Geophysical Research Abstracts,
Vol. 10, EGU2008-A-11001, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-11001
EGU General Assembly 2008

A Hamiltonian numerical scheme for a hydrostatic atmosphere

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Although our climate is ultimately driven by (nonuniform) solar heating, many aspects of the flow can be understood qualitatively from forcing-free and frictionless dynamics. In the limit of zero forcing and dissipation, our weather system falls under the realm of *Hamiltonian fluid dynamics* and the flow conserves potential vorticity, energy and phase space structure.
We have found a conservative numerical scheme for an adiabatic and hydrostatic atmosphere. The steps are as follows. First, we derive a mixed Eulerian-Lagrangian Hamiltonian description of the continuum atmosphere based on a so-called *parcel formulation*, [1.]. Key point here is that we use isentropic coordinates. The next step is to introduce a finite element discretization in the entropic direction. What remains is a stack of shallow water-type flows that are coupled through an elliptic equation in the entropy coordinate only. Next, we use a *Hamiltonian Particle-Mesh* method, [2], to discretise the horizontal dynamics. This method is based on a discrete version of the parcel formulation and uses a symplectic time integrator. Potential vorticity as well as Hamiltonian phase space structure are exactly conserved. Energy is conserved asymptotically in the time step.
Several challenging nonlinear solutions will be tested.
A successful application of our method can be found in [3.], where a simplifying *layer-model* approximation is used in the entropic direction.

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3. Bokhove, O. & Oliver, M. (2008): 'Isentropic N–layer models for atmospheric dynamics'. Accepted subject to minor modifications *Q. J. Roy. Met. Soc.* & http://eprints.eemcs.utwente.nl/