Review of "A moist aquaplanet variant of the Held-Suarez test for atmospheric dynamical cores", by D. R. Thatcher and C. Jablonowski.

Geoscientific Model Development, discussion paper

Recommendation: accept after minor revisions

General evaluation

The authors present a moist variant of the widely used Held-Suarez test for atmospheric dynamical cores and demonstrate its application by comparing and discussing results from several dynamical cores of the Community Atmosphere Model (CAM). The extended test adds significant value to the existing suite of dynamical core tests because it considers important aspects of physics-dynamics coupling in an environment that is sufficiently simple for interpretable results. The implementation of the test is described clearly with FORTRAN code provided as supplementary material. In addition, the application to the CAM dycores convincingly demonstrates that the test can reveal certain weaknesses of a model and help understanding the underlying reasons. There are only a few minor issues that require some clarification. I therefore recommend acceptance for publication subject to minor revisions.

Minor comments

1. At several places in the description of the test case, the assumption is made that physics-dynamics coupling takes place at constant pressure. While this is standard for hydrostatic models, this is not necessarily the case for nonhydrostatic models. The distinctions needed depending of the type of physics-dynamics coupling should be mentioned explicitly where appropriate, e.g. on p. 8271 / Eq. (2) and p. 8274 / discussion after Eq. (13).

2. Eqns. (7), (9) and (13): Shouldn't the sensible heat flux be proportional to $\theta_s - \theta_a$ rather than $T_s - T_a$?

3. p. 8275, 2nd para: As many nonhydrostatic models employ a height-based coordinate, a comment would be desirable on how sensitive the results are to the profile function in Eq. (14). Would one have to convert the vertical profile function from linear in z to linear in σ?

4. Eq. (18): At the poles, T_{eq} is more than 40 K colder than the SST. I see that the relaxation coefficient k_T is rather small at the poles, but I still wonder if this yields reasonable heat fluxes.

5. p. 8279, 1st para of section 3: Similar to comment #3, it would be important to know how sensitive the results are to the setup of the vertical model levels. In models with a height-based coordinate system, the layer setup cited here cannot be exactly replicated.

6. p. 8295, top: Does the "se_ftype = 0" option apply to all physics forcing terms, including latent heat release from the saturation adjustment? I ask this question because at convection-resolving scales, applying the latent heat release term as a gradual forcing in the dynamical core tends to severely (and detrimentally) affect convective dynamics.

7. p. 8297, 2nd para: Do the CAM developers have a hypothesis about the reason for the strong circular gravity wave structures in the SE dycore? Their large spatial extent over several thousands of kilometers raises the questions why they propagate with nearly no damping over such large distances, and if they propagate at a physically reasonable phase speed. Gravity waves with a vertical wavelength of twice the tropopause height (~ 30 km) should have a propagation speed of about 50 m/s, implying that there would have to be a stationary on-off forcing over many hours in order to excite circular waves of the spatial extent observed here.

8. p. 8299, 3rd para: Very good point!

9. p. 8303, 2nd para, discussion of Fig. 14: Do the different physics time steps (600 vs. 1800 s) play a role for the precipitation intensity spectra?

Editorial comments

p. 8270, bottom: R_v should be 461.5 J/(kg K), not 462.5

p. 8276 / Eq. (17): Model developers usually associate p_{top} with the model top pressure. I would prefer p_{pbl} or something like that.

p. 8279, ln. 4/5: The subject seems to be missing in this sentence.

p. 8289, ln. 26: In Table 2, it says 2.10 rather than 2.11 mm/day for MITC.

p. 8230, ln. 12: "Instantaneous precipitation rates" refers to one physics time step?

p. 8291, ln. 21: c_p already denotes the specific heat capacity at constant pressure. Please use e.g. c_{ph} for the phase speed.

p. 8300, ln. 6: The term "hemispherically averaged" is a bit misleading. I was first thinking of "averaged over the northern and southern hemisphere, respectively"; only after looking at Fig. 12, I understood what it means. Perhaps this could be formulated a bit more clearly.