

A high order finite element method for the shallow-water equations on the cubed sphere

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A mimetic finite element method for the shallow-water equations is presented. The weak form of the equations of motion is derived from their Hamiltonian formulation, ensuring conservation of energy. Compatible spaces are used for vorticity, velocity and mass, ensuring properties such as $\text{div} \cdot \text{curl} = 0$ and $\text{curl} \cdot \text{grad} = 0$ as well as conservation of potential vorticity following Cotter & Shipton (2012)¹. Specific finite element spaces are built on the cubed sphere as the image of local polynomial interpolation operators. The construction ensures good dispersion properties by allotting one degree of freedom for mass and two for velocity per quadrangular element. Numerical experiments confirm the mimetic properties and formal order of accuracy of the building blocks of the method. Third-order convergence is achieved on the solid-body rotation in geostrophic balance, while other standard test-cases show a convergence rate between 2 and 3.

[1] Mixed finite elements for numerical weather prediction, C.J. Cotter, J. Shipton, *J. Comp. Phys.* 231, 2012.