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Linearity-preserving monotone local projection stabilization schemes for continuous finite elements

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Abstract

This paper presents some new tools for enforcing discrete maximum principles and/or positivity preservation in continuous piecewise-linear finite element approximations to convection-dominated transport problems. Using a linear first-order advection equation as a model problem, we construct element-level bilinear forms associated with first-order artificial diffusion operators and their two-scale counterparts. The underlying design philosophy is similar to that behind local projection stabilization (LPS) techniques and variational multiscale (VMS) methods. The difference lies in the structure of the local stabilization operator and in the way in which the resolved scales are detected. The proposed stabilization term penalizes the difference between the nodal values and cell averages of the finite element solution in a manner which guarantees monotonicity and linearity preservation. The value of the stabilization parameter is determined using a multidimensional limiter function designed to prevent unresolvable fine scale effects from creating undershoots or overshoots. The result is a nonlinear high-resolution

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