Simulations of West African Climate with an Adaptive Grid Dynamics Core in CAM

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Outline

- Features of EULAG Dynamics Core
- CAM-EULAG Atmospheric GCM
  - Comparison with observations
  - Comparison with CAM-FV
- Further Plans

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^{nd} order accuracy.

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

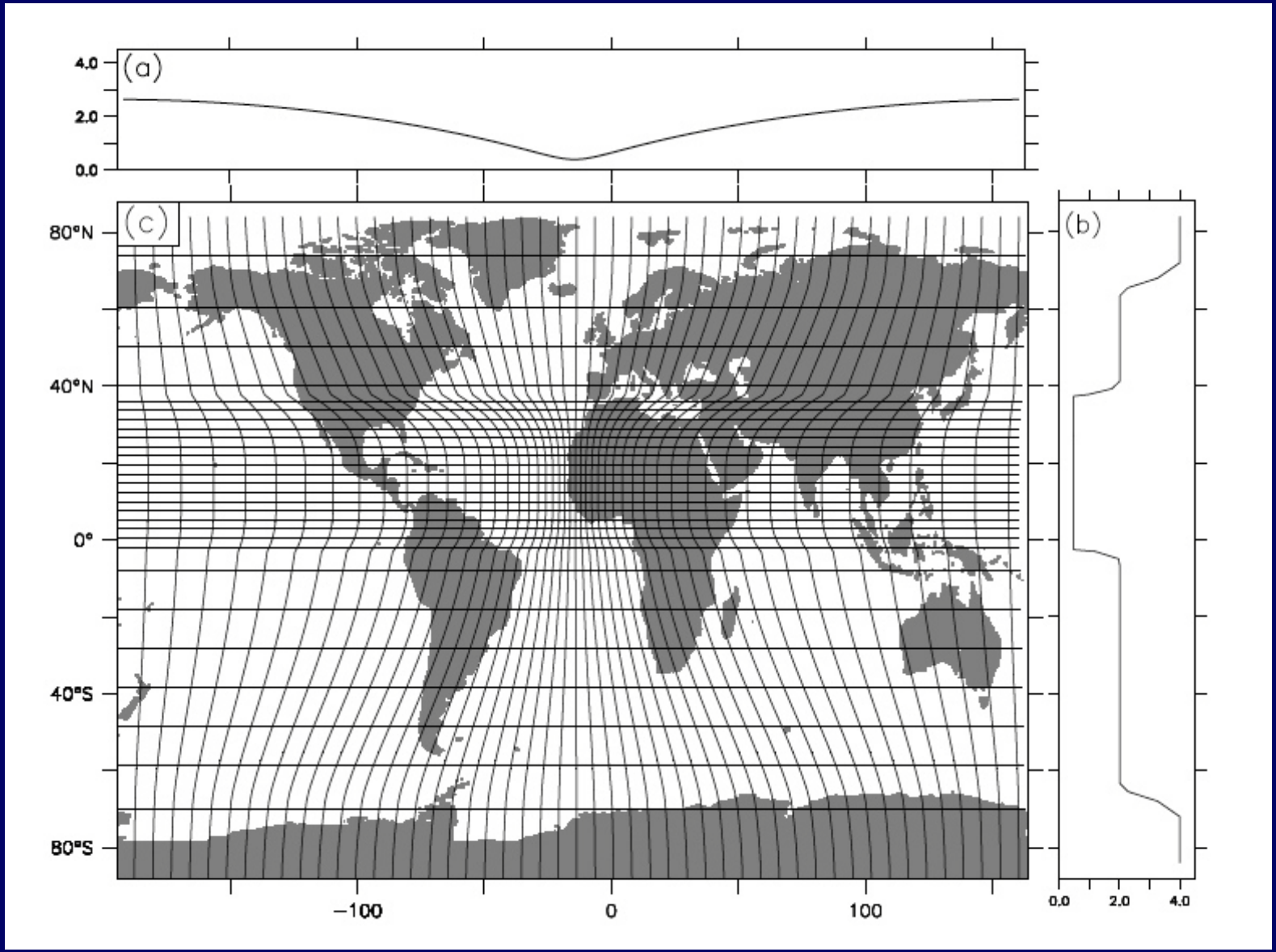
EULAG Features

- Monotone, positive-definite advection (MPDATA)
- Continuous (t,x)-refinement without degrading MPP
- Equation set:
  - Current: nonhydrostatic, deep moist anelastic approximation
  - Testing: Durran equation set; fully-compressible equations

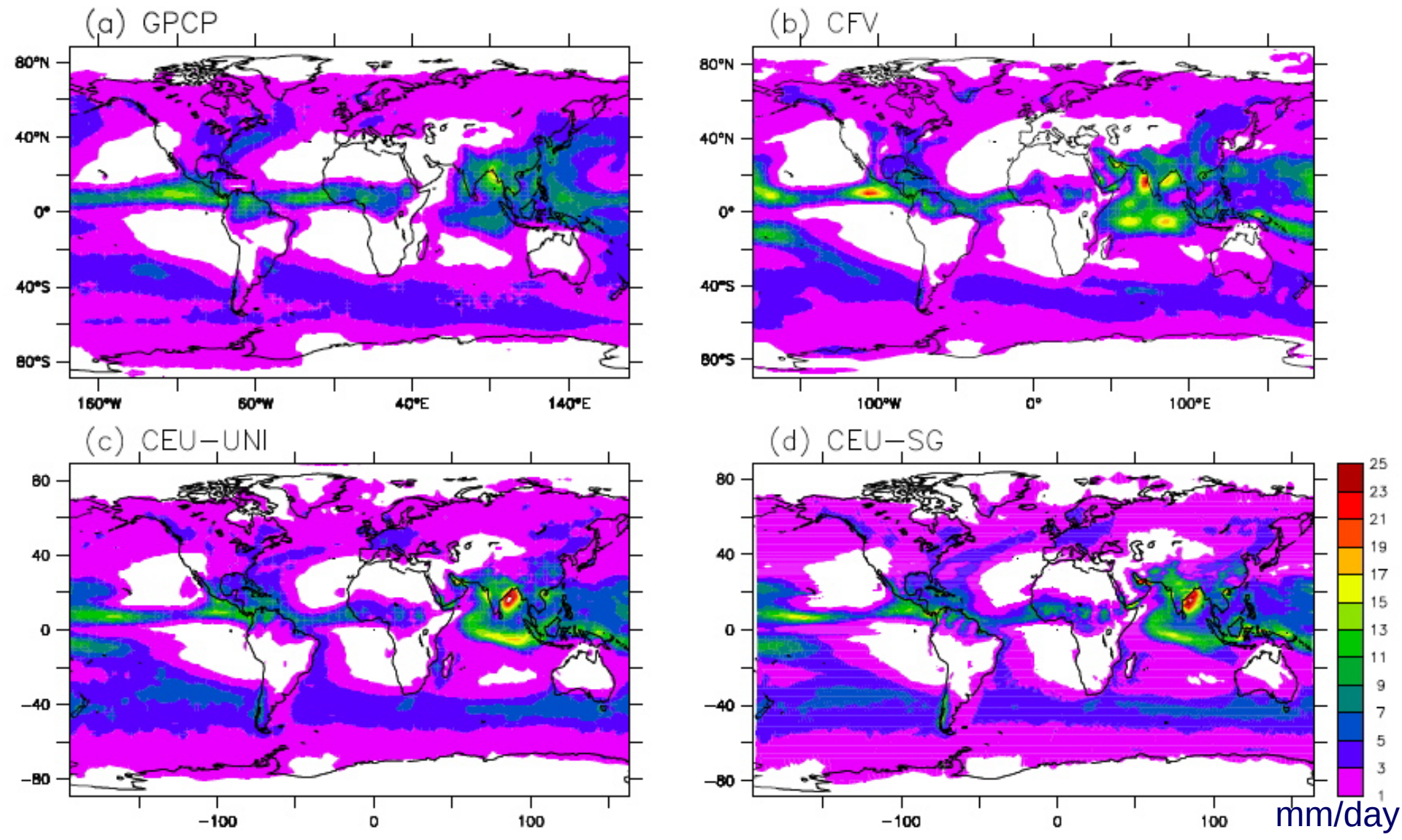
CAM-EULAG: Simulation

- Cores: EULAG (uniform & stretched-grid), FV
- Physics: CAM3 (same settings as for FV)
- Experiment: AMIP-type, observed SSTs
- Horizontal resolutions :
  - 2˚x2.5˚ [CAM-EULAG uniform; FV]
  - Stretched-grid: 0.5˚ over West Africa
- Vertical grid: 26 levels
- Periods:
  - 1995 – 2000 (discard 1st yr.)
  - 1996 – 2007 (discard first two yr.: SG only)

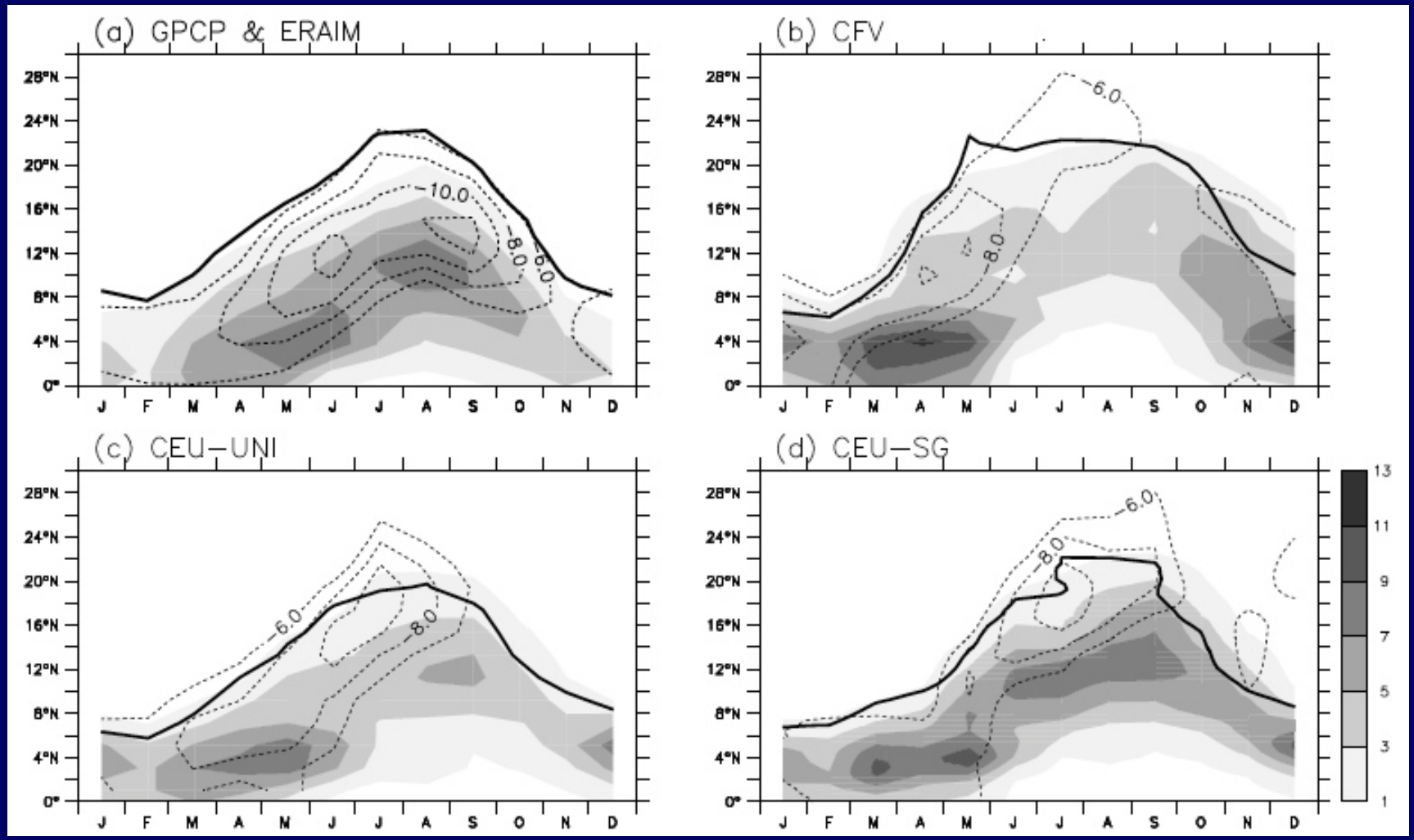
CAM-EULAG: Stretched Grid



CAM-EULAG: Global Precipitation



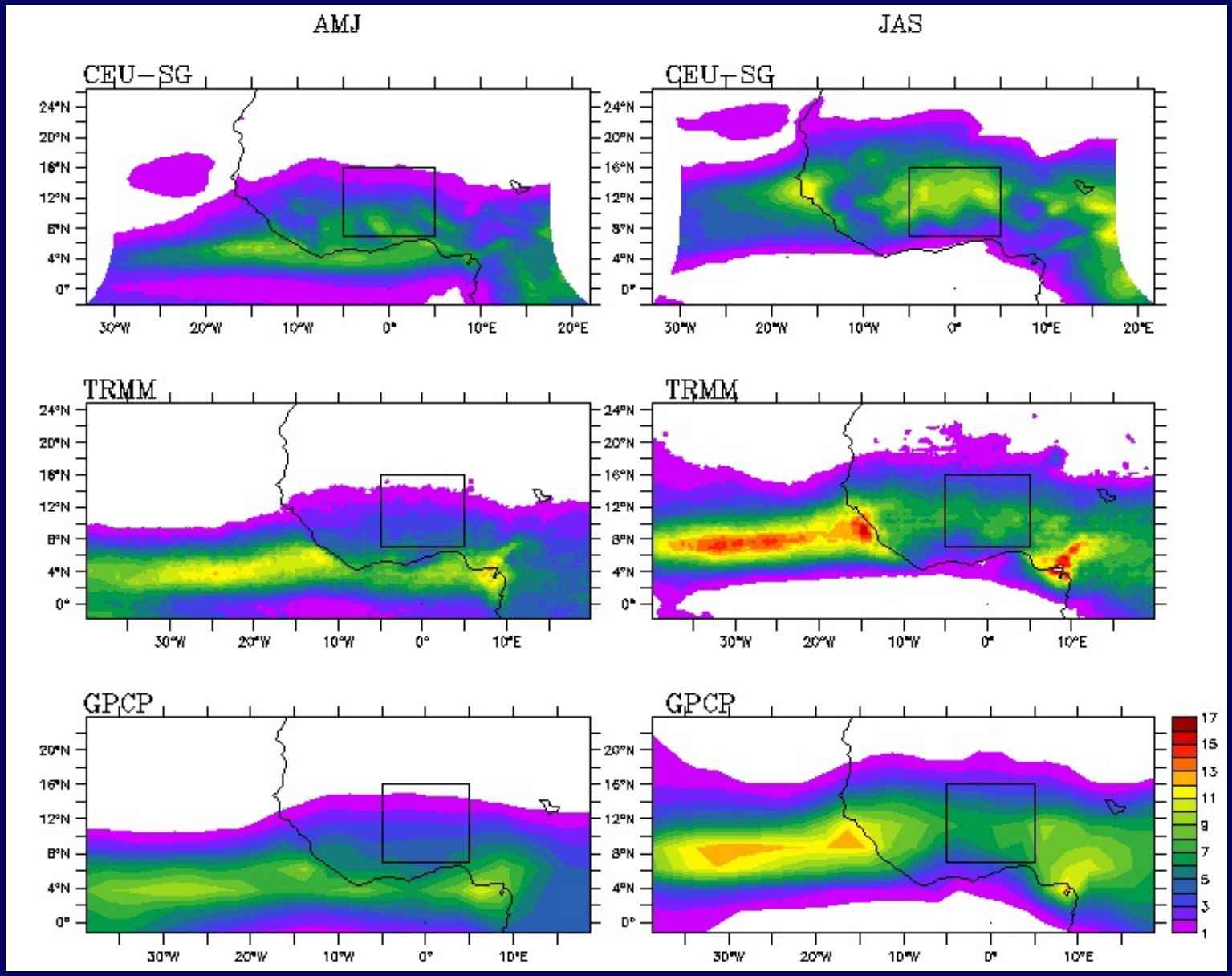
CAM-EULAG: West Africa Annual Cycle



Region: 10 W – 10 E

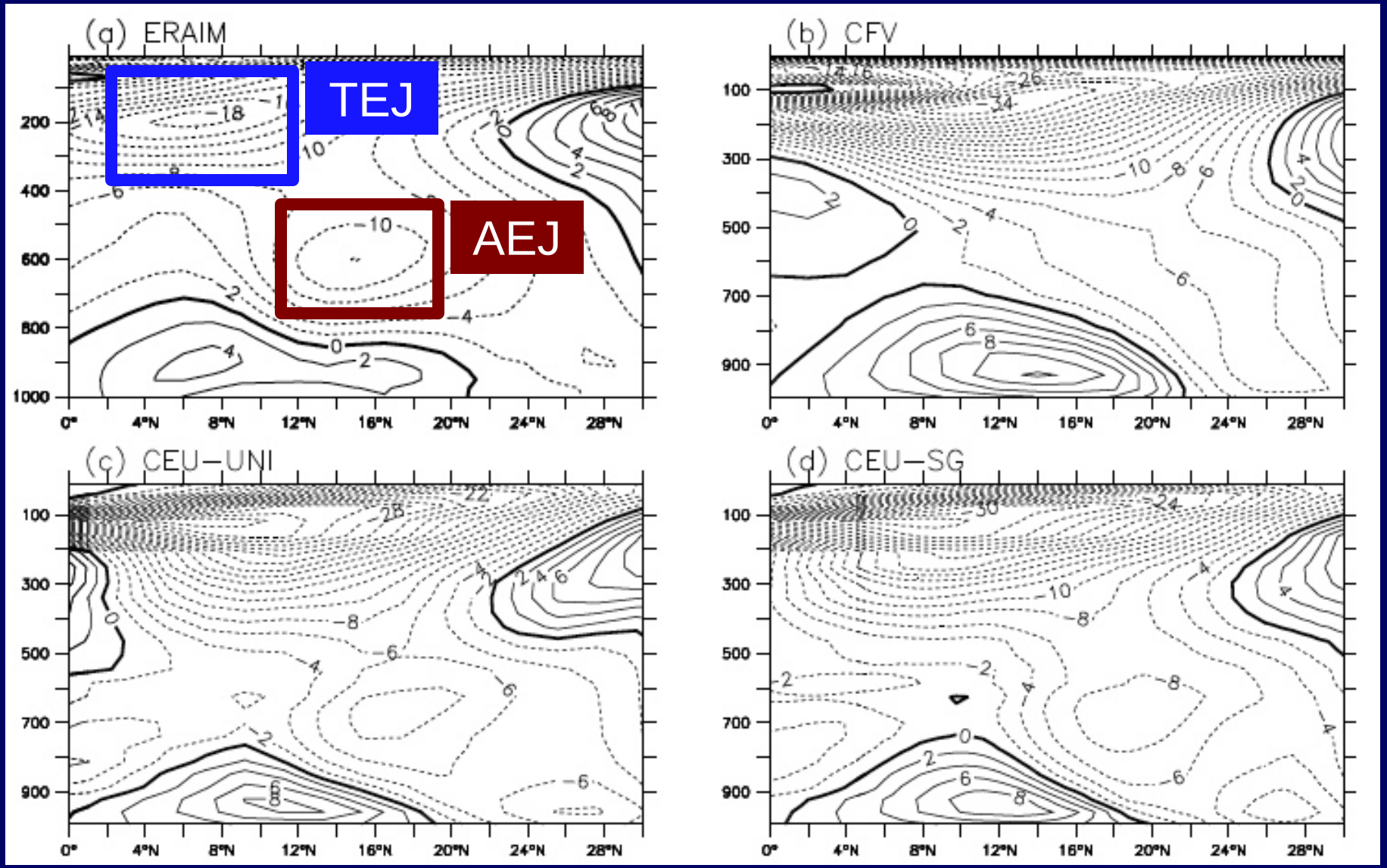
Precip [mm/d], 600 hPa Zonal Wind [dashes]
Intertropical Discontinuity [solid line]

CAM-EULAG: Precipitation Distribution



[mm/d]

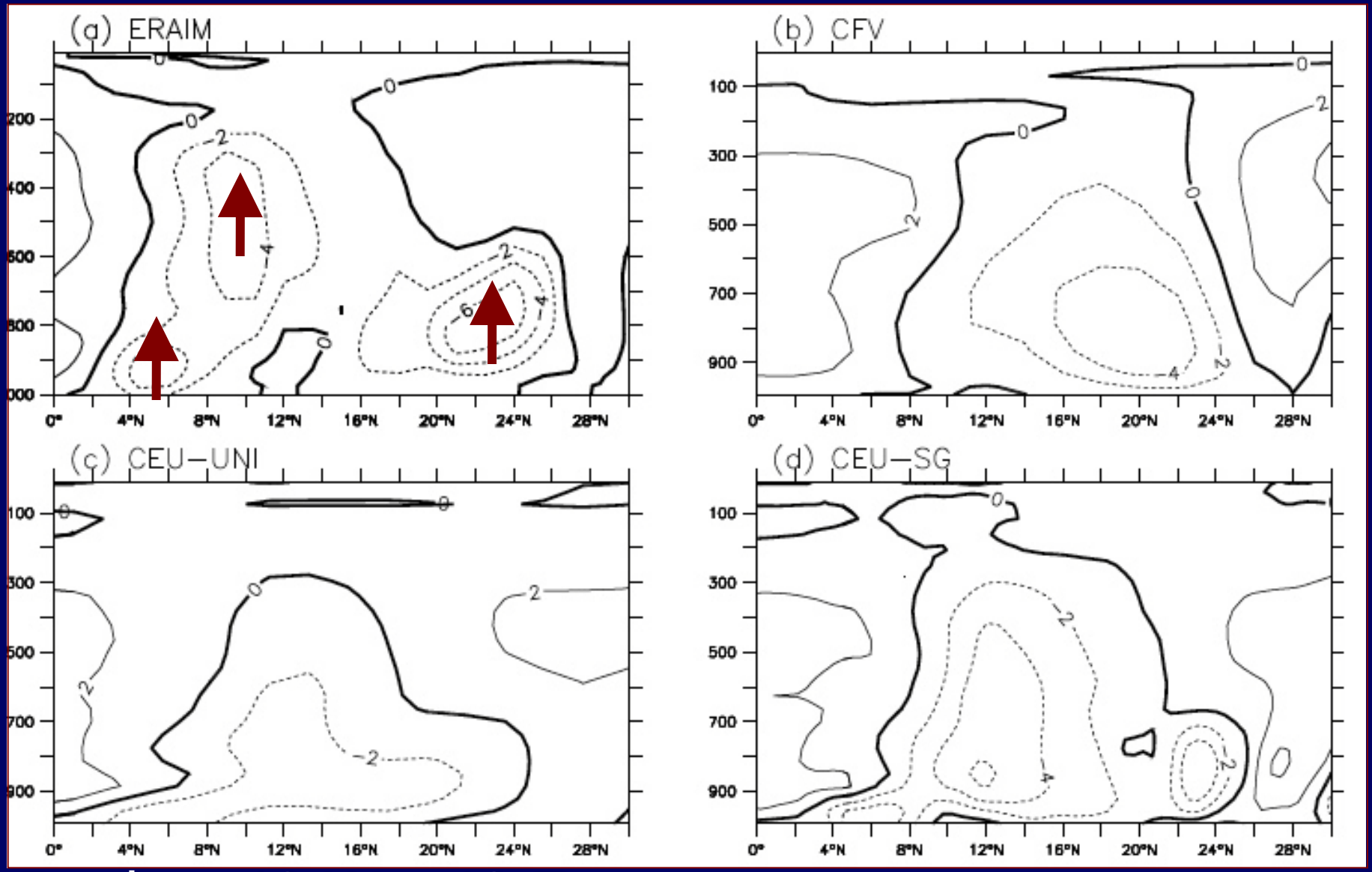
CAM-EULAG: West Africa Zonal Wind



Region: 10 W – 10 E

[m/s]

CAM-EULAG: West Africa Vertical Wind



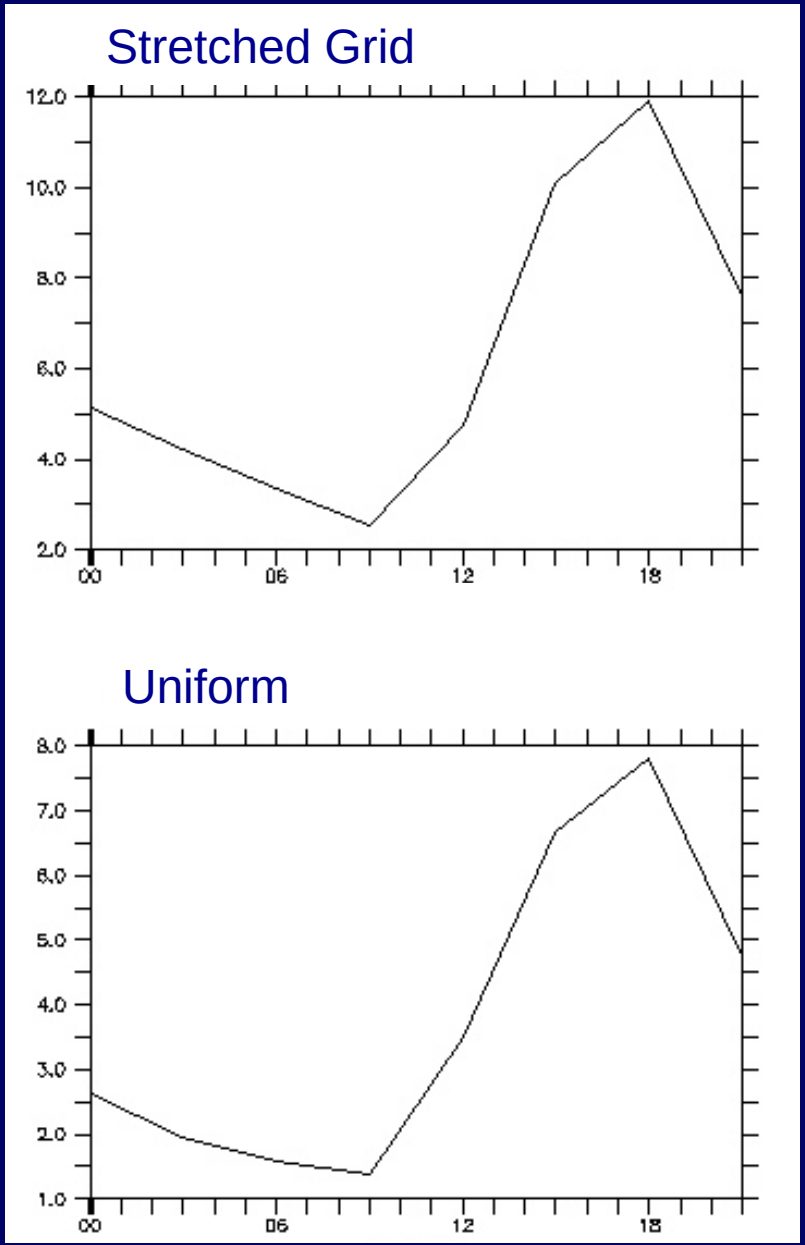
Region: 10 W – 10 E

[mb/s]

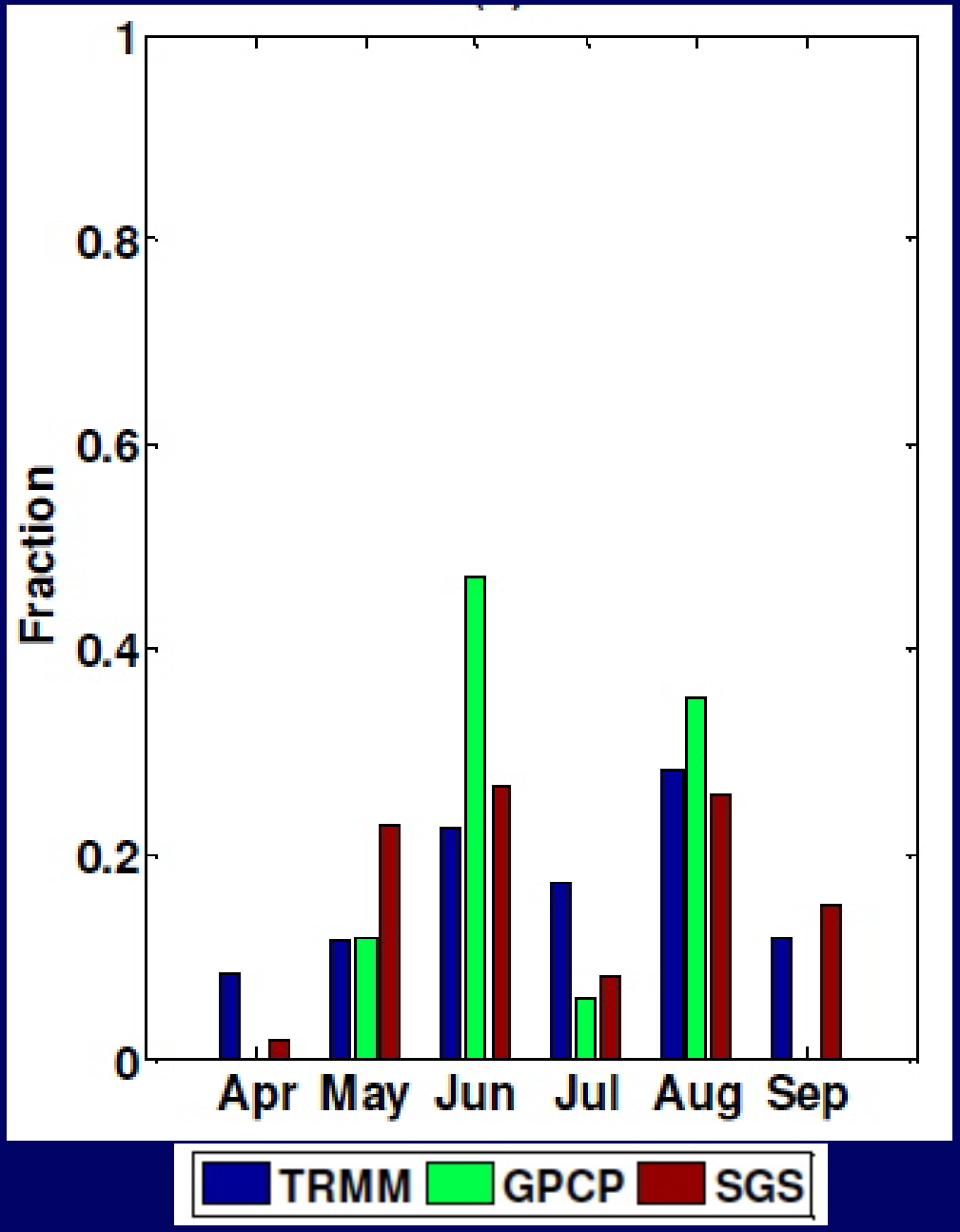
CAM-EULAG: Precipitation Diurnal Cycle [mm/d]

TRMM Data:
Diurnal Range ~ 2.5 – 9.5 mm/d
Diurnal Max ~ 16-20 hr UCT
(Lee et al., JGR, 2007)

Region: 10 W – 5 E



CAM-EULAG: Timing of 99% Precipitation



Further Plans

- CAM3 → CAM4 → CAM5
- Optimization for MPP computing
- Refinement of filtering (esp. @ poles)

Summary

- CAM3 coupled to a non-hydrostatic dynamic core with capability for dynamic (& static) grid adaptation (EULAG)
- CAM-EULAG simulation with realistic land-ocean performs as well as CAM-FV
- Grid stretching improves simulation
- Stretching poses no serious problems

Thank you!

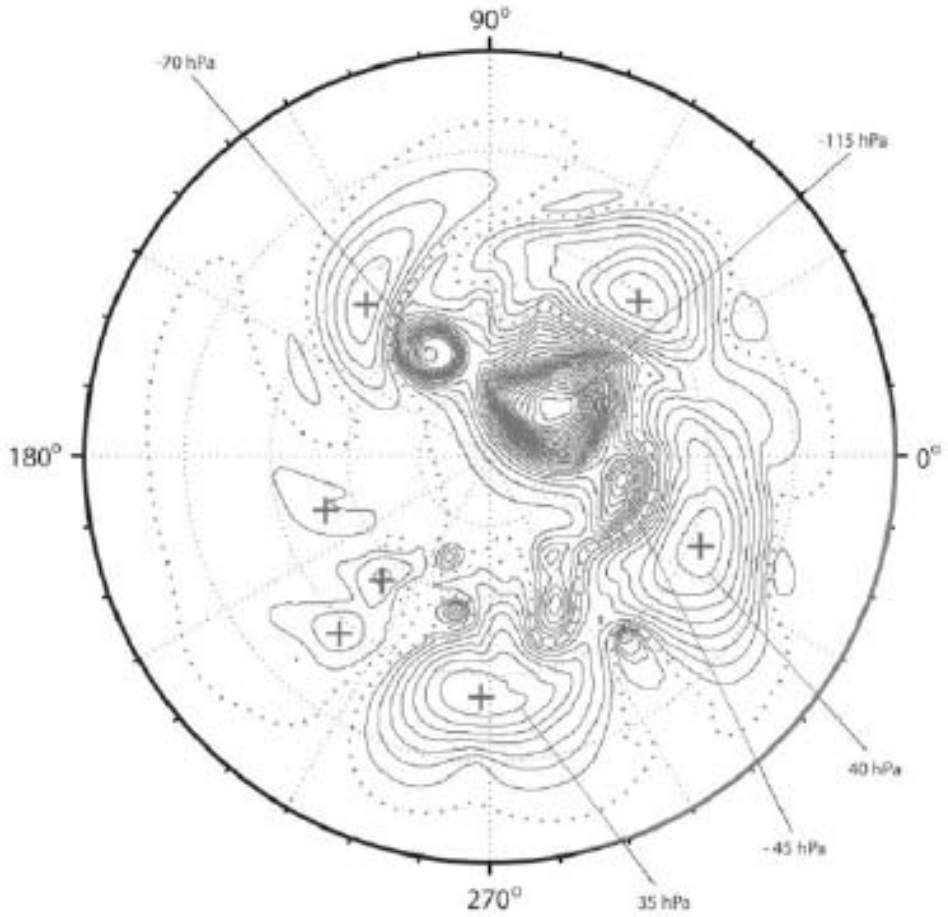
Surface Pressure:

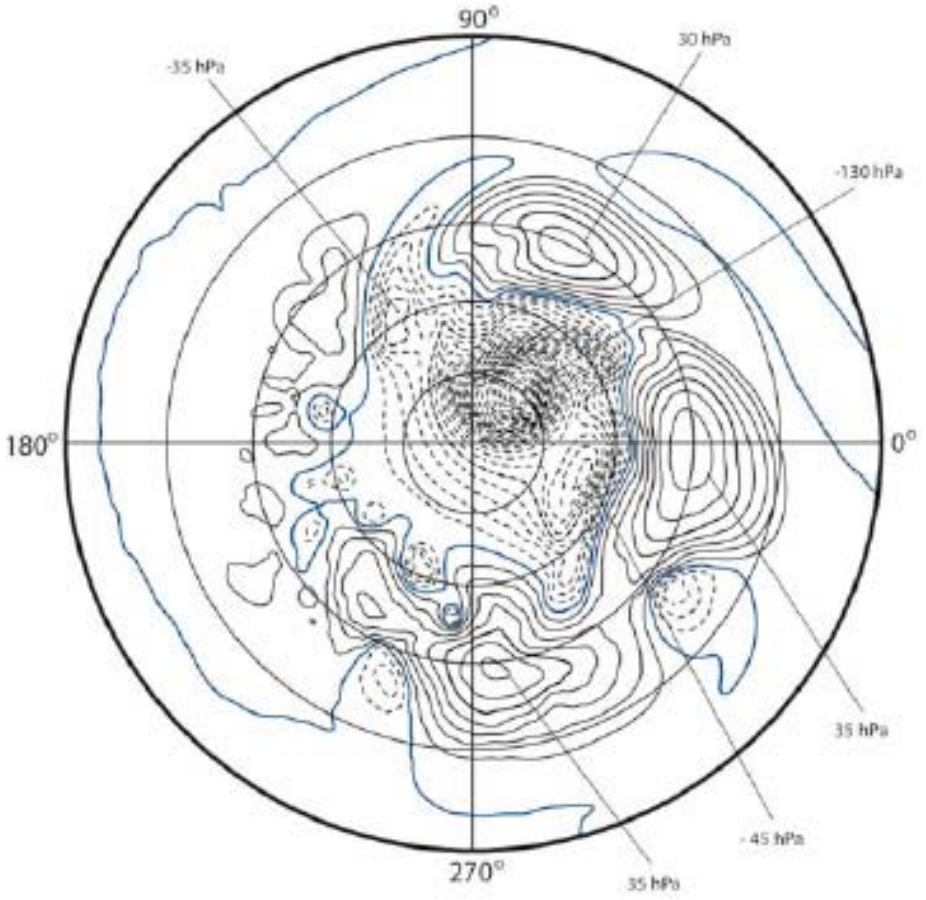
High resolution grid: 16 days

JW test 7

JW results using CAM Eulerian spectral dycore

EULAG results using Eulerian advection (0.7°)



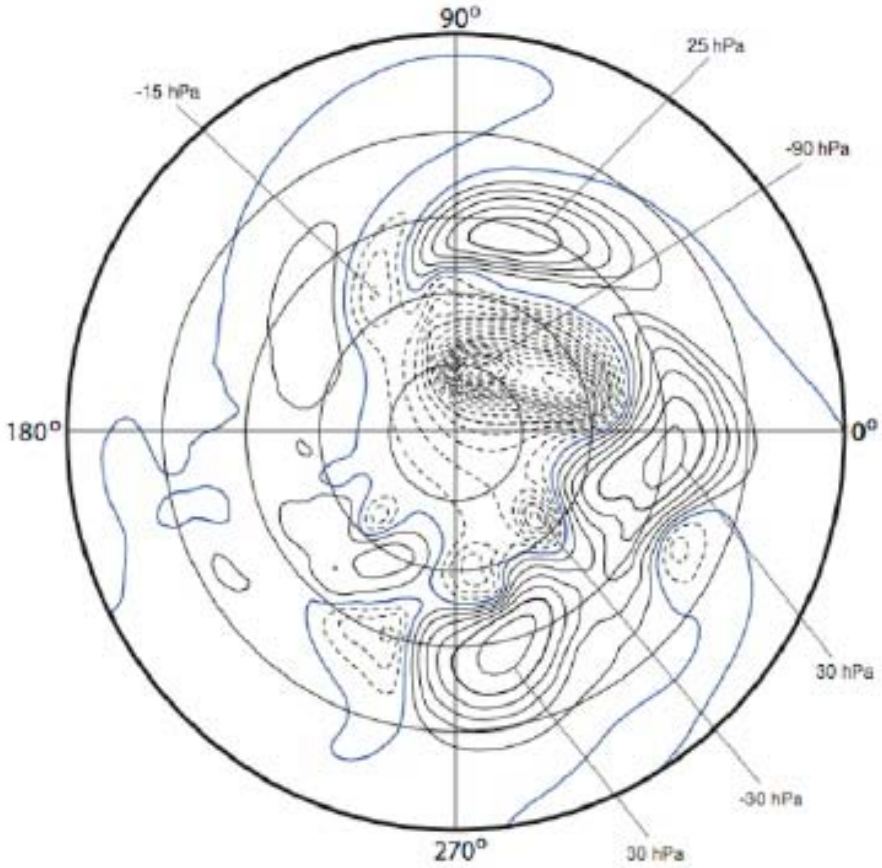


Surface Pressure:

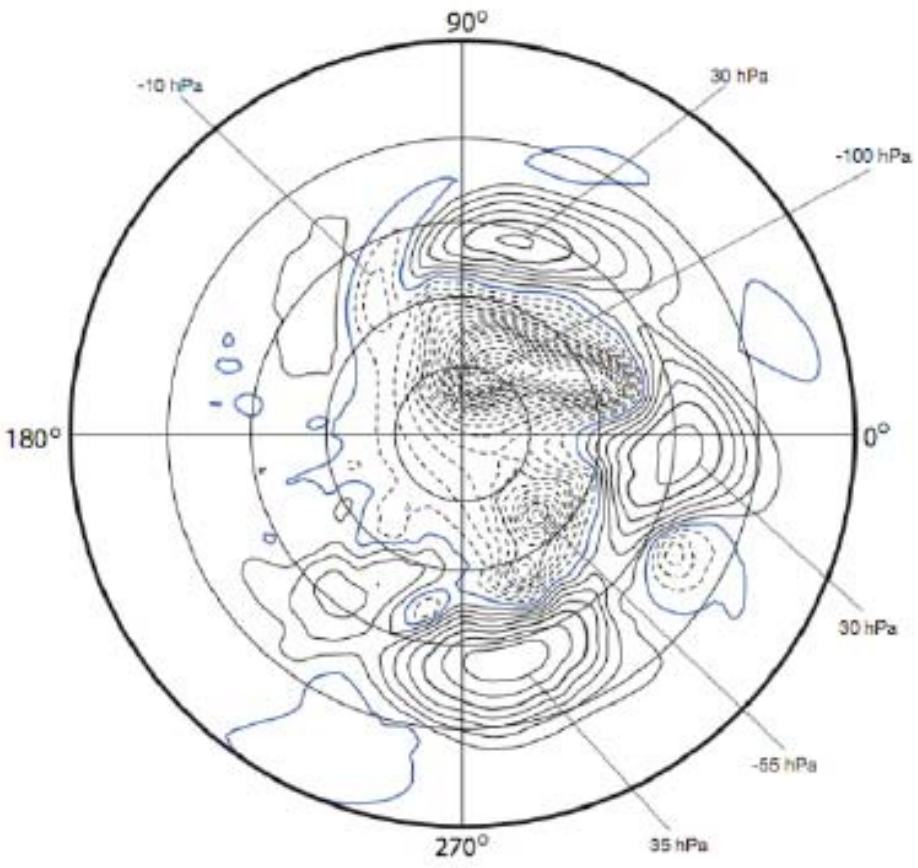
Medium resolution grid: 16 days

JW, concluded

EULAG results (1.4°) using Semi-Lagrangian advection



EULAG results (1.4°) using Eulerian advection

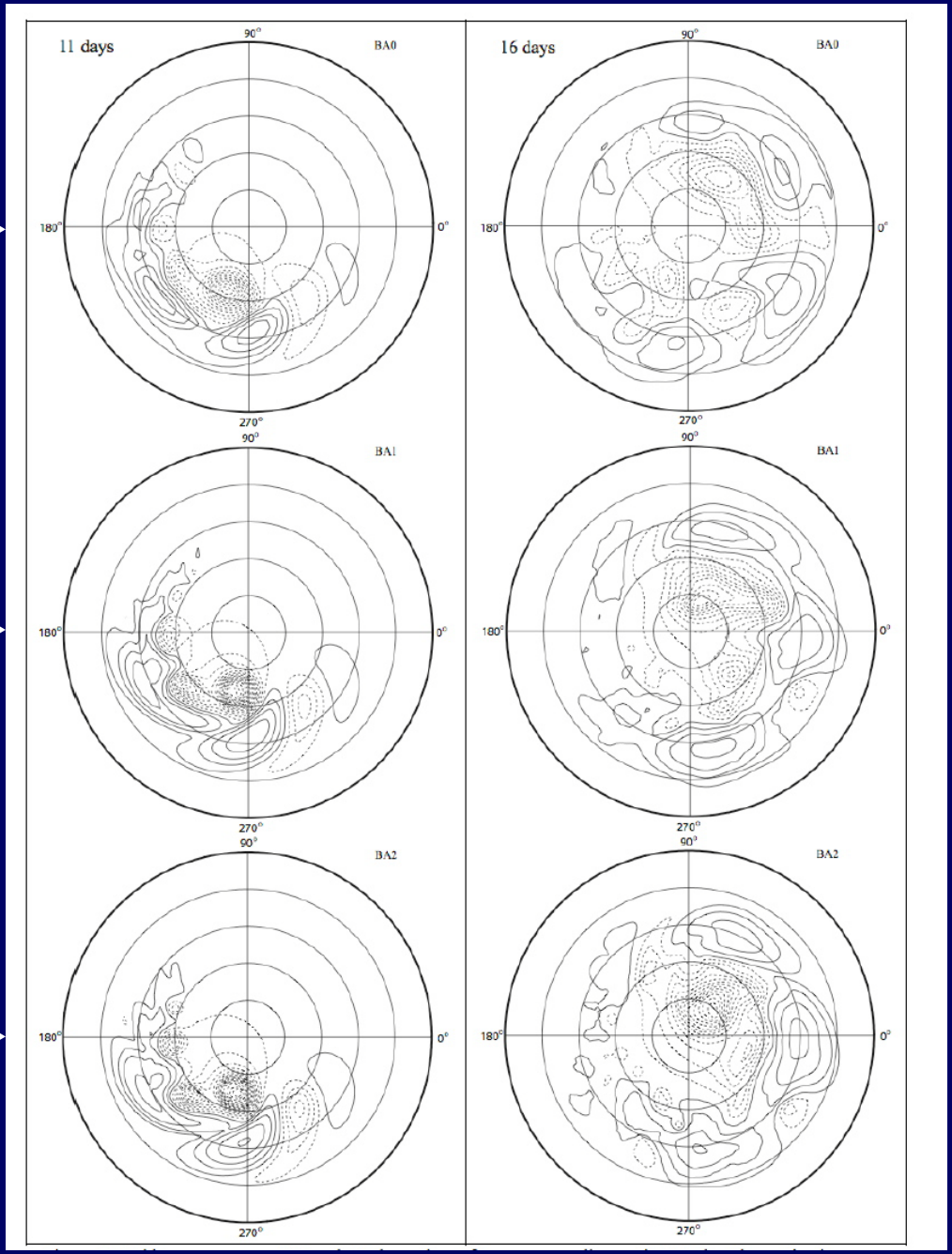


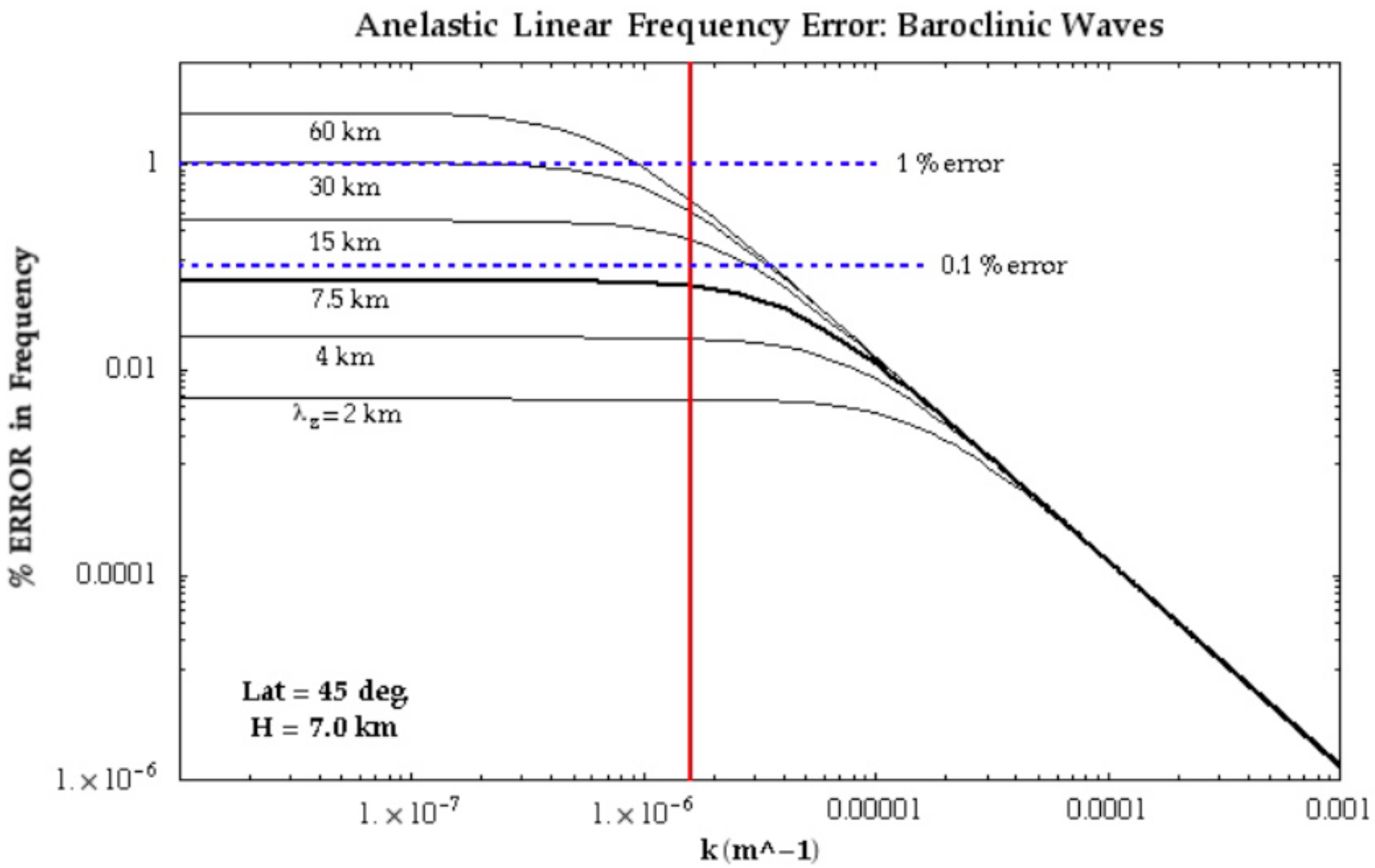
EULAG: Baroclinic Wave Test

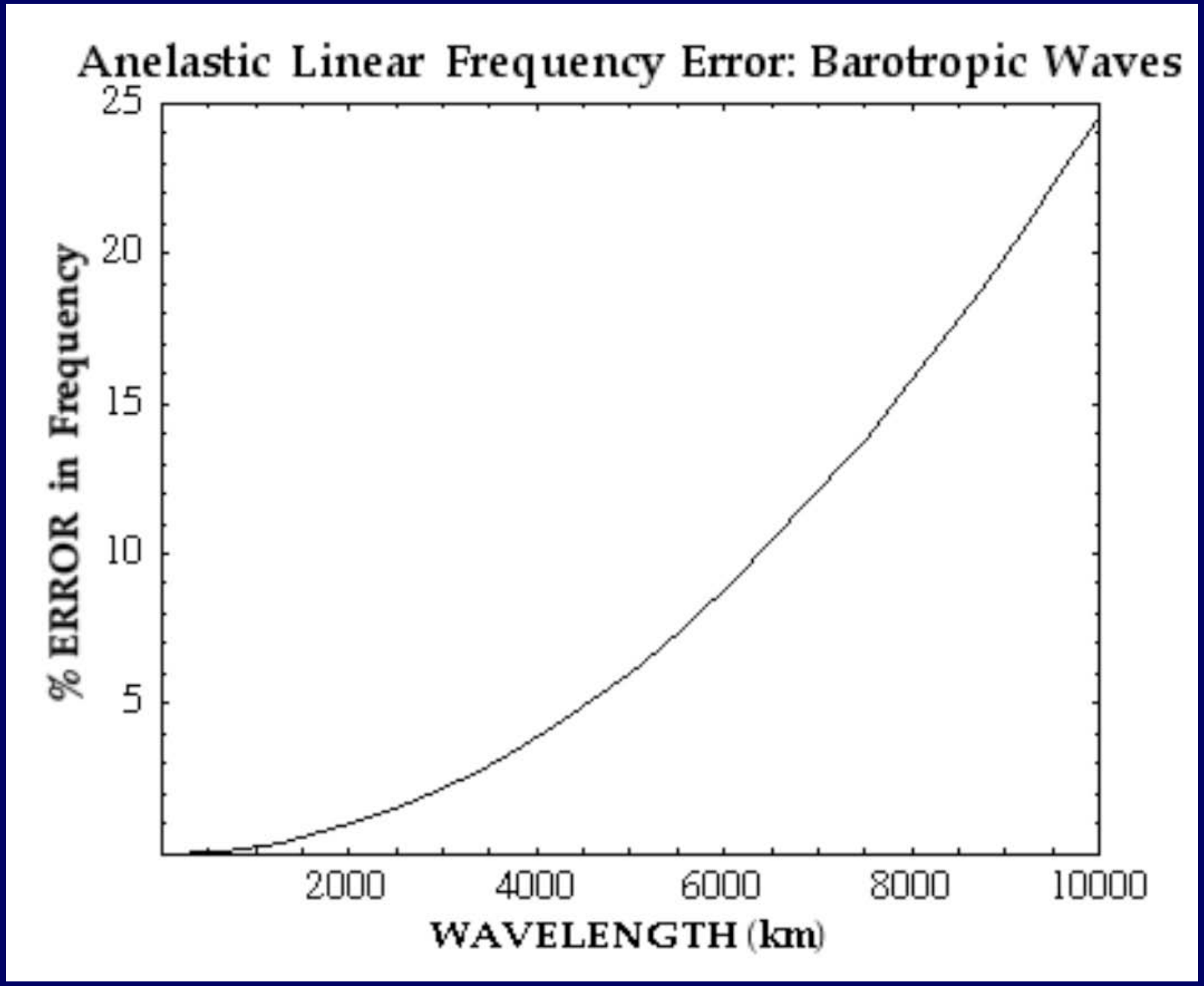
2.8˚ →

1.4˚ →

0.7˚ →




Anelastic Linear Frequency Error: Baroclinic Waves
% ERROR in Frequency
1
0.01
0.0001
1.×10^-6
60 km
30 km
15 km
7.5 km
4 km
λz=2 km
1 % error
0.1 % error
Lat = 45 deg,
H = 7.0 km
1.×10^-7
1.×10^-6
0.00001
0.0001
0.001
k (m^-1)


Anelastic Linear Frequency Error: Barotropic Waves
% ERROR in Frequency
25
20
15
10
5
2000
4000
6000
8000
10000
WAVELENGTH (km)

CAM-EULAG: Stretched Grid