

SAND2011-1692C

Quasi-Monotone Advection Methods for Spectral Elements

Oksana Guba*, Mark Taylor*, Amik St.-Cyr**

*Sandia National Labs, NM, Albuquerque

**NCAR, Boulder, CO

SIAM Conference on Mathematical &
Computational Issues in the Geosciences

March 24, 2011



**Sandia
National
Laboratories**

Outline

- 1 What is HOMME (FEM based on GLL polynomials)
- 2 HOMME in Community Atmospheric Model (CAM)
- 3 Swirl Test Case for tracers (div-free, very distortive flow)
- 4 Optimal limiter
- 5 Mixing diagnostics
- 6 Some performance issues

Swirl Test Case

Reference to Test Case: Ramachandran D. Nair and Peter H. Lauritzen, 2010: [A Class of Deformational Flow Test Cases for Linear Transport Problems on the Sphere](#). J. Comput. Phys.: Vol. 229, Issue 23, pp. 8868–8887

Key features of test: Very distortive, final solution known.

Figure: Test case, gauss bells with high resolution

Advection of Tracers

Flux formulation:

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\mathbf{u}\rho) = 0, \quad (1)$$

$$\frac{\partial(\rho q)}{\partial t} + \nabla \cdot (\mathbf{u}\rho q) = 0, \quad (2)$$

ρ is a density, \mathbf{u} is a prescribed velocity ($\nabla \cdot \mathbf{u} = 0$), q is a tracer density per unit mass. We use ρ -field, initialized to 1 everywhere at initial time, for limiting.

Advective formulation is available in HOMME but...

Why we need limiter:

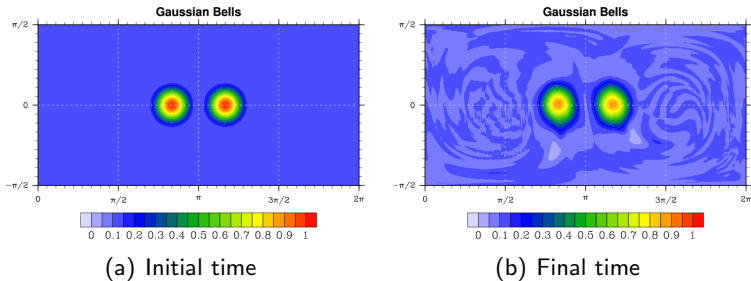
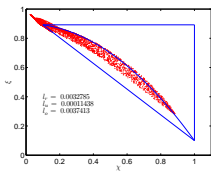
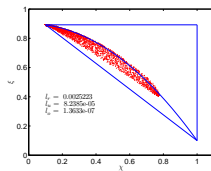


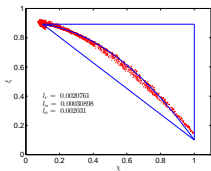
Figure: Low resolution, cosine bells, no limiter

Mixing diagnostics for Two Chemicals

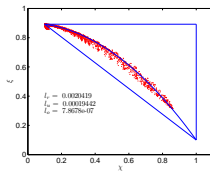
Reference: Peter Lauritzen, John Thuburn. [Evaluating Advection/Transport Schemes Using Interrelated Tracers, Scatter Plots and Numerical Mixing Diagnostics](#). Submitted.

Key features of diagnostics: Measures numerical error in terms of physical and non-physical mixing.

(a) $NE=20$, no limiter(b) $NE=20$, limiter OP1**Figure:** Mixing diagnostics for $np=4$



(a) NE=8, no limiter



(b) NE=8, limiter OP1

Acknowledgements



Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Thanks! Hurricane Movie as a Bonus

Figure: Hurricane