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A comparative study of two different finite difference methods for solving advection–diffusion reaction equation for modeling exponential traveling wave in heat and mass transfer processes

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Abstract
An unconditionally-positive finite difference (UPFD) and the standard explicit finite difference schemes are compared to the analytical solution of the advection–diffusion reaction equation which describes the exponential traveling wave in heat and mass transfer processes. It is found that although the unconditional positivity of the UPFD scheme, this scheme is less accurate than the standard explicit finite difference scheme. This is because the UPFD scheme contains additional truncation-error terms in the approximations of the first and second derivatives with respect to x, which are evaluated at different moments in time. While these terms tend to zero as the mesh is refined, the UPFD scheme nevertheless remains less accurate than its standard explicit finite difference counterpart. The presented results are important when modeling a heat and mass transfer processes using the investigated advection–diffusion reaction equation. Furthermore, current and future developers of coupled multi-species transport models may draw on the ideas of solutions methods employed in this study to further develop numerical models for various types of coupled multi-species transport problems.

Keywords Advection–diffusion reaction equation · Exponential traveling wave · Finite difference schemes · Heat and mass flow · Coupled multi-species transport problems

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