REDUCED-ORDER SUBSCALES FOR POD MODELS IN FLUID MECHANICS

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Abstract

In this work we introduce the concept of Reduced Order Subscales (ROS) for Reduced Order Models (ROM) based on Proper Orthogonal Decomposion (POD). The basic idea consists in splitting the full-order solution into the part which can be captured by the ROM and the part which cannot, the ROS, for which a model is required. The proposed model for the subscales is defined as a linear function of the solution of the ROM. The coefficients of this linear function are obtained by comparing the solution of the full-order model with the solution of the ROM for the same initial conditions, which, for convenience, are evaluated in the snapshots used to train the original ROM. The difference between both solutions are the ROS, for which a model can be built using a least-squares procedure. The subscales are then introduced as a correction in the ROM, resulting in an important improvement in accuracy. We also explore the possibility of changing dynamically the expression of the ROS, as well as accounting for their effect in the nonlinear terms of the equations. The enhanced ROM is tested in several numerical examples of incompressible flow problems. These practical cases show that the use of the subscales leads to more accurate solutions, successfully corrects errors introduced by hyper-reduction, and allows one to solve complex flow problems using a reduced number of degrees of freedom.