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Variational integrators for anelastic and pseudo-incompressible flows

The anelastic and pseudo-incompressible equations are two well-known soundproof approximations of compressible flows useful for both theoretical and numerical analysis in meteorology, atmospheric science, and ocean studies. In this talk we derive and test structure preserving numerical schemes for these two systems. The numerical schemes are based on a finite dimensional approximation of the group of volume preserving diffeomorphisms and are derived via a discrete version of the Euler-Poincaré variational formulation of the anelastic and pseudo-incompressible systems.

The resulting variational integrators allow for a discrete version of Kelvin circulation theorem, are applicable to irregular meshes and exhibit excellent long term energy behavior. We then report a series of tests for these models on regular and irregular meshes with strongly deformed cells. In the benchmark test of hydrostatic adjustment we verify that the models correctly represent the dispersion relations. We further show that these schemes correctly capture the Kelvin Helmholtz instability. Finally, on the rising and falling bubble test cases we illustrate the models' accurate representation of advection dominated processes. For these test cases and grid types, these variational models show excellent long time energy conservation.

This is a joint work with François Gay-Balmaz (Laboratoire de Météorologie Dynamique, École Normale Supérieure/CNRS, Paris, France).