Implementation of a Non-Hydrostatic, Adaptive-Grid Dynamics Core in the NCAR Community Atmospheric Model

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Outline

• Features of EULAG Dynamics Core
• EULAG Baroclinic Wave Test
• CAM-EULAG Aqua-Planet
EULAG Features

- Nonoscillatory, Forward in Time (NFT) model integration algorithm, with optional semi-Lagrangian and fully conservative Eulerian variants.

- Tensor formalism underlies numerical model, enabling static and dynamic grid stretching with uniformly 2\textsuperscript{nd} order accuracy.

- Robust preconditioned, non-symmetric Krylov solver for pressure: inverts stiff full elliptic problems to a round-off error (viz. exact projection).
EULAG Features

- Trapezoidal-rule integrals for gravity-rotation and condensation amplify accuracy for well defined physics.
- Monotone, positive-definite advection (MPDATA)
- Continuous (t,x)-refinement without degrading MPP
- DNS, LES, and ILES turbulence models as options
- Default nonhydrostatic, deep moist anelastic approximation; a variety of gov. equations available for dynamics (dry), including Eulerian conservation laws for high-speed flows.
Baroclinic Wave Test – Day 6

• Color: Jablonowski & Williamson (2006)
• Lines: EULAG simulation
Baroclinic Wave Test

- Lines: EULAG simulation
Baroclinic Wave Test

Surface Pressure: 8 days, cnt = 10 hPa

Convergence with resolution:
  - Red – 2.8°
  - Blue – 1.4°
  - Black – 0.7°
Aqua-Planet Simulation

- **Cores:** EULAG, FV and ESP
- **Experiment:** Aqua-planet
- **Forcing:** Idealized, zonally symmetric SST
- **Horizontal resolutions:** $2^\circ \times 2.5^\circ$ [EULAG, FV] and T42 [ESP]
- **Vertical grid:** 26 levels
- **Time step:** 600s (EULAG), 900s (FV and ESP)
- **Initialization:** Eulag started from rest, FV and ESP from their standard initial conditions
Zonally Averaged Zonal Wind

- Westerly Jet cores:
  - EULAG (55 m/s)
  - FV (65 m/s)
  - ESP (60 m/s)

- Easterly peaks:
  - EULAG (10 m/s)
  - FV (10 m/s)
  - ESP (10 m/s)
Zonally Averaged Vertical Wind

- Maximum updrafts:
  - EULAG (4.0 cm/s)
  - FV (2.2 cm/s)
  - ESP (1.8 cm/s)
- Updraft locations:
  - ~ ± 3° off equator
Precipitation

(a) Total precipitation

(b) Convective precipitation

(c) Non-convective precipitation

LatITUDE

Precipitation (mm/day)
Power Spectra: Kinetic Energy

(D. Williamson, NCAR, 2007)
Summary

- CAM3 coupled to a non-hydrostatic dynamic core with capability for dynamic (& static) grid adaptation (EULAG)

- EULAG baroclinic wave simulation agrees with standard hydrostatic CAM

- CAM-EULAG aqua-planet simulation agrees with standard CAM3
Thank you!