Dynamical Core Model Intercomparison Project (DCMIP) and Summer School

July/30-August/10/2012

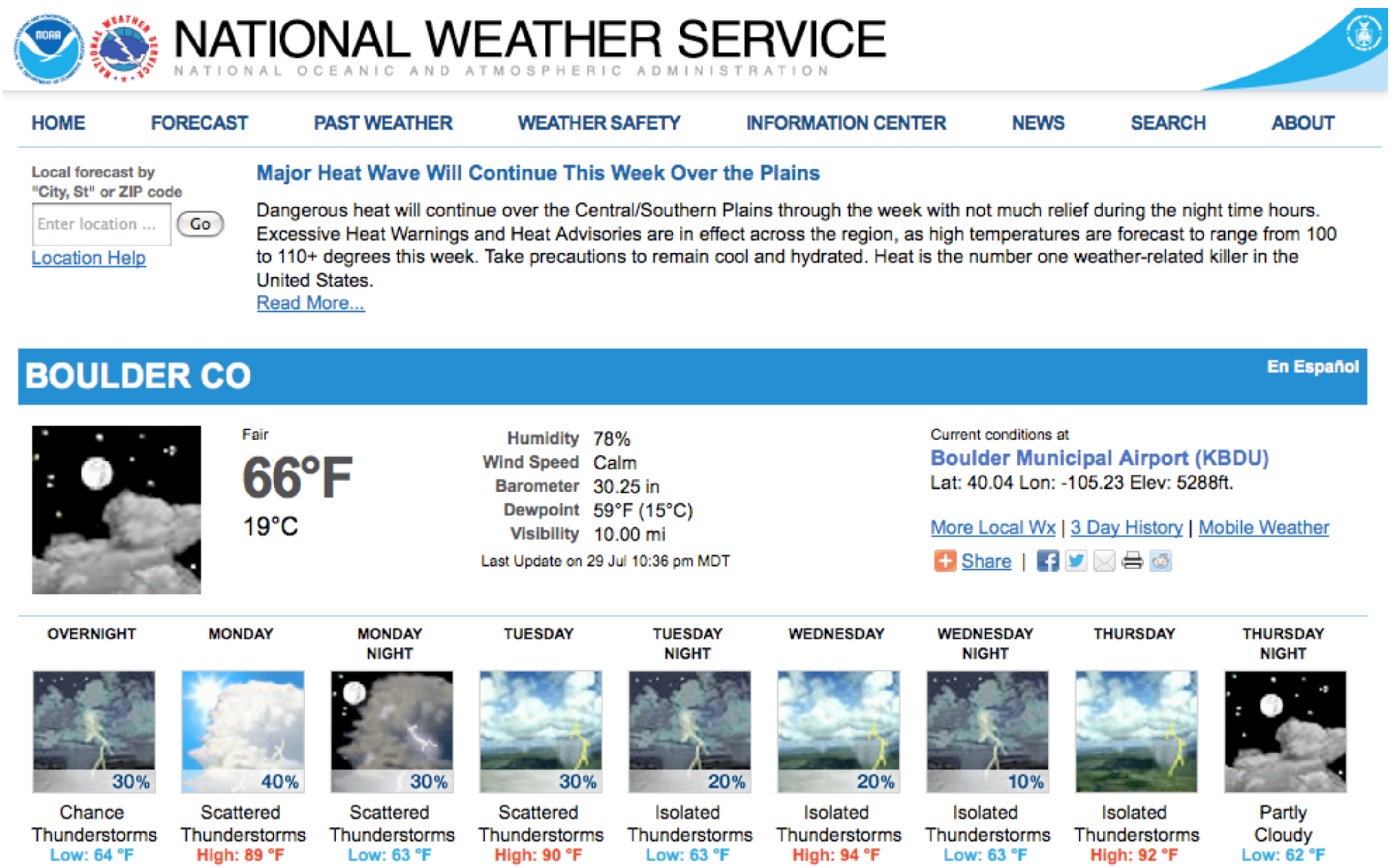
at the National Center for Atmospheric Research (NCAR), Boulder, CO

Organized by: Christiane Jablonowski, Paul Ullrich, James Kent, Kevin Reed (University of Michigan), Mark Taylor (Sandia National Laboratories), Peter Lauritzen and Ram Nair (NCAR)

Welcome to Boulder

Boulder lies at 1655 m a.s.l. (5430 feet)
It is sunny and dry: drink lots of water, use lots of sunscreen (especially if going on hikes)

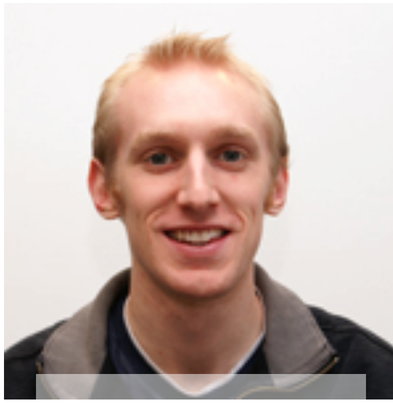
The weather forecast for this week:



The Ideas behind DCMIP

- The summer school DCMIP-2012 highlights the newest modeling techniques for global climate and weather models.
- DCMIP-2012 pays special attention to non-hydrostatic global models and their dynamical cores that now emerge in the General Circulation Model (GCM) community.
- DCMIP-2012
  - Teaches students and postdocs, both via lectures and hands-on sessions, at NCAR and the elsewhere in the world (via the webcast)
  - Conducts an international dynamical core model intercomparison
  - Defines, tests and probably establishes new dynamical core tests
- Our vision: establish DCMIP as a long-term virtual community via the cyberinfrastructure-supported workspace

DCMIP Organizers and Architects of the DCMIP Test Case Suite



James Kent

Paul Ullrich

Christiane Jablonowski

Kevin Reed

Peter Lauritzen

Ram Nair

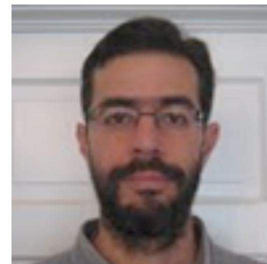
Mark Taylor

Meet the Cyberinfrastructure and Commodity Governance (CoG) Research Team

Cecelia DeLuca
(NOAA ESRL)

Sylvia Murphy
(NOAA ESRL)

Luca Cinquini
(NOAA ESRL)



Allyn Treshansky
(NOAA ESRL)

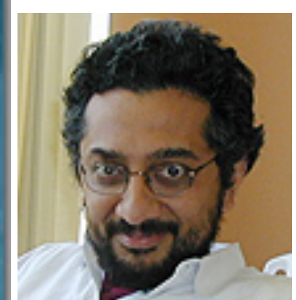
Irina Overeem
(CU Boulder)

Richard Rood
(University of Michigan (UM))

Paul Edwards (UM)

Jillian Wallis
(UM)

Christiane
Jablonowski (UM)



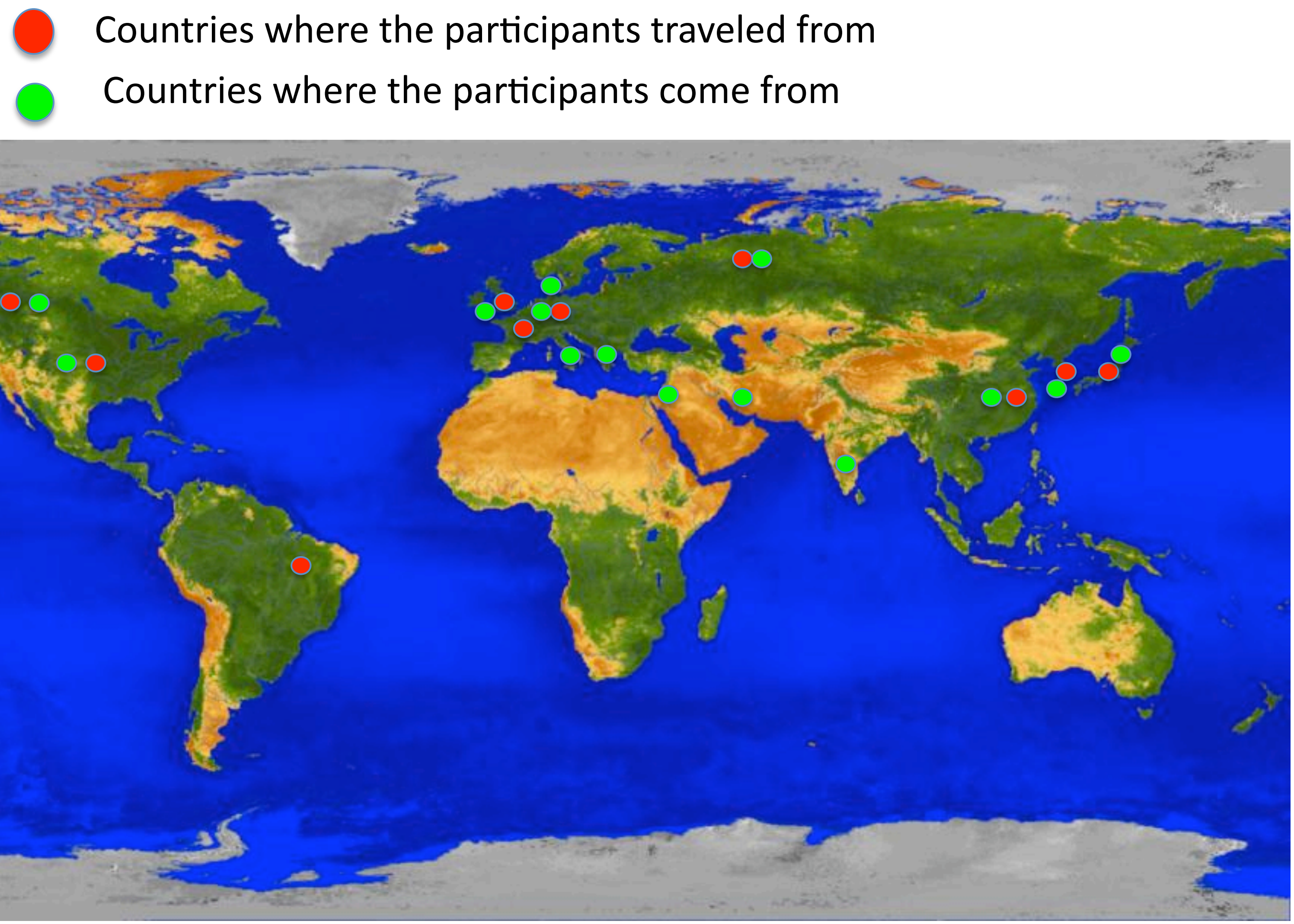
Balaji (GFDL)

James Syvitski,
(CU Boulder)

Meet the DCMIP Modeling Mentors

R. Bleck, T. Smirnova, S. Sun
D. Dazlich, R. Heikes, C. Konor
T. Dubos, Y. Meurdesoif
M. Duda, W. Skamarock
T. Frisius
A. Gassmann
M. Giorgetta
M. Gross
L. Harris
J. Kent
J. Klemp, S.-H. Park
J. Lee
S. Malardel
T. Melvin
H. Miura, R. Yoshida
A. Qaddouri
K. Reed
D. Reinert
L. Silvers
M. Taylor
R. Walko, M. Otte

Meet the DCMIP Participants



We thank the DCMIP Sponsors …

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

NSF

Office of Science
U.S. DEPARTMENT OF ENERGY

NCAR

MICHIGAN

We thank the local NCAR Host and Administrative Team

CISL Computational & Information Systems Laboratory

We thank in particular:

- Richard Loft (Director of NCAR CISL's Technology Development Division (TDD))
- David Hart (NCAR CISL User Services Manager)
- Jennifer Williamson (NCAR CISL administrator)
- Michelle Smart and the NCAR CISL data base services team
- Davide Del Vento, Sidd Gosh, Si Liu (CISL Help Desk and Consulting Services)
- Jay Alipit (NCAR Multimedia Services)
- Nick Wehrheim and WSST team (NCAR's Workstation Support Services Team)
- Barb Lupi (University of Michigan Administrator)

DCMIP Models: Cubed-Sphere Grids

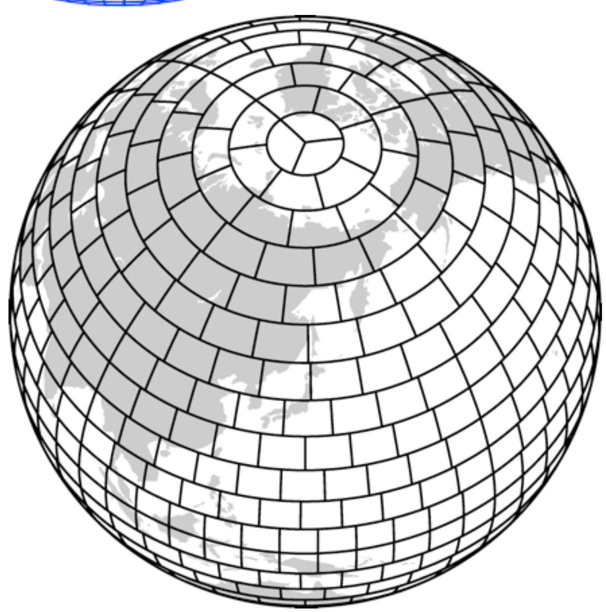
Cubed-sphere grids

- CAM-SE
- FV3-GFDL
- MCORE

DCMIP Models: Latitude-Longitude

Latitude-longitude or Gaussian grids

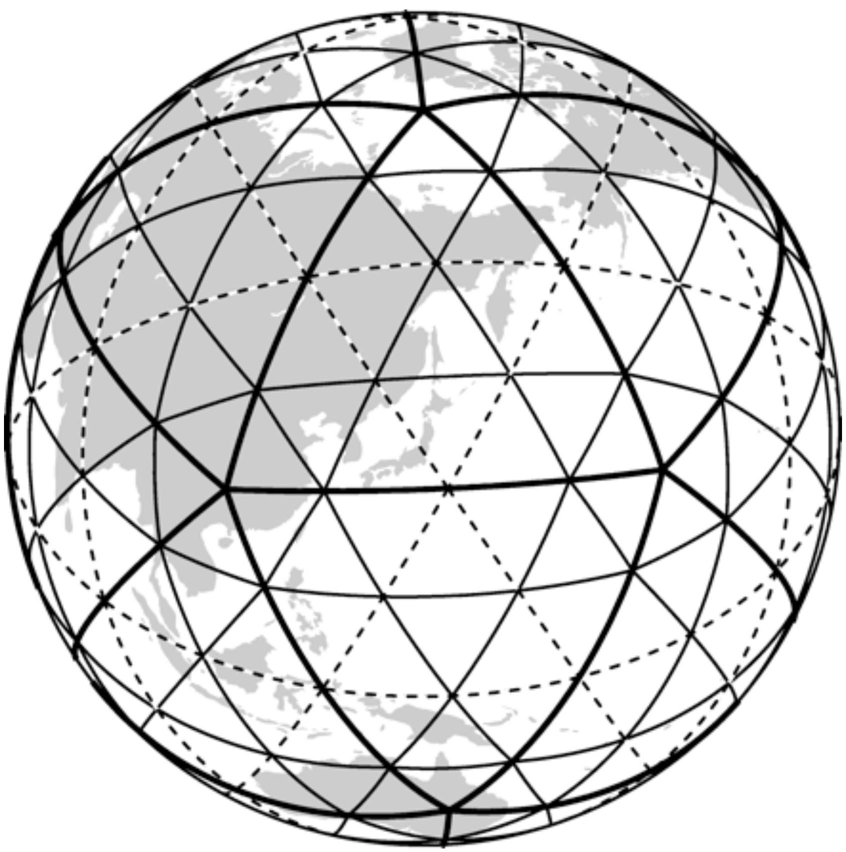
- CAM-FV
- PUMA
- GEM-latlon
- ENDGame



Reduced Gaussian grid

- IFS

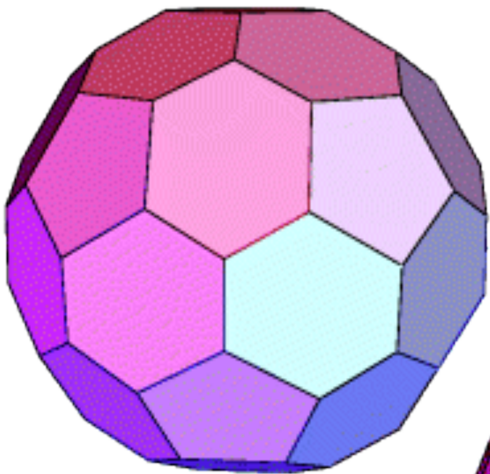
DCMIP Models: Triangular Grids

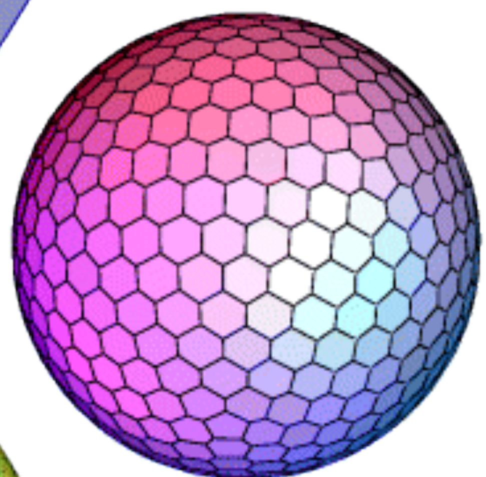


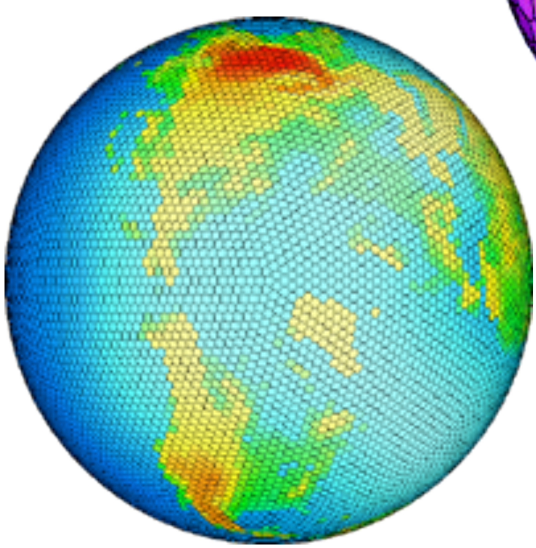
Spherical geodesic or icosahedral-based grids

- ICON-MPI-DWD
- DYNAMICO
- FIM
- NIM
- NICAM
- OLAM (also hexgonal)

DCMIP Models: Hexagonal Grids



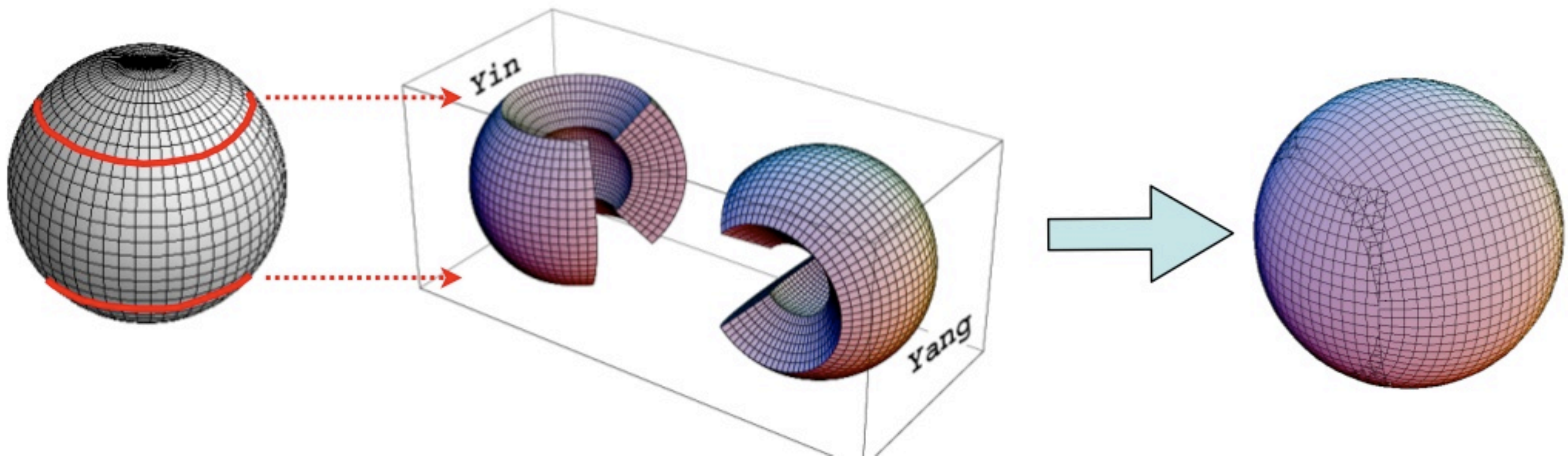




Hexagonal or spherical Voronoi grids

- ICON-IAP
- MPAS
- OLAM
- UZIM

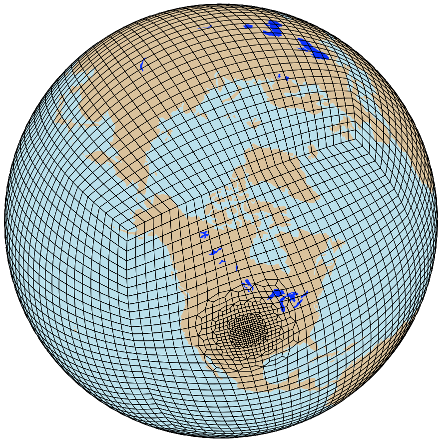
DCMIP Models: Yin-Yang Grid

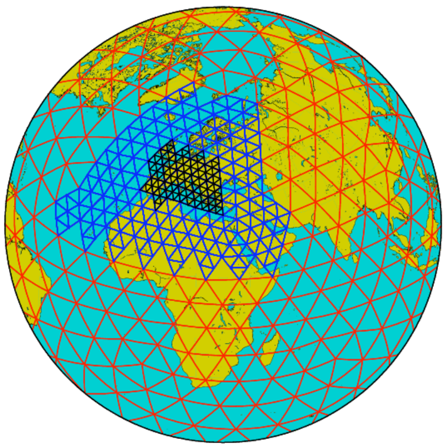


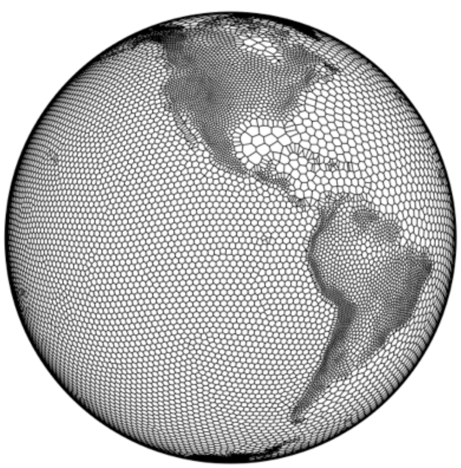
Yin-Yang grid

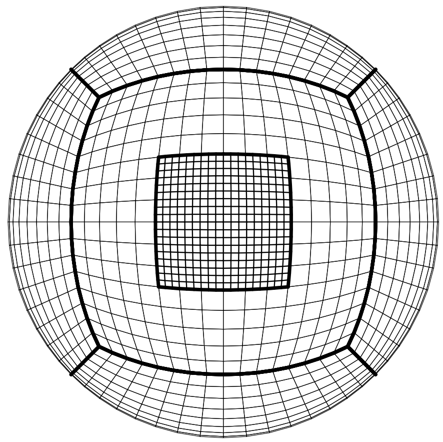
- GEM-yinyang

DCMIP Models: Nested Grids

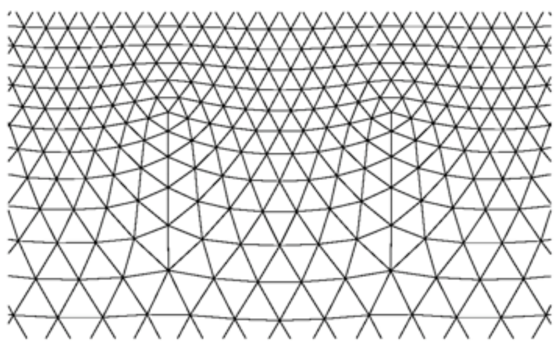






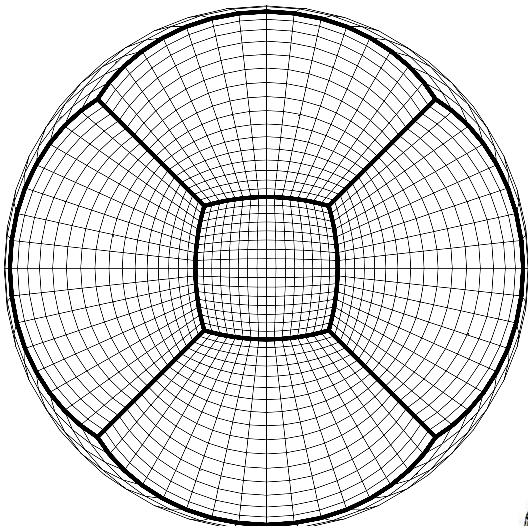


Models with optional variable-resolution-grid via embedded high-resolution regions

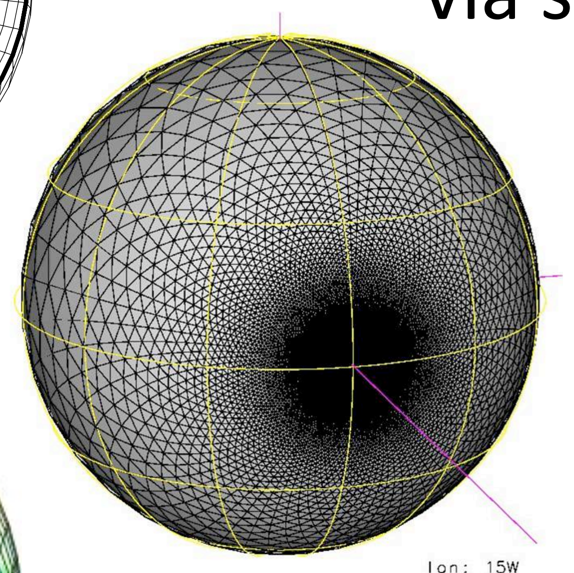


- CAM-SE
- FV3-GFDL
- ICON-MPI-DWD
- OLAM
- MPAS

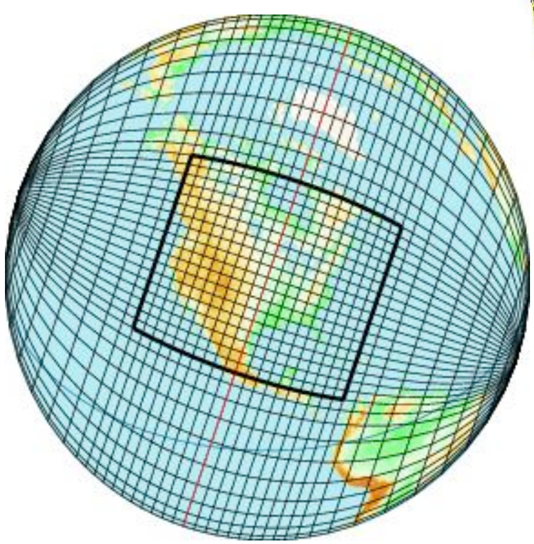
DCMIP Models: Stretched Grids



Models with optional variable-resolution-grid via stretched grids

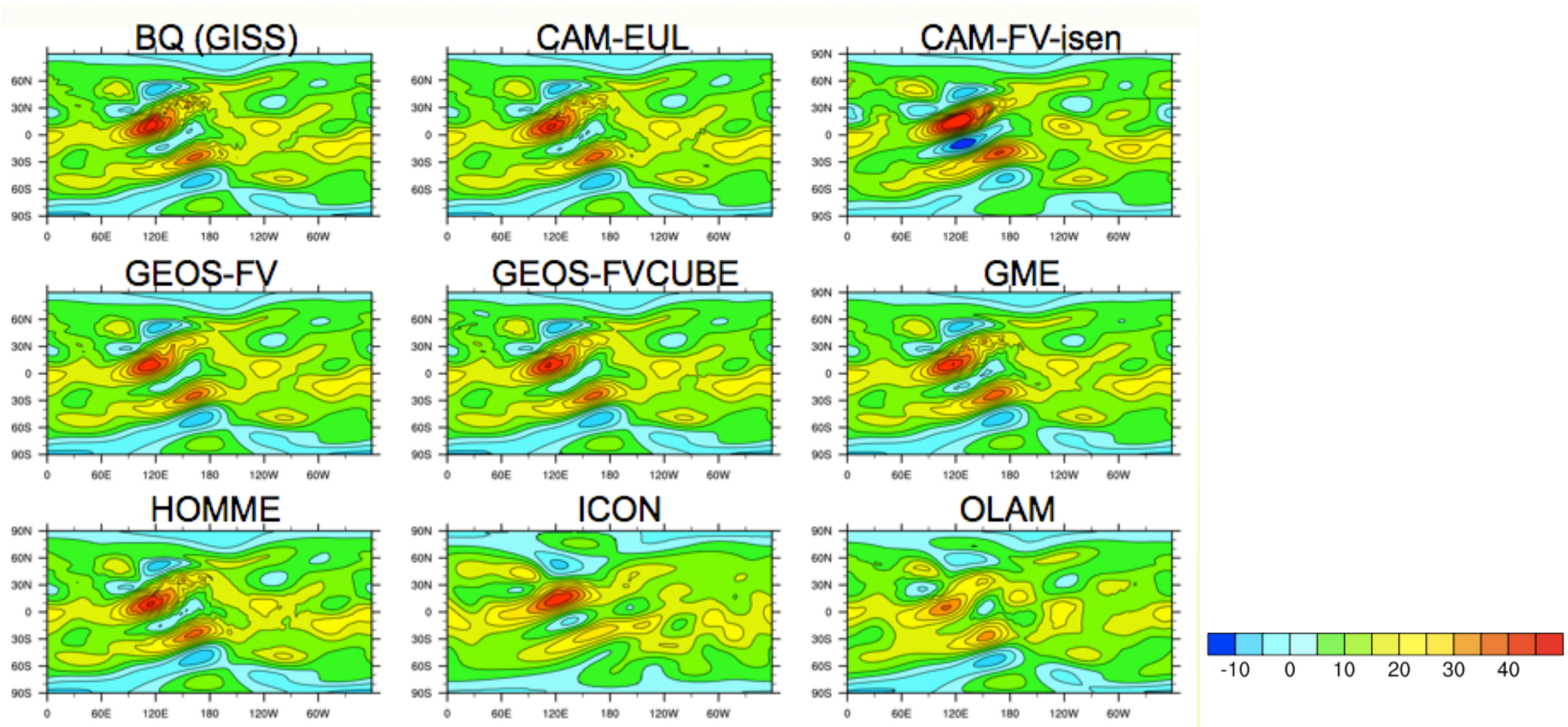


- FV3-GFDL
- NICAM
- GEM-latlon



The Idea behind the 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



Results from the 2008 Dynamical Core Intercomparison during the NCAR ASP Summer Colloquium: Mountain-generated Rossby waves, 700 hPa zonal wind (m/s) at day 15

Why now?

- Traditionally: Test cases for 3D dynamical cores on the sphere
  - are hard to find in the literature
  - are often not fully documented
  - have (often) not been systematically applied by a large number of modeling groups
  - lack standardized & easy-to-use analysis techniques
- The time is right: A new generation of dynamical cores emerges in the community, testing is essential to understand the pros and cons of the new model designs
- This is the goal of DCMIP

Goals and Wish-List for the DCMIP Test Suite

Test cases should

- be designed for **hydrostatic** and **non-hydrostatic** dynamical cores on the sphere,
  ideally: for both **shallow** and **deep atmosphere** models
- be easy to apply: analytic initial data (if possible)
  suitable for **all grids**
  formulated for **different vertical coordinates**
- be easy to evaluate: standard diagnostics
- be relevant to atmospheric phenomena
- reveal important characteristics of the numerical scheme
- have an analytic solution or converged reference solutions
- find broad acceptance in the modeling community

The Architecture of the DCMIP Test Suite

The tests are hierarchical and increase in complexity (you can run them in any order though):

- Advection
  - Pure 3D advection without orography
  - Pure 3D advection in the presence of orography
- Dry dynamical core without rotation
  - Stability of a steady-state at rest in presence of a mountain
  - Mountain-induced gravity waves on small planets
  - Thermally induced gravity waves on small planets
- Dry dynamical core with the Earth's rotation
  - From large (hydrostatic) to small (nonhydrostatic) scales, nonlinear baroclinic waves on a shrinking planet
- Simple moisture feedbacks
  - Moist baroclinic waves with large-scale condensation
  - Moist baroclinic waves with simplified physics (simple-physics)
  - Idealized tropical cyclones

Logistics:
How does the DCMIP Summer School work?

- The next two weeks will be busy
- Bus picks us up at 8am every morning
- Morning lectures start at 8:30am in the NCAR Foothills Lab, FL2 Auditorium
- There will be about 2-3 tutorial-like 45-minute lectures every morning, plus a 15-minute discussion period
- We will also hear from all modeling mentors how they think about the design of their dynamical cores
- During the hands-on afternoon sessions we work in small teams on the DCMIP model intercomparison

Scientific Themes of the Lectures

- Overview of Dynamical Cores and Trends in Dynamical Core Modeling
- Numerical Methods in Dynamical Cores
- Connecting the Dynamical Core and Physical Parameterizations
- Tracers in Atmospheric Models and their importance for climate models
- Evaluating dynamical cores and General Circulation Models (GCMs), Uncertainty & Ensembles
- Emerging computational aspects and challenges for GCMs
- Diversity in Dynamical Cores participating in DCMIP
- Tuning of dynamical cores and physical parameterizations
- Dynamical Core Model Intercomparison, what did we learn?

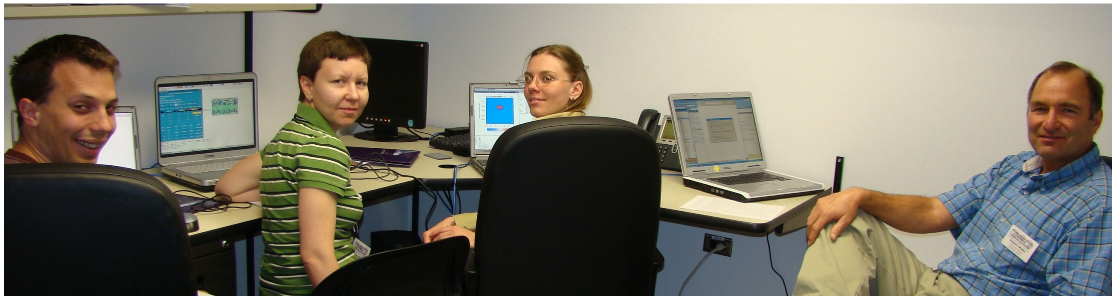
What to expect during a typical afternoon

- The modeling teams stay together for the two weeks
- The teams run the DCMIP test case suite on the NCAR supercomputers
- The teams analyze and intercompare the data via GUI interfaces and prepared NCL scripts
- Teams will have access to results from other modeling groups for immediate discussions
- One organizer will be present in each room to assist with NCL, graphics, NCO, and NetCDF data formats
- Important: The organizers will be gatekeepers to ensure DCMIP-compliant data sets (NetCDF CF compliance, and formatting issues, e.g. variable names, etc.)
- On 8/10 all teams present the highlights of their findings

What to do during a typical afternoon

- Have fun and interact
- Run test cases
- Suggest modifications of the test setups to your group: e.g. why not test a different diffusion coefficient, a variable-resolution setup, a non-hydrostatic configuration
- Analyze your data, and intercompare them with others
- Discuss your findings in your groups and with others
- Edit the DCMIP webpage, create new pages, upload figures and comment on them
- If you find something everybody should know, post your message as ‘news’ on the DCMIP web page
- Help quality-control the netCDF data, they need to comply with the DCMIP standards

What to expect? Snapshots of a typical afternoon (in 2008)

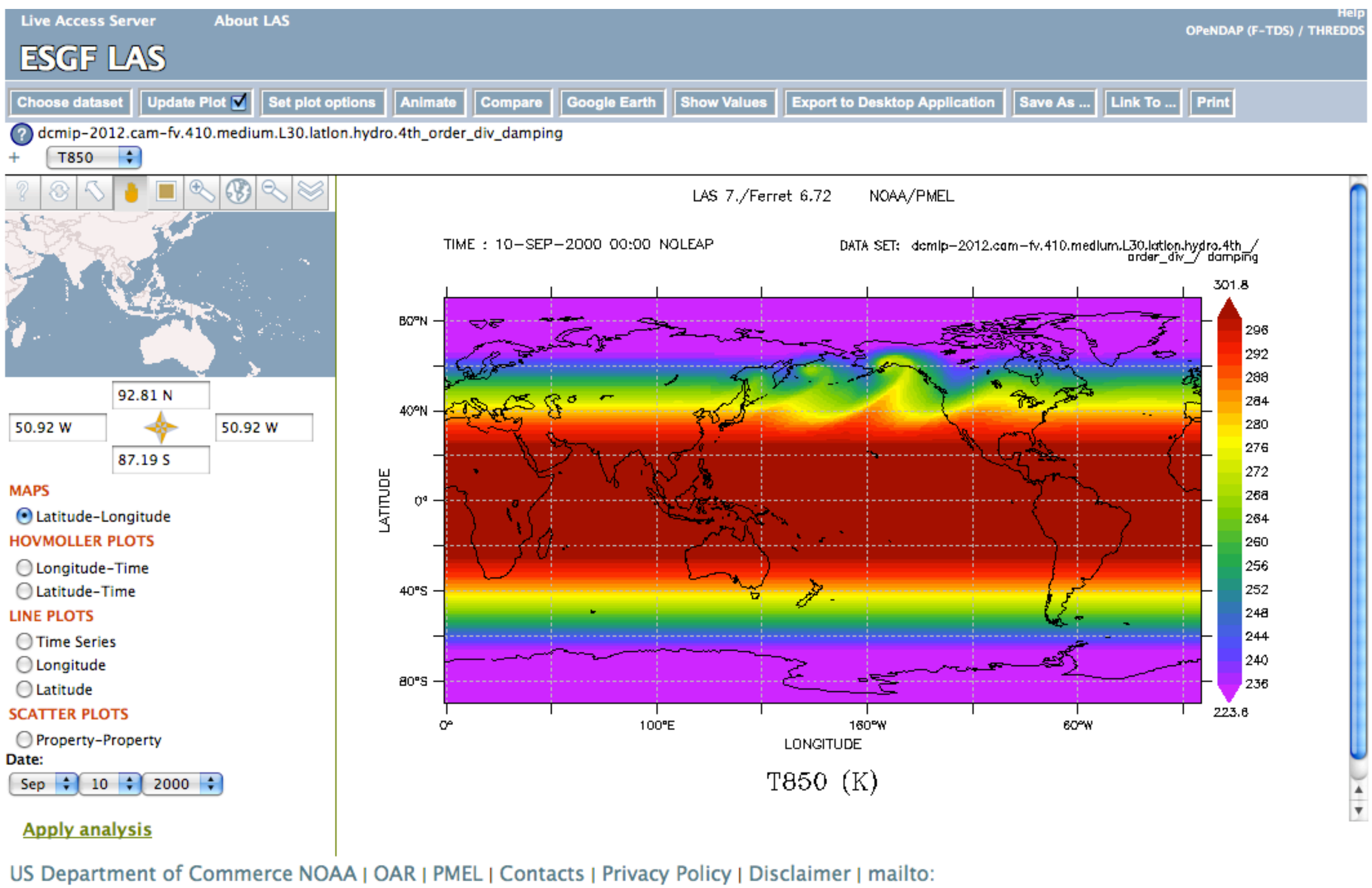


Cyberinfrastructure Support for DCMIP

- Interactive communication platform via a Wiki-driven shared workspace http://earthsystemcog.org/projects/dcmip-2012/
- Model metadata services:
  - Customized metadata form
  - Metadata viewer
- Data services:
  - Earth System Grid (ESG) data base, on NOAA server
  - Searchable data catalog
  - Linked to model metadata
  - Linked on online visualization: Live Access Server (LAS)

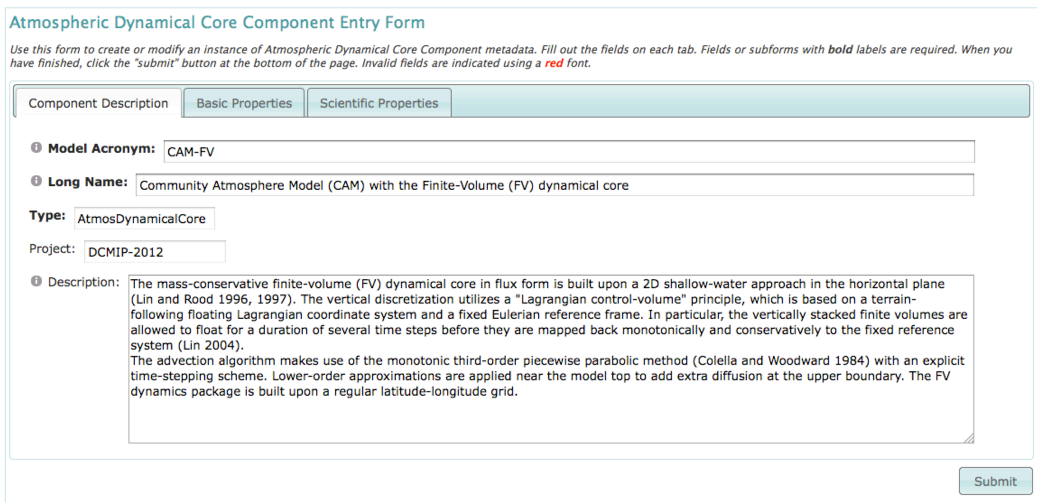
Prototype: Online Visualization via the NOAA Live Access Server

- Once the data are quality-controlled, they will be uploaded to a NOAA Earth System Grid server
- The data will be searchable, and linked to the NOAA Live Access Server via the DCMIP web page
- Caution: This functionality is new. The visualization will likely break at times, be kind.



Associating Data with Models: Model Metadata

- For modeling mentors: we ask you to provide metadata about your models via a metadata entry form http://earthsystemcog.org/projects/dcmip-2012/metadata



Atmospheric Dynamical Core Component Entry Form

*Use this form to create or modify an instance of Atmospheric Dynamical Core Component metadata. Fill out the fields on each tab. Fields or subforms with **bold** labels are required. When you have finished, click the "submit" button at the bottom of the page. Invalid fields are indicated using a **red** font.*

Component Description | Basic Properties | Scientific Properties

Model Acronym: CAM-FV

Long Name: Community Atmosphere Model (CAM) with the Finite-Volume (FV) dynamical core

Type: AtmosDynamicalCore

Project: DCMIP-2012

Description: The mass-conservative finite-volume (FV) dynamical core in flux form is built upon a 2D shallow-water approach in the horizontal plane (Lin and Rood 1996, 1997). The vertical discretization utilizes a "Lagrangian control-volume" principle, which is based on a terrain-following floating Lagrangian coordinate system and a fixed Eulerian reference frame. In particular, the vertically stacked finite volumes are allowed to float for a duration of several time steps before they are mapped back monotonically and conservatively to the fixed reference system (Lin 2004).
The advection algorithm makes use of the monotonic third-order piecewise parabolic method (Colella and Woodward 1984) with an explicit time-stepping scheme. Lower-order approximations are applied near the model top to add extra diffusion at the upper boundary. The FV dynamics package is built upon a regular latitude-longitude grid.

Submit

- The model metadata will be linked to the data to provide extra scientific information about the model experiment
- The metadata will be viewable via the DCMIP web page

Logistics: Foothills Lab (FL) Breakout Rooms for the Hands-on Sessions

- **FL2-1002:**
  - ICON-MPI-DWD
  - ICON-IAP
  - MPAS
  - DYNAMICO
- **FL2-1003:**
  - IFS
  - UZIM
  - OLAM
  - NICAM
- **EOL Atrium (first week) and FL2 Auditorium (second week):**
  - NIM
  - FIM
  - CAM-SE
- **FL2-3107 (first week) and FL3-2072 (second week):**
  - FV3-GFDL
  - MCORE
  - ENDGAME

And finally ....

- Have fun
- Get help from your mentor and the organizing team if you get stuck
- Get help from NCAR's computing support group in case of technical difficulties
- Enjoy the time in Boulder and learn something about dynamical cores in a unique framework