# Efficient Sampling Strategies in Hybrid Full-Order/Reduced-Order CFD Models

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## ABSTRACT

The non-linearity and complexity of the Navier-Stokes Equations (NSE) make the use of Reduced-Order Models (ROMs) in computational fluid dynamics extremely challenging for real-life parameterized problems.

In order to mitigate some of the difficulties, we present a hybrid strategy for model order reduction based on a domain decomposition approach [1]. The main idea is to split the domain of interest in two subdomains and to use different approximation methods in each one: the full-order CFD model is employed within a crucial region, whereas the flow in the rest of the domain is described by a semi-empirical model based on Proper Orthogonal Decomposition (POD) [2]. Generally speaking, this approach delegates non-linear effects to the canonical model, whereas linear phenomenology is addressed by the ROM. The two model are coupled in an overlapping region through a modified Schwarz method, resulting in a non-local boundary condition for the CFD model on the reduced subdomain.

We discuss the convergence conditions of the algorithm as well as the ability of the model to perform predictive simulations for different parameters. It can be shown that the approximation error depends on the choice of both the decomposition and the full-order solutions used to train the ROM. In this work, we focus on the second aspect. Since the systematic exploration of the parameter space is usually prohibitive, efficient sampling strategies must be introduced. We present two possible approaches based on Greedy methods. The first approach uses as error indicator the residuals of the NSE evaluated by projection onto the POD basis, whereas the second one employs the projection error built exploiting a leave-one-out cross validation technique [3].

The effectiveness and drawbacks of the proposed approaches are highlighted for incompressible turbulent flows.

## REFERENCES

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