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FINITE VOLUME SCHEME PRESERVING LOCAL-MAXIMUM PRINCIPLES FOR RADIONUCLIDE TRANSPORT CALCULATIONS

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In the context of nuclear waste disposal simulation, we are interested in a transport model in porous media which can be described by a convection-diffusion-dispersion equation applied on highly anisotropic heterogeneous geological layers.
We want to construct a cell-centered scheme which satisfies the following :
It is second order accurate for smooth solutions.
It takes into account heterogeneous anisotropic tensors.
It takes into account distorted meshes.
It satisfies discrete minimum and maximum principles without geometric constraints on the mesh and without conditions on the anisotropy ratio.

The fourth property is crucial for diffusion terms in modelling two-phase flows in porous media and for coupling transport equation with a chemical model.
To our knowledge, there are no linear schemes satisfying all of the above requirements. For example, for classical finite elements, it is well known that for the Laplacian, the resulting global matrix associated with the scheme is an M-Matrix if some geometrical constraints are satisfied.
In this paper, we present a cell-centered finite volume scheme preserving the local-maximum principles even for highly anisotropic tensors. The main idea is to calculate the gradient using a nonlinear scheme. For parabolic or elliptic problems, the resulting global matrix is a strictly diagonally dominant M-Matrix. Using an unstationary analytical solutions, we show the robustness and the accuracy of this algorithm in comparison with results obtained by Mixed Hybrid Finite Element and linear finite volume schemes which do not satisfy the minimum and the maximum principles on this test.

Keywords:
Radionuclide Transport, Numerical Simulation, Negative Concentrations, Finite Volumes, Maximum Principle