Statistically accurate simulations for atmospheric flows

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A Hamiltonian particle-mesh method for quasi-geostrophic potential vorticity flow is proposed. The microscopic vorticity field at any time is an area- and energy-conserving rearrangement of the initial field. We construct a statistical mechanics theory to explain the long-time behavior of the numerical solution. The statistical theory correctly predicts the spatial distribution of particles as a function of their point vorticity. A nonlinear relation between the coarse grained mean stream function and mean vorticity fields is predicted, consistent with the preservation of higher moments of potential vorticity reported in [R. V. Abramov, A. J. Majda 2003, PNAS 100 3841–3846].