Reduced order models for low Mach number flows

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ABSTRACT

We present a Proper Orthogonal Decomposition (POD) based Reduced Order Model (ROM) for the solution of low Mach number flow problems using three different models [1]: the Boussinesq approximation, the low Mach number limit equations, and the compressible Navier-Stokes equations. In the development of this model we carry out some strategies used previously in the solution of other problems, such as the Petrov-Galerkin projection [2], the hyper-reduction approach and the use of reduced order sub-scales [3].

The construction of the ROM is split in three stages including the off-line and on-line parts of the solution. A first stage where a full order model solved using a variational multi-scale framework [4] and the basis for the ROM space is constructed through a single value decomposition; a second stage where additional off-line procedures are done, such as the sampling of elements using the method of empirical cubature [5] or the construction of the ROM sub-scales; and a third one which consists on the on-line solution of the problem.

With the proposed strategy we solve some numerical examples that allow us to examine and compare the performance and the quality of the solution obtained with the ROM for each of the approximation models.

REFERENCES

[1] Javier Principe and Ramon Codina. Mathematical models for thermally coupled low speed flows. *Advances in Theoretical and Applied Mechanics*, 2(2):93–112, 2009.

[2] Kevin Carlberg, Charbel Bou-Mosleh, and Charbel Farhat. Efficient non-linear model reduction via a least-squares Petrov–Galerkin projection and compressive tensor approximations. *International Journal for Numerical Methods in Engineering*, 86(October 2010):1885–1891, 2011.

[3] Joan Baiges, Ramon Codina, and Sergio Idelsohn. Reduced-Order Modelling strategies for the finite element approximation of the Incompressible Navier-Stokes equations. pages 1–26, 2014.

[4] Matias Avila, Javier Principe, and Ramon Codina. A finite element dynamical nonlinear subscale approximation for the low Mach number flow equations. *Journal of Computational Physics*, 230(22):7988–8009, September 2011.

[5] J. A. Hernandez. Dimensional hyper-reduction of parameterized , nonlinear finite element models via empirical cubature. 2016.