Full Order Model and Reduced Order Model Consistency for Evolve-Filter-Relax Regularization

M. Strazzullo[1], M. Girfoglio[2], F. Ballarin[3], T. iliescu[4], and G. Rozza[2]

[1]*Department of Mathematical Sciences "G.L. Lagrange", Politecnico di Torino, Corso duca degli Abruzzi 24, I-10129 Torino, Italy*
[2]*mathLab, Mathematics Area, SISSA, via Bonomea 265, I-34136 Trieste, Italy*
[3]*Department of Mathematics and Physics, Catholic University of the Sacred Heart, via Musei 41, I-25121 Brescia, Italy*
[4]*Department of Mathematics, Virginia Tech, Blacksburg, VA 24061, USA*

The goal of this talk is to provide a recipe to alleviate the spurious oscillations generally produced by full order models (FOMs) in marginally-resolved simulations of convection-dominated incompressible flows. In a parametric setting (in our case for time-dependent and physical parametric problems), these simulations can be unbearable in terms of computational time and resources.
We propose Proper Orthogonal Decomposition-based reduced order models (ROMs) to solve them in a smaller amount of time. Specifically, we investigate whether the evolve-filter-relax (EFR) numerical stabilization is needed both at the FOM and the ROM level.
Indeed, we present two ROM strategies:

(i) the EFR-noEFR, in which the EFR stabilization is used at the FOM level and not at the ROM level.

(ii) The EFR-EFR, in which the EFR stabilization is used both at the FOM and at the ROM level.

We perform the reduction in terms with respect to both time and Reynolds number for a 2D incompressible flow past a circular cylinder. The results are both reconstructive and predictive and they suggest that FOM-ROM consistency is beneficial in the proposed setting [1].

References

[1] M. Strazzullo, M. Girfoglio, F. Ballarin, T. Iliescu, and G. Rozza. Consistency of the full and reduced order models for evolve-filter-relax regularization of convection-dominated, marginally-resolved flows. *International Journal for Numerical Methods in Engineering*, 2022.