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Computational Efficiency of Semi-Analytic Roe Solver for Two-Layer Shallow Water Systems in Simulating Geophysical Flows

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Coupled shallow water equations (SWE) are widely used to simulate two-layer flows in many geophysical systems, such as sea straits, estuaries, gravity currents, mudflows, debris flows, and submarine avalanches. Numerical schemes based on the finite volume methods (FVM) are often used to solve the governing partial differential equations (PDE) for SWE. Amongst the most accurate and robust FVM schemes are Roe schemes, which belong to the family of Riemann solvers. Roe scheme, however, requires the computation of the complete eigenstructure of the flux matrix at each time step. Traditionally, the eigenstructure of a two-layer system is computed numerically, which may have a negative effect on the computational speed of the numerical solver. Recently, a much faster semi-analytical implementation of the Roe solver (A-Roe) was introduced. An additional advantage of the A-Roe scheme is an integrated treatment for a possible loss of hyperbolicity. Here, we illustrate some practical advantages of the A-Roe scheme and examine its computational efficiency in simulating several geophysical flows characterized by a two-layer structure.