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Very high order approximation of the Euler equations in presence of buoyant forces

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SUMMARY

The Euler equations are used to model astrophysical and atmospheric phenomena, in particular for climate modeling and weather forecasting purposes. Most of the phenomena of interest can be regarded as small perturbations of the underlying equilibrium state of relevance [1], called hydrostatic equilibrium, where the the pressure forces are balanced by the gravity force. Capturing such perturbations is a challenging task and require the use of well-balanced schemes, which are able to preserve the hydrostatic equilibrium at the discrete level with machine accuracy. In this work, we introduce a novel approach to construct well-balanced finite volume schemes of arbitrary order of accuracy based on augmented Riemann solvers. We use the HLLS solver to compute the fluxes at cell interfaces, ensuring an exact balance between fluxes and sources at cell interfaces. To the knowledge of the authors, this solver has not been applied to the Euler equations yet. We also introduce a particular discretization of the source term to satisfy the well-balanced property. The high order of accuracy is obtained by means of a Weigthed Essentially Non-Oscillatory (WENO) spatial reconstruction [2] and a Runge-Kutta time integrator. The resulting scheme is assessed using a variety of test cases involving steady and transient solutions. The fidelity of the model for the resolution of vortical structures and the representation of the statistical properties of turbulent flows is also evaluated. As a future work, the model will include the presence of uneven topography using immersed boundaries and will be coupled with a level-set equation solver for the simulation of surface fire.

Keywords: fluid mechanics, finite volumes, Riemann solvers, well-balanced

AMS Classification: 35Q31, 65M08

References

[1] Alina Chertock, Shumo Cui, Alexander Kurganov, eyma Nur zcan, Eitan Tadmor. Well-balanced schemes for the Euler equations with gravitation: Conservative formulation using global fluxes. *Journal of Computational Physics* **volume**(358), 36–52, 2018.

[2] Guang-Shan Jiang, Chi Wang Shu. Efficient Implementation of Weighted ENO Schemes. *Journal of Computational Physics* **volume**(126), 202–228, 1996.

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