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

AMWG Workshop, Boulder, February/28/2017

Christiane Jablonowski & DCMIP organizing team

Organizing team

Paul A. Ullrich, UC Davis
paullrich@ucdavis.edu

Christiane Jablonowski, U. Michigan
cjablono@umich.edu

Colin Zarzycki, NCAR
zarzycki@ucar.edu

Kevin Reed, Stony Brook U.
kevin.a.reed@stonybrook.edu

James Kent, U. South Wales
james.kent@southwales.ac.uk

Peter Lauritzen, NCAR
pel@ucar.edu

Ram Nair, NCAR
rnair@ucar.edu

DCMIP-2016 Organizers

Paul Ullrich

Christiane Jablonowski

Colin Zarzycki

Kevin Reed

James Kent

Peter Lauritzen

Ram Nair

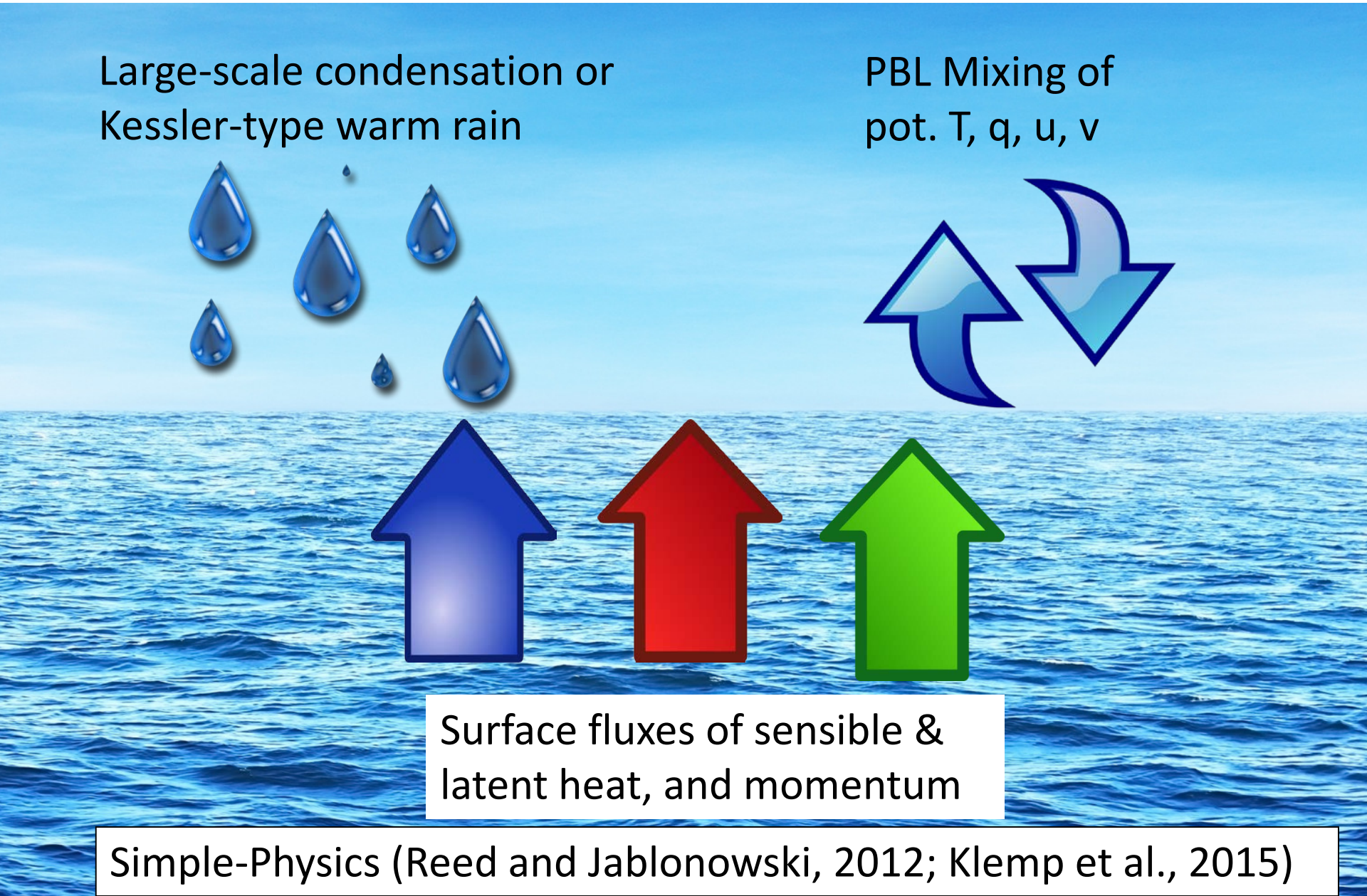
How does DCMIP work?

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/

Design of the Idealized Physics Processes



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

Who are the DCMIP-2016 participants?

DCMIP-2016 Sponsors

NCAR CISL Computational & Information Systems Lab

NCAR

Office of Science
U.S. Department of Energy

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DEPARTMENT OF THE NAVY
USN ONR Science & Technology

NOAA
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U.S. DEPARTMENT OF COMMERCE

NASA

MICHIGAN

Research Computing

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DCMIP-2016 Model Mentors

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

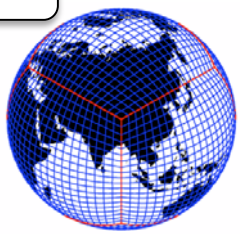
David Hall

Colin Zarzycki

NEPTUNE (Naval Research Laboratory)

Kevin Viner

Alex Reinecke

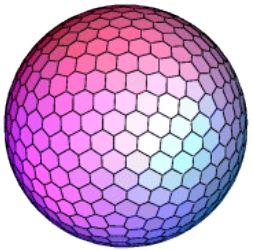


UZIM (Colorado State University)

David Randall

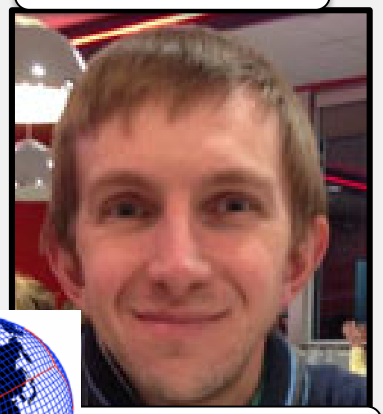
Don Dazlich

Ross Heikes

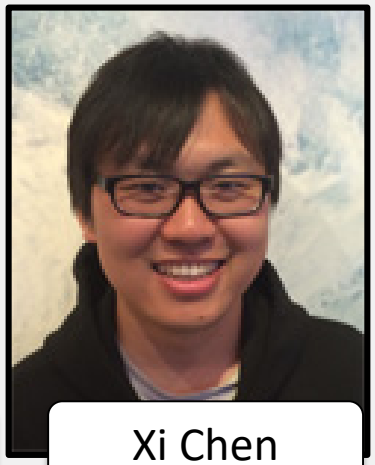


DCMIP-2016 Model Mentors

FV3 (GFDL)



Lucas Harris

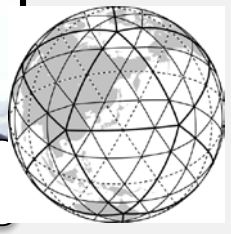


Xi Chen

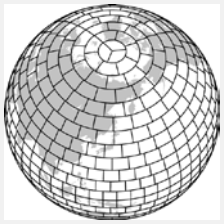
ICON (German Weather Service & Max-Planck Institute, Hamburg)

Daniel Reinert

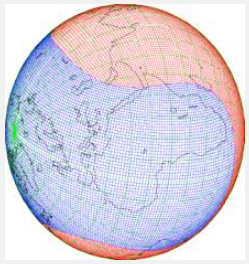
Marco Giorgetta



IFS/FVM (ECMWF)



Christian Kuehnlein



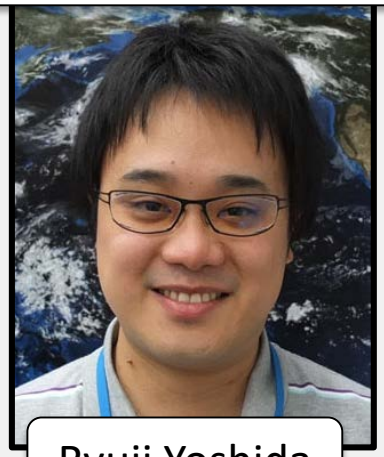
GEM (Environment Canada)

Vivian Lee

Abdessamad Qaddouri

DCMIP-2016 Model Mentors

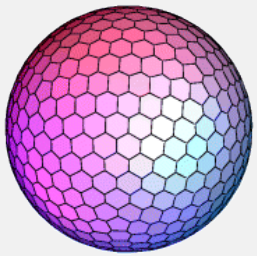
NICAM (RIKEN, University of Tokyo, Japan)

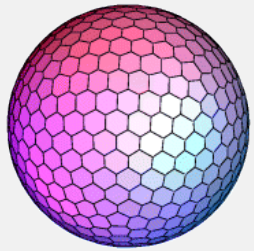


Ryuji Yoshida

Hiroaki Miura

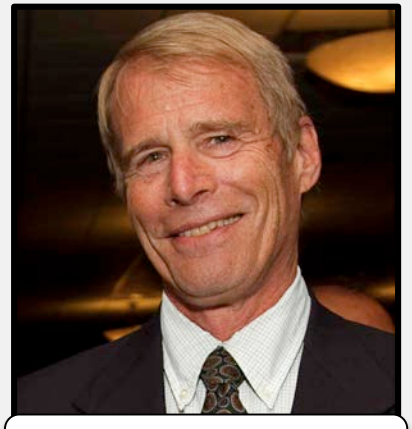
Tomoki Ohno





MPAS (NCAR)

William Skamarock



Joseph Klemp

Sang-Hun Park

Michael Duda

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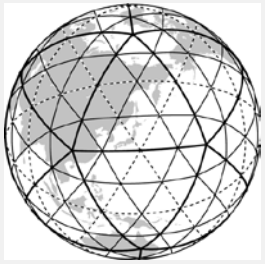
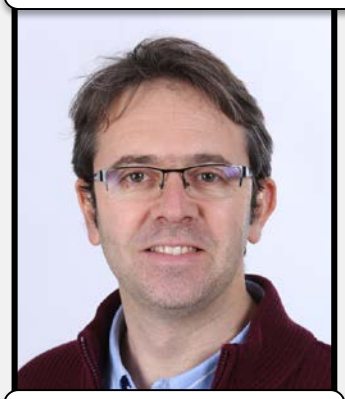


DYNAMICO (LMD, IPSL, France)

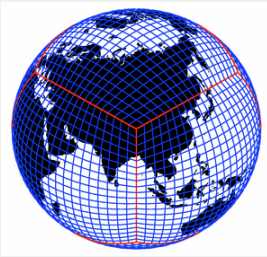


Thomas Dubos

Yann Meurdesoif

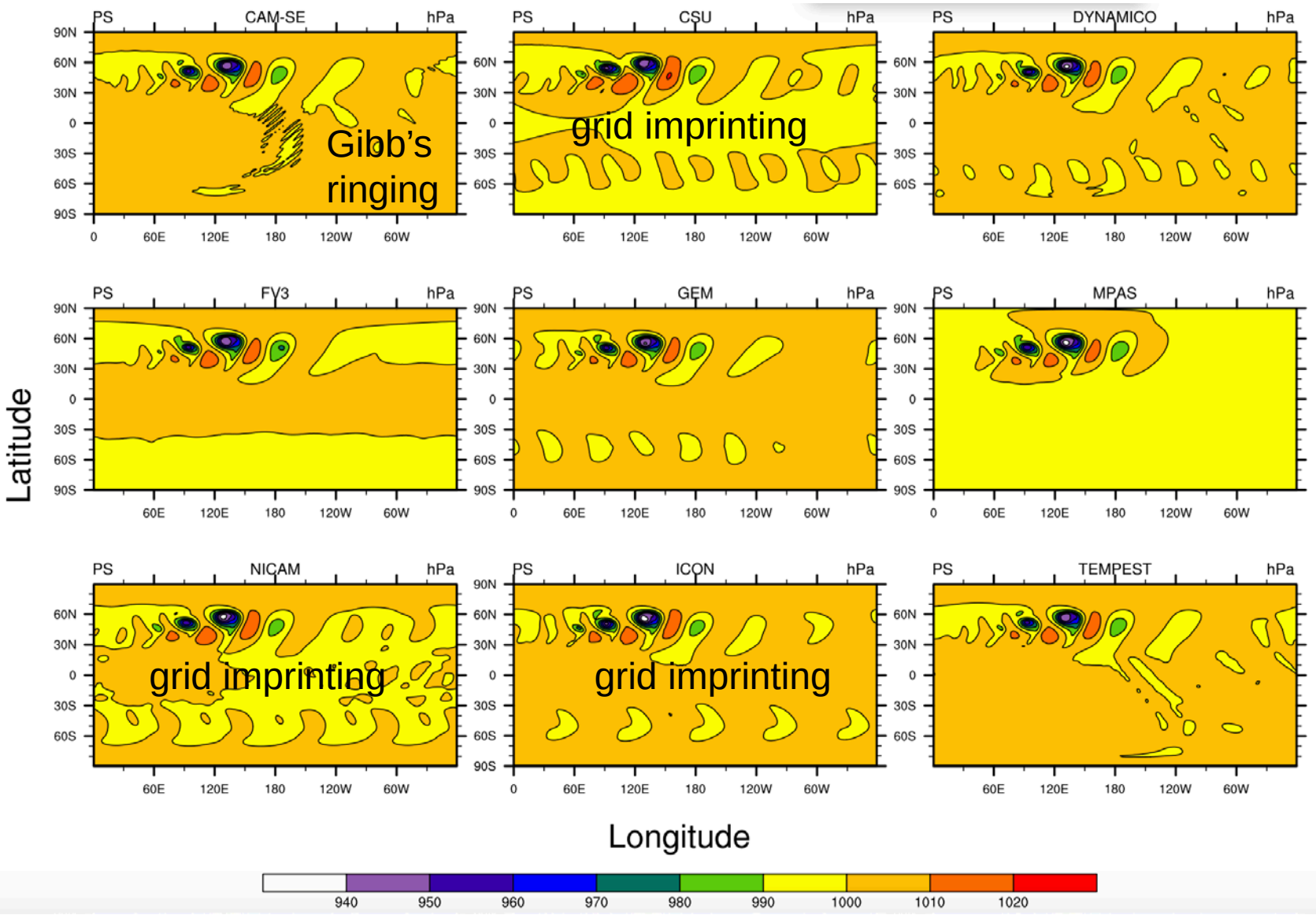
TEMPEST
(U. California, Davis)

Paul Ullrich



DCMIP-2016 Snapshots: Moist Baroclinic Wave Test Case

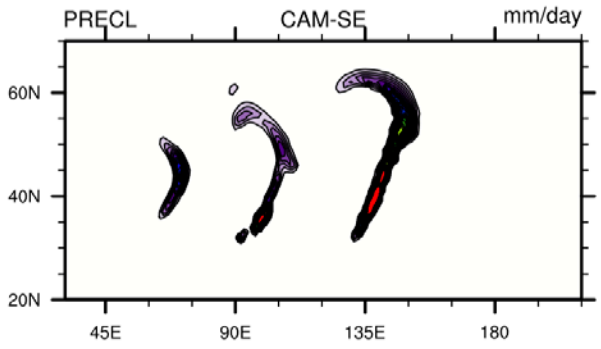
Surface pressure at day 10 (Δx=110 km): overall patterns similar, details differ

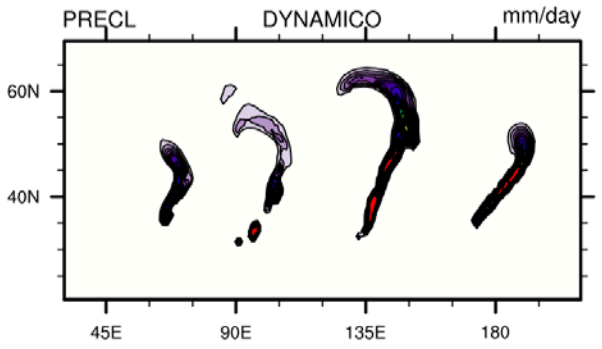


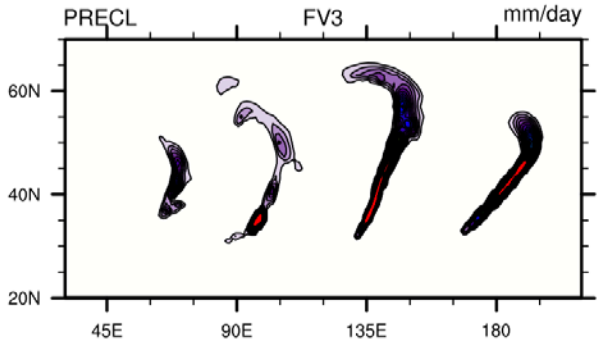
Ullrich et al. (2014), moist baroclinic wave with Kessler-type precipitation, no PBL

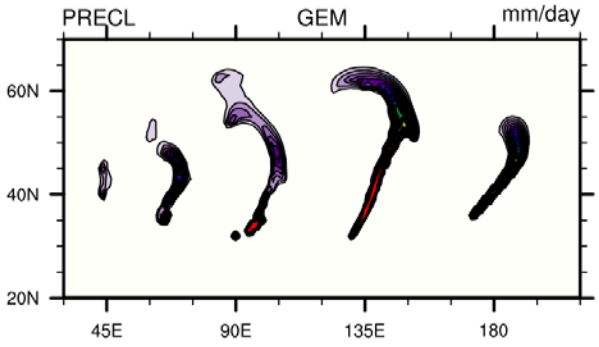
DCMIP-2016 Snapshots: Moist Baroclinic Wave Test Case

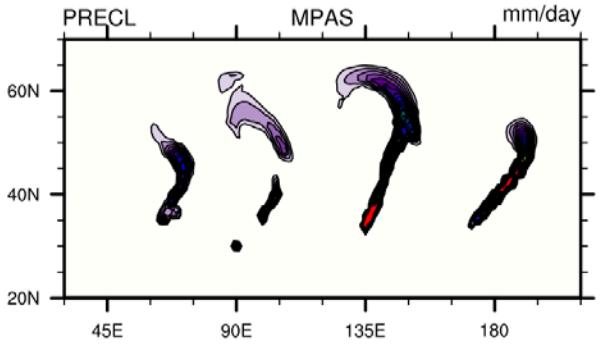
Precipitation rates at day 10 approx. 110 km grid spacing:

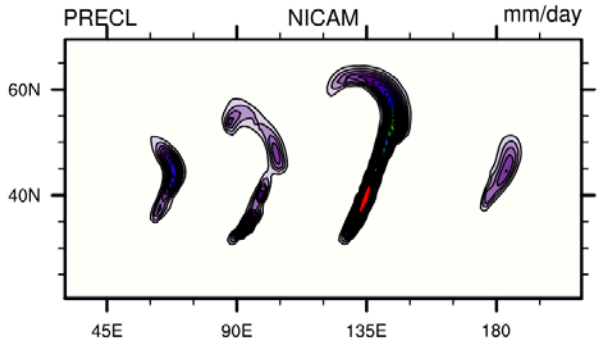


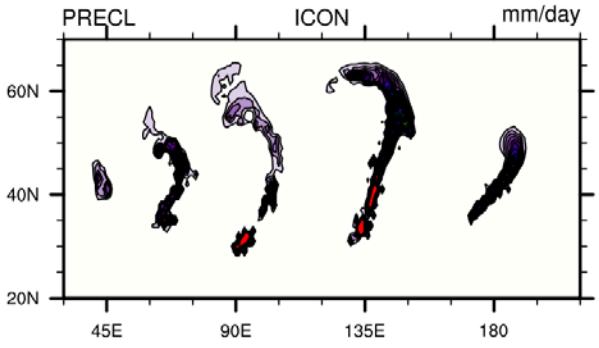








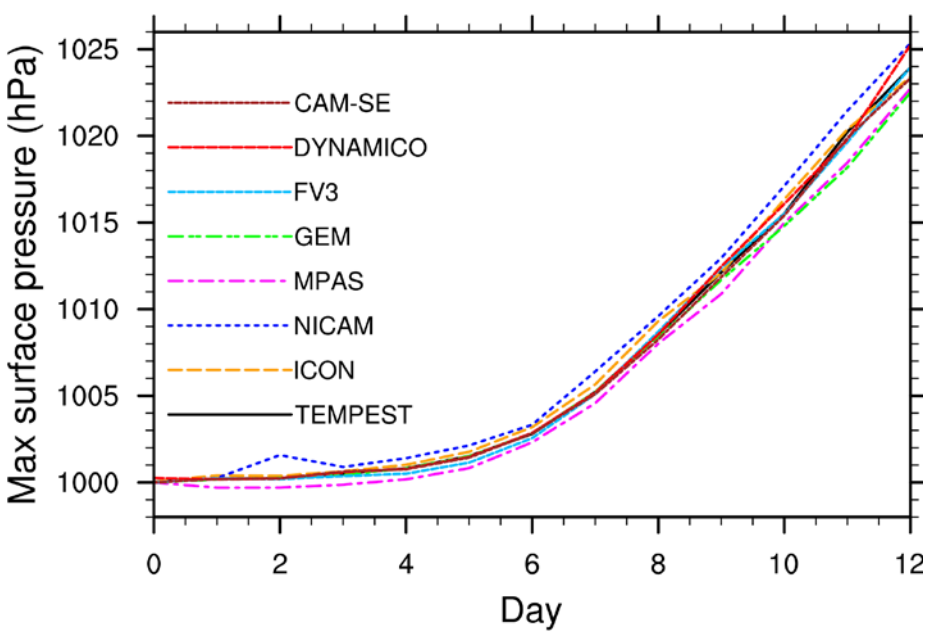


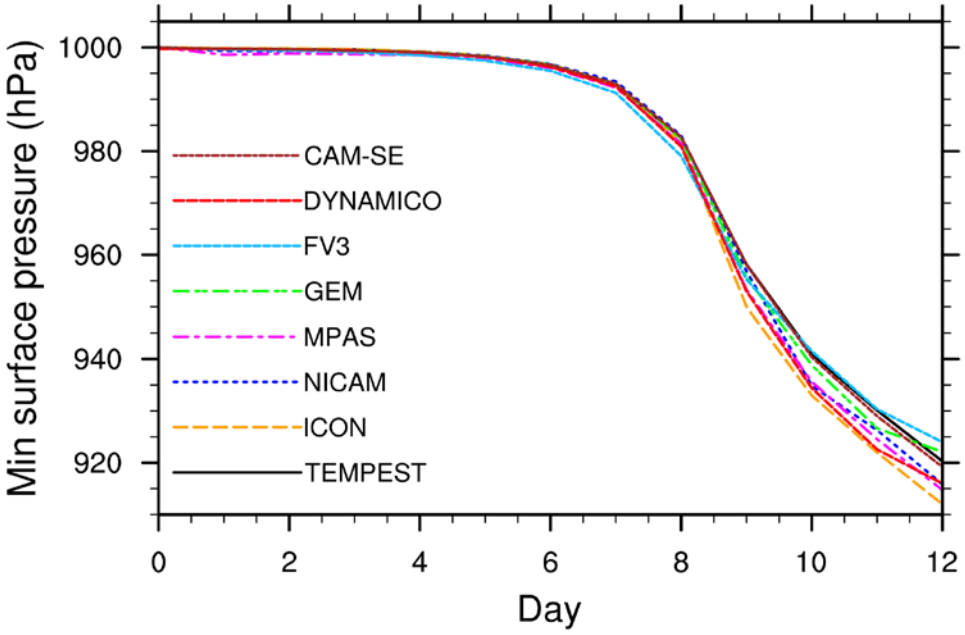


Differing number of precipitation cells (and differing strength)

DCMIP-2016 Snapshots: Moist Baroclinic Wave Test Case

Evolution of the maximum and minimum surface pressure over 12 days, approx. 110 km grid spacing:

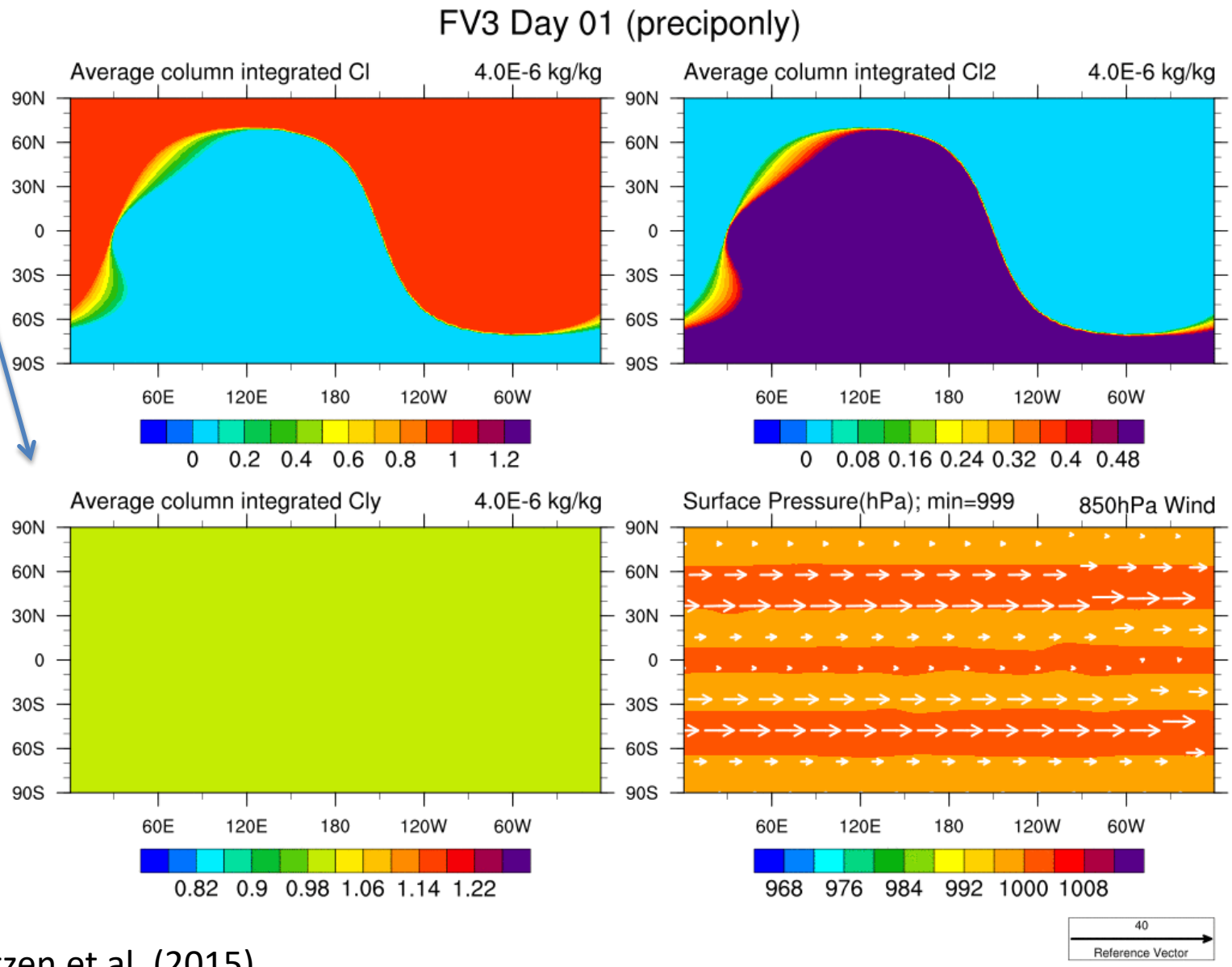




We currently investigate whether the spread by day 12 (10-15 hPa) is mainly driven by the moist interactions or whether it is already present in the corresponding dry experiments.

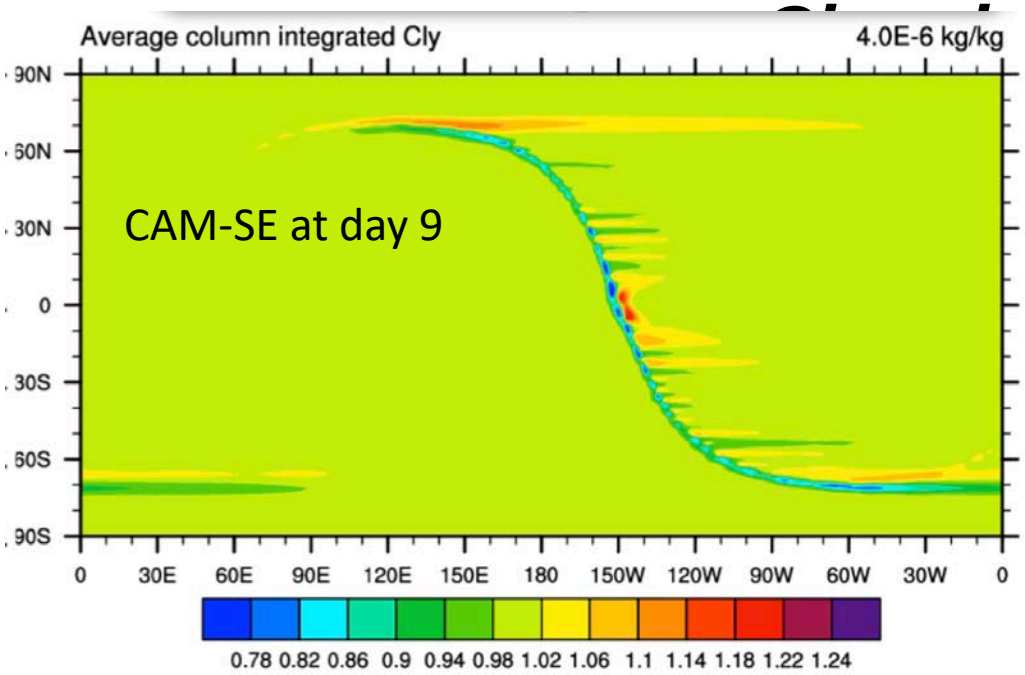
DCMIP-2016 Snapshots: "Toy" Terminator Chemistry

Tracer advection test with correlated tracers (Cly = sum of Cl and Cl2 (needs to stay constant)



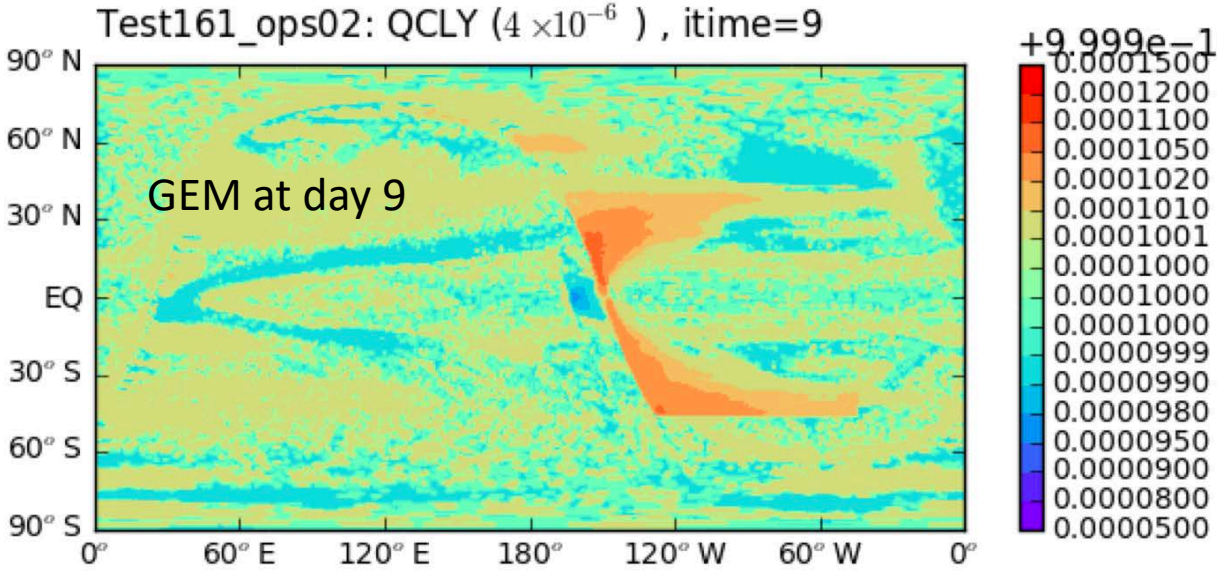
Lauritzen et al. (2015)

DCMIP-2016 Snapshots: "Toy" Terminator Chemistry



Analytical solution:
Column-integrated Cly needs to be constant

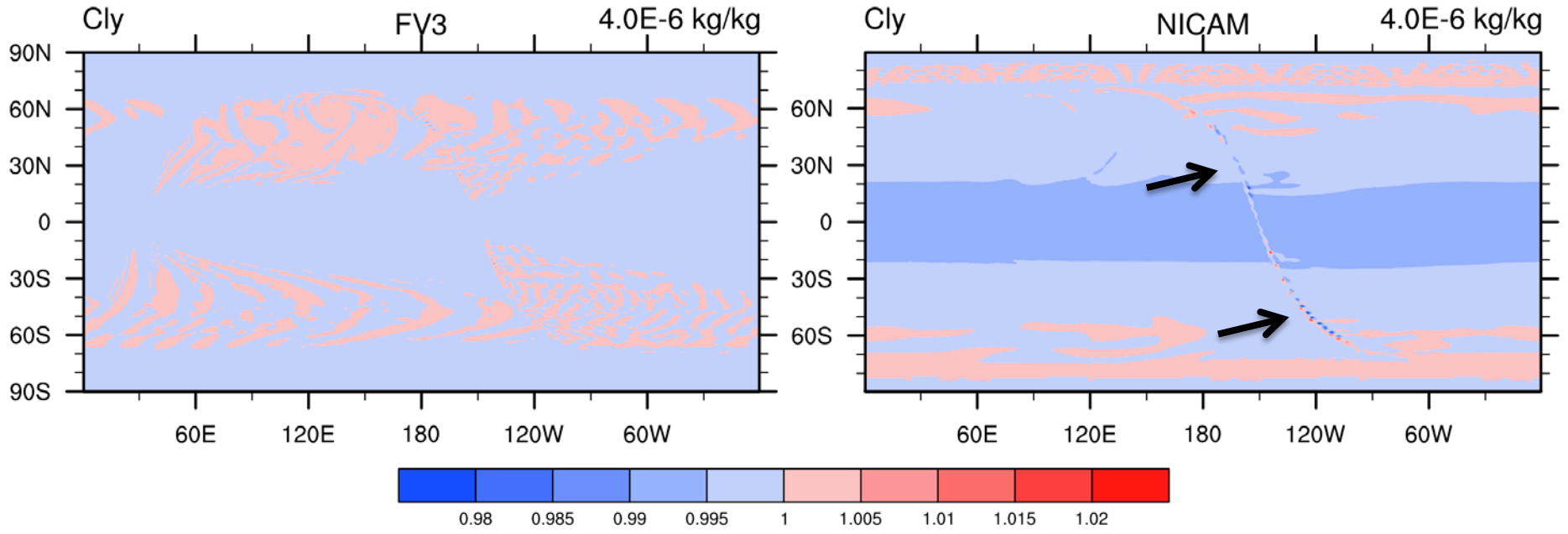
Colors indicate the numerical errors in the advection schemes:
they can break tracer correlations



DCMIP-2016 Snapshots: "Toy" Terminator Chemistry

FV3 (Day 10)

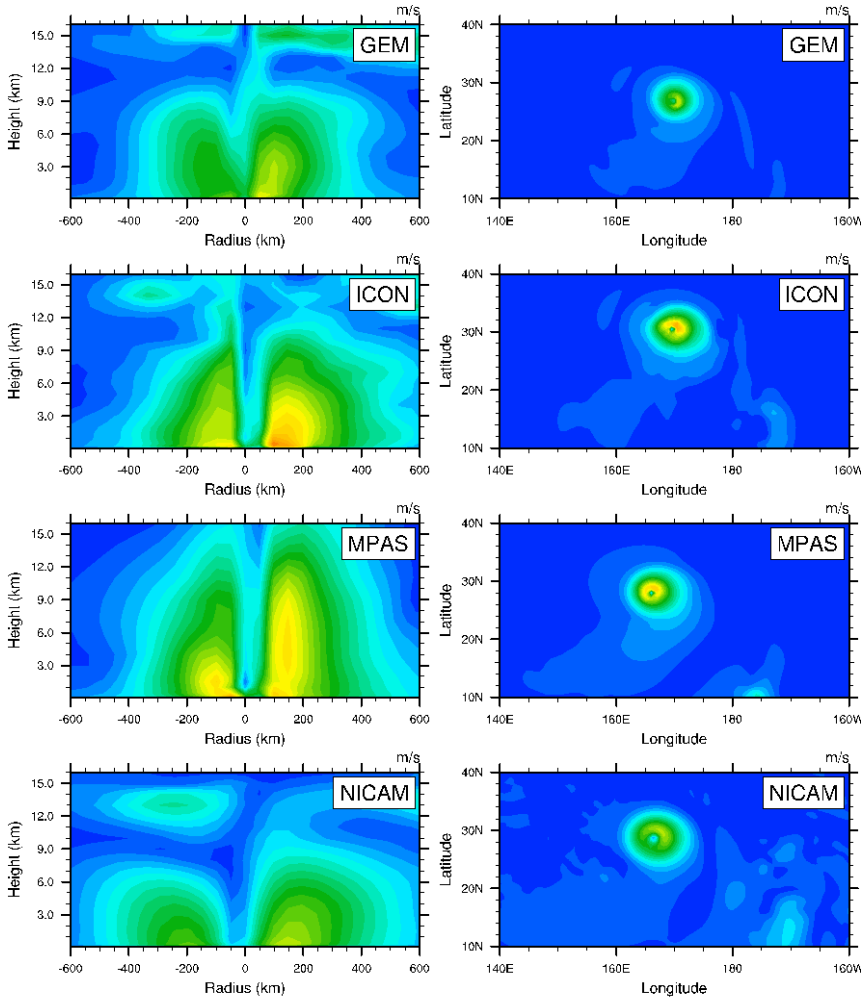
NICAM (Day 10)

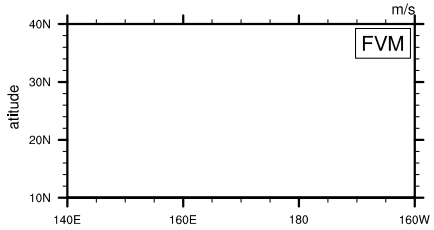


Very low errors

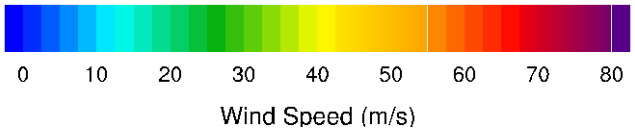
Errors mostly develop along terminator line.

DCMIP-2016 Snapshots: Tropical Cyclone at 1km





Wind speed (day 10)



Δx=
50-60km

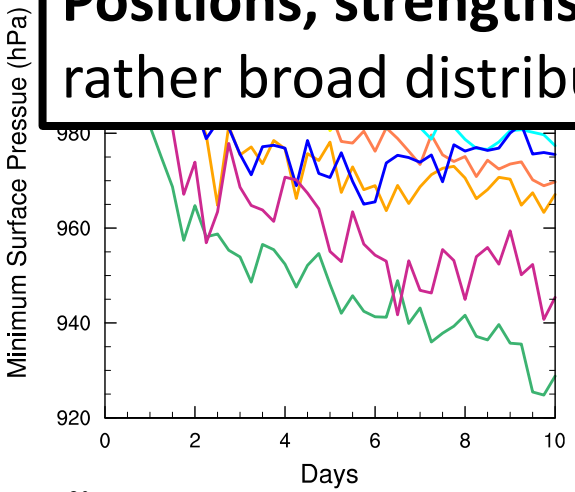
Description of the initial conditions and simple-physics: Reed and Jablonowski (2011, 2012)

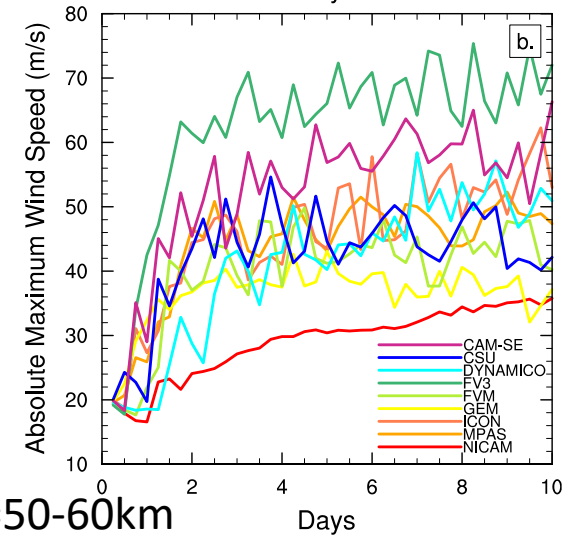
Snapshots: Tropical Cyclone

High resolutions (Δx=25-30 km)

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

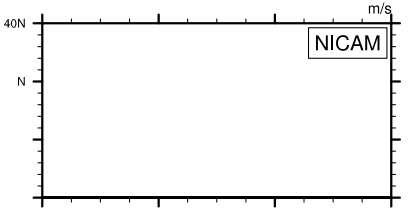
Positions, strengths and diameters of the tropical cyclones show rather broad distributions that need to be understood.





Δx=50-60km

Wind speed (day 10): Stronger, more structured cyclones (except NICAM)



DCMIP-2016 Snapshots: Tropical Cyclone, wind at day 10

- DCMIP encourages exploration of new test configurations: Alternative representation of the simplified planetary boundary layer (more mixing) modifies the shapes of the tropical cyclone

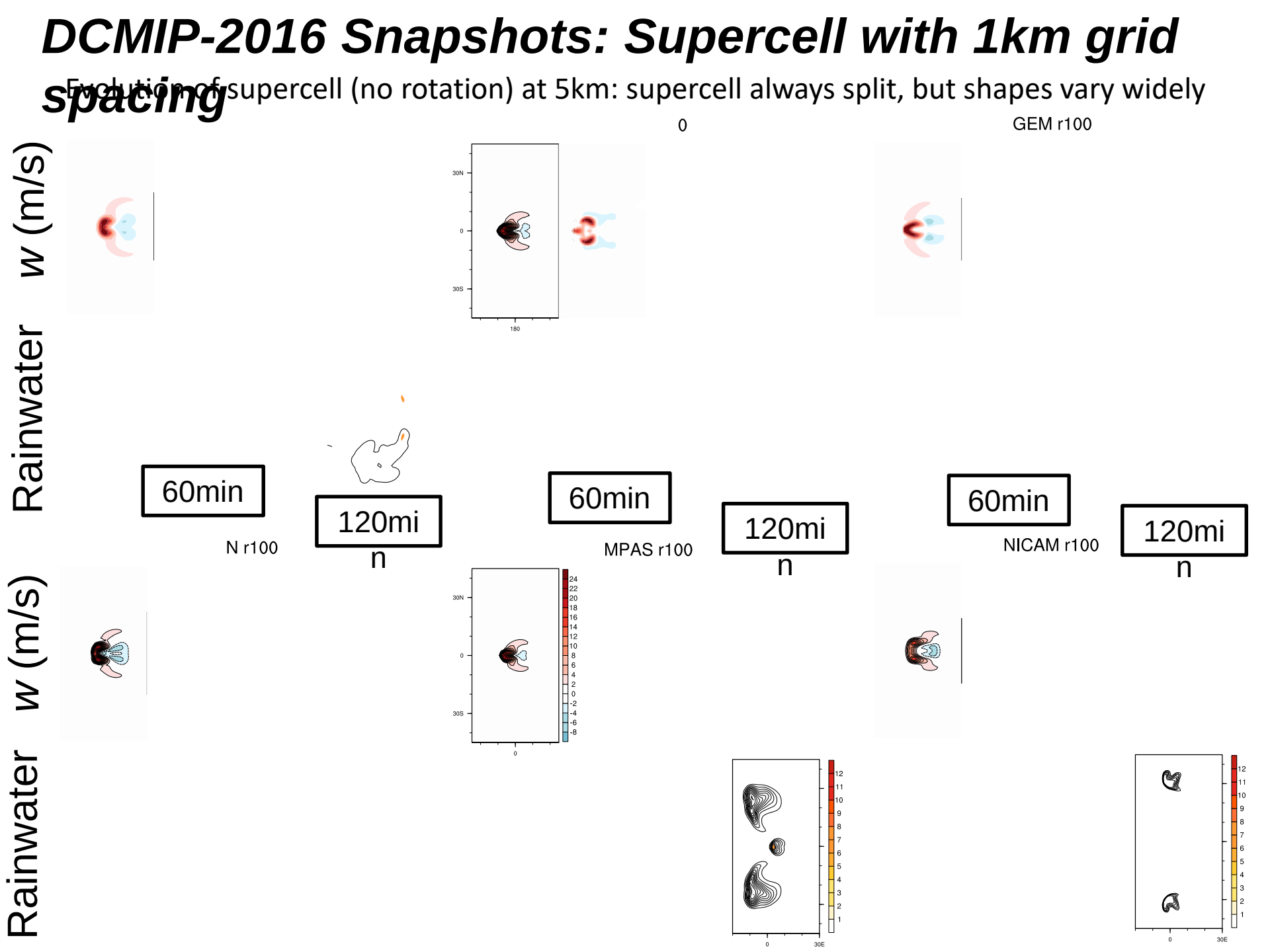
DCMIP-2016 Snapshots
Supercell

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

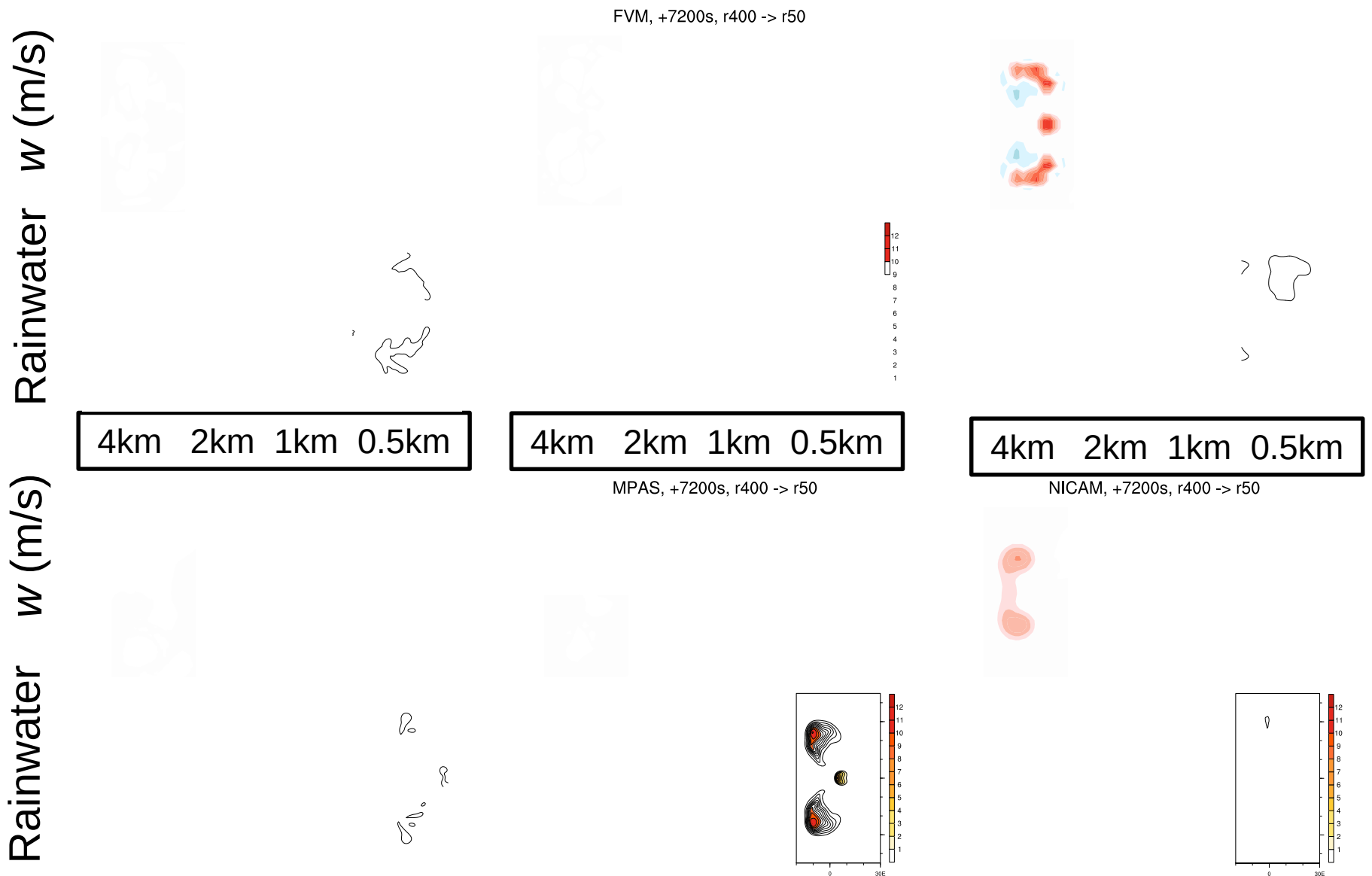
DCMIP-2016 Snapshots: Supercell with 1km grid spacing

Evolution of supercell (no rotation) at 5km: supercell always split, but shapes vary widely



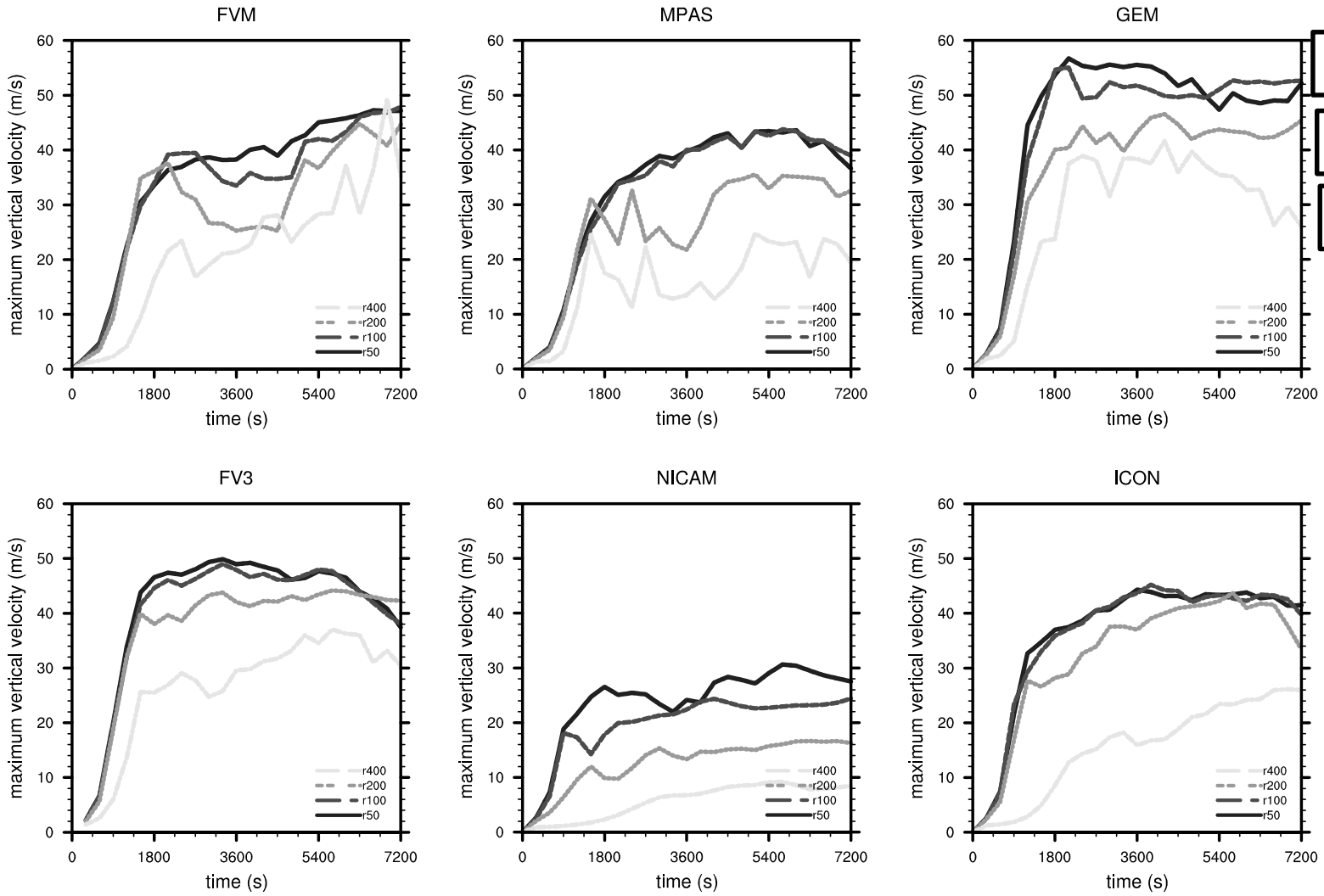
DCMIP-2016 Snapshots: Supercell after 120 minutes

Dependence on resolution: some signs of convergence at 1km and finer



DCMIP-2016 Snapshots: Supercell at various resolutions

Maximum vertical velocities: single model shows signs of convergence at 1km and finer, but inter-model spread is large



Gives insight into physics-dynamics coupling and the impact of diffusion

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

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