Optimization of the ADER-DG method in GPU applied to linear hyperbolic PDEs

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SUMMARY

We optimized the ADER-DG numerical method using the CUDA-C language to run the code in a Graphic Processing Unit (GPU). We focus on solving linear hyperbolic partial differential equations where the method can be expressed as a combination of precomputed matrix multiplications becoming a good candidate to be used on the GPU hardware. Moreover, the method is arbitrarily high-order involving intensive work on local data, a property that is also beneficial for the target hardware. We compare our GPU implementation against CPU versions of the same method observing similar convergence properties up to a threshold where the error remains fixed. This behaviour is in agreement with the CPU version but the threshold is slightly larger than in the CPU case. We also observe a big difference when considering single and double precision where in the first case the threshold error is significantly larger. Finally, we did observe a speed-up factor in computational time which depends on the order of the method and the size of the problem. In the best case our novel GPU implementation runs 23 times faster than the CPU version. We used three partial differential equation to test the code considering the linear advection equation, the seismic wave equation and the linear shallow water equation, all of them considering variable coefficients.

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KEY WORDS: ADER-DG; CUDA; variable coefficient; linear hyperbolic; seismic wave; shallow water; linear advection

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