

Towards an all-scale cloud-resolving model

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An all-scale numerical framework has been developed allowing integrations of cloud-resolving moist atmospheric dynamics using either anelastic or fully-compressible Euler equations. The compressible model applies either an explicit acoustic-mode resolving scheme requiring short timesteps or a novel implicit scheme allowing timesteps as long as these used in the anelastic model. Overall goal is to study the anelastic and compressible moist dynamics across the entire range of spatial scales, from small-scale to planetary, and to develop theoretical basis and practical implementations of the soundproof methodology to an all-scale atmospheric modeling. The latter concerns the importance of pressure perturbations associated with atmospheric circulations on the representation of moist thermodynamics. A simple scale analysis suggests that nonhydrostatic pressure perturbations (diagnosed in the anelastic system or prognosed in the compressible system) are of negligible importance for the small-scale and mesoscale moist thermodynamics. For larger-scale flows, however, at least the hydrostatic component of the pressure perturbation needs to be included.

To compare anelastic and compressible solutions and the origins of their differences, a set of numerical simulations including small-scale dynamics, mesoscale orographic flows, moist deep convection and larger-scale planetary flows is analyzed. Since we apply a unified numerical framework that minimizes numerical disparities between the models, a better exposition of the differences stemming from different mathematical formulations is possible. The numerical results for small- and mesoscale dynamics, including severe deep convection, are practically the same for anelastic and compressible models. The differences become significant for the canonical test of the dry baroclinic wave development. Despite these differences, benchmark climate simulations based on the Held-Suarez setup show that anelastic and compressible models provide similar solutions with a comparable meridional transport of the temperature and momentum. Most recent moist simulation results will be presented at the conference.