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NUMERICAL ANALYSIS OF MULTI-TERM FRACTIONAL DIFFUSION EQUATION ON ADAPTIVE MESH

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ABSTRACT

This work investigates a multi-term general fractional advection-diffusion equation, where the time derivative is a general Caputo fractional operator incorporating a weight and a strictly increasing scale function. First, we develop and analyze a numerical scheme. The temporal discretization is implemented on uniform, graded, and adaptive meshes, while a high-order compact difference scheme is employed for the spatial domain. The adaptive mesh is generated through the equidistribution of a positive monitor function. A rigorous stability and convergence analysis is performed for the uniform and graded mesh schemes. We rigorously prove that these schemes achieve an optimal convergence order of $\min(2-\alpha_1,\ r\alpha_1)$ in time and fourth-order accuracy in space, where α_1 is the leading fractional order and r is the grading parameter. The performance of the proposed schemes is evaluated through three numerical examples with non-smooth solutions. The adaptive mesh consistently outperforms both graded and uniform meshes in these tests. Furthermore, the results clearly illustrate the significant impact of the weight and scale functions on the solution's behavior.