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A FREE PARAMETER SPACE-TIME NONLINEAR SUBGRID METHOD FOR TRANSPORT PROBLEMS

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ABSTRACT

A multiscale method for the numerical solution of the evolutionary initial and boundary value problems arising from advection-diffusion-reaction equations is proposed in this work. Both advection dominated and reaction dominated regimes are considered. The nonlinear subgrid scale (NSGS) finite element model developed in [7, 6] is extended to transient problems using the semi-discrete approach.

The NSGS method is based on a multiscale (two-level) decomposition of the discrete approximation spaces and the local problem is modified introducing an artificial viscosity acting only on the unresolved scales. It only adds to the Galerkin formulation a subgrid nonlinear operator which is automatically tuned by the resolved scale solution accuracy. A particular feature of this method is that, unlike other nonlinear multiscale methods, it does not depend on the choice of any heuristic parameter such as the stabilization parameter in stabilized methods [2, 1, 5] and the tuned-up parameter in subgrid scale methods [3, 4]. The NSGS method is able to capture local discontinuities on steep layers and combines the advantage of not having to tune-up a stabilizing parameter with the simplicity of a subgrid viscosity method.

In the present work, we develop and analyze the NSGS method for transient problems using θ-schemes. We pay particular attention on the temporal aspects of time discretization schemes and their interplay with the subgrid artificial viscosity operator. Numerical experiments are conducted to cover a variety of parameter ranges in order to show the behavior of the proposed methodology.

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