VARIATIONAL MULTISCALE METHOD FOR COMPRESSIBLE FLOWS

M. Vázquez[1], M. Moragues[1,*], G. Houzeaux[1], R. Aubry[1] and S. Marras[1]

[1]Barcelona Supercomputing Center
Nexus I, C. Nord UPC, Barcelona, Spain
e-mail: mariano.vazquez@bsc.es

ABSTRACT

This paper presents a Variational Multiscale method for Compressible flows, VMS-C, whose preliminar version was already presented in [1,2]. The VMS method was introduced by Hughes and co-workers [3] in the context of incompressible flows. A compressible version for mixed Finite Volumes method is proposed in [4] and a first version for supersonic flow is presented in [5]. In the present paper, we derive a new formulation for a wide range of Mach numbers, analyzing different linearization strategies and stabilization parameter τ choices. In its basic formulation, the subscale is modelled using a diagonal τ times the space residual, but for some particular examples, the subscale is directly modelled with a "non-diagonal" stabilization parameter matrix. The wide range of Mach numbers is tested with examples ranging from transient atmospheric flows benchmarks up to hypersonic flows. In the very low Mach range, the potential temperature θ is preferred instead of the total energy, complemented in both cases with the density and linear momentum Navier-Stokes equations. For the case of supersonic flows, an anisotropic shock-capturing diffusion is added. Viscous problems are addressed, particularly supersonic ones with temperature dependent viscosities. In this paper, the explicit version of the VMC-C algorithm is addressed, parallelized with almost linear scalability up to thousands of processors, extending the tests of [1,2].

REFERENCES

[1] R. Aubry, M. Vázquez and G. Houzeaux. CFD-ready mesh generation strategy in large-scale parallel compressible flow problems. *Proceedings of FEF09 Conf.* **37**, Tokio. (2009)

[2] S. Marras, M. Vázquez, O. Jorba, R. Aubry and J. M. Baldasano. A Parallel, Variational Multiscale (VMS) Finite Element Approach to Atmospheric Modeling *Proceedings of ICC-SME Conf.* **37**, Grecia. (2009)

[3] T. Hughes. Multiscale Phenomena: Green's functions, the Dirichlet-to-Neumann formulation, subgrid scale models, bubbles and the origins of stabilized methods. *CMAME* **127**, pp. 387-401. (1995)

[4] F. Rispoli and R. Saavedra. A stabilized finite element method bsed on SGS models for compressible flows. *CMAME* **196**, pp. 652-664. (1995)

[5] B. Koobus, C. Farhat. A variational multiscale method for the large eddy simulation of compressible turbulent flows on unstructured meshes-application to vortex shedding. *CMAME* **193**, pp. 1367-1384. (2004)