SECOND-ORDER ACCURATE STRUCTURE-PRESERVING SCHEME FOR SOLUTE TRANSPORT ON POLYGONAL MESHES

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Abstract. We analyze the structure-preserving properties of a conservative finite-volume scheme on polygonal meshes used for modeling solute transport on a surface with variable elevation. Polygonal meshes not only provide enormous mesh generation flexibility, but also tend to improve stability properties of numerical schemes and reduce bias towards any particular mesh direction. The mathematical model is given by a system of weakly coupled shallow water and linear transport equations. The equations are discretized using different explicit cell-centered finite volume schemes for flow and transport subsystems with different time steps. The discrete shallow water scheme is well balanced and preserves the positivity of the water depth. We provide a rigorous estimate of a stable time step for the shallow water and transport scheme and prove a bounds-preserving property of the solute concentration. The scheme is second-order accurate over fully wet regions and first-order accurate over partially wet or dry regions. Theoretical results are verified with numerical experiments on rectangular, triangular, and polygonal meshes.

Keywords: Hyperbolic coupled system; Shallow water equations; Linear solute transport; Finite-volume (FV) schemes; Polygonal meshes; Bounds-preservation

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References

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