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VERIFICATION AND VALIDATION EXERCISES IN SIMULATIONS OF TURBULENCE

Filipe S. Pereira[1], Luís Eça[2] and Guilherme Vaz[3]

[1]Currently at LANL, MS F644, 87544 Los Alamos, New Mexico, United States of America, fmsoarespereira@gmail.com

[2]IST, Av. Rovisco Pais 1, 1049-001 Lisbon, Portugal, luis.eca@ist.utl.pt

[3]MARIN, 2, Haagsteeg 2, 6708 PM Wageningen, The Netherlands, g.vaz@marin.nl

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The use of numerical simulations to investigate turbulent flows with practical interest has grown during the last decades. Nonetheless, the correct use of such technique requires the assessment of the predictions accuracy which is measured by the magnitude of numerical and modelling errors. The quantification of these errors is therefore essential to the reliability of the simulations and to their use in engineering applications.

Verification and Validation exercises are the required techniques to perform the quantification of the aforementioned errors. Verification assesses the quality of the application of numerical methods to resolve the governing equations of the mathematical model through the estimation of numerical errors. These have four sources: discretization, iterative, round-off errors, and statistical errors. On the other hand, Validation exercises quantify modelling errors in order to evaluate the quality of the mathematical model to represent a particular physical problem. In turbulence simulations, discretization, iterative, and statistical errors are the main sources of numerical errors, whereas the physical resolution (portion of the turbulence field being resolved) and the turbulence model are the main contributors to the modelling error.

This paper illustrates the relevance of numerical and modelling errors to the accuracy of turbulence simulations through Verification and Validations exercises. Moreover, it also assesses the advantages of the quantification of modelling errors when compared to traditional visual inspections. Towards this end, two test-cases are analysed: the flow around the KVLCC2 tanker at $Re = 4.6 \times 10^6$, and the flow past a circular cylinder at $Re = 3.9 \times 10^3$. The first flow problem addresses the relevance of iterative errors, discretization errors, and turbulence models (modelling error) to RANS predictions. The second case, in turn, discusses discretization and modelling (physical resolution) errors in Scale-Resolving Simulations. These studies employ the Verification and Validation techniques proposed in [1, 2], and use the numerical data of [3, 4]. The data confirm the relevance of the aforementioned sources of numerical and modelling errors to the predictions accuracy, and demonstrate that the quantification of these errors is critical for such studies.

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