6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

ADAPTIVE TIME-INTEGRATION STRATEGIES FOR LARGE-EDDY SIMULATION

Francesco Capuano[1], Benjamin Sanderse[2], Enrico M. De Angelis[1] and Gennaro Coppola[1]

[1] Department of Industrial Engineering, Università di Napoli "Federico II", 80125 Napoli, Italy. E-mail: francesco.capuano@unina.it

[2] Centrum Wiskunde & Informatica (CWI), Amsterdam, The Netherlands. E-mail: b.sanderse@cwi.nl

Keywords: *Large-Eddy Simulation, Adaptive Time Stepping, Numerical Dissipation*

Adaptive time-stepping methods can significantly increase the efficiency of numerical computations, especially when coupled with an error-control technique. Despite the potential benefits, adaptive strategies have been rarely applied in Large-Eddy Simulation (LES) of turbulent flows. Simulations are usually time-advanced by means of standard explicit or semi-implicit methods, and the time step is chosen on the basis of the linear stability constraint [1]. Current trends tend to maximize the maximum stable time step by dynamically analyzing the eigenvalues of the semi-discretized system [2].

On the other hand, recent work has shown that for time-step sizes close to the stability limit, the artificial dissipation rate due to Runge-Kutta time integration, $\varepsilon^{\mathrm{RK}}$, can grow significantly and even compete with the subgrid-scale and physical dissipation rates, $\varepsilon^{\mathrm{SGS}}$ and ε^{V} respectively [3]. Based on this consideration, a self-adaptive, low-dissipative strategy is proposed in this work, with the ultimate aim of creating an efficient time integration method for LES of turbulent flows with a built-in error estimate. The developed algorithm consists in adjusting the time-step size dynamically to ensure that $\varepsilon^{\mathrm{RK}}$ is smaller than $\varepsilon^{\mathrm{V}} + \varepsilon^{\mathrm{SGS}}$ at each time step within a desired tolerance.

The effectiveness of this approach, as compared to embedded RK methods and standard CFL-based time step selection criteria, is analyzed and discussed in the work by LES of canonical turbulent flows.

REFERENCES

[1] R.W.C.P. Verstappen and A.E.P. Veldman, Direct numerical simulation of turbulence at lower costs. *J. Eng. Math.*, Vol. **32**, pp. 143–159, 1997.

[2] F.X. Trias, O. Lehmkuhl, A self-adaptive strategy for the time integration of Navier-Stokes equations. *Numerical Heat Transfer, Part B*, Vol. **60**, pp. 116–134, 2011.

[3] F. Capuano, E.M. De Angelis, G. Coppola and L. de Luca, An analysis of time-integration errors in Large-Eddy Simulation of incompressible turbulent flows. *ERCOFTAC Series*, to appear, 2018.