The Dynamical Core Model Intercomparison Project DCMIP-2016

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Christiane Jablonowski & DCMIP organizing team

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DCMIP-2016 Organizers

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- Colin Zarzycki
- Kevin Reed
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What is DCMIP?

• An international dynamical core model intercomparison project to quantify difference in modern dynamical cores via idealized test cases.

• A 2-week summer school & workshop that highlights the newest numerical modeling techniques for climate & weather models.

• DCMIP-2016 emphasized non-hydrostatic global models, physics-dynamics coupling and variable-resolution modeling.

• DCMIP is a community project that
  • started with an NCAR Advanced Study Program (ASP) Colloquium in 2008 (DCMIP-2008),
  • followed by DCMIP-2012, held at NCAR in August 2012 https://www.earthsystemcog.org/projects/dcmip-2012/,
  • followed by DCMIP-2016, held at NCAR in June 2016 https://www.earthsystemcog.org/projects/dcmip-2016/
How does DCMIP work?

**DCMIP-2016**: 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: 
[https://github.com/ClimateGlobalChange/DCMIP2016](https://github.com/ClimateGlobalChange/DCMIP2016)
Design of the Idealized Physics Processes

Large-scale condensation or Kessler-type warm rain

Surface fluxes of sensible & latent heat, and momentum

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

Simple-Physics (Reed and Jablonowski, 2012; Klemp et al., 2015)
**DCMIP Test Suite**

Define and establish a collection of easy-to-use idealized test cases for different flow scenarios to foster objective dynamical core intercomparisons.

- **Deterministic Tests**
  - 2D Shallow Water Test Cases
  - 3D Dry Dynamical Core Test Cases
  - 3D Dynamical Core + Simplified Physics Test Cases
- **Increasing complexity**
- **Statistical Tests**
  - 3D Aqua-Planet Experiments (APE)
  - 3D Atmospheric Model Intercomparison (AMIP)

**DCMIP**
- DCMIP 2008
- DCMIP 2012
- DCMIP 2016
Who are the DCMIP-2016 participants?
DCMIP-2016 Model Mentors

HOMME-NH/CAM-SE (NCAR, DoE, CU)

David Hall
Colin Zarzycki

NEPTUNE (Naval Research Laboratory)

Kevin Viner
Alex Reinecke

UZIM (Colorado State University)

David Randall
Don Dazlich
Ross Heikes
DCMIP-2016 Model Mentors

- **FV3 (GFDL)**
  - Lucas Harris
  - Xi Chen

- **ICON (German Weather Service & Max-Planck Institute, Hamburg)**
  - Daniel Reinert
  - Marco Giorgetta

- **IFS/FVM (ECMWF)**
  - Christian Kuehnlein

- **OLAM (U. Miami)**
  - Bob Walko

- **GEM (Environment Canada)**
  - Vivian Lee
  - Abdessamad Qaddouri
DCMIP-2016 Model Mentors

NICAM (RIKEN, University of Tokyo, Japan)
- Ryuji Yoshida
- Hiroaki Miura
- Tomoki Ohno

MPAS (NCAR)
- William Skamarock
- Joseph Klemp
- Sang-Hun Park
- Michael Duda
DCMIP-2016 Model Mentors

- **DYNAMICO (LMD, IPSL, France)**
  - Thomas Dubos
  - Yann Meurdesoif

- **TEMPEST (U. California, Davis)**
  - Paul Ullrich

- **ENDGame (U.K. Met Office)**
  - Thomas Melvin
DCMIP-2016 Sponsors
DCMIP-2016 Models...

Latitude-Longitude Grids
ENDGame (U.K. Met Office)

Reduced Gaussian Grid
FVM (ECMWF)
DCMIP-2016 Models...

**Cubed Sphere Grids**
- HOMME-NH / CAM-SE (NCAR, DoE, CU)
- FV3 (GFDL)
- TEMPEST (U. California, Davis)
- NEPTUNE (Naval Research Laboratory)

**Triangular Grids**
- ICON (DWD & Max-Planck)
- DYNAMICO (LMD & IPSL)
DCMIP-2016 Models…

Hexagonal or Spherical Voronoi Grids

MPAS (NCAR)
OLAM (U. Miami)
UZIM (CSU)
NICAM (U. Tokyo, RIKEN)
DCMIP-2016 Models…

**Yin-Yang Grid**

GEM (Environment Canada)
DCMIP-2016 Models...

Variable-Resolution and Stretched Grids

HOMME-NH/CAM-SE
FV3
ICON
MPAS
OLAM
NICAM
DCMIP-2016 Highlights: Moist Baroclinic Wave Test Case

Surface pressure at day 9, approx. 110 km grid spacing:

- wave in CAM-SE evolves quicker in comparison to other dycores
- some grid imprinting is visible in DYNAMICO, GEM, UZIM

Ullrich et al. (2014), moist baroclinic wave with Kessler-type precipitation, no PBL
**DCMIP-2016 Highlights: “Toy” Terminator Chemistry**

Tracer advection test with correlated tracers: Cly is the sum of Cl and Cl2 (needs to stay constant). Lauritzen et al. (2015)
DCMIP-2016 Highlights: “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 Highlights: Tropical Cyclone

Tropical Cyclone Day 0.00

- Zonal Velocity 500m (m/s)
- Surface Pressure (hPa)
- Meridional Velocity 500m (m/s)
- Surface Temperature (K)
DCMIP-2016 Highlights: Tropical Cyclone, wind at day 10

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

- **MPAS (NCAR)**
  - 1500m Horiz. Wind
  - ≈55 km grid spacing

- **FVM (ECMWF)**
  - 1500m Horiz. Wind
**DCMIP-2016 Highlights: Supercell**

Computed on a reduced-size Earth at non-hydrostatic scales, Kessler precipitation (no PBL or surface fluxes): Klemp et al. (2015)
DCMIP-2016 Highlights: Supercell with 250m grid spacing

Supercell solutions shows wide spreads after 2h, gives insight into physics-dynamics coupling and the impact of diffusion.

Vertical velocity at 5 km

Rain water at 5 km

GEM model

NICAM model
References


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