A Spectral Element Atmospheric Model for Multi-Resolution Climate Modeling
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Research Objectives
• Couple SEAM with CAM Physics & CLM: CAM-SEM
• Apply CAM_SEM for long-term global climate simulations
• Apply CAM_SEM with LMR for both global and regional climate simulations

Previous Work
• 2-D shallow water model (Taylor et al. 1997)
  - Mapping sphere to cube
  - Standard shallow water tests
• 3-D atmospheric dynamical model (η-coordinates)
  - Held-Suarez experiments (Taylor)
  - Polar vortex experiments (Taylor, Fournier)

Recent Development
• Converted to Fortran 90
• Finished implementation of η-coordinates
• Implemented a LMR scheme for time integration
• Coupled with CAM physics & CLM

Spectral Element Method
• Spectral element method
  - Grid-flexibility of finite element method
  - High-order accuracy of spectral method
• Application in SEAM
  - Mapping sphere to cube (Taylor et al. 1997)

Semi-Lagrangian Transport
• Divided into horizontal & vertical transport
• Horizontal transport on spectral element nodes
  - Use RK2 for trajectory calculations
  - Use local spectral element basis for interpolation
  - Impose max/min limiter on moisture
• Vertical transport in η-coordinates, similar to CAM-EUL (Collins et al. 2003)
  - Use RK2 for trajectory calculations
  - Use Hermitian cubic interpolation
  - Impose a sufficient condition for monotonicity

RK4 Scheme
• A 4th-order Runge-Kutta scheme
• A 1-step scheme
• Equivalence to the semi-Lagrangian scheme
• Sub-cycling for dynamics
  - Use four Δt/4-steps for dynamics and one Δt-step for physics

Held-Suarez Experiment
• Use CAM-SEM dynamical core (η-version)
• Integrate 1200 days with Δt=450s
• Compared with CAM-EUL simulation

Full-Physics Experiment
• Use CAM-SEM with CAM physics & CLM
• Integrate 1200 days with Δt=1200s
• Compared with CAM2.0.1

Summary
• SEAM is successfully coupled with CAM physics & CLM
• A semi-Lagrangian scheme for moisture transport and a RK4 scheme for time integration were implemented in CAM-SEM
• Held-Suarez, aqua-planet, full physics, and LMR experiments were performed for 1200 days with CAM-SEM

Future Work
• Use SCRIP to prepare the surface boundary data for CLM
• Refine coupling procedure: e.g. eliminate the redundant computation in phypkg on overlapping elemental boundary points
• Investigate the dependence of model simulations on physics and resolutions
• Apply CAM-SEM with LMR for both global and regional climate simulations

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• References