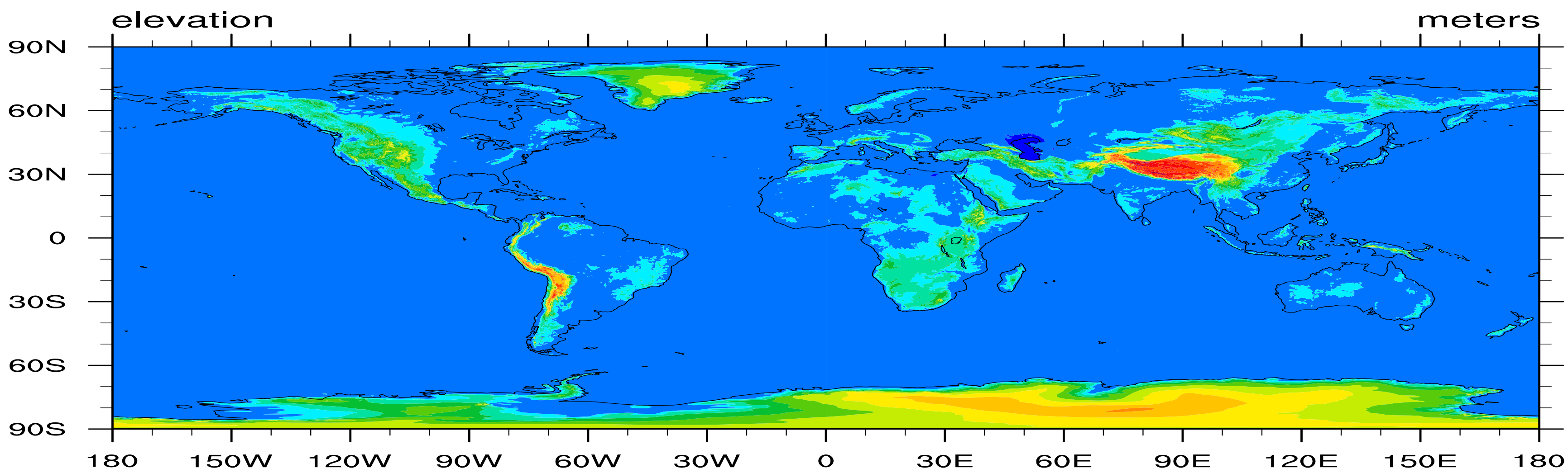
SciDAC Scientific Discovery through Advanced Computing

CGD Climate & Global Dynamics

NCAR NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

Rethinking orography in CAM

Peter Hjort Lauritzen§, Julio Bacmeister§, Mark Taylor* and Rich Neale§



17th CESM workshop, Breckenridge, June 18, 2012

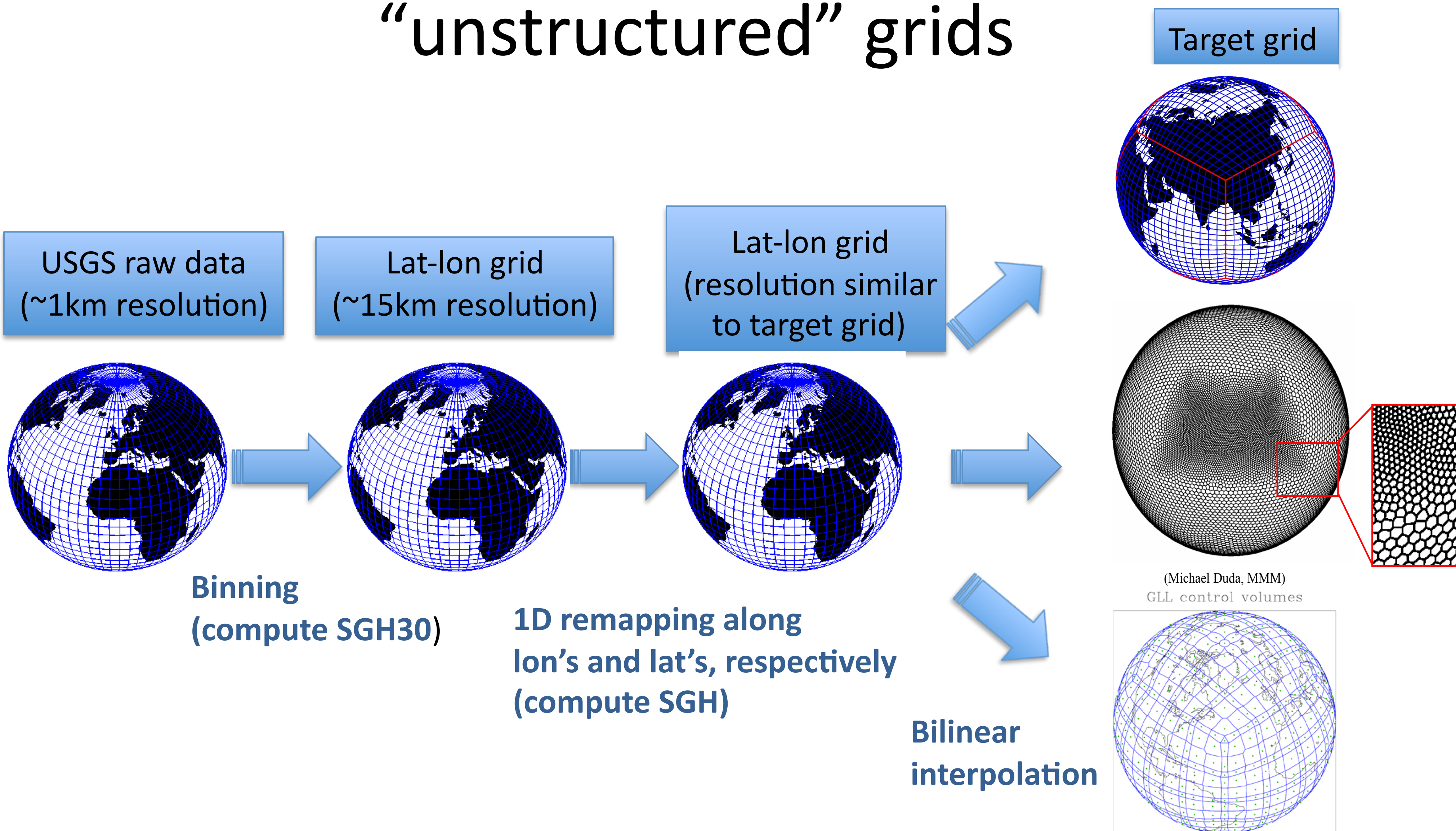
§ NCAR   *Sandia National Laboratories

(thanks to Andy Mai for doing all the runs and diagnostics)

Orography variables

- **PHIS**: surface geopotential
- **SGH30**: standard deviation of topography on scales approximately < 3-6 km.
  Used for turbulent mountain stress (TMS) parameterization
  (sub-grid-scale orographic drag)
- **SGH**: standard deviation of topography on scales approximately > 3-6km (and < grid scale)
  (momentum flux deposition due to unresolved gravity waves)
- (**LANDFRAC**: land-ocean mask)

Default topo file generation for “unstructured” grids



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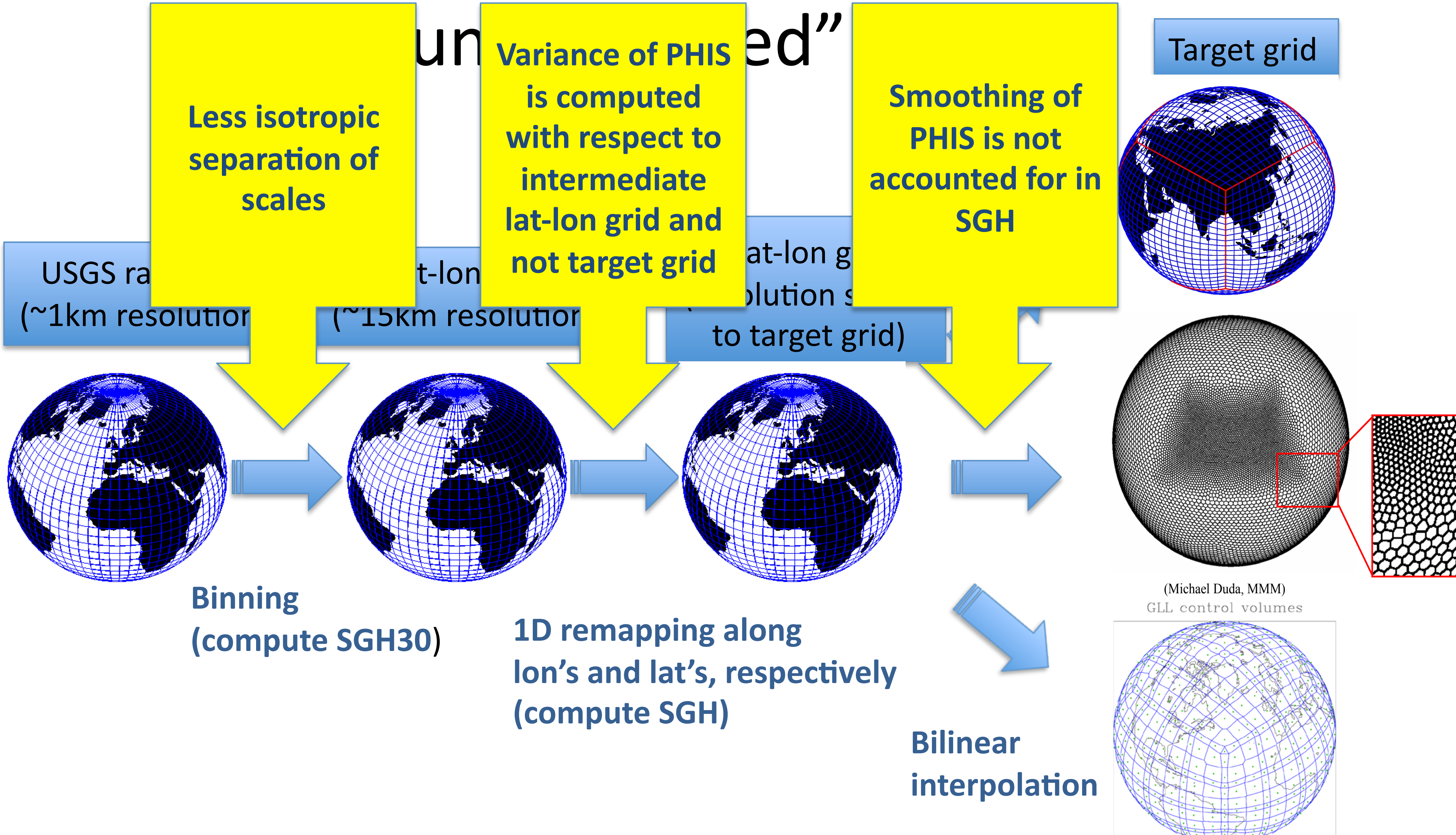
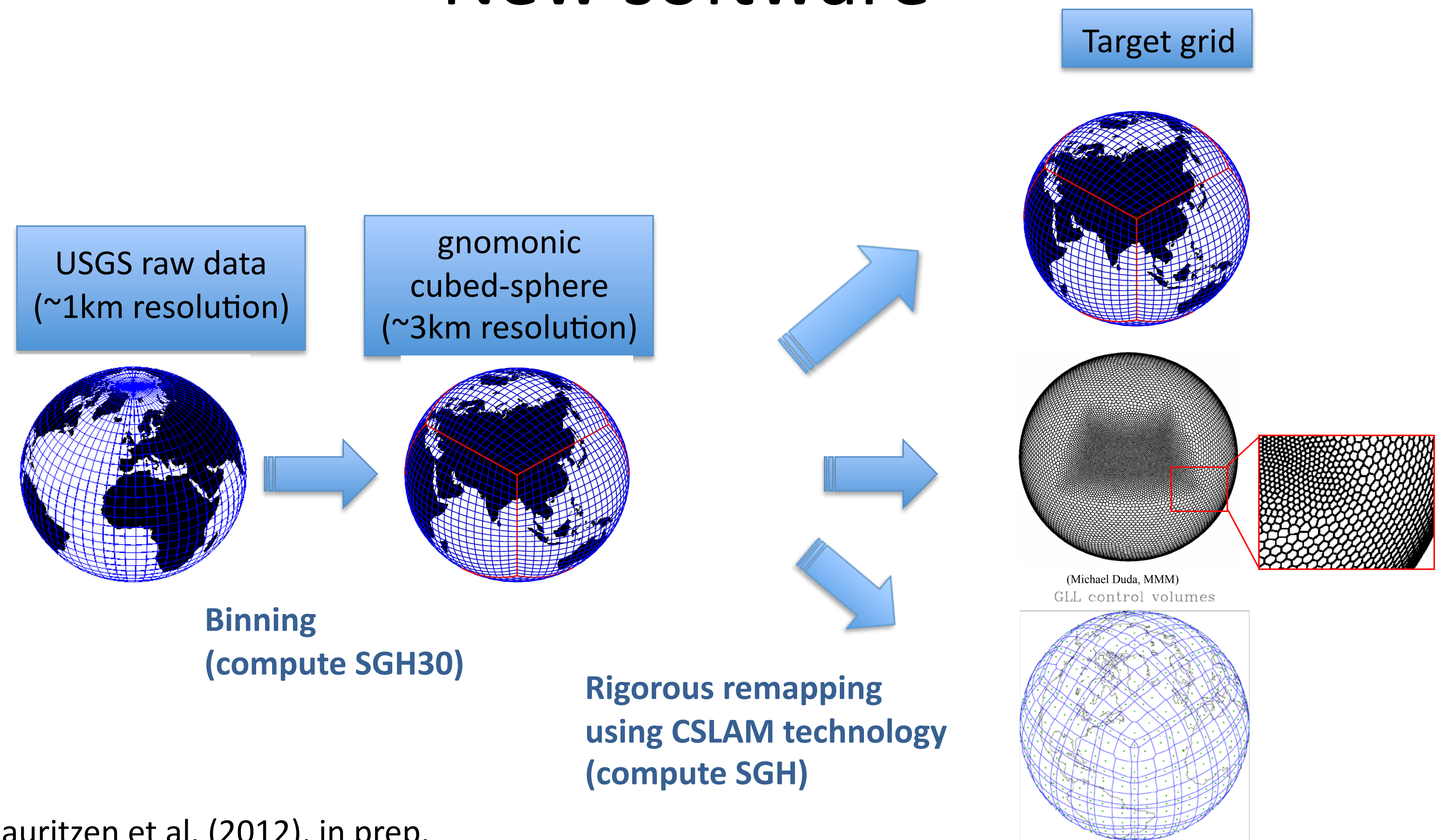


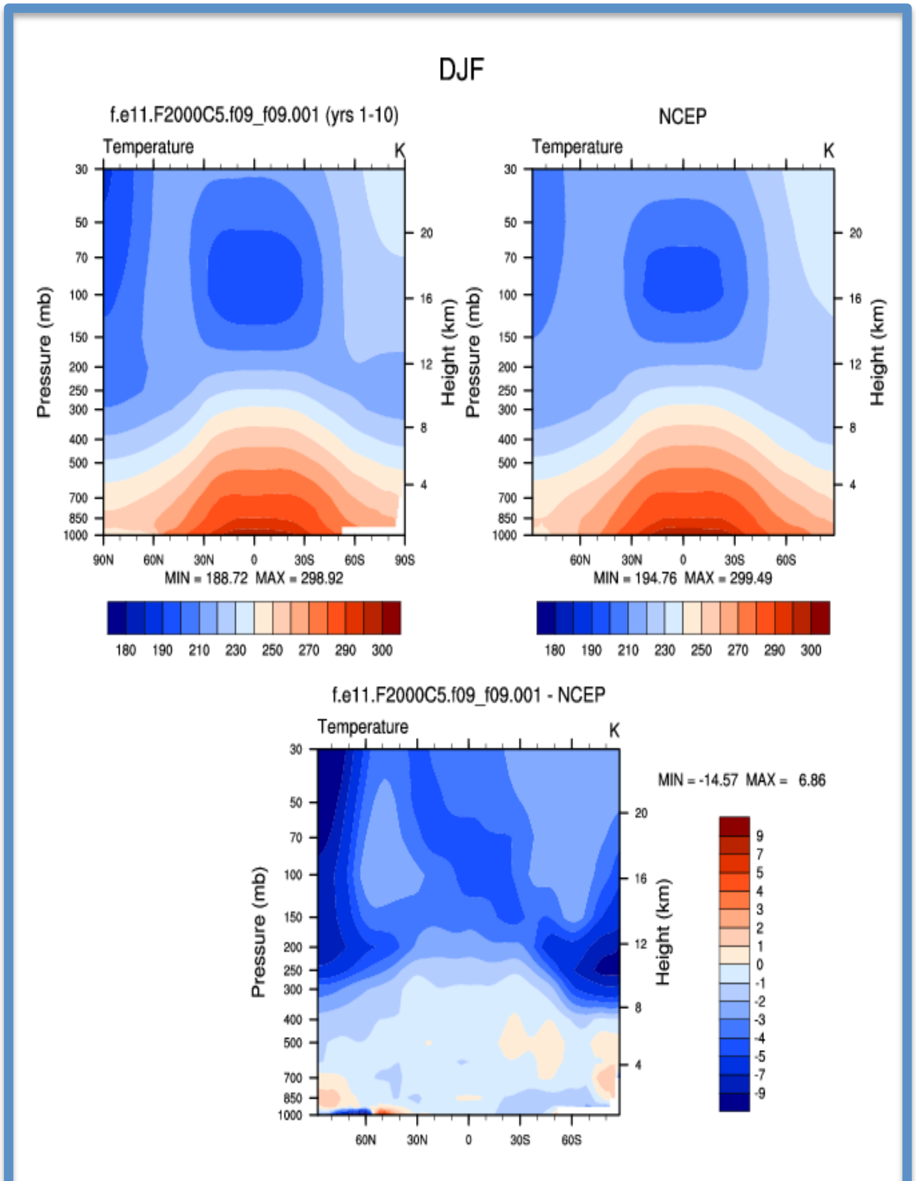
New software



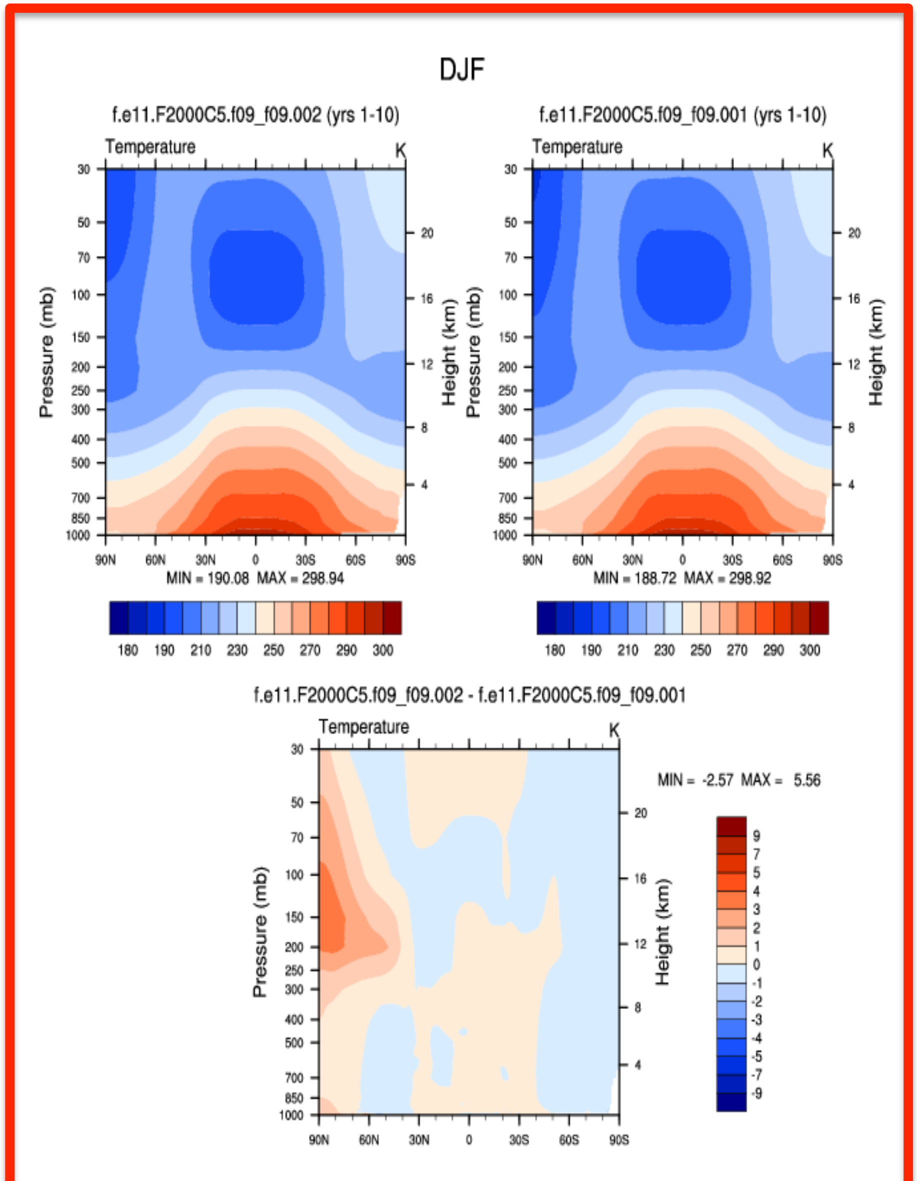
Lauritzen et al. (2012), in prep.

Zonal temperature: CAM-FV 1 degree

Control and OBS



Consistent (SGH & SGH30) and Control



A standard test case suite for two-dimensional linear transport on the sphere

P. H. Lauritzen[1], **W. C. Skamarock**[1], **M. J. Prather**[2], **and M. A. Taylor**[3]

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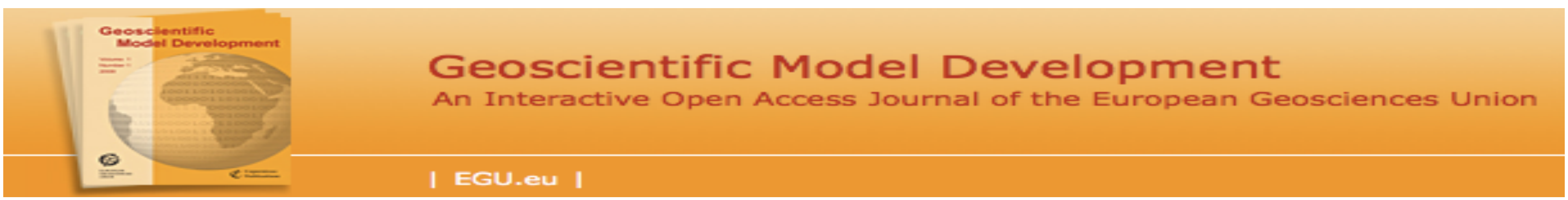
Abstract. It is the purpose of this paper to propose a standard test case suite for two-dimensional transport schemes on the sphere intended to be used for model development and facilitating scheme intercomparison. The test cases are designed to assess important aspects of accuracy in geophysical fluid dynamics such as numerical order of convergence, "minimal" resolution, the ability of the transport scheme to preserve filaments, transport "rough" distributions, and to preserve preexisting functional relations between species/tracers under challenging flow conditions.

Results manuscript in preparation with results from 10-15 state-of-the-art transport schemes



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Integrating a scalable and efficient semi-Lagrangian multi-tracer transport scheme in CAM-SE (HOMME)

Christoph Erath
NCAR and CU Boulder, Colorado

CESM 2012, Breckenridge, CO, USA

Wednesday, 20. June 2012

DOE BER Program DE-SC0001658

joint work:

Jose Garcia[1], Peter Lauritzen[1], Mark Taylor[2], and Henry Tufo[3]

[1]NCAR, Boulder, CO [2]SNL, Albuquerque, NM [3]CU Boulder, CO

Remapping

Two-dimensional transport equation on the sphere (no source/sinks):

$$\frac{d}{dt}\int_{A(t)} \psi \, dx = 0,$$

$\psi \ldots$ tracer density $\quad t \ldots$ time $\quad A(t) \ldots$ Lagrangian area

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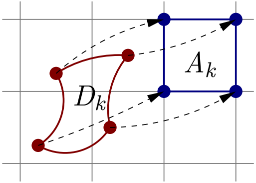


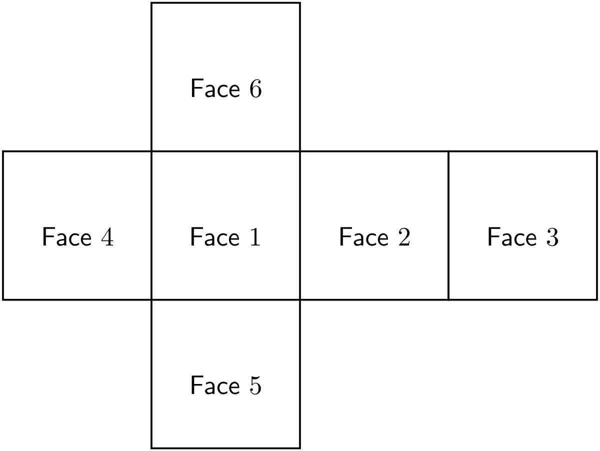
The third order CSLAM scheme:

$$\overline{\psi_k}^{n+1}|A_k| = \int_{D_k} \psi^n_{k,rec} \, dx = \text{reconstruction} \times \text{weights}$$

weights... can be reused for each tracer ->multi-tracer efficient!

Different Halo Zone and Grid

because of the departure cell and the reconstruction.



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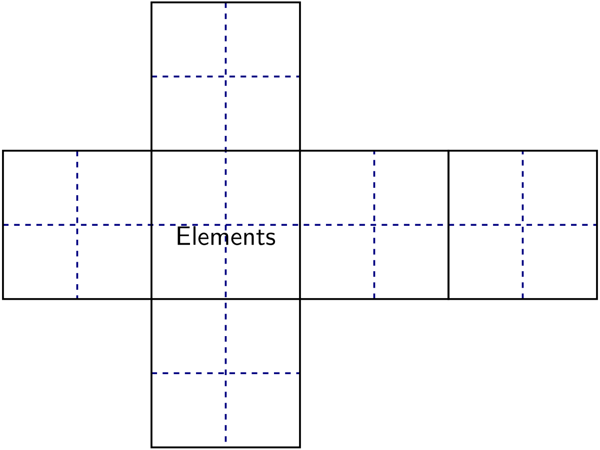

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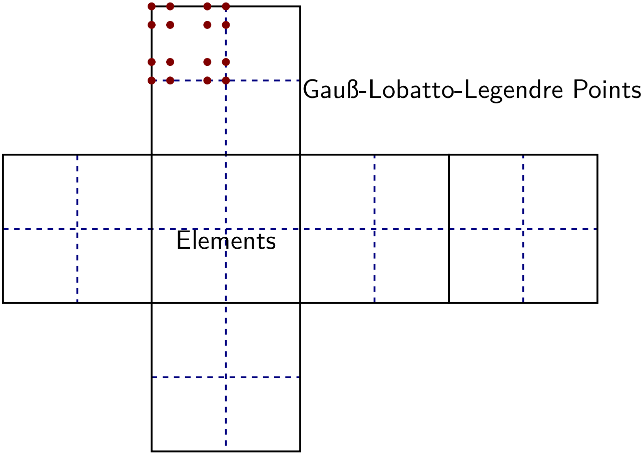

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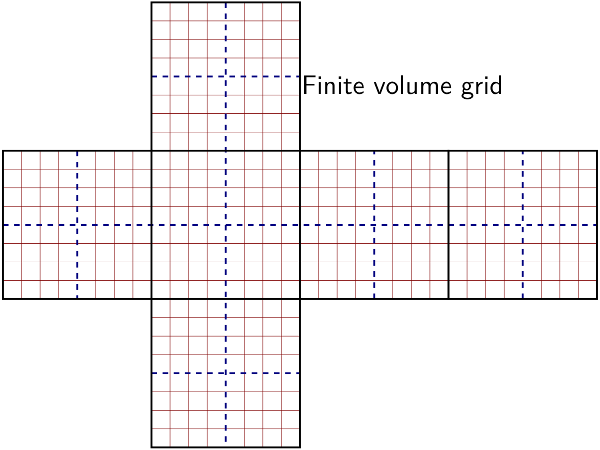

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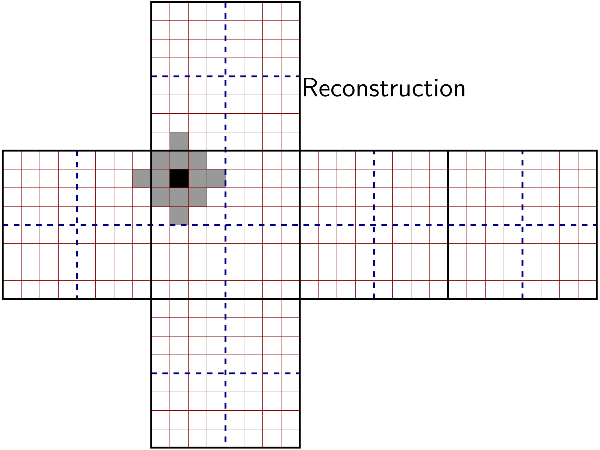
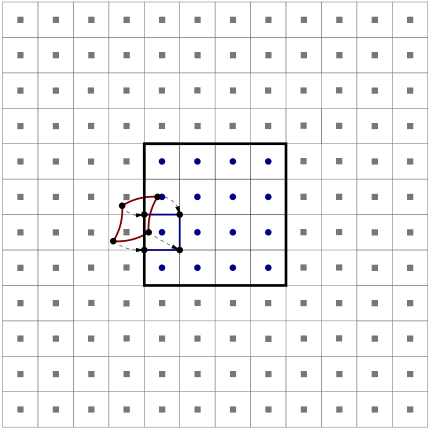


Different Halo Zone and Grid

because of the departure cell and the reconstruction.

One element with its halo zone!



Summary of CSLAM in CAM-SE (HOMME)

- Why HOMME? Because it is scalable up to 170000 cores.
- We want to have a multi-tracer efficient advection scheme.
- Departure grid and order of the scheme define the depth of the halo zone.
- Departure and arrival cells are always on the same core.

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Communication

Reconstruction coefficients depend on the tracer value, only ONE nearest neighbor communication for each time step (array of multiple tracer values).

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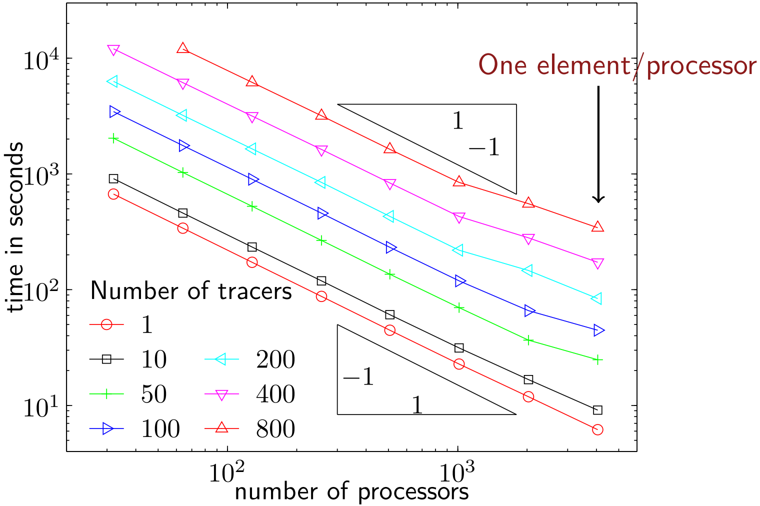
Mass conservation

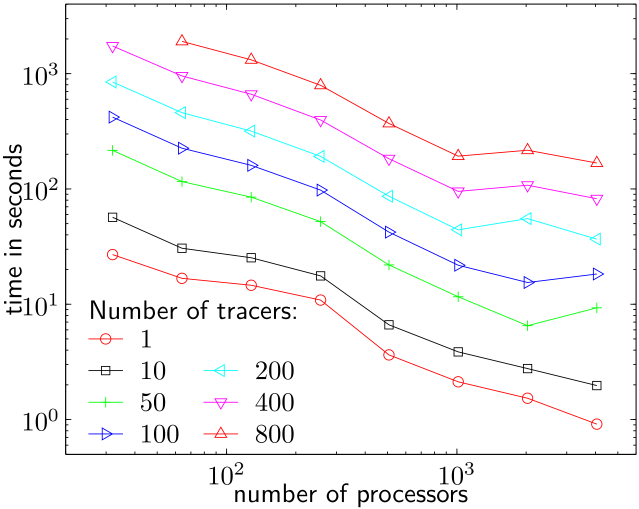
The scheme in HOMME conserves mass to machine precision as well!

Scalability on NCAR/CU Blue Gene/L System

Standalone CSLAM, standard benchmark test.



Communication Time



Comparison: Spectral Elements (SE) advection scheme versus CSLAM in HOMME on NCAR's Cray XT5m

- Integrated in the atmospheric primitive equations SE, calculate CSLAM departure grid from SE velocities
- Resolution 0.75 degree on the equator, tstep$= 50$ s for the dynamics, running the baroclinic test case for 15 days
- CFL SE < 0.28 with shape preserving mode, CFL CSLAM< 1 Tracer time steps: SE$= 250$ s, CSLAM$= 800$ s

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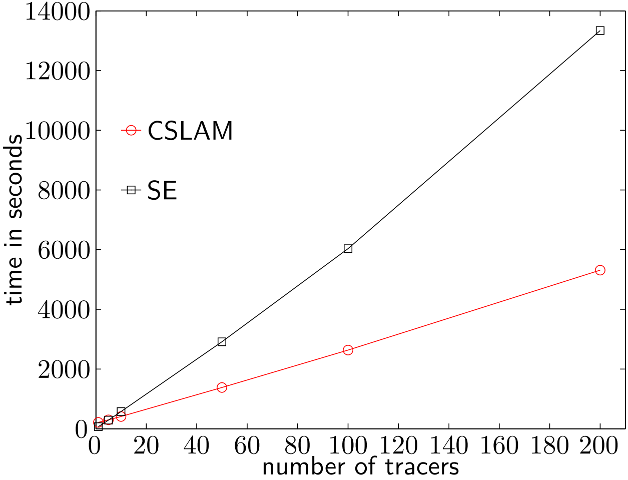
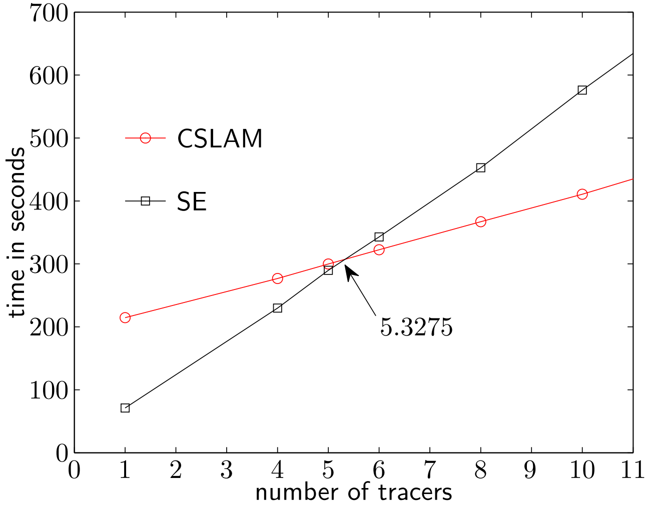
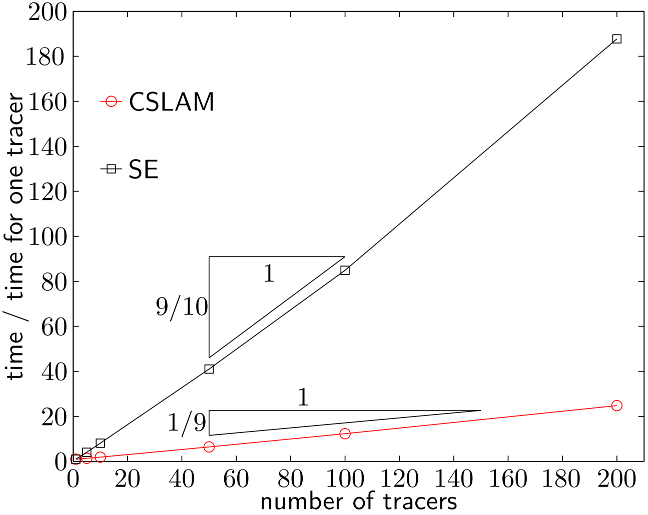
Advection schemes SE and CSLAM



Advection schemes SE and CSLAM



Performance



Future Work

- More robustness tests.
- Consistent coupling of CAM-SE mass field and CSLAM.
- Integrating in CAM-SE from HOMME “should be” straight forward.

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Further Questions?

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- http://www.csc.cs.colorado.edu/~ce/