A Standard Test Set for Nonhydrostatic Dynamical Cores of NWP Models

Objective: Compile a set of test cases to verify the correctness and examine the robustness of nonhydrostatic solvers (not full NWP models). Publish this test set (journal paper, web page, etc.) to facilitate community use.

Philosophy: Our foremost needs are for tests encompassing important linear and nonlinear nonhydrostatic flows encountered as NWP models increase resolution from hydrostatic regime (dx ~ 10 km) to nonhydrostatic regime (dx ~ 1 km), e.g. terrain-forced flows, gravity waves and convection (strongly nonlinear flows). The primary purpose of these tests are for testing coding correctness and the appropriateness of approximations, and to test model robustness, accuracy and efficiency.

Background: At the SRWNP (Short Range Numerical Weather Prediction) workshop in Bad Orb, Germany, 27-29 October 2003, we presented the following proposed test set. The 80+ participants at the workshop strongly endorsed the proposal. In this paper we invite the input of the wider community in the development of this test set.

Proposed Initial Test Set

(1) Inertia gravity waves in a periodic channel (Skamarock and Klemp, 1994, MWR, 2623-2630)
(3) Resting atmosphere
(4) Potential flow over a mountain
(5) 2-D mountain waves (hydrostatic and nonhydrostatic, linear and nonlinear)
   (e.g. Klemp and Lilly, 1978, JAS, 78 - 107; Durran and Klemp, 1982, JAS, 2490 - 2506)
(6) 3-D mountain waves
(8) Squall lines and/or supercells?

Guiding Principles

(1) Tests should be easy to configure.
(2) Tests should be easy to evaluate.
(3) Tests should require only minimal physics (dissipation, very simple moist physics).
(4) Tests should test something in the solver.
(5) Test set should be a minimal set.

Test Documentation: the crucial component

Existing test cases are scattered in the literature, and tend to be poorly documented, especially for the uninitiated, hence we will strive to provide complete documentation of

(1) setup of tests and interpretation of results.
(2) solution (analytic, numerically converged, subjective).
(3) identification of solver components tested by test, and interpretation of results with respect to solver components.

Implementation

Primary implementation will be on a web page that will be maintained and updated as need - it will evolve over time. It is expected that new tests will be added. Additionally, test results from models may be posted and discussion of tests and test results could also be posted. Finally, in the future, test cases or other aspects of NWP models (such as physics) could also be accomodated here.

Contact W. Skamarock at skamaroc@ucar.edu or (303)-497-8161
The test case website is http://mmm.ucar.edu/individual/skamarock/test_cases/test_cases.html
Comments, suggestions and help with the test cases are welcome.

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Proposed Test Case Examples

Density Current

**Verification:** speed, u, w, q min/max
Graphs show density current with various spatial resolutions (50, 100, 200, 400 meters) and time steps (1, 2, 4, 8 seconds).

**Model components tested:** coding, nonlinear behavior, model efficiency and robustness (using different timesteps and spatial resolutions, translation vel).

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Schaer Test Case

**Verification:** Solution, structure and amplitude
Graphs show results of Schaer test case with Leapfrog and COAMPS models.

**Model components tested:** metric terms, divergence operators and advection (computation of \( \omega \)).

**Steady-state solution:** not a test of time integration (except in SL models).

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Moist Convection

**Supercell test case:** fixed viscosity (500 m²/s), Kessler Microphysics, periodic x,y boundaries, \( (X,Y,Z = 90,90,20 \text{ km}) \), unidirectional shear.

**Verification:** structure, amplitude, cell propagation.

**Model Components tested:** everything except terrain.