Reduced Order Fluid-Structure Interaction Models for Vascular Flows

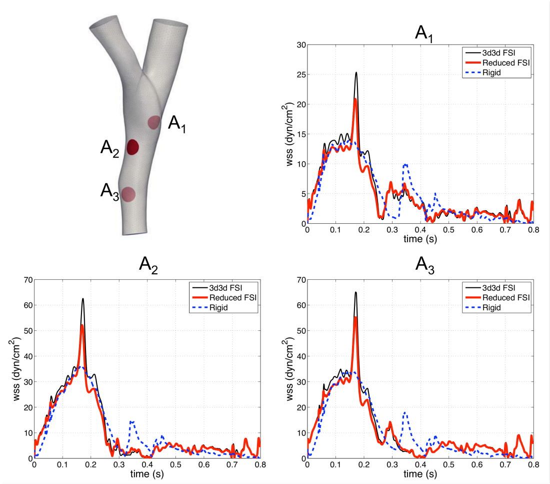
Claudia Colciago, Simone Deparis*, Alfio Quarteroni

* CMCS – MATHICSE
EPFL Lausanne, Switzerland
e-mail: simone.deparis@epfl.ch, web page: http://cmcs.epfl.ch/people/deparis

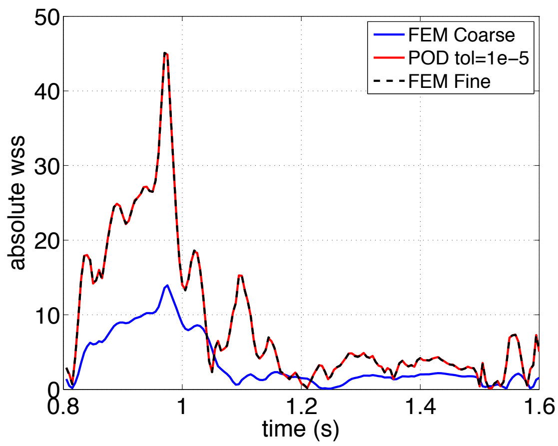
ABSTRACT

We are interested in reducing the computational complexity for hemodynamics simulations. A rich model for this kind of unsteady flows relies on three dimensional Fluid-Structure Interaction (3D-3D FSI), which couples the Navier-Stokes equations with a structure described by continuum mechanics. If the outputs of interest are mainly related to fluid quantities or average wall displacement, in some situations it is possible to reduce the dimension of the structural model by integrating/averaging over its thickness, like in [1] or [2]. In [2] and [3] the fluid computational domain is also kept fixed [2,3]. In this talk we present the full model and some comparisons in realistic blood-flow simulations.

The fixed computational domain allows for reducing the computational complexity by applying Proper Orthogonal Decomposition (POD) or the Reduced Basis Method (RBM). By relaxing the requirement on error control, we are able to combine POD and RBM and reduce the computational burden by four orders of magnitude. Since we lack of error estimates we will compare the results on specific outputs – wall shear stresses (WSS), velocity, and pressure – using a finite element (FE) solver and the reduced order modeling proposed here.



WSS, 3D-3D FSI, reduced FSI, and rigid



WSS, POD and FE with fine or coarse mesh

REFERENCES

[1] Nobile, F. and Vergara, C. “An effective fluid-structure interaction formulation for vascular dynamics by generalized robin conditions”, *SIAM Journal on Scientific Computing*, 30(2):731–763 (2008).

[2] Figueroa, C. A., Vignon-Clementel, I. E., Jansen, K. E., Hughes, T. J., and Taylor, C. A. “A coupled momentum method for modeling blood flow in three-dimensional deformable arteries”, *Computer Methods in Applied Mechanics and Engineering*, 195(41-43):5685–5706 (2006).

[3] Colciago, C. M., Deparis, S., and Quarteroni, A. “Comparisons between reduced order models and full 3D models for fluid-structure interaction problems in haemodynamics”, *Journal of Computional Applied Mathematics*, 265(0):120–138 (2014).