On the implementation of OpenMP and Hybrid MPI/OpenMP parallelization strategies for an explicit DG solver

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Abstract. The paper deals with the OpenMP parallel implementation of a high-order Discontinuous Galerkin solver for computational fluid dynamics (CFD) and computational aeroacoustics (CAA) applications. The use of the shared memory view of the OpenMP paradigm is here explored through three different parallel implementation strategies. The numerical experiments on 2D and 3D test cases, which consider the effects of different platforms, compilers and space discretizations, indicate that all the code versions perform quite satisfactory. In particular, the OpenMP domain decomposition algorithm reaches the highest level of parallel efficiency at low computational loads, while a colouring approach excels for the largest simulations. The performance gain observed in using a hybrid MPI/OpenMP version of the DG code on large HPC facilities will be demonstrated.

Keywords. Discontinuous Galerkin; OpenMP; Hybrid parallelization; Computational Aeroacustics.

1. Introduction

The paper aims to devise efficient OpenMP and hybrid MPI/OpenMP parallelization strategies for a high-order Discontinuous Galerkin solver applied to computational fluid dynamics (CFD) and computational aeroacoustics (CAA). Parallel implementations, in the context of DG solvers, are commonly based on the MPI library, which typically calls for a domain decomposition approach and can be used on both distributed and shared memory platforms. On the other hand, the use of OpenMP is known to be a valuable alternative on shared memory systems but in the current literature few papers deal with an OpenMP implementation of a DG solver. To the authors' knowledge only [1] and [2] deal, at least partially, with hybrid MPI/OpenMP implementations of a fully unstructured DG solvers.

Although the usage of OpenMP is confined to shared memory systems, some advantages over the MPI-based parallelization are clear, for example the small programming effort required for the parallelization of an application and the the-

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