Collocation-based model order reduction: analysis and applications

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Abstract. In this work, we consider a novel reduced-order modeling strategy called collocation Model Order Reduction (cMOR), designed as an alternative to more classic projection-based Model Order Reduction (pMOR). While pMOR computes the reduced solution through Galerkin or Petrov-Galerkin projection onto a reduced basis, cMOR instead solves the governing equations at a set of strategically selected collocation points, identified via hyper-reduction techniques. The method maintains the typical two-stage structure of pMOR, with an offline phase for constructing a Reduced Basis (RB) from solution snapshots, and an online phase where the High-Dimensional Model (HDM) is evaluated only at the reduced set of points, allowing the full solution to be reconstructed through the RB. Within this setting, we present a theoretical analysis of stability and convergence of the method, and we validate our findings through numerical simulations in the field of Computational Fluid Dynamics (CFD). These results confirm the robustness and accuracy of cMOR, while its formulation ensures straightforward integration into existing simulation workflows.