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# A two-step model order reduction method to simulate a compressible flow over an extended rough surface

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## Abstract

In this paper the ideas presented in the article “Effective boundary conditions: a general strategy and application to compressible flows over rough boundaries”, *Communications in Computational Physics*, **21(2)**, 358–400, 2017 to simulate efficiently a compressible flow over a rough surface are extended to a two-step model order reduction strategy. The first level consists in the formulation of effective boundary conditions, to take into account the effect of the roughness without resolving it. **This requires the solution of a parameter-dependent cell problem on the micro-scale. To reduce its computational cost we add an additional step, where a second level of reduction is applied to the cell problem by means of the reduced basis method.** Through numerical computations we verify the gain in efficiency of this strategy.

**Keywords:** Model order reduction, multiscale modeling, compressible flow.

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## 1. Introduction

From nature it is well-known that microstructures on surfaces aligned in the streamwise direction of the flow, so-called riblets, can significantly reduce drag. For instance, the skin of a shark exhibits small-scale structures that makes the shark one of the fastest hunters in the ocean [35]. In oil channels experiments have been conducted to study biological surfaces, e.g., shark-skin replicas, hairy surfaces such as seal fur [9, 4, 22]. These have confirmed that drag can be reduced in the range of 10%. Engineers try to mimic this effect for economical and eco-

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