A kinetic switching criterion for hybrid modelling of multiscale gas flows

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Abstract.

In some important engineering applications, gas flows are often found to be hydrodynamic in one part of device and highly rarefied in the others. To solve this kind of multi-scale flow problems efficiently and accurately, hybrid methods coupling hydrodynamic and kinetic methods are attractive. The successful implementation of hybrid methods relies on the accurate assessment of the level of non-equilibrium (rarefaction) in the local flowfield. Currently available criteria, such as Knudsen and Mach numbers, are based on macroscopic parameters and have been shown to be restrictive. Here, we propose a new kinetic criterion that utilises the fundamental molecular distribution function to assess the local flow field. Through numerical evaluation we show that our criterion provides a reasonable assessment and, in particular, it behaves consistently for both high-speed and low-speed flows, which is not the case for the other criteria based on macroscopic parameters. As our criterion fully utilises the accurate information provided by the molecular distribution function, it is particularly suitable for recently developed multi-scale kinetic methods.