Lessons learned from the Dynamical Core Model Intercomparison Project (DCMIP-2016)

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Organizing team

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How does DCMIP work?

DCMIP: 2-week summer school and dynamical core model intercomparison project
in 2016: use idealized moist test cases and focus on non-hydrostatic models, physics-dynamics coupling and variable-resolution modeling systems.

Three “core” test cases with idealized physics processes:

• Test 1: Moist baroclinic instability with “toy” Terminator chemistry
• Test 2: Moist tropical cyclone test
• Test 3: Moist mesoscale storm test (supercell)

“Living” Test case document and DCMIP-2016 web page:
https://github.com/ClimateGlobalChange/DCMIP2016
https://www.earthsystemcog.org/projects/dcmip-2016/
Large-scale condensation or Kessler-type warm rain

PBL Mixing of pot. T, q, u, v

Surface fluxes of sensible & latent heat, and momentum

Simple-Physics (Reed and Jablonowski, 2012; Klemp et al., 2015)
Who are the DCMIP-2016 participants?
DCMIP-2016 Sponsors

NCAR
Office of Science
U.S. Department of Energy

NCAR UCAR
CISL
Computational & Information Systems Lab

DEPARTMENT OF THE NAVY
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Science & Technology

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National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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Research Computing

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DCMIP-2016 Snapshots: Moist Baroclinic Wave Test

Surface pressure at day 10 ($\Delta x=110$ km): overall patterns similar, details differ

Ullrich et al. (2014), moist baroclinic wave with Kessler-type precipitation, no PBL
DCMIP-2016 Snapshots: Moist Baroclinic Wave Test Case

Precipitation rates at day 10 approx. 110 km grid spacing:

Differing number of precipitation cells (and differing strength)
We currently investigate whether the spread by day 12 (10-15 hPa) is mainly driven by the moist interactions or whether it is already present in the corresponding dry experiments.
DCMIP-2016 Snapshots: “Toy” Terminator Chemistry

Tracer advection test with correlated tracers, i.e., the sum of Cl and Cl₂ (needs to stay constant)

Lauritzen et al. (2015)
**DCMIP-2016 Snapshots: “Toy” Terminator Chemistry**

**Analytical solution:** Column-integrated Cly needs to be constant.

Colors indicate the numerical errors in the advection schemes: they can break tracer correlations.
DCMIP-2016 Snapshots: “Toy” Terminator Chemistry

FV3 (Day 10)  NICAM (Day 10)

Very low errors  Errors mostly develop along terminator line.
DCMIP-2016 Snapshots: Tropical Cyclone

Description of the initial conditions and simple-physics: Reed and Jablonowski (2011, 2012)
Snapshots: Tropical Cyclone

Wide spread: Evolution of the minimum surface pressure and maximum wind speed

High resolutions ($\Delta x=25-30$ km)

Delta $x=50-60$ km

Positions, strengths and diameters of the tropical cyclones show rather broad distributions that need to be understood.

Wind speed (day 10): Stronger, more structured cyclones (except NICAM)
DCMIP encourages exploration of new test configurations: Alternative representation of the simplified planetary boundary layer (more mixing) modifies the shapes of the tropical cyclone.
DCMIP-2016 Snapshots
Supercell

Computed on a reduced-size Earth at non-hydrostatic scales with Kessler precipitation (no PBL or surface fluxes):
See Klemp et al. (2015)

Model Tempest
DCMIP-2016 Snapshots: Supercell with 1km grid spacing

Evolution of supercell (no rotation) at 5km: supercell always split, but shapes vary widely.
**DCMIP-2016 Snapshots: Supercell after 120 minutes**

**Dependence on resolution:** some signs of convergence at 1km and finer
DCMIP-2016 Snapshots: Supercell at various resolutions: single model shows signs of convergence at 1km and finer, but inter-model spread is large.
Conclusions

• The interactions between a dynamical core and moisture processes can already be simulated with very simple model configurations, like large-scale condensation or a Kessler warm-rain scheme, or a slightly more complex ‘simple-physics’ package

• These moist dynamical core configurations reveal aspects of the physics-dynamics coupling

• Idealized test cases are a useful tool (with quick turn around times) to test/understand the moisture aspects, causes and effects can be analyzed more easily

• Current status: we investigate the causes of the dycore differences, GMD papers will follow this summer
References


DCMIP-2016 project page: https://www.earthsystemcog.org/projects/dcmip-2016/