A semi-implicit fully exactly well-balanced relaxation scheme for the shallow water system

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SUMMARY

In this work we develop first and second order semi-implicit schemes that are fully well-balanced for the one-dimensional shallow water equations, meaning they preserve all smooth steady states of the system, and not just the water-at-rest ones. Semi-implicit methods can be computationally more efficient than explicit ones, especially in the low-Froude regime, where the wave speed significantly exceeds the fluid velocity. This is all achieved by integrating splitting and relaxation techniques. Unlike recent Lagrangian-based methods, this approach preserves all steady states while avoiding the complexities inherent in Lagrangian formalism.

Keywords: fully exactly well-balanced schemes, semi-implicit schemes, shallow water, relaxation schemes

AMS Classification: 76M12, 35L60, 65M08

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