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Parcel and Particle Eulerian–Lagrangian Methods for Geophysical Flows

O. Bokhove

Department of Applied Mathematics, University of Twente, P.O. Box 217, 7500AE, Enschede, The Netherlands (o.bokhove@math.utwente.nl)

Parcel Eulerian–Lagrangian Hamiltonian formulations have recently been used in structure-preserving numerical schemes, asymptotic calculations, and alternative explanations of fluid parcel (in)stabilities. A parcel formulation describes the dynamics of one fluid parcel with a Lagrangian kinetic energy but an Eulerian potential, prescribed or given by an integral relation, evaluated at the parcel's position. First, we derive the geometric link between the parcel Eulerian–Lagrangian formulation and Hamiltonian formulations of geophysical fluid flows such as generalized two-dimensional vorticity-stream-function dynamics, the rotating two-dimensional shallow water equations, and the rotating three-dimensional compressible Euler equations (Bokhove, 2005; Bokhove and Oliver, 2006). Second, we explain the essentials of structure-preserving Hamiltonian particle-mesh methods and show some simulation results (Frank and Reich, 2004). Finally, we outline how structure-preserving Hamiltonian particle-mesh methods can be used as a basis in (idealized) forced-dissipative climate simulations.

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