

Meshfree semi-Lagrangian methods for transport on spheres and other surfaces

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We present three new semi-Lagrangian methods based on radial basis functions (RBFs) for numerically simulating transport on a sphere. The methods are meshfree and are formulated entirely in Cartesian coordinates. They thus allow for quasi-optimal node distributions and naturally bypass any apparent artificial singularities associated with surface based coordinate systems. The semi-Lagrangian framework allows these new methods to avoid the use of any stabilization terms (such as hyperviscosity) during time-integration, thus reducing the number of parameters that have to be tuned. Furthermore, it allows for time-steps that at least an order of magnitude larger than the CFL condition allows. The three new methods are based on interpolation using 1) global RBFs, 2) local RBF stencils, and 3) RBF partition of unity. Standard test cases consisting of solid body rotation and deformational flow are used to compare and contrast the methods in terms of their accuracy, efficiency, conservation properties, and dissipation/dispersion errors. We also discuss the extension of these methods to more general surfaces and to advection-reaction-diffusion equations.