MPDATA method for non–uniform mesh

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Abstract: MPDATA[1,2] is multidimensional positive definite advection transport algorithm proposed by Piotr K. Smolarkiewicz in 1983. This method is used to efficiently solve the advection transport problem of non-negative thermodynamic variables (such as liquid water or water vapor) in the atmospheric dynamics model. This method has been proved to be an effective numerical solution to the advection transport problem for uniform meshes. However, since there is no uniform mesh division on the sphere, the traditional MPDATA method is faced with the incompatibility problem for the non-uniform and quasi-uniform meshing of the sphere, resulting in the numerical algorithm failing to reach the designed second-order accuracy. Firstly, this paper analyzes the insufficiency of traditional MPDATA methods for non-uniform grids. That is, the incompatibility of the first-order numerical scheme and the approximation of boundary derivative. Then the MPDATA method suitable for non-uniform grid is proposed. According to the characteristics of non-uniform grid and the characteristics of well-balance[3] central grid point algorithm, the MPDATA method suitable for 1-d and 2-d complex grid structure is designed. The consistency and positivity of the algorithm are proved by mathematical analysis. Finally, the theoretical proof is verified by numerical simulation.

Reference

[1] Smolarkiewicz P. A Simple Positive Definite Advection Scheme with Small Implicit Diffusion[].