U.S. Department of Energy

Office of Science

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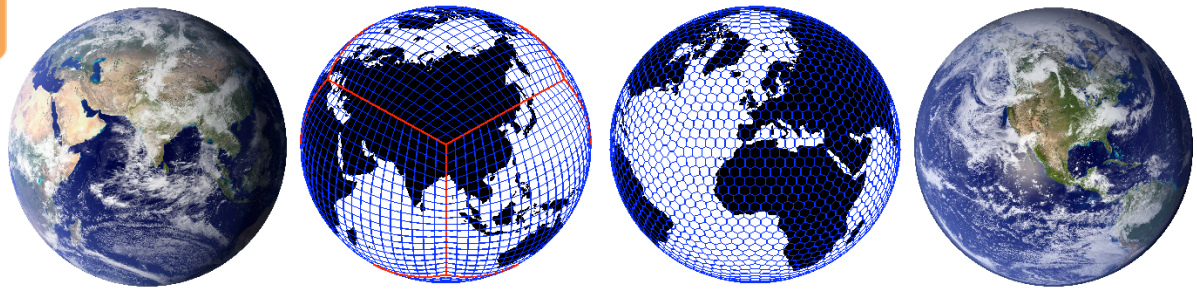


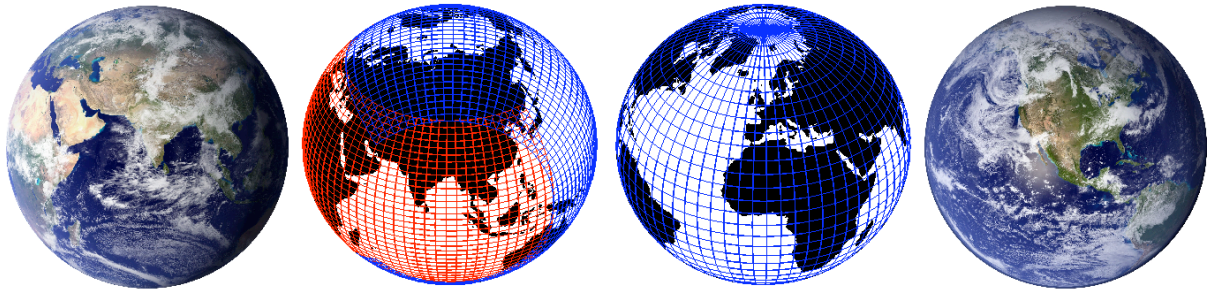
NCAR's 2008 ASP Summer Colloquium on

Numerical Techniques for Global Atmospheric Models

Peter Hjort Lauritzen (NCAR),

Christiane Jablonowski (Univ. of Michigan),

Mark Taylor (Sandia Nat. Lab.), Ram Nair (NCAR)

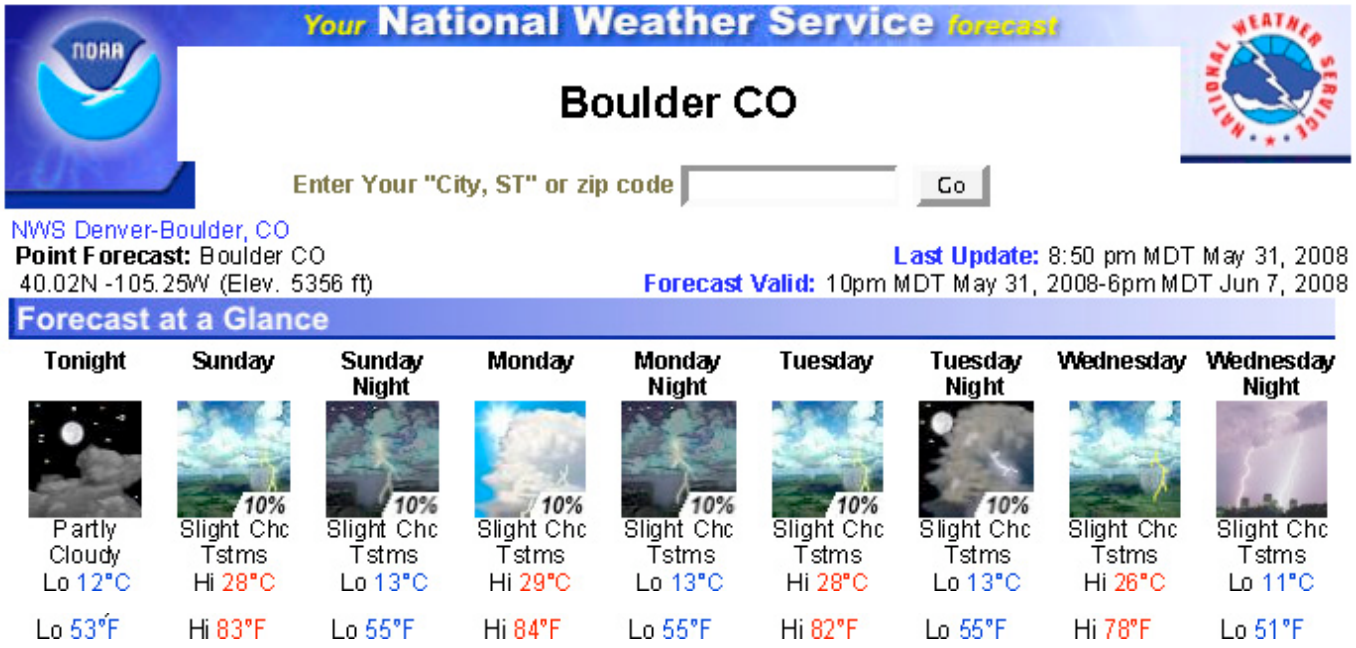


Welcome to Boulder

NCAR

Boulder is at 1655 m a.s.l. (5430 feet)
NCAR Mesa Lab is at 1885 m a.s.l. (6184 feet)

Sunny and dry: drink lots of water, use lots of sunscreen (especially if going on hikes)



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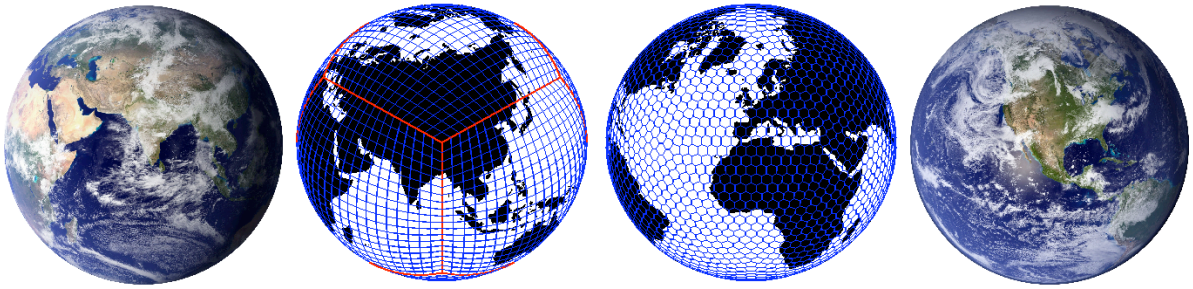

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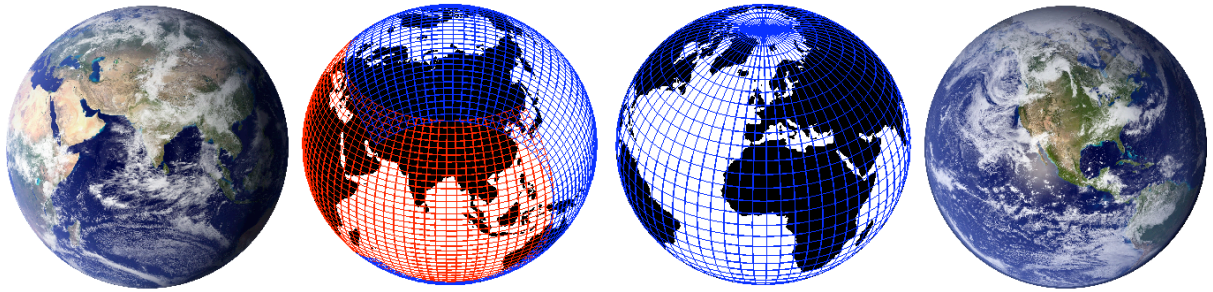

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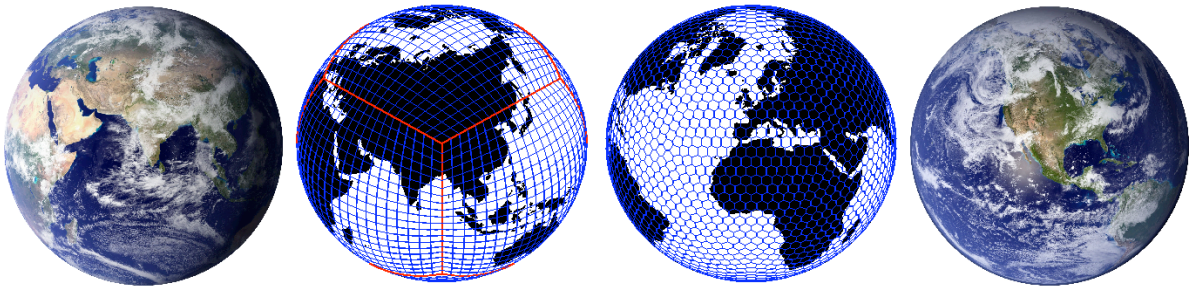


NCAR's 2008 ASP Summer Colloquium on

Dynamical cores for Global Atmospheric Models

"Definition" of an atmospheric dynamical core:

The formulation of a numerical model of the atmosphere is usually considered to be made up of a dynamical core, and some parameterizations. Roughly speaking, the dynamical core solves the governing fluid and thermodynamic equations on resolved scales, while the parameterizations represent subgrid scale processes and other processes not included in the dynamical core such as radiative transfer. Here, no attempt is made to give a precise definition of 'dynamical core' because, as discussed below, there are some open questions concerning exactly which terms and which processes should be included in a dynamical core.

Thuburn (2007); lecture on Friday

NCAR

This talk

- Motivation for the colloquium
- Overview of the next two weeks
- Some details on tutorials

World Modeling Summit for Climate Prediction, May 2008, ECMWF (UK)

NATURE|Vol 453|15 May 2008 NEWS

They say they want a revolution

Climate scientists call for major new modelling facility.

Climatologists have called for massive investment in computer and research resources to help revolutionize modelling capabilities. The eventual aim is to provide probabilistic climate predictions that are as useful, and usable, as weather forecasts.

At the end of a four-day summit held last week at the European Centre for Medium-Range Weather Forecasts in Reading, UK, the scientists made the case for a climate-prediction project on the scale of the Human Genome Project. A key component of this scheme, which would cost something up to, or over, a billion dollars, would be a world climate research facility with computer power far beyond that currently used in the field.

"We need to be breathtakingly bold." — Leo Donner

Questions on how severe the effects of global warming will be, and which regions will be hit in what ways, are beyond the capabilities of current climate science, at least in part because of computing constraints. Today's climate models are run on computers in the 10-teraflop range, meaning they are capable of 10 trillion operations a second. Despite this speed, models on these computers are still coarse-grained, cutting the world into cells more than 100 kilometres across.

Increasing computing power 10,000 times — to speeds in the hundreds of petaflops — would allow modellers to study simulations at the kilometre scale, enabling better predictions on the activity of hurricanes and, eventually, the local deep convection that transfers much energy into the upper atmosphere (see 'A real solution?'). This research could then be fed into operational models.

The scientists think they could answer at least some of the 'big' questions on the effects of global warming if the technology was available. But national climate-modelling efforts, such as those of the Met Office in Exeter, UK, or the National Center for Atmospheric Research (NCAR) in Boulder, Colorado, aren't attracting the required level of funding. Although Japan's Earth Simulator in Yokahama was once the world's fastest computer, there are now 29 faster ones, with the first petaflop machines only months away.

"We need to be breathtakingly bold, frankly, in terms of some of the calculations that we're going to do in order to push the climate-prediction effort forward," says Leo Donner, a physical scientist at the Geophysical Fluid Dynamics Laboratory of Princeton University, New Jersey. Antonio Navarra, a climate modeller at the National Institute of Geophysics and Volcanology in Bologna, Italy, spells out the implication: "We're reaching the point where national resources are insufficient to answer the scientific questions."

More money and cutting-edge challenges would also provide some hope of retaining highly trained programmers with expertise in climate modelling. Conference chair Jagadish Shukla of the Institute of Global Environment and Society in Calverton, Maryland, says this resource is "decreasing faster than the sea ice" as staff are lured from research by the financial rewards and job security provided by companies such as Google.

Addressing the summit on its opening day, economist Jeffrey Sachs, the director of the Earth Institute at Columbia University, New York, said that there would be "a lot of interest among politicians in investing the hundreds of millions of dollars necessary, if scientists can provide answers to key questions... such as future food supply". Although governments are the obvious source of funding, Lawrence Gates, a now-retired climate scientist from the Lawrence Livermore National Laboratory in California, urged the attendees to explore philanthropic options.

How increased investment is divided between new facilities and existing ones is likely to be controversial. Some fear that a single global institute could threaten national centres, potentially taking the onus off governments to fund the institutions that are closest to stakeholders and could be expected to provide the predictions that have most real-world use. "Everyone is agreed that there needs to be a substantial investment in climate modelling, but whether a single centre is the solution is another question. There may be other ways," says John Mitchell, the chief scientist at the Met Office. Donner says that a sketch, presented on the conference's last day, of how the global facility might fit into the research world "seems to relegate national centres to little more than distributors of data".

However, Shukla was adamant that "every science breakthrough leads to the formation of an institute to address the problem". "We are facing a darwinian change in the way we are working and we shouldn't be afraid of that," says Navarra. The meeting could have come to grief on such differences, according to Julia Slingo, the director of the Centre for Global Atmospheric Modelling at the University of Reading, but in the end the level of consensus, she says, was "fantastic".

Various attendees expressed frustration at the fact that the new facility could not be funded purely on the basis of the world-class science it would do — and indeed the fact that it would produce great research might count against it, making it seem more like a "toy for the boys" than a policy-informing instrument.

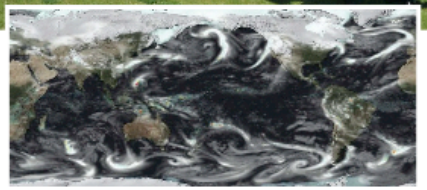
"If we just ask for enhanced understanding, then we have very little chance of getting the necessary funding," warned Shukla. But as Mitch Moncrieff from NCAR put it "we need a quantum leap in research to provide better predictions, even if the politicians don't get that". And there was widespread agreement that they need to get it fast. "We need a revolution as it has got to be done extremely quickly", said Brian Hoskins, director of the Grantham Institute for Climate Change at Imperial College London, UK. ■

Olive Heffernan

See Editorial, page 257.

Researchers from around the world gathered in Reading, UK, for the summit.

R. HINE, ECMWF



P. LI, VISAGE/NCAS CLIMATE; WALKER INST., UNIV. READING

State of the art: a model (left) from the UK National Centre for Atmospheric Science and the Met Office running on Japan's Earth Simulator.

A real solution?

Is the answer to climate prediction sitting in your pocket? Lenny Oliker, John Shalf and Michael Wehner of the Lawrence Berkeley National Laboratory in California think it could be. In a proposal discussed at the Reading climate-modelling summit (see main story) they suggest that the very small processors in mobile phones might be ideal components for very large climate computers — if 20 million of them could be wired together in the right way.

To run at the sort of kilometre-scale resolution that could accurately model cloud processes, they argue, a computer has to be able to run at a sustained speed of around 10 petaflops, and a peak speed of perhaps 20 times that or more. If built with traditional high-performance chips such as AMD's Opteron or Intel's Xeon, such a machine would be extremely expensive and power-hungry — perhaps requiring as much as 100 megawatts. Processors developed for cell phones are small — less than a square millimetre in area — and frugal in their power requirements, needing less than a tenth of a watt each. These advantages, the researchers argue, far outweigh the slower speed at which such processors work and would permit construction of a multi-petaflop computer that was much cheaper both to build and to run.

In some ways this is an extrapolation of the approach that IBM has taken to its successful Blue Gene line of supercomputers, which also rely on many relatively small and slow processors. But it goes further in the sheer number of processors and in an architecture designed specifically for the demands of climate calculations, rather than general-purpose computing.

Per Nyberg of Seattle-based supercomputer makers Cray — which, like rivals IBM and NEC, sent speakers to the summit with an eye to business opportunities — was understandably sceptical. "You can come up with back-of-an-envelope calculations about how cheaply you can build a computer but you have to be very, very careful." He argues that radical approaches can founder on software and on efficiency of usage, with a useful rate of number crunching far below the peak speed. And if the machine doesn't work as advertised, the expense of developing programs for it could be wasted. Wehner acknowledges the risks, but thinks careful prototyping and code development could minimize them. "We should build it and see," he says. **Oliver Morton**

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SIDELINES

ON THE RECORD

"It is important because if you're driving down the highway and you saw a crash of a small spaceship and a car or a bus full of kids, you really wouldn't know what to do."

Denver citizen Jeff Peckman explains his proposed ballot initiative to create an Extraterrestrial Affairs Commission. The city is obliged to discuss the measure.

SHOWBIZ NEWS

This one's for you

Canadian singer/songwriter Neil Young now has a trapdoor spider named after him: the *Myrmekiaphila neilyoungi* (pictured). Long may you run ... away from it.

SCORECARD

Long-lived data

An engineer has extracted data from a partially melted hard drive that fell to Earth after the *Columbia* shuttle explosion in 2003.

CECI NEWS SERVICES/REUTERS

Short-lived art

Curators at the New York Museum of Modern Art have had to kill an artwork consisting of a tiny jacket made of living stem cells after it grew too big.

3 GOOD REASONS

... to send astronauts to an asteroid

1. With the right asteroid it's easier than going to the Moon.
2. No one has been to an asteroid before.
3. Everyone loves *Le Petit Prince*.

A NASA study outlining such a plan is due to be published soon in *Acta Astronautica*.

COURTESY OF GALLIMARD EDITIONS

Sources: Rocky Mountain News, Art Newspaper, Yahoo News, thestar.com

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World Modeling Summit for Climate Prediction, May 2008, ECMWF (UK)

They say they

ON THE RECORD

"It is important because if you're driving down the highway and you saw a crash of a small spaceship and a car or a bus full of kids, you

A message from Summit: We need higher resolution in climate models (Note, however, that resolution alone will not solve all our problems !!!!).

Today's climate models cut the world into grid cells that are on the order of 100km across

To explicitly resolve important phenomena (e.g., deep convection) in the atmosphere we need resolutions on the order of kilometers or less.

To achieve this we need an over 10,000 times increase in computing power!

Reading climate-modelling summit (see main story) they suggest that the very small processors in mobile phones might be ideal components for very large climate computers — if 20 million of them could be wired together in the right way.

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See Editorial, page 257.

been to an asteroid before.

3. Everyone loves *Le Petit Prince*.

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Sources: *Rocky Mountain News, Art Newspaper, Yahoo News, thestar.com*

SIDELINES

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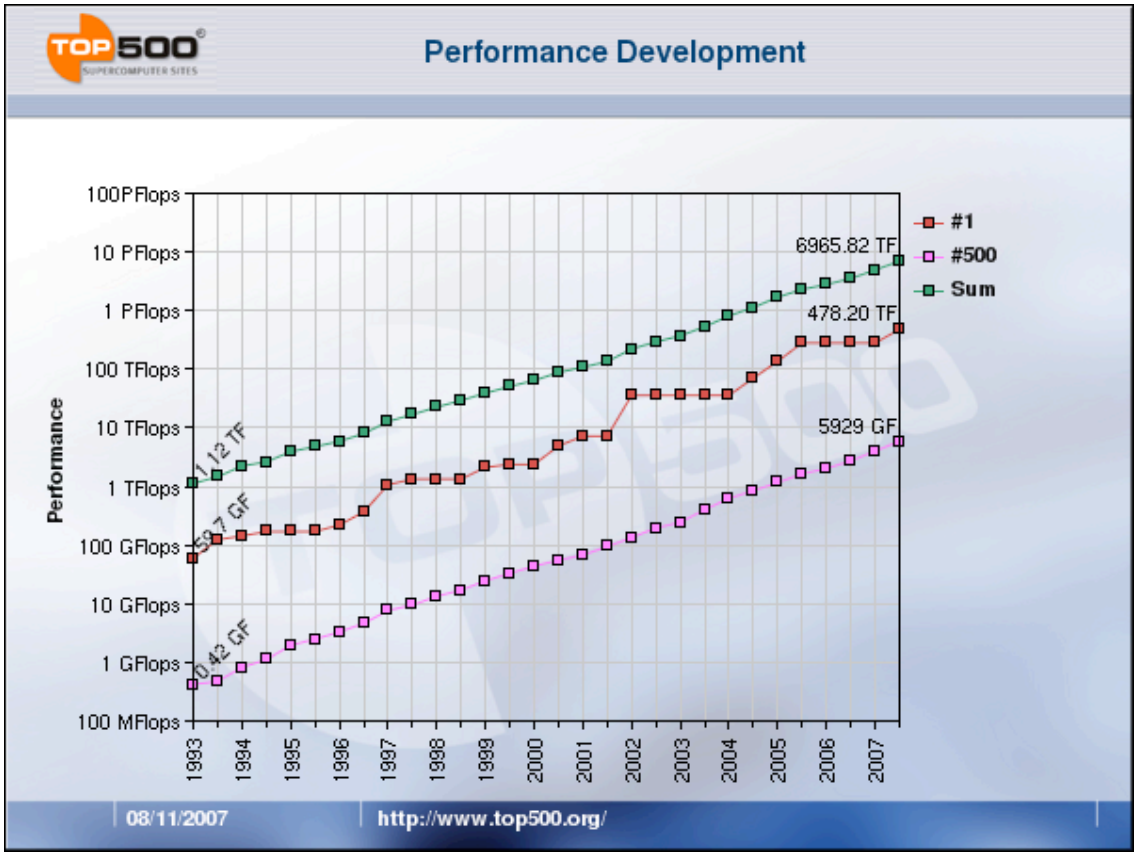
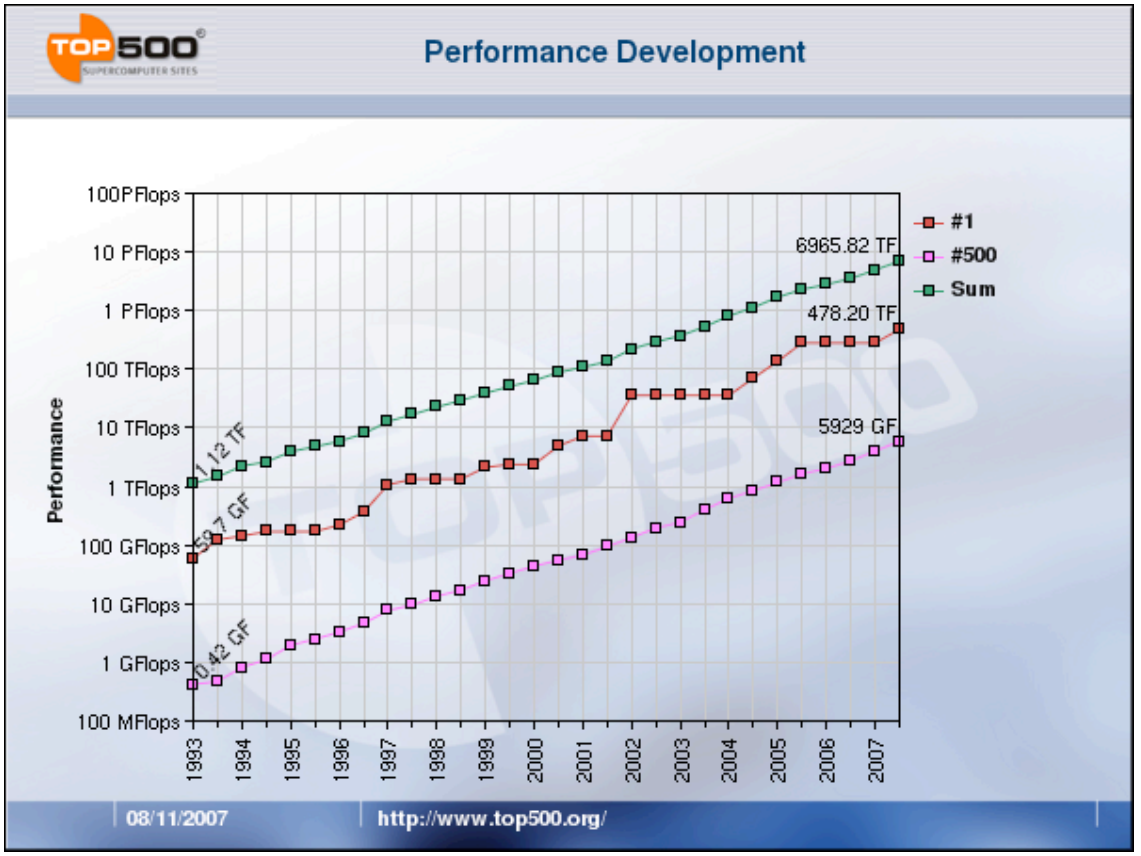
Historical progress in peak performance



Extrapolating the above curve => it will take about 20 years to have the computing power to run climate models at 1km global resolution

NCAR

Historical progress in peak performance



The future "super-super" computers:
We don't know the details but they will be **massively parallel**
(R.Loft's talk tomorrow)

NCAR

Example

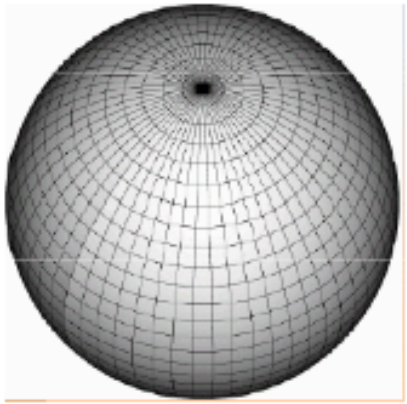
IBM Blue Gene/L 2006: 130,000 CPUs

Even if we had a computer with millions of CPUs
we would not be able to exploit it …
our current operational global atmospheric models
will not scale to hundreds of thousands of CPUs.

Why?

NCAR

The trouble with computers and our atmospheric cores…

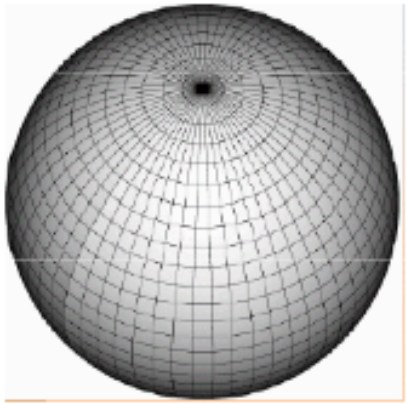


Spherical grid

From B.Skamarock's presentation at the NCAR Earth System Modeling workshop (http://www.essl.ucar.edu/repository/esm.php

NCAR

The trouble with computers and our atmospheric cores…



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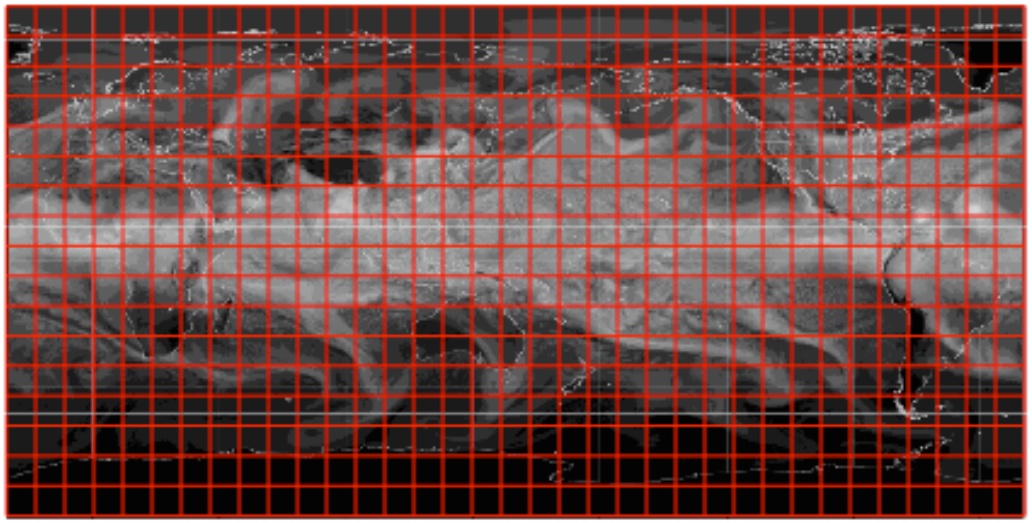

Rectangular computational space

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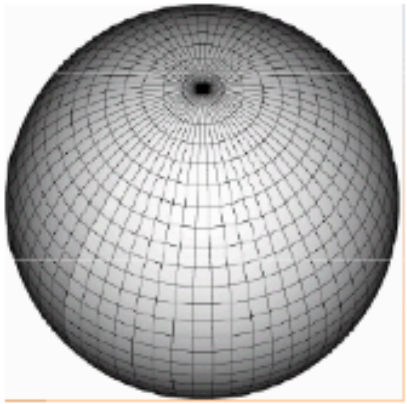

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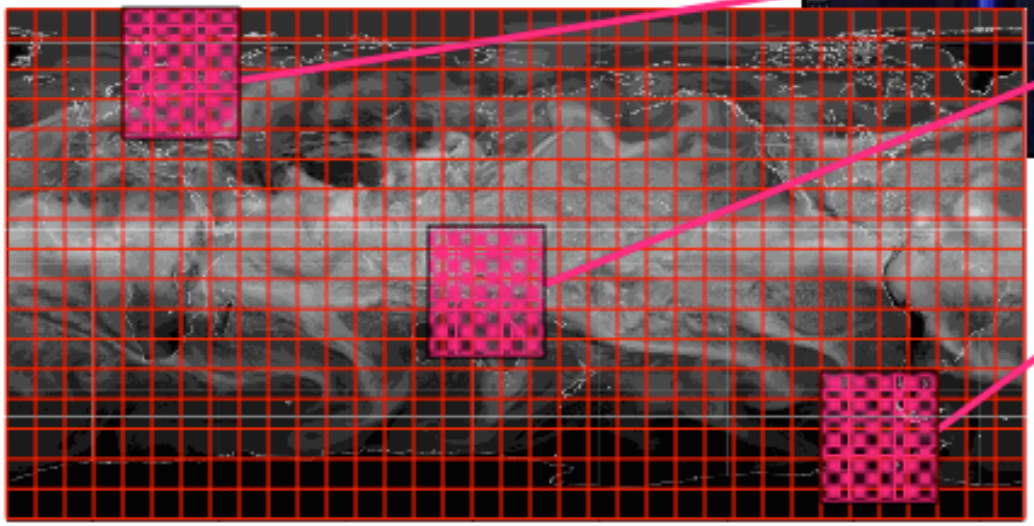

Grid patches reside on distributed-memory nodes

Rectangular computational space

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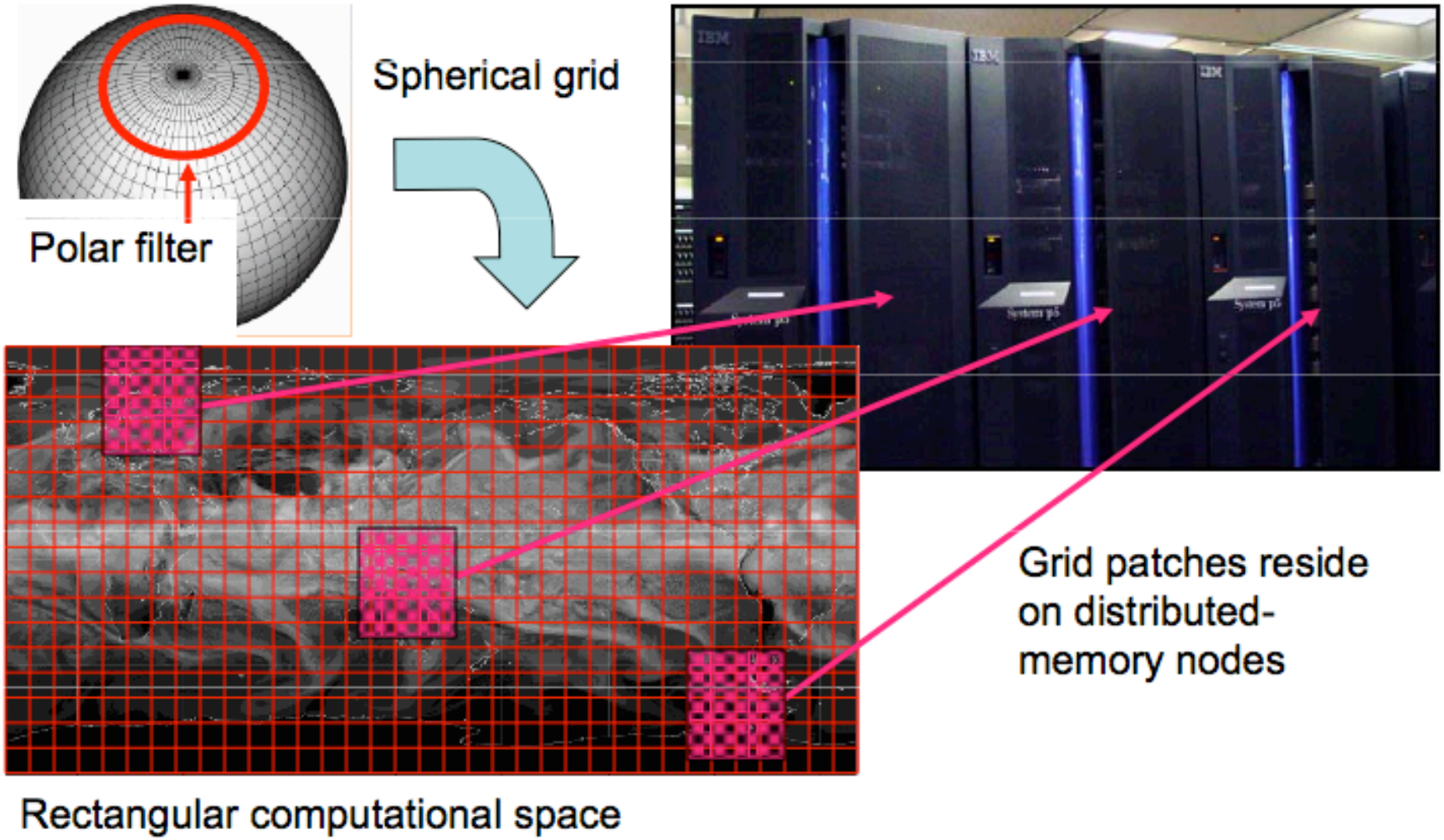

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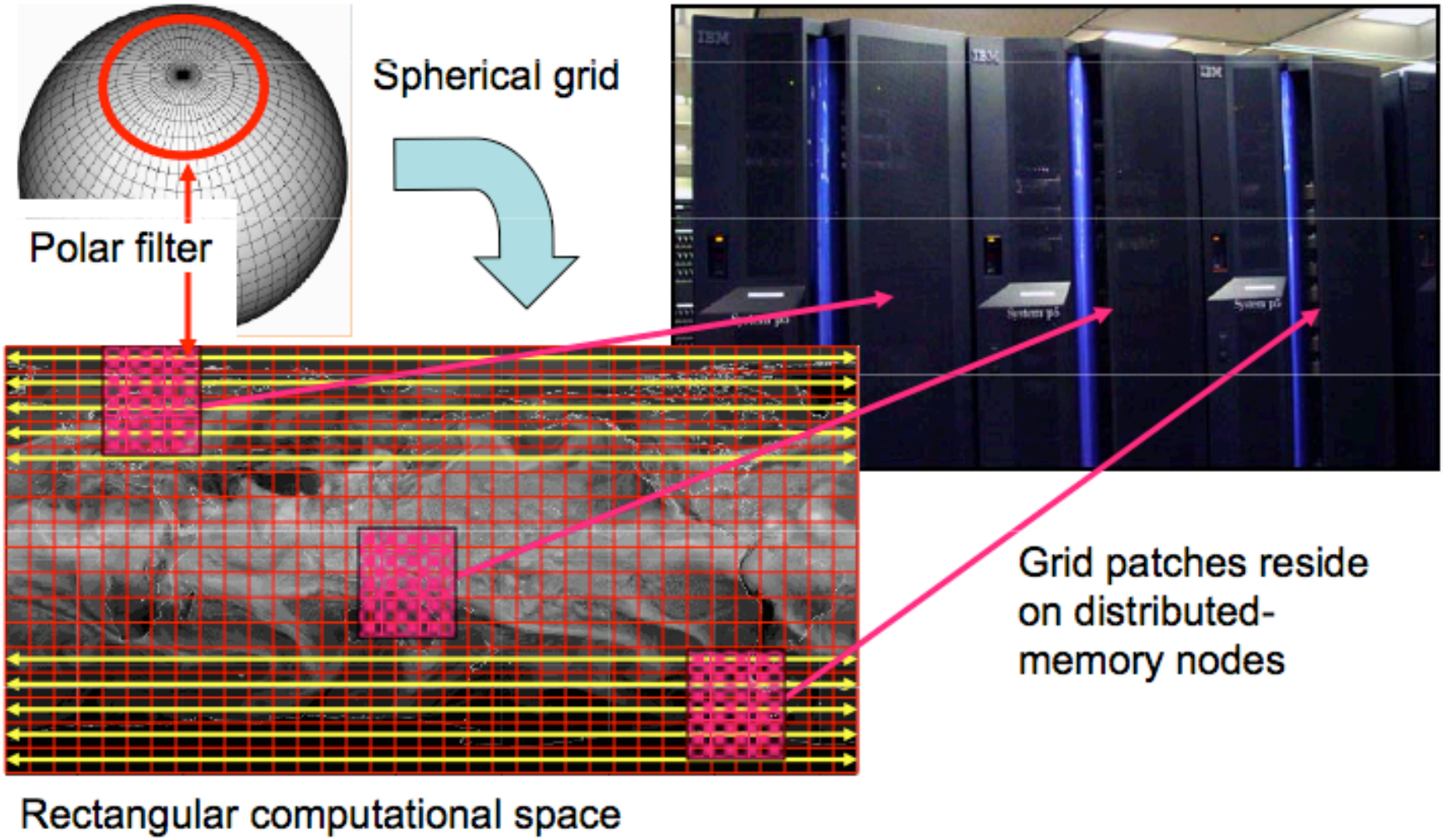

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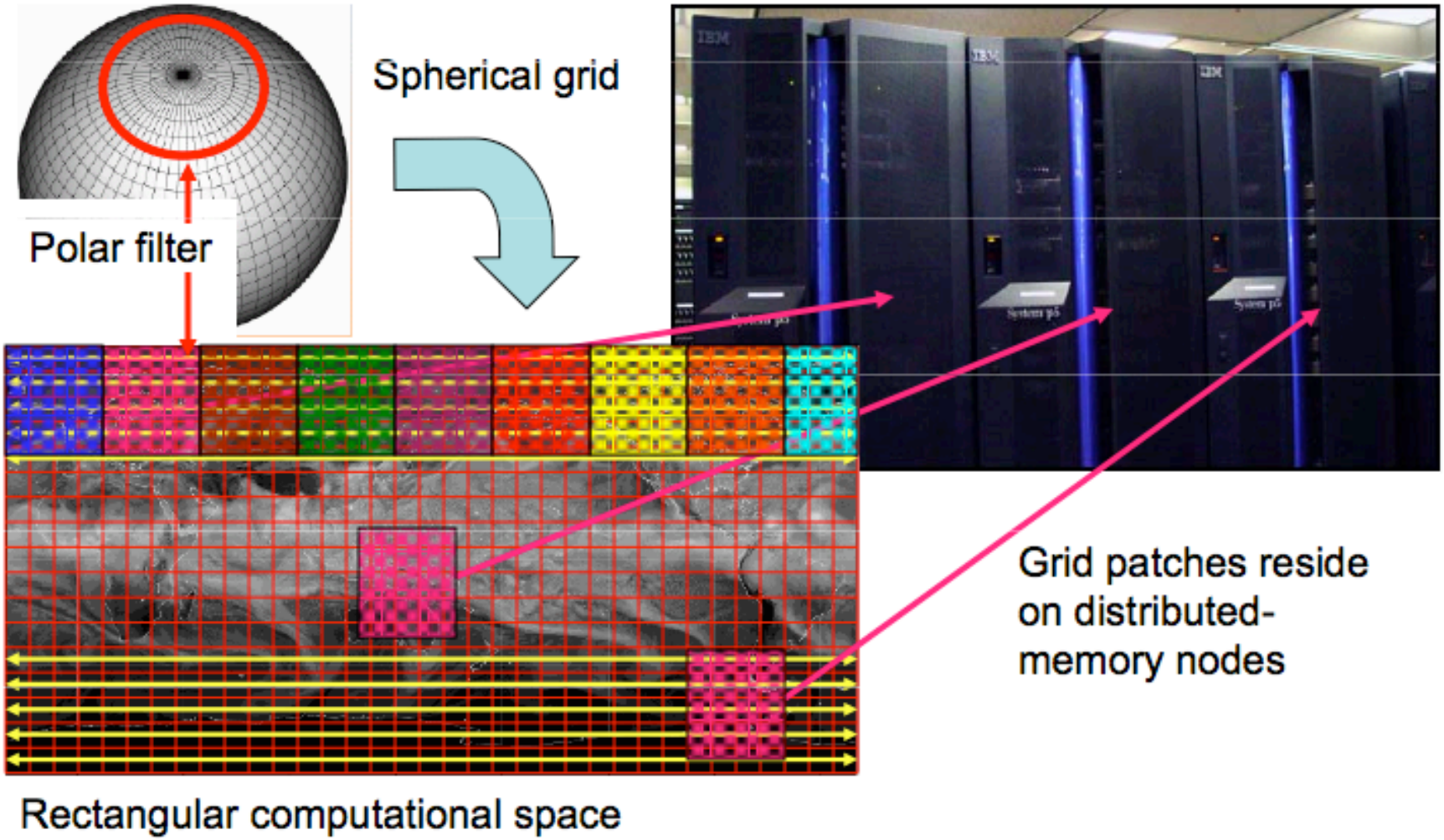

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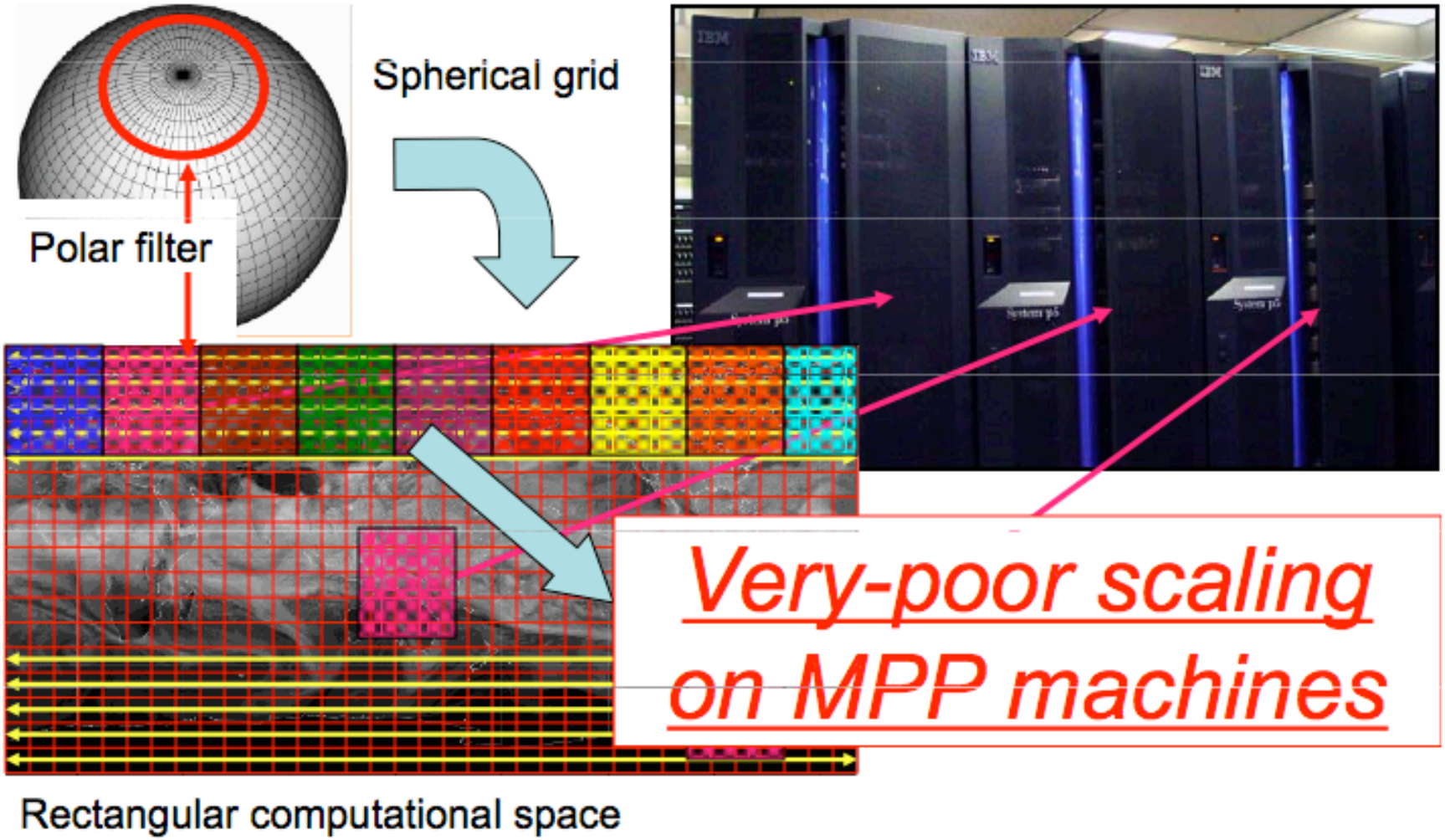

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Need dynamical cores that scale on massively parallel platforms

Increasing demands for conservation and accuracy
(numerical method should not be a spurious source or sink for mass, energy; model should work well for a wide range of scales)

Need more flexibility: E.g. regional refinement capabilities

model developers have been forced to go back to the drawing boards and develop next-generation models that meet at least some of these requirements!

we are currently in this process

Structure of colloquium

- Lectures in the morning and tutorials in the afternoon:

	Monday June 2		Tuesday June 3		Wednesday June 4		Thursday June 5		Friday June 6	
	Refreshments at 8:30		Refreshments at 8:30		Refreshments at 8:30		Refreshments at 8:30		Refreshments at 8:30	
Session 1	09:15 10:00	Intro and overview (*Lauritzen*)	09:00 10:00	Basic Dynamics II (*Thuburn*)	09:00 10:00	Horizontal discretizations (*Thuburn*)	09:00 10:00	Vertical discretizations (*Thuburn*)	09:00 10:00	Conservation (*Thuburn*)
	10:00 10:25	Curator (*Murphy*)	10:00 10:50	Meeting the Challenges of Petascale Earth System Modeling (*Loft*)	10:00 10:50	Finite-Volume methods in meteorology -a semi-Lagrangian view (*Lauritzen*)	10:00 10:50	Adaptive Grids for Atmospheric General Circulation Models (*Jablonowski*)	10:00 10:50	Numerical Noise: The Pros and Cons of Filters, Diffusion and other Damping Mechanisms (*Jablonowski*)
	10:25 10:50	Use of Supercomputers (*Page*)								
Break										
Session 2	11:15 12:15	Basic Dynamics I (*Thuburn*)	11:15 12:15	Idealized Test Cases for Dynamical Core Experiments (*Jablonowski*)	11:15 12:15	The use of modeling frameworks to facilitate interoperability (*Deluca and Putman*)	11:15 12:15	Tiling the Sphere with Quadrilaterals: Cubed-sphere grids and their challenges for numerical methods. (*Taylor*)	11:15 12:15	A little bit more about waves and turbulence (*Tribbia*)
Lunch	Meet at MSR at 1PM									
Tutorials	01:00 03:00	Intro to model by mentor Run a test case (low resolution)	01:00 03:00	Student projects	01:00 03:00	Student projects	01:00 03:00	Student projects	01:00 05:00	Student projects
Break	Refreshments at MSR		Refreshments at MSR		Refreshments at MSR		Refreshments at MSR		Refreshments at MSR	
Tutorials	03:15 05:00	Student projects	03:15 05:00	Student projects	03:15 05:00	Student projects	03:15 05:00	Student projects	03:15 05:00	Student projects
5:15	Bus to Williams Village		Bus to Williams Village		Bus to Flagstaff		Bus to Williams Village		Bus to Williams Village	
					06:00 07:30	**Picnic, group photo, hike**				
	06:30 08:30	Presentations (6:30-7PM) and dinner (7-8:30PM) for model mentors and lecturers **only** (location: Boulder Creek Living Room at the Millenium Hotel; cash bar)			07:30	Bus to Williams Village				

NCAR

Some questions discussed in the colloquium lectures

- What are the different numerical approaches used today and what are their advantages and deficiencies?
- Which system of equations should be used (hydrostatic, non-hydrostatic, Boussinesq, etc.)?
- Which computational grids are available? What kind of spherical geometry is optimal (is there one?)?
- What are the choices for the vertical coordinate and which prognostic variables should be selected?
- How do we build 3D models and how do we assess the accuracy of our models? This includes a thorough discussion of standard test cases.
- What conservation properties can be achieved in numerical models and how?
- Introduction to next generation scientific computing platforms (massively parallel machines) and the effect on the design of next generation models.
- Modeling frameworks.

NCAR

Lectures

We have been contacted by Springer about creating a *Lecture Notes in Computational Science and Engineering* Book series publication based on the colloquium lectures.

Based on the positive response from keynote lecturers we are moving forward with this project.

Springer

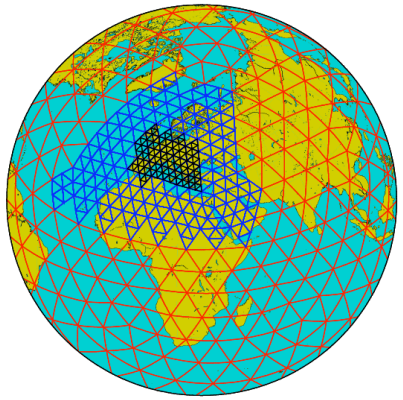
Tutorials: Hands-on experience with state-of-the-art dynamical cores

We invited major modeling groups worldwide to participate in the colloquium (this entailed porting their model to NCAR supercomputers and setting them up for idealized test cases)

10 modeling groups accepted our invitation

Participating models

(in random order)

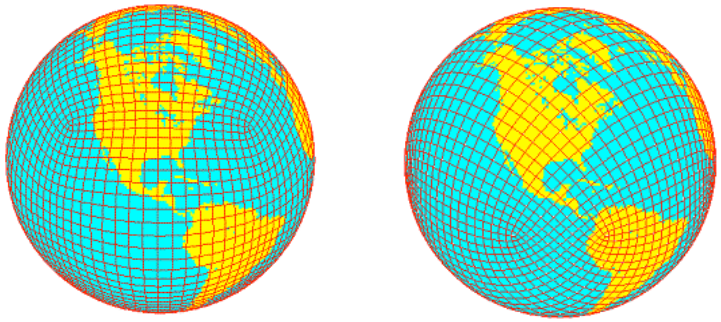


Icosahedral grid (triangles)

- ICON (ICOsahedral Non-hydrostatic General Circulation Model) developed at the Max-Planck-Institut (MPI) for meteorology in Hamburg, Germany.

Participating models

(in random order)



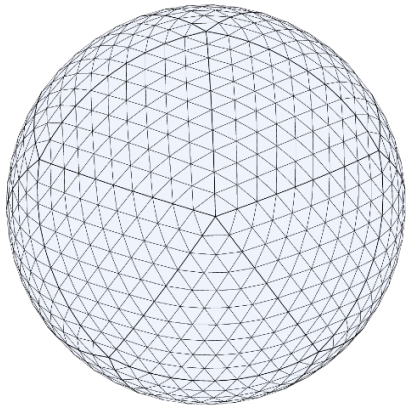
Quasi-Uniform Cubic or Octagonal grid

- ICON (ICOsahedral Non-hydrostatic General Circulation Model) MPI.
- GEF (Global Eta Framework), developed at the
  Earth System Science Interdisciplinary Center, University of Maryland,
  U.S.A.

Participating models

(in random order)

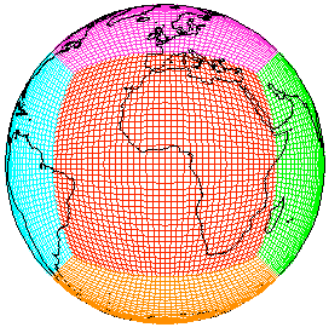
Global triangulation based on icosahedron



- ICON (ICOsahedral Non-hydrostatic General Circulation Model), MPI.
- GEF (Global Eta Framework), University of Maryland.
- OLAM (ocean-land-atmosphere model) developed at Duke University, USA.

Participating models

(in random order)



http://sivo.gsfc.nasa.gov/cubedsphere_overview.html

- ICON (ICOsahedral Non-hydrostatic General Circulation Model), MPI.
- GEF (Global Eta Framework), University of Maryland.
- OLAM (ocean-land-atmosphere model), Duke University.
- GEOS (Goddard Earth Observing System) developed at NOAA(National Oceanic and Atmospheric Administration)-GFDL(Geophysical Fluid Dynamics Laboratory)/NASA(National Aeronautics and Space Administration), USA.

Participating models

(in random order)

http://www.giss.nasa.gov/tools/modelE/

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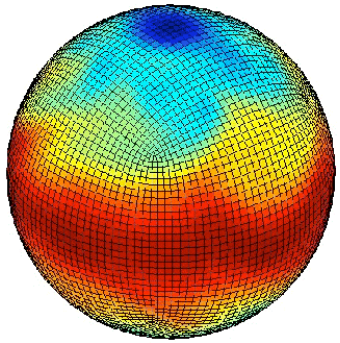
- OLAM (ocean-land-atmosphere model), Duke University
- GEOS (Goddard Earth Observing System), NOAA-GFDL/NASA.
- BQ_Core (B-grid Quadratic Upstream), GISS (Goddard Institute for Space Studies), developed at NASA.

Participating models

(in random order)

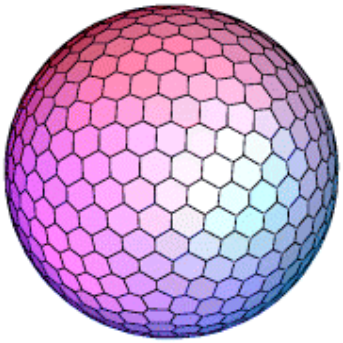


http://mitgcm.org/

- ICON (ICOsahedral Non-hydrostatic General Circulation Model), MPI.
- GEF (Global Eta Framework), University of Maryland.
- OLAM (ocean-land-atmosphere model), Duke University
- GEOS (Goddard Earth Observing System), GFDL/NASA
- BQ_Core (B-grid Quadratic Upstream), GISS, NASA.
- MITgcm (Massachusetts Institute of Technology General Circulation Model), MIT, USA.

Participating models

(in random order)



http://kiwi.atmos.colostate.edu/BUGS/BUGSoverview.html

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- BQ_Core (B-grid Quadratic Upstream), GISS, NASA.
- MITgcm (Massachusetts Institute of Technology General Circulation Model), MIT.
- CSUgcm (Colorado State University General Circulation Model), CSU, USA.

Participating models

(in random order)

http://www.dwd.de/

- ICON (ICOsahedral Non-hydrostatic General Circulation Model), MPI.
- GEF (Global Eta Framework), University of Maryland.
- OLAM (ocean-land-atmosphere model), Duke University
- GEOS (Goddard Earth Observing System), NOAA-GFDL/NASA
- BQ_Core (B-grid Quadratic Upstream), GISS, NASA.
- MITgcm (Massachusetts Institute of Technology General Circulation Model), MIT.
- CSUgcm (Colorado State University General Circulation Model), CSU.
- GME, German Weather Service.

Participating models

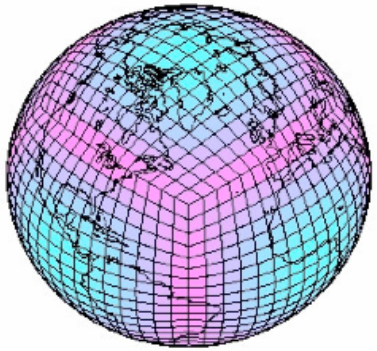
(in random order)

http://www.ccsm.ucar.edu/

- ICON (ICOsahedral Non-hydrostatic General Circulation Model), MPI.
- GEF (Global Eta Framework), University of Maryland.
- OLAM (ocean-land-atmosphere model), Duke University
- GEOS (Goddard Earth Observing System), NOAA-GFDL/NASA
- BQ_Core (B-grid Quadratic Upstream), GISS, NASA.
- MITgcm (Massachusetts Institute of Technology General Circulation Model), MIT.
- CSUgcm (Colorado State University General Circulation Model), CSU.
- GME, German Weather Service.
- CAM (Community Atmosphere Model), NCAR, USA.

Participating models

(in random order)



https://www.wiki.ucar.edu/display/homme/Home

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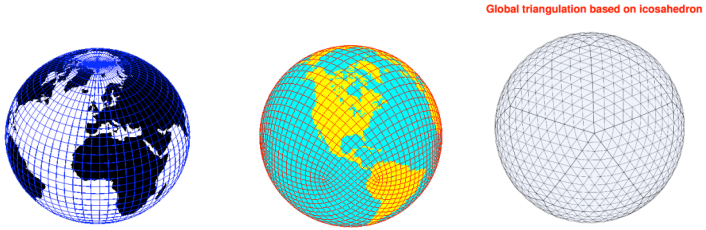
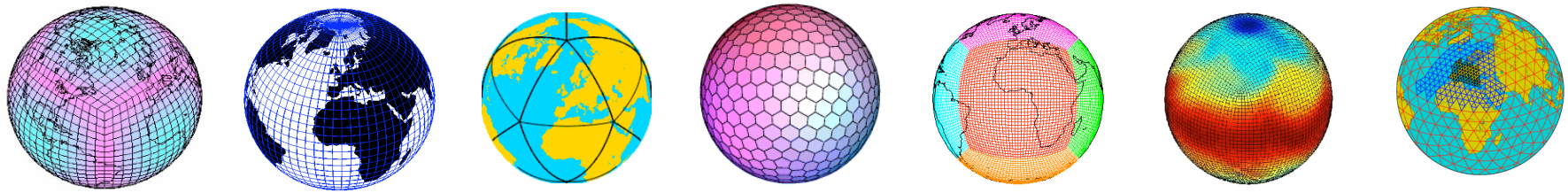
- GEOS (Goddard Earth Observing System), NOAA-GFDL/NASA
- BQ_Core (B-grid Quadratic Upstream), GISS, NASA.
- MITgcm (Massachusetts Institute of Technology General Circulation Model), MIT.
- CSUgcm (Colorado State University General Circulation Model), CSU.
- GME, German Weather Service.
- CAM (Communicty Atmosphere Model), NCAR.
- HOMME (High Order Method Modeling Environment), NCAR/Sandia.

Participating models

(in random order)





- You have been assigned to one modeling group (approximately 3-4 for each model version). Which model have I been assigned to?

  See list in "welcome packet" or on the colloquium Wiki.

  (You were assigned to modeling group in alphabetic order and the criterion that no two students from the same institution could be in the same group).

- There is (at least) one modeling mentor per modeling group who will guide you through the tutorials. We meet at 1PM in this seminar room so that you can team up with your modeling mentor (ASP staff will show each group to their rooms). All groups will be spread out all over the Mesa Lab (it was quite a challenge to find rooms!) - each room should have an overhead projector or screen!

NCAR

Tutorials

- Run the model you are assigned to on idealized test cases:
  - identify strength/weaknesses in the numerical methods used in the model (5% of your time)
  - get experience/skills with working on supercomputers (95% of your time)-“What can go wrong will go wrong!”

NCAR

Tutorials

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  - identify strength/weaknesses in the numerical methods used in the model (5% of your time)
  - get experience/skills with working on supercomputers (95% of your time)-“What can go wrong will go wrong!”

That is why we asked you to bring your own computer!

Tutorials: "Ambition" for today

- Your modeling mentor will give you a brief scientific introduction to the model you are going to work on

- Thereafter:

  - logon to the network (username: dycore; password: 2008ASP)

See instructions in "Welcome Packet" (tutorial document)

You're sharing a fixed amount of bandwidth. Please be a good neighbor. PLEASE DO NOT USE THE NETWORK FOR PERSONAL WEB BROWSING (refrain from applications that use a large amount of the limited wireless bandwidth such as video/ audio streams).

Tutorials: “Ambitions” for today

- Your modeling mentor will give you a brief scientific introduction to the model you are going to work on

- Thereafter:
  - logon to the network
  - login to Bluevista with your cryptocard (most of you have already tried this!)
  - run a low resolution version of the model

Please be patient with your modeling mentor(s)
(it takes a lot of “engineering” to work on supercomputers)

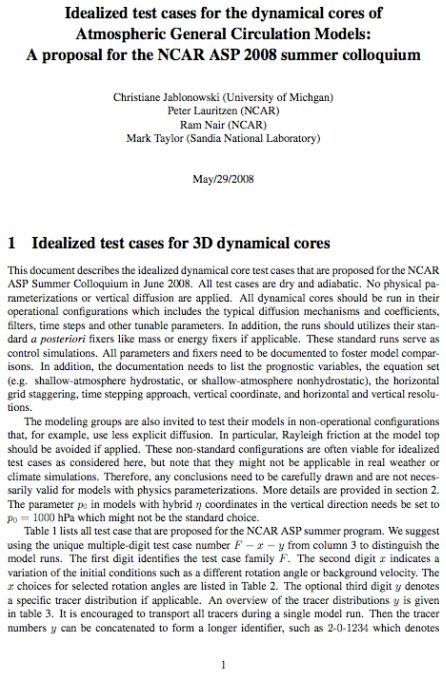
Tutorials: Beyond today

Run idealized test case suite

Documentation: hard copy document in your “welcome packet”

Note:

1. 1st errata also in “welcome packet”
2. Updates to Fig.12 & 13
   (see pdf-version on the Wiki under
   test cases)



Idealized test cases for the dynamical cores of Atmospheric General Circulation Models: A proposal for the NCAR ASP 2008 summer colloquium

Christiane Jablonowski (University of Michgan)
Peter Lauritzen (NCAR)
Ram Nair (NCAR)
Mark Taylor (Sandia National Laboratory)

May/29/2008

1 Idealized test cases for 3D dynamical cores

This document describes the idealized dynamical core test cases that are proposed for the NCAR ASP Summer Colloquium in June 2008. All test cases are dry and adiabatic. No physical parameterizations or vertical diffusion are applied. All dynamical cores should be run in their operational configurations which includes the typical diffusion mechanisms and coefficients, filters, time steps and other tunable parameters. In addition, the runs should utilizes their standard *a posteriori* fixers like mass or energy fixers if applicable. These standard runs serve as control simulations. All parameters and fixers need to be documented to foster model comparisons. In addition, the documentation needs to list the prognostic variables, the equation set (e.g. shallow-atmosphere hydrostatic, or shallow-atmosphere nonhydrostatic), the horizontal grid staggering, time stepping approach, vertical coordinate, and horizontal and vertical resolutions.

The modeling groups are also invited to test their models in non-operational configurations that, for example, use less explicit diffusion. In particular, Rayleigh friction at the model top should be avoided if applied. These non-standard configurations are often viable for idealized test cases as considered here, but note that they might not be applicable in real weather or climate simulations. Therefore, any conclusions need to be carefully drawn and are not necessarily valid for models with physics parameterizations. More details are provided in section 2. The parameter p_0 in models with hybrid η coordinates in the vertical direction needs be set to $p_0 = 1000$ hPa which might not be the standard choice.

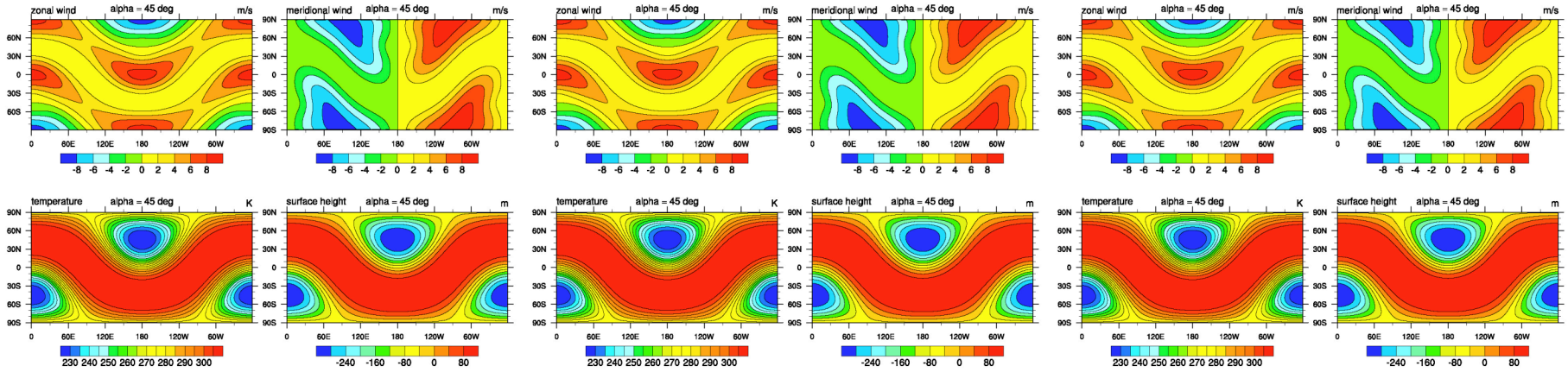
Table 1 lists all test case that are proposed for the NCAR ASP summer program. We suggest using the unique multiple-digit test case number $F - x - y$ from column 3 to distinguish the model runs. The first digit identifies the test case family F. The second digit x indicates a variation of the initial conditions such as a different rotation angle or background velocity. The x choices for selected rotation angles are listed in Table 2. The optional third digit y denotes a specific tracer distribution if applicable. An overview of the tracer distributions y is given in table 3. It is encouraged to transport all tracers during a single model run. Then the tracer numbers y can be concatenated to form a longer identifier, such as 2-0-1234 which denotes

1

Tutorials: Test cases

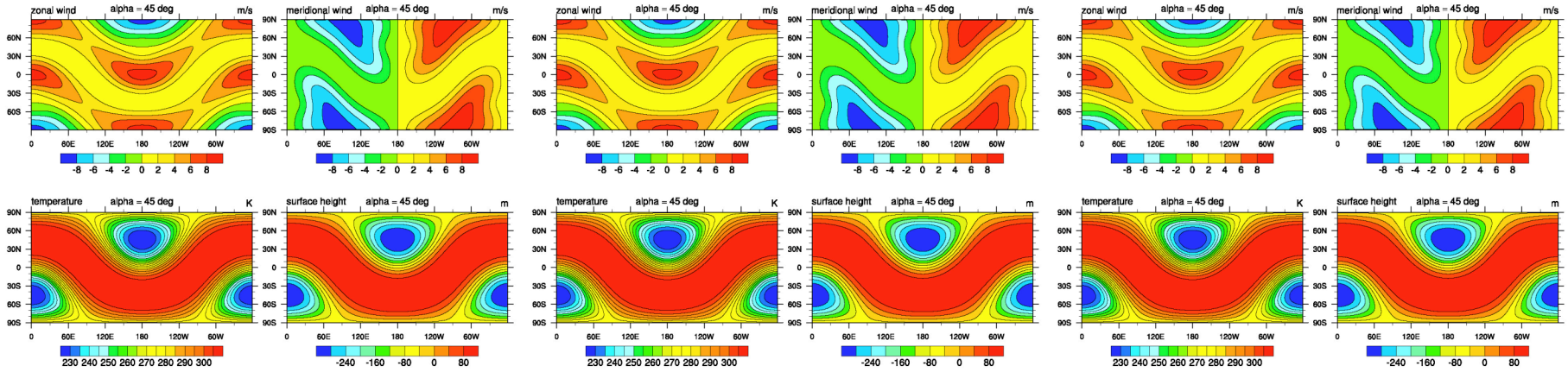
- 6 test cases with variants are going to be run at different resolutions
- total number of configurations per modeling group is approximately 50-70

  (in addition, modeling mentor may suggest to tweak default settings: increase diffusion coefficients, change advection scheme, …)
- In each group: Coordinate the runs among you! Collaborate; discuss; …



Tutorials: Test cases

- If you collectively do all test cases we will produce an unprecendented large dynamical core intercomparison dataset (probably more than 500 datafiles).
- **More details on test cases in Dr. Jablonowski's talk tomorrow.**
- Dr. Jablonowski will walk around to the different modeling groups during the tutorials to discuss the test cases



Tutorials: Managing Bluevista

- Details in talk this morning (Mike Page)
- See Wiki under “Student tutorials” for list of useful “super computer”-commands.
- Learn by mistake … (things will go wrong!)

Tutorials: Computing resources

We have limited computing resources

Coordinate the runs so that no two persons run a model on the same test case at the same resolution, time-step, etc.!

Bluevista is going to be heavily loaded during the colloquium:

- do not submit more than 1 job at a time
- do not use more than three nodes at a time in the *dycore* queue (if using more nodes run in *regular* queue)
- run high-resolution jobs over night (each modeling group can run one higher node job every 24 hours)
- more details on the Wiki

Tutorials: Data

- For the organizers to manage these datasets after the colloquium, we ask you to (after you have successfully run a test case):

  - write non-defaults model settings to a text file (resolution, dt, etc.)
  - copy data to my directory on the Mass Storage System (MSS) **strictly following file name conventions**.

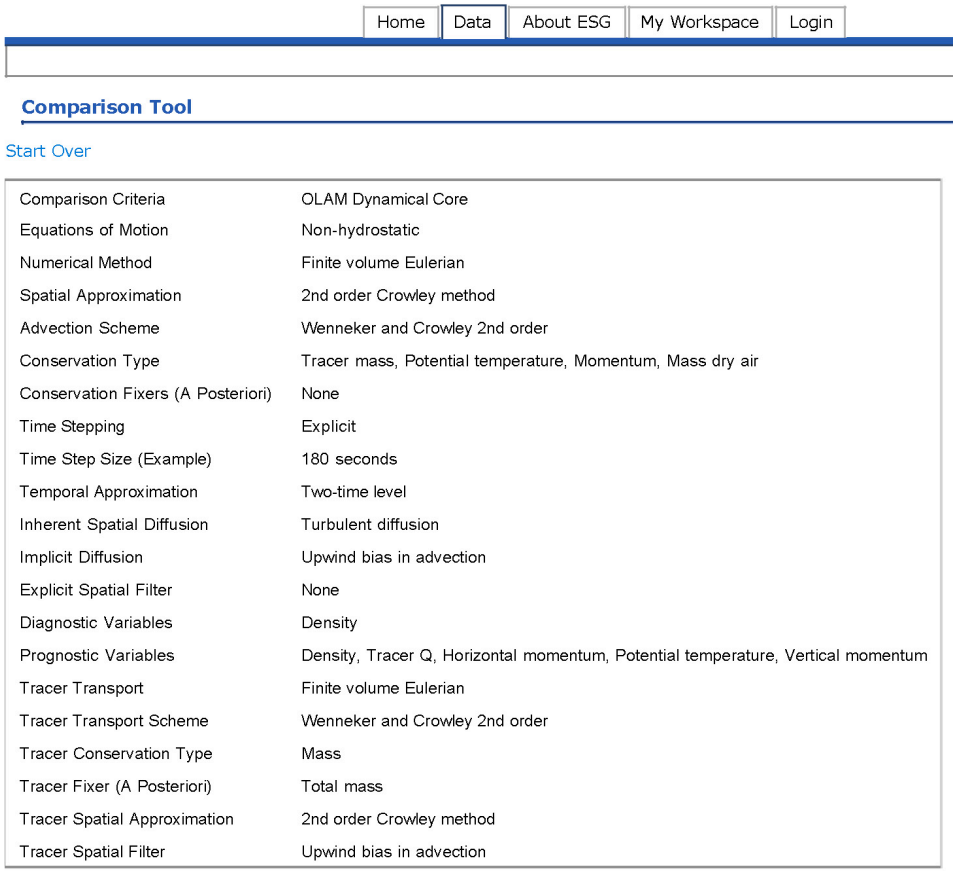
Example:

olam_dycore_1-0-0_low_L26

All details are in "welcome packet"- tutorial document

Tutorials: Data management

- datafiles and model metadata is managed with Earth System Curator (next talk)



Comparison Criteria	OLAM Dynamical Core
Equations of Motion	Non-hydrostatic
Numerical Method	Finite volume Eulerian
Spatial Approximation	2nd order Crowley method
Advection Scheme	Wenneker and Crowley 2nd order
Conservation Type	Tracer mass, Potential temperature, Momentum, Mass dry air
Conservation Fixers (A Posteriori)	None
Time Stepping	Explicit
Time Step Size (Example)	180 seconds
Temporal Approximation	Two-time level
Inherent Spatial Diffusion	Turbulent diffusion
Implicit Diffusion	Upwind bias in advection
Explicit Spatial Filter	None
Diagnostic Variables	Density
Prognostic Variables	Density, Tracer Q, Horizontal momentum, Potential temperature, Vertical momentum
Tracer Transport	Finite volume Eulerian
Tracer Transport Scheme	Wenneker and Crowley 2nd order
Tracer Conservation Type	Mass
Tracer Fixer (A Posteriori)	Total mass
Tracer Spatial Approximation	2nd order Crowley method
Tracer Spatial Filter	Upwind bias in advection

Tutorials: Visualization

- For visualization NCL (NCAR Command Language) scripts are available on the Wiki

https://www.wiki.ucar.edu/display/dycores/Visualization

(local NCL expert Dennis Shea provides support together with Christiane Jablonowski)

Since not all modeling groups have provided us with sample datasets and not everybody has complied strictly with our output conventions, we have not been able to test the scripts on all model outputs ….

So there can be problems with plotting; Dennis & Christiane will do what they can to make the visualization Software work (so be patient!).

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Tutorials: End

- Last day of colloquium we ask each student group to give a short 10 min presentation on their main findings (focus on one or two test cases where you found “interesting” behavior).

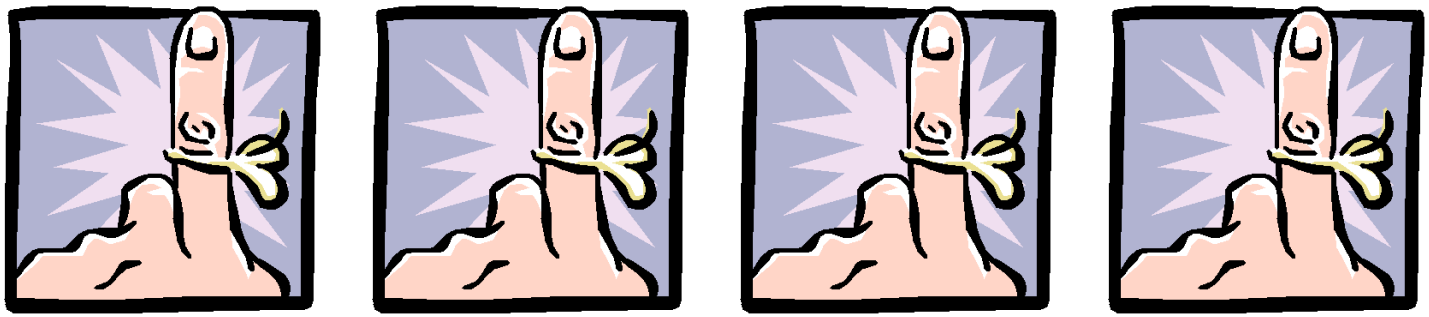
NCAR

Practical information

- Posters: Display at the Main Seminar mezzanine from Tuesday 3 to Friday 13.

  (no official poster session - use breaks)
- Occasional printing: B&W printer in outer Damaon room (see instructions in tutorial document or Wiki)

Return Cryptocards to Scott Briggs Friday 13



More practical information

- Challenging workshop:

  - Logistical problems ask Peter, Ram, Mark or Christiane
    (who will probably direct you to Scott Briggs or Kathleen Barney)
  - Computer problems: ask modeling mentors, Mike Page, …

- Meals in NCAR cafeteria (just downstairs), and coffee break refreshments are in front of this room (expect next Monday: in outer Damon room).

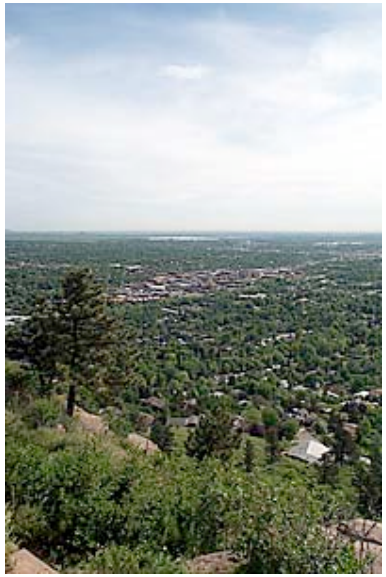
- No exams, no grades. Just the science and learning. The more you put in the more you get out.

- Lecturers will be around for at least a few days – feel free to interact with them.

- Ask lots of questions

All work no play?

- Picnic this Wednesday at Flagstaff
- Weekend to explore Boulder area
- Plenty of great science can be done on hikes around NCAR at lunchtime!



The Mesa Laboratory and the Flatirons

© 2003 UCAR

Tall towers of the Mesa Laboratory

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Many thanks to…

- Folks at NCAR's Advanced Study Program (ASP)
  Maura Hagan, Paula Fisher, Kathleen Barney, Scott Briggs
- Modeling mentors: All participating modeling groups
- "Helpers":
  CISL (Ginger Caldwell, Mike Page, Michelle Smart,…)
  Curator group (Cecilia Deluca, Sylvia Murphy, …)
- Lecturers for donating their time and effort to visit Boulder
- Sponsors: NCAR's ASP (main sponsor), NASA, DOE.