
Preface

The second Workshop on “Quality and Reliability of Large-Eddy Simulations”, QLES2009, was held at the University of Pisa from September 9 to September 11, 2009. Its predecessor, QLES2007, was organized in 2007 in Leuven (Belgium). The focus of QLES2009 was on issues related to predicting, assessing and assuring the quality of LES. The development of computational resources and the corresponding tendency to apply LES-methodologies to turbulent flow problems of significant complexity, such as arise in various applications in technology and in many natural flows, makes the issue of assessing and optimizing the quality of LES predictions a timely challenge. Different error sources are present in LES, which are mainly related to physical modeling (especially as regards subgrid scales), to numerical discretization techniques, to boundary-condition treatment, and to grid resolution and design. These errors may interact in a complex non-linear manner, eventually leading to unpredictable and unexpected effects on LES results.

To establish the credibility of LES as a tool for innovation in industrial flow applications and for the study of complex-physics problems, clear standards and criteria to assess and predict the quality and the reliability of the simulation results should be devised. To this aim, an understanding of the non-linear accumulation and interaction of the different errors arising in large-eddy simulations, and of their dependence on the different simulation parameters, is required. This is also crucial for the development of methodologies and techniques aimed at controlling the different errors and, hence, at optimizing the quality of LES results.

The main goal of QLES2009 was to enhance the knowledge on error sources and on their interaction in LES and to devise criteria for the prediction and optimization of simulation quality, by bringing together mathematicians, physicists and engineers and providing a platform specifically addressing these aspects for LES.

In total 64 participants from 12 countries registered for the workshop. The majority of participants was from academia and research institutes. In addition, several companies and consultancy agencies were represented.

QLES2009 gathered 7 invited lectures, held by speakers from different scientific fields: Johan Meyers (Katholieke Universiteit Leuven, Belgium), Thierry Poinsot (Institut de Mécanique des Fluides de Toulouse, CNRS, France), Philippe Spalart

(Boeing Commercial Airplanes, USA), Marc Parlange and Chad Higgins (Ecole Polytechnique Fédérale de Lausanne, Switzerland), Andreas M. Kempf (Imperial College London, United Kingdom), Lars Davidson (Chalmers University, Sweden), Jean-Luc Guermond (Texas A&M University, USA).

Johan Meyers presented an overview of recent developments of the “error-landscape” methodology, aimed at investigating the quality and reliability of large-eddy simulations by constructing a full response surface of the LES error behavior. Thierry Poinsoit illustrated the application of LES to the simulation of complex reacting flows and discussed issues related to the reliability and the repeatability of LES results for such applications. Philippe Spalart drew the attention to a careful grid generation and optimization as a key issue to obtain accurate and reliable LES predictions for external flows. Marc Parlange and Chad Higgins described recent a-priori tests of models for subgrid-scale processes in stable and unstable atmospheric boundary-layers, carried out by using data from field experiments. Jean-Luc Guermond reviewed the mathematical properties of the 3D incompressible Navier-Stokes equations and their relation to LES. He also illustrated how the notion of suitable weak solutions can be used to devise LES closure models. Andreas Kempf discussed quality issues and the possibility of using quality indicators and error-charts in combustion LES, for which the presence of a wide range of chemical and mixing scales makes the assessment of simulation quality and reliability even more challenging than for “fluid-flow only” LES. Finally, Lars Davidson addressed the issue of how to estimate the resolution of LES simulations of recirculating flows.

Next to the invited lectures, 33 contributed presentations were selected by a Scientific Committee of experts.

From the presentations and the discussions held during the workshop, it was clear that the tendency to apply LES to various, very complex, industrial and environmental problems, already observed during the previous QLES workshop, further enhanced in the last two years. Several examples of such complex applications, comprising atmospheric and geophysical problems, particle-laden flows, combustion, aeronautical engines or conductive fluids and plasmas, were shown during the workshop, and LES was generally found to be able to give satisfactory results. It was also made clear, however, that this requires a profound knowledge of the problem and a careful combination of physical modeling, numerics, grid resolution and quality. Although SGS modeling is still felt as the most critical issue in LES, several contributions were given at the workshop on the sensitivity of the quality of LES results also to numerical methods, boundary conditions treatment and grid resolution. Recent developments and applications of methodologies aimed at understanding, predicting and minimizing error dynamics in LES were also presented.

In the spirit of the QLES series, this workshop gave a stimulating contribution to the development of higher standards for the assurance of quality and reliability of large-eddy simulations. Critical and open issues remain in order to increase the accessibility of LES to non-specialist users. As also highlighted at QLES2007, the development of a fully consistent theory on errors in LES, comprising the definition of mathematically sound quantitative error measurements and the simulation or modeling of error dynamics, is certainly needed. A related crucial issue is the sensi-

tivity of the LES results to different parameters. This sensitivity analysis is complicated for LES by some peculiar features: for instance, grid independence can only be reached in the DNS limit and even the complete repeatability of a LES simulation may be questionable due to round-off errors, which may be a source of random disturbances, especially in massively parallel simulations. However, from a practical viewpoint, the main difficulty is that it is not affordable to carry out a large number of LES simulations, especially for complex applications, due to the large computational costs of each simulation. Thus, the development of tools aimed at estimating LES sensitivity from a limited number of simulations is required to obtain significant achievements in this direction. As previously mentioned, progress in these fields has been reported at QLES2009, but there is still room for development.

The present book contains the written contributions to QLES2009 and is divided in three parts, which reflect the main topics addressed at the workshop: (i) SGS modeling and discretization errors; (ii) Assessment and reduction of computational errors; (iii) Mathematical analysis and foundation for SGS modeling.

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