earlier material. On p. 245 a footnote states that it is 'beyond the scope of the current section to discuss Lighthill's analogy'. However, this footnote would be better replaced by some indication of the sections in the book where this analogy is addressed. Also, for a book on 'LES for Acoustics' the introductory material on acoustics is perhaps a little too long, occupying the first 89 pages. With regard to editing, again pruning would have helped with perhaps the removal of more basic thermodynamic equations and perhaps, for example, solutions for acoustic modes in ducts. Restricting the material to that more necessary for an LES practitioner, rather than a more general acoustician would, I feel, be beneficial. Perhaps more general material could have been dealt with in a brief descriptive way.

The book's abstract implies an industrial emphasis with careful discussion of the 'advantages and weaknesses of both commercial and research methodologies'. To my mind the book does not sufficiently succeed at this hard task. For this to happen, and to help the novice reader make sense of the LES strategies outlined, I think it would have been helpful to make the broad distinction between academic and industrial LES work more explicit. The former tends to use high-order, perhaps spectral or compact, scheme based solvers with more advanced LES models along with sometimes large filter widths. Industrial LES tends to use solvers of RANS origin with around second-order accuracy. Thus these solvers potentially provide numerical influences of comparable magnitude to those of the LES model itself. Even when nominally neutrally dissipative centred schemes are used, substantially dissipative elements are frequently introduced in some, sometimes subtle, fashion into more industrial codes. Hence, excessive concern regarding the choice of LES model is fruitless or even counterproductive. Under these circumstances it is sensible to use the best numerically conditioned, the one the code has, or with many dissipative solvers

and modest grids not to bother with the LES model at all. When the LES model's dissipation is combined with that of the numerics an excess of dissipation is most likely. The book, I feel, does not explicitly make these points to the reader – however I think many of the authors involved would agree with them. Lots of LES models are presented but no practical guidance on what is the best choice, especially in the light of numerical issues and the industrial and academic LES simulation contexts.

The numerical methods section would have been the correct place to build on the MILES discussion started in the LES section but now using the 'modified equation' approach. Through the modified equation the dramatic influence of cell topology for different numerical disctretizations could also then have been demonstrated. Again, this is a crucial aspect for practical simulations, which is only very briefly mentioned in the later applications chapters. Some discussion on the pros and cons of Chimera grid topologies and wave propagation at interfaces along with effects of grid stretching, especially with more non-standard schemes, like for example the compact scheme, would have been helpful for a reader interested in the more practical application of LES. Through the modified equation, the potentially dramatic influence of different temporal discretizations could have also been demonstrated, along with the fact that some solvers are designed for the spatial and temporal schemes to work in harmony with, to an extent, broad cancellation of error traits/terms. Instead the temporal discretizations discussion is very much Runge–Kutta focused. In this numerical methods chapter the likely strong numerical influences in LES could have been more formally explicitly reinforced and again the general pros and (importantly) cons of different numerical methods given. With regard to numerical influences, I was surprised (in a later applications chapters) to see an LES simulation for a whole car involving just 5.2 million grid points (with no mention of wall modelling). For many case studies no grid information at all is given. However, for potential new LES users such data are very helpful for roughly gauging necessary computational demands.

Of course, the key problem with LES, relative to for example RANS is its high computational cost. This is especially so for industrial LES where a reasonable solution turnaround time is vital if it is desired to make any design impact. Hence, I was disappointed to see just 2.5 lines of the book (see p. 202) dedicated to the key aspect of gaining good initial conditions, a paper in German being referenced for the reader interested in such information. In most papers and texts this information is scant, hence this is not a direct criticism of this book, but LES texts in general.

Page 365 raises the important issue of boundary conditions, stating that 'mean flow inlet data of good quality' are available to the analyst but turbulence statistics lacking. I would go further than this and say that even mean flow data like the momentum thickness are frequently missing. Hence, based on this and the preceding technical points, my feeling is that for industrial LES, problem definition, solution uniqueness, transition issues, near-wall modelling, and grid structure along with its implications for filter definition, are of potentially greater importance than the LES model, that can in themselves be theoretically questionable. I suspect this hierarchy is almost opposite to that subliminally implied to a reader of this book. Although the general technical points I make above are embedded in the text their expression is not explicit. I suspect a key reason for this is that it is difficult to express a coherent viewpoint with so many contributors.

Pure LES and MILES, to an extent, perhaps present two extreme modelling philosophies. As implied above, the book does not focus as much attention as it might on the latter controversial approach. This, to my mind is a shame, since, perhaps hybrid LES–MILES models (or even hybrid LES–MILES–RANS) might

offer a middle ground and hence a way forward for practical engineering where numerical influences will always be present and their use in some positive sense along with augmentation by useful LES ingredients could be an effective strategy.

Although this review might sound negative, many of the above points are of course ones of philosophy and editing. Putting these points aside, the book is a mostly an excellent scholarly endeavour that is well worth studying. I am certainly glad the authors took the trouble to support the task of compiling such a badly needed text, providing such an excellent up-to-date sound reference source. I felt the chapter on hybrid LES-RANS methods was especially good, probably being the best report on the state of this field currently available. The LES methods chapter was also of note for its good quality.

P. G. Tucker