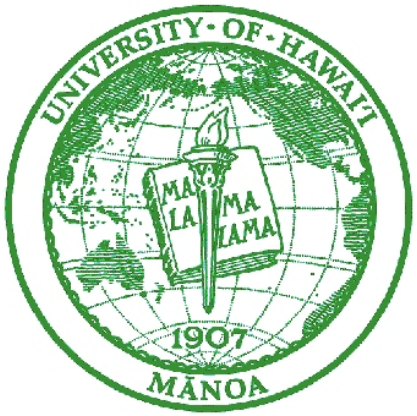
Topographic Drag in Ultra-fine Resolution Global Simulations

AGU Chapman Conference

February 28-March 4, 2011











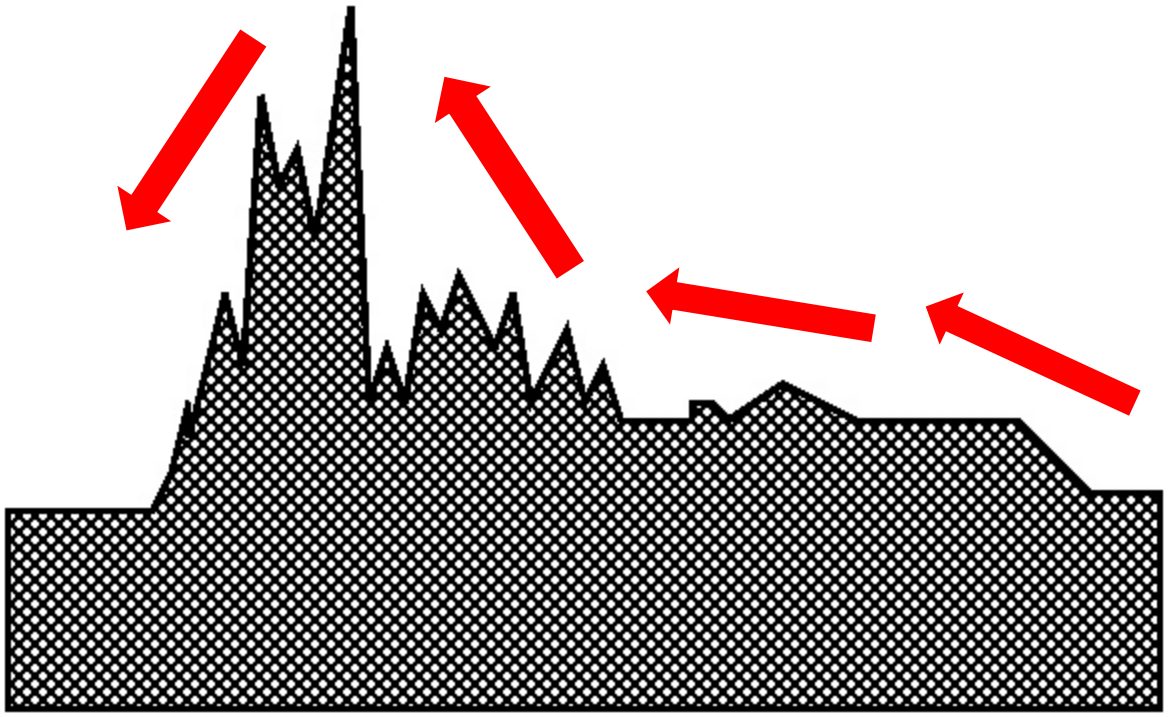


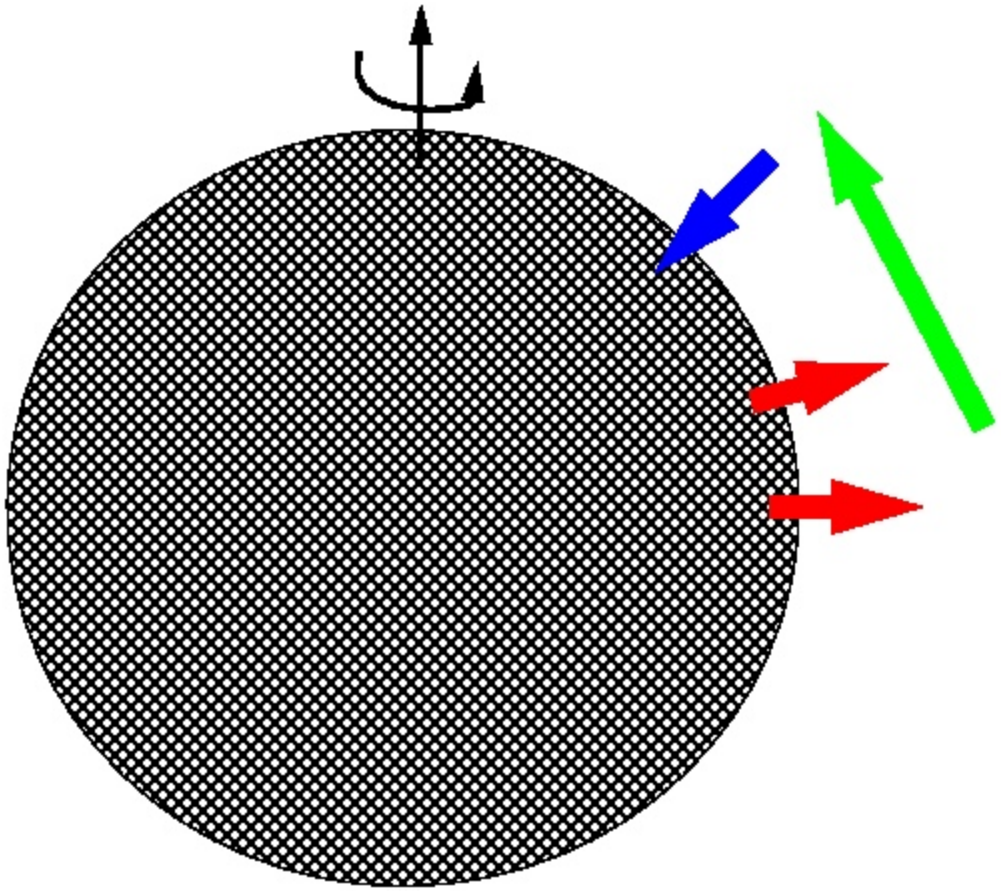
Topographic Drag in Ultra-fine Resolution Global Simulations

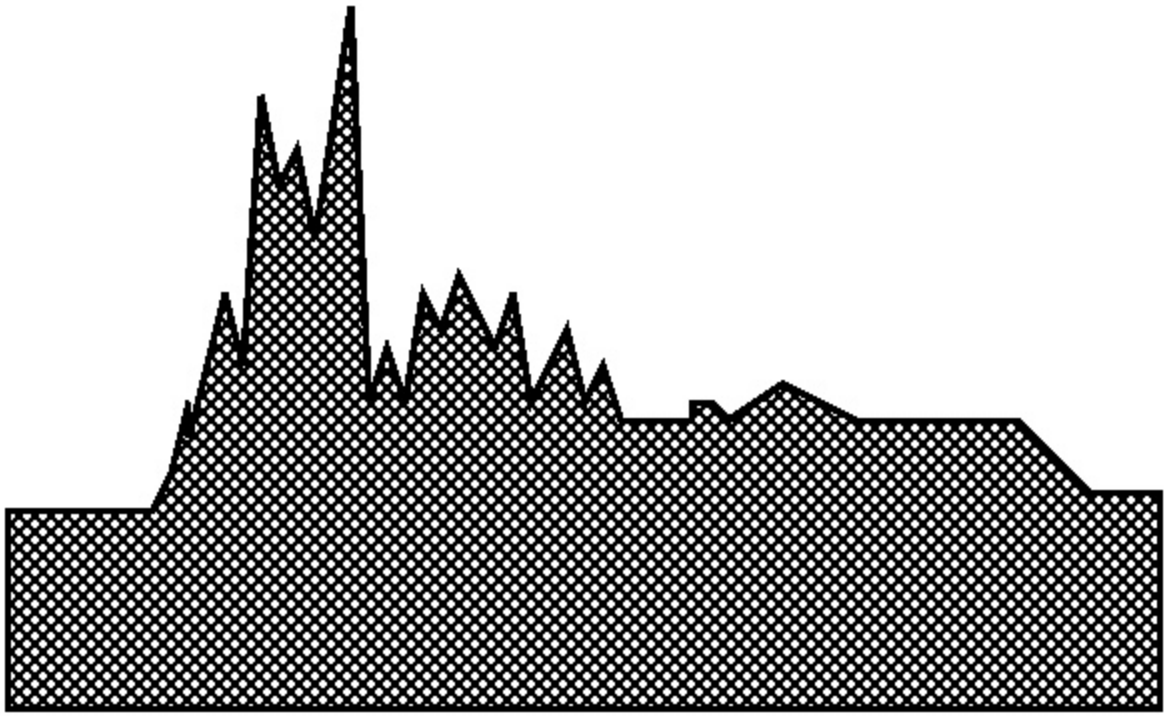
Thanks to

Wataru Ohfuchi, Earth Simulator Center, JAMSTEC

Masaki Satoh, AORI, University of Tokyo



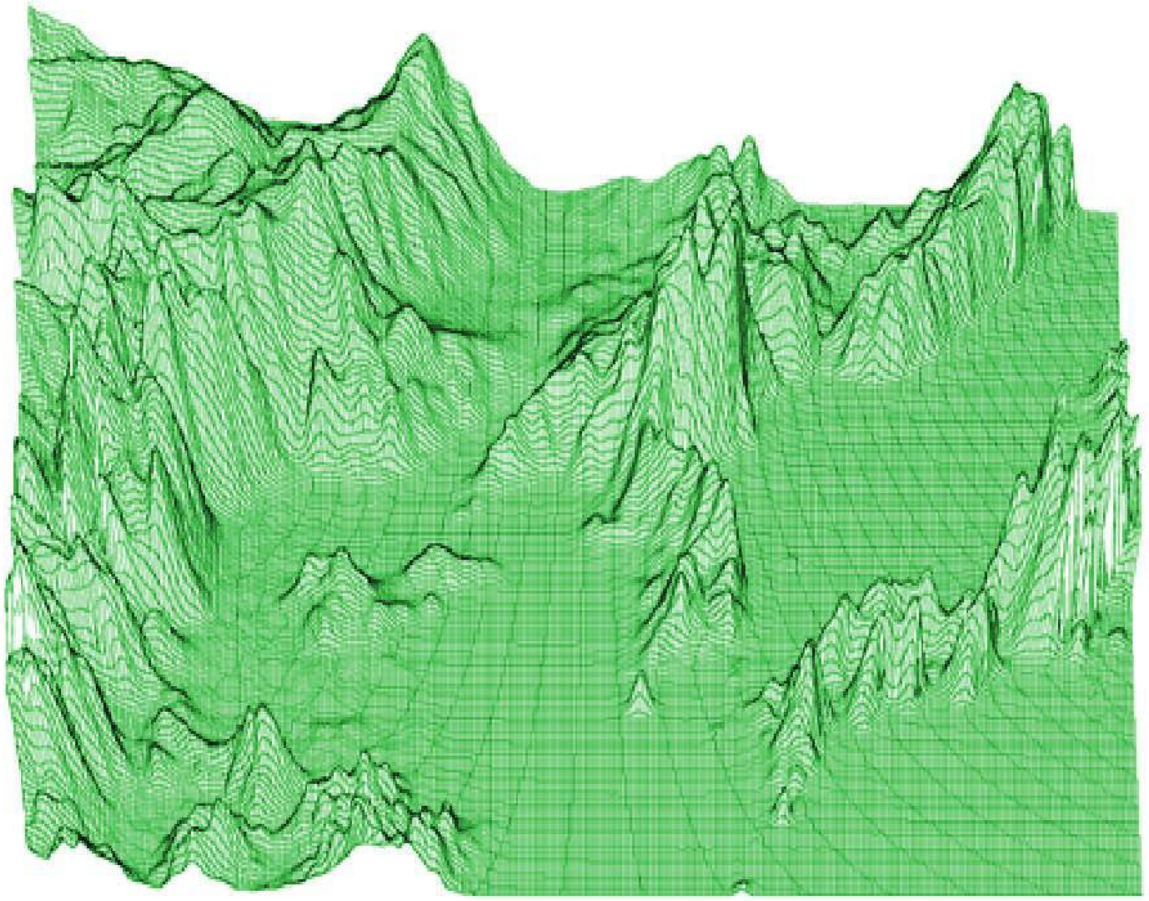


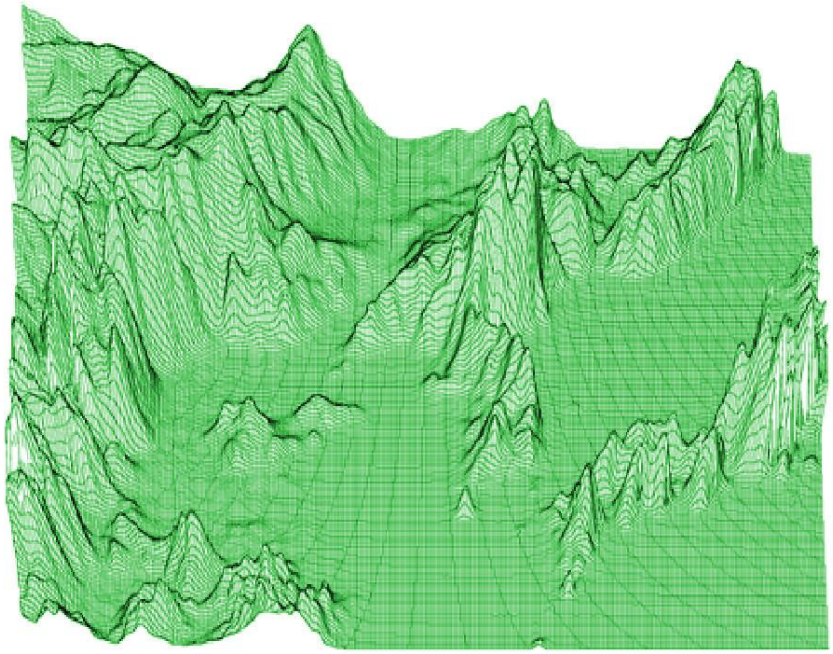


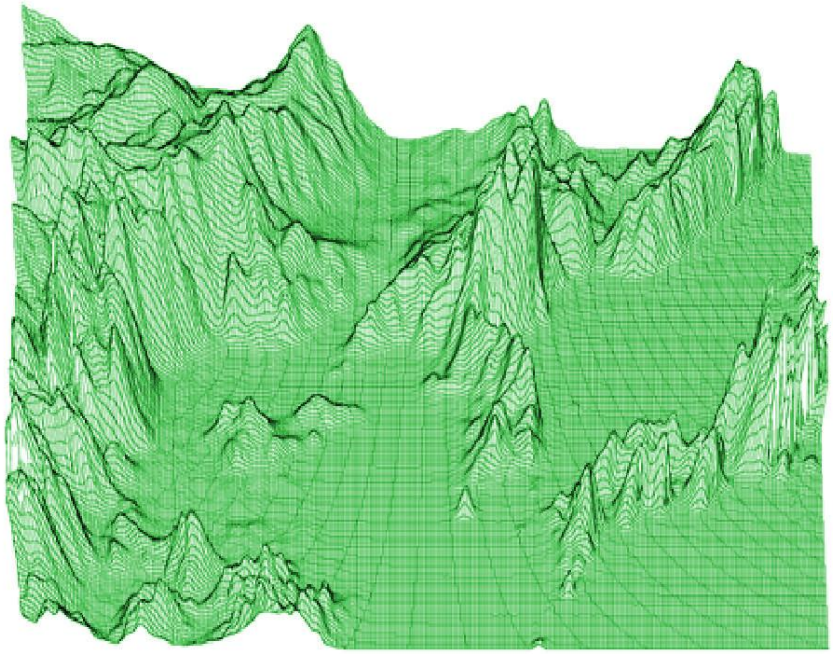
$$\frac{\partial M}{\partial t} = -\int\int \frac{\partial p}{\partial x} dx\, dz$$

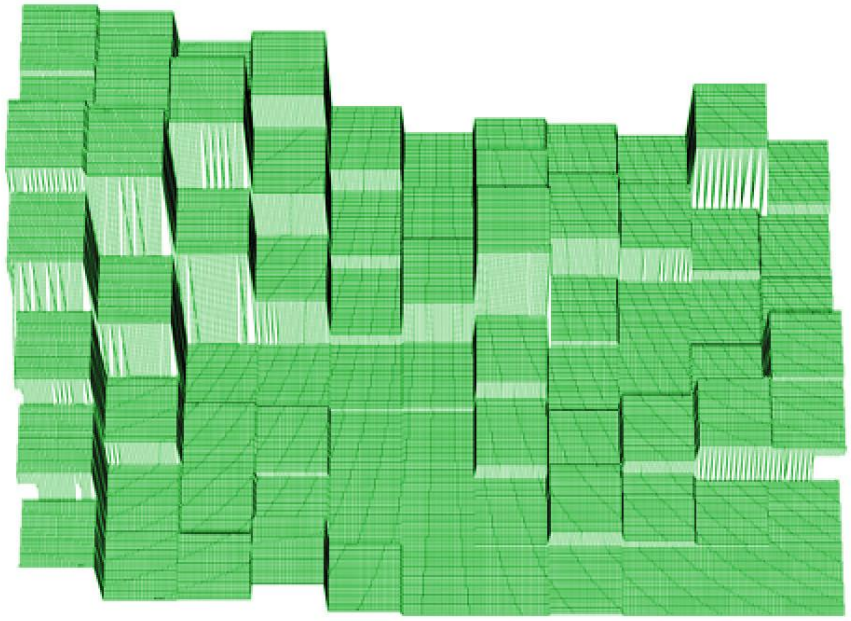
$$\int_{0}^{highest} \left(\sum_{i} \left(p_i^{E} - p_i^{W} \right) \right) dz$$

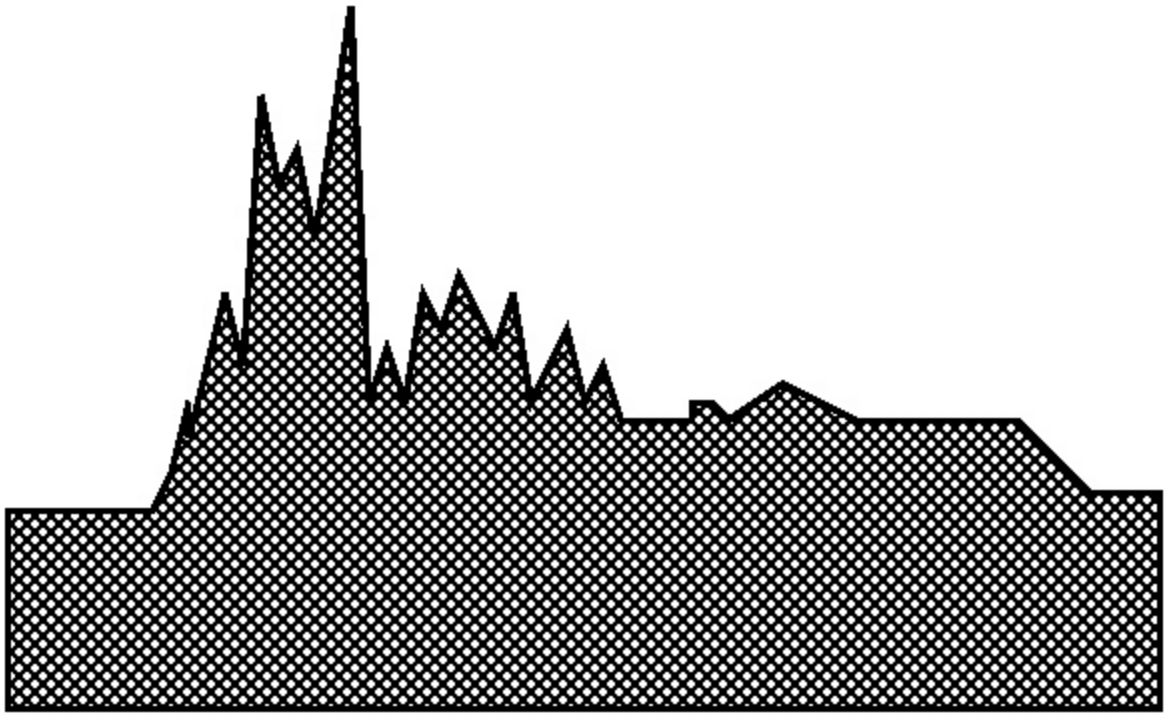
$$\int p \frac{\partial Z}{\partial x} dx$$

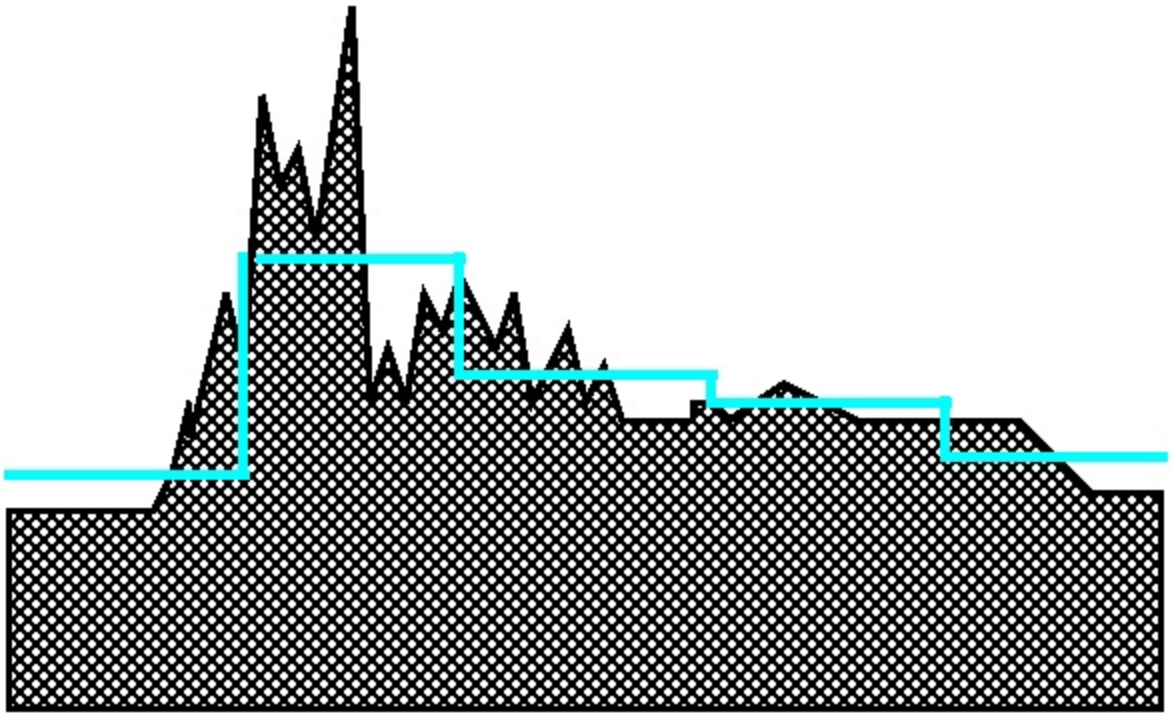


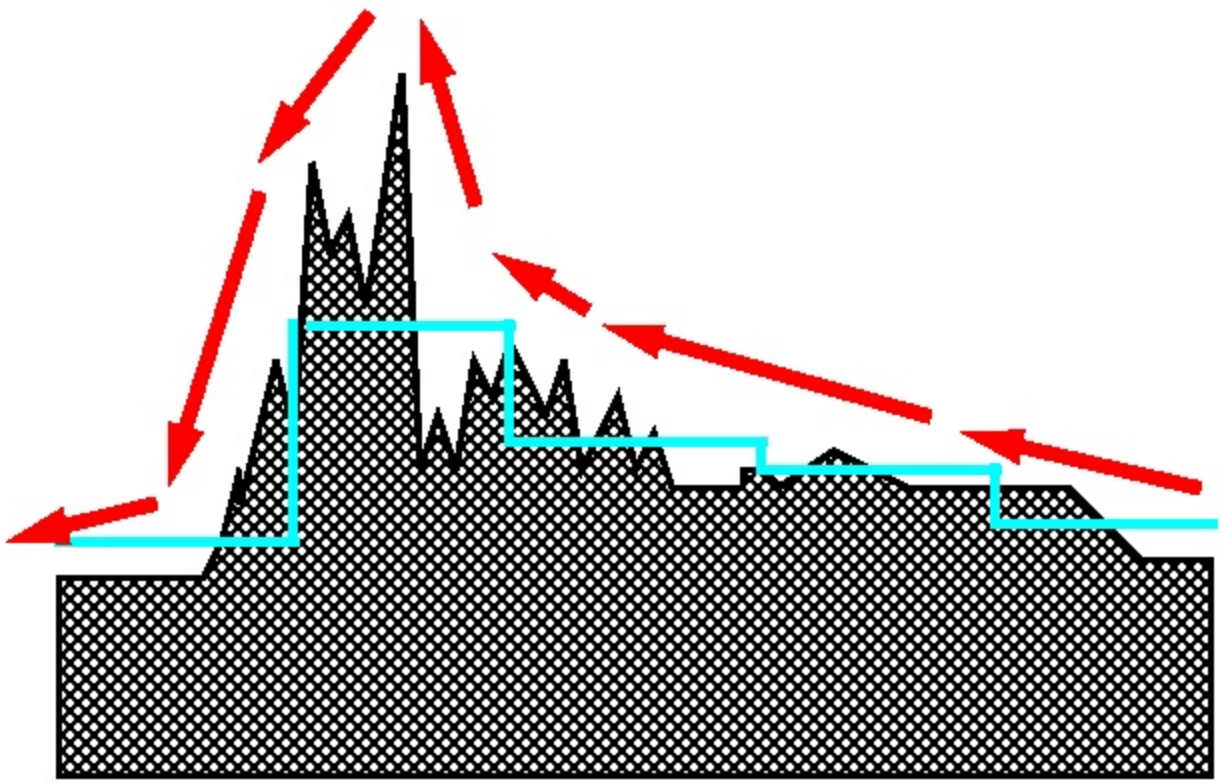












$$\tau_0 = -\left(E\frac{\mu_e}{2}h_e^{\,2}\right)\rho_0 N_0 V_0$$

$$h_e = \min(2S_d, F_c U_0/N_0) \tag{2.34}$$

where S_d is the standard deviation associated with that part of the subgrid scale orography which is most likely to give rise to vertically propagating gravity waves. The

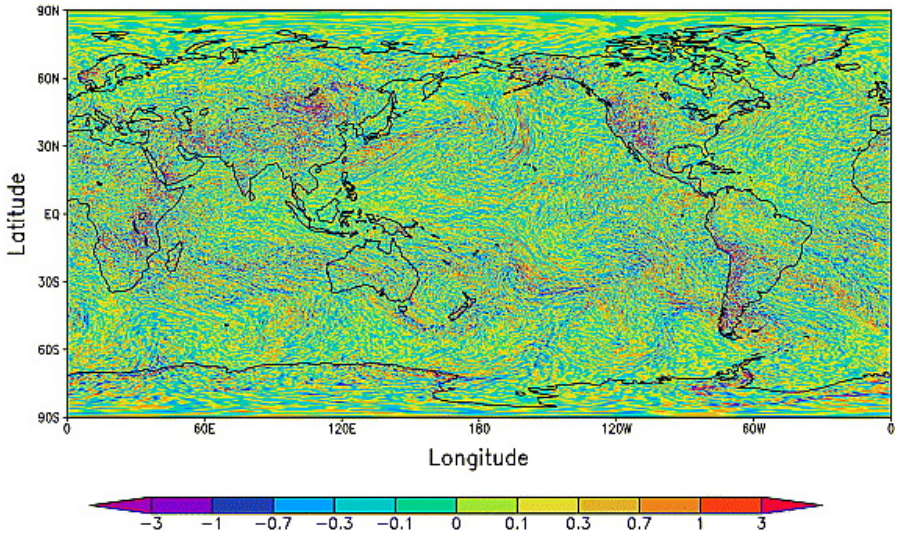
Compare total explicitly resolved zonal-mean topographic stress in the high-resolution model with the stress computed with the simulated *p* and *Z* smoothed to ~3-degree resolution

"subgrid scale" stress = total – smoothed

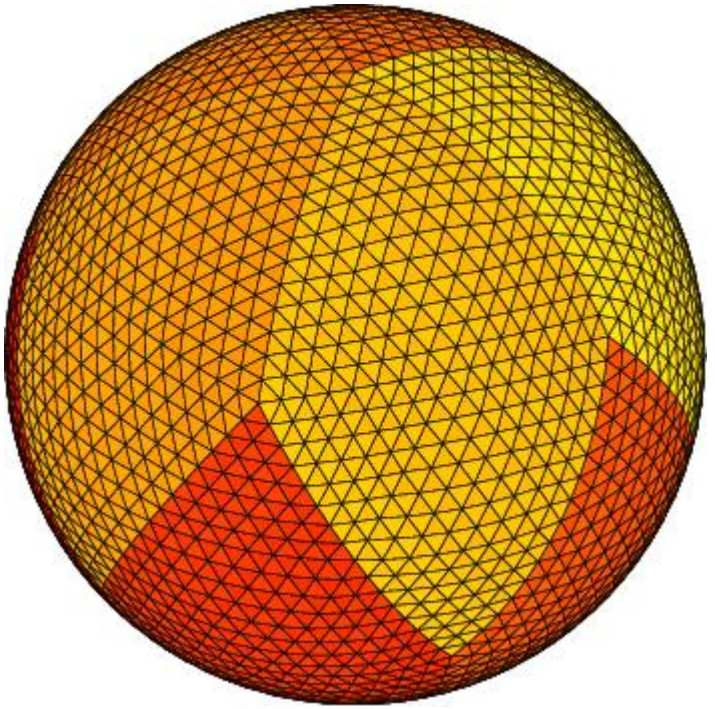
This is (hopefully?) the component of the topographic stress that needs to be parameterized in a ~3-degree resolution model

Two AGCMs

AFES

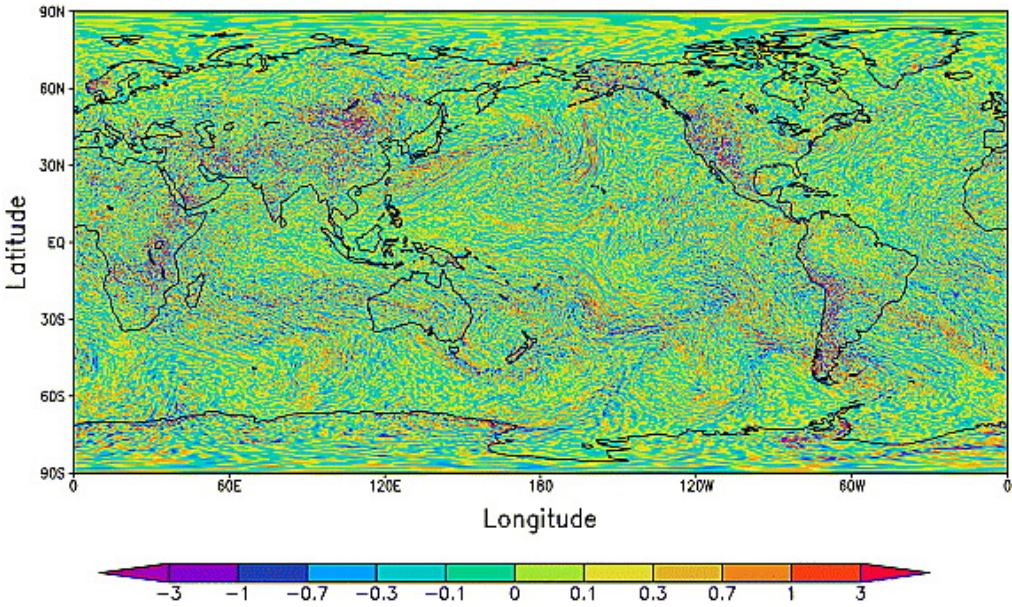


NICAM

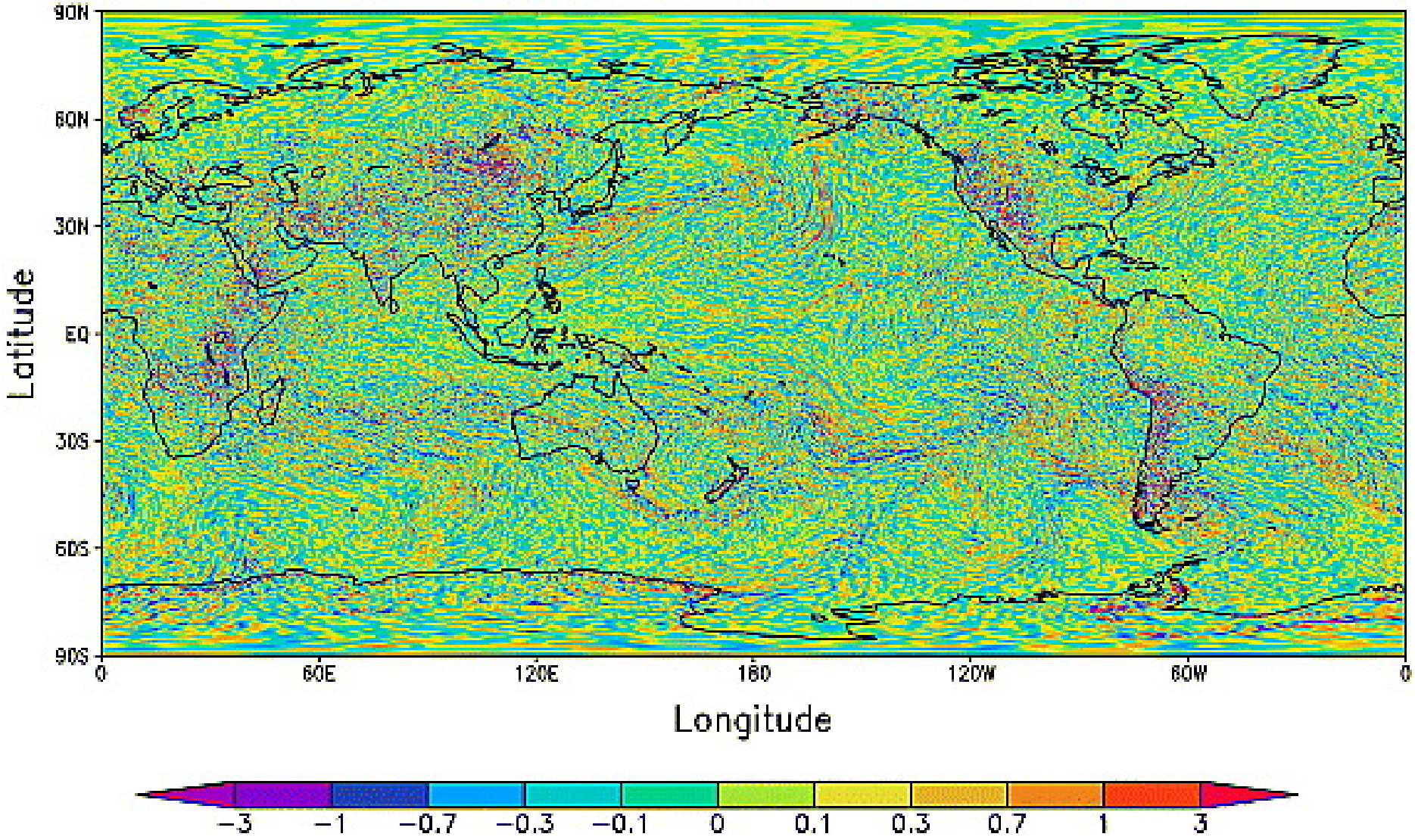


AFES

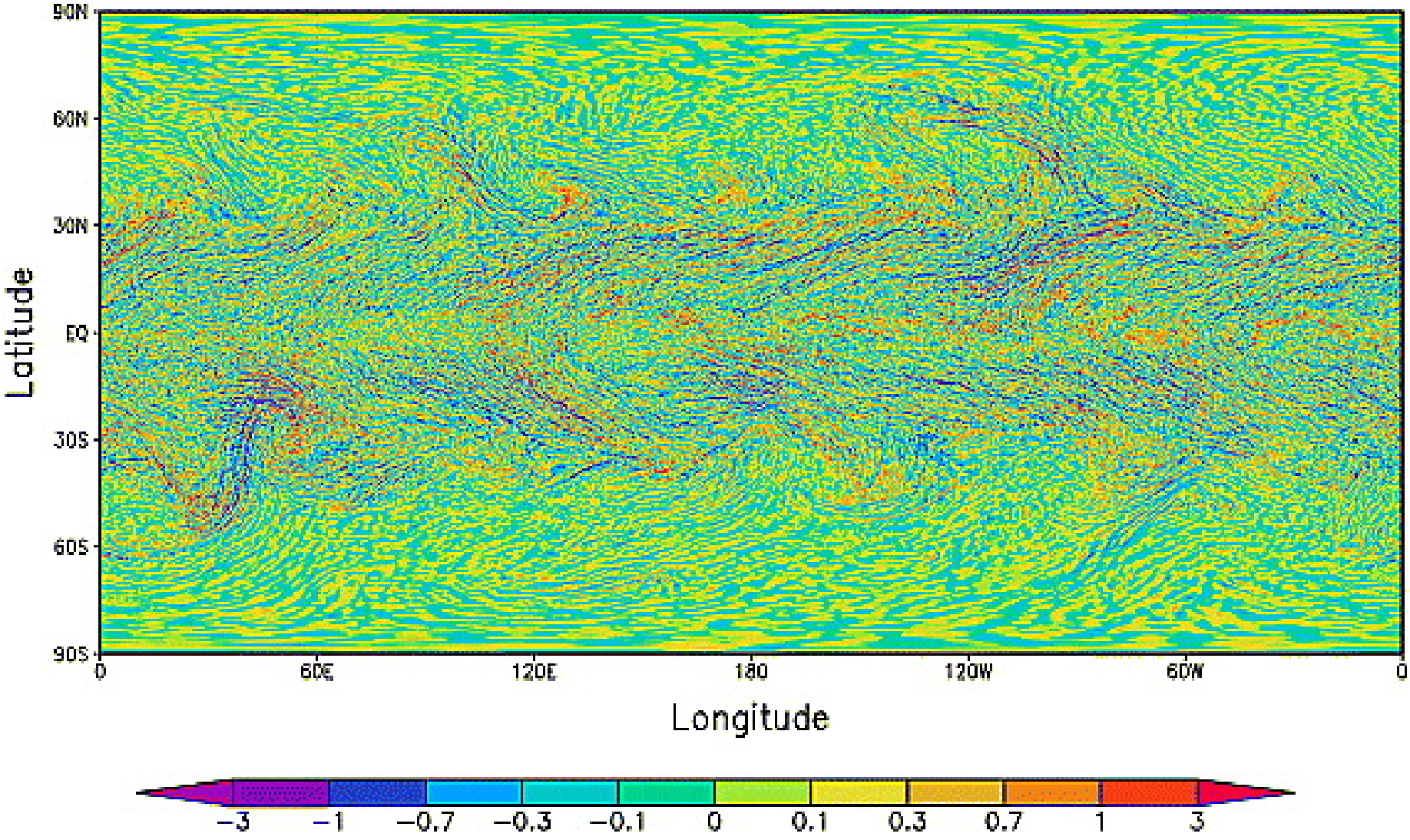
- AFES “Atmospheric GCM For the Earth Simulator”
- Standard spectral GCM solving hydrostatic equations
- T1279 resolution (column physics is done on a Δx~10 km transform grid)
- 96 levels to ~0.1 hPa



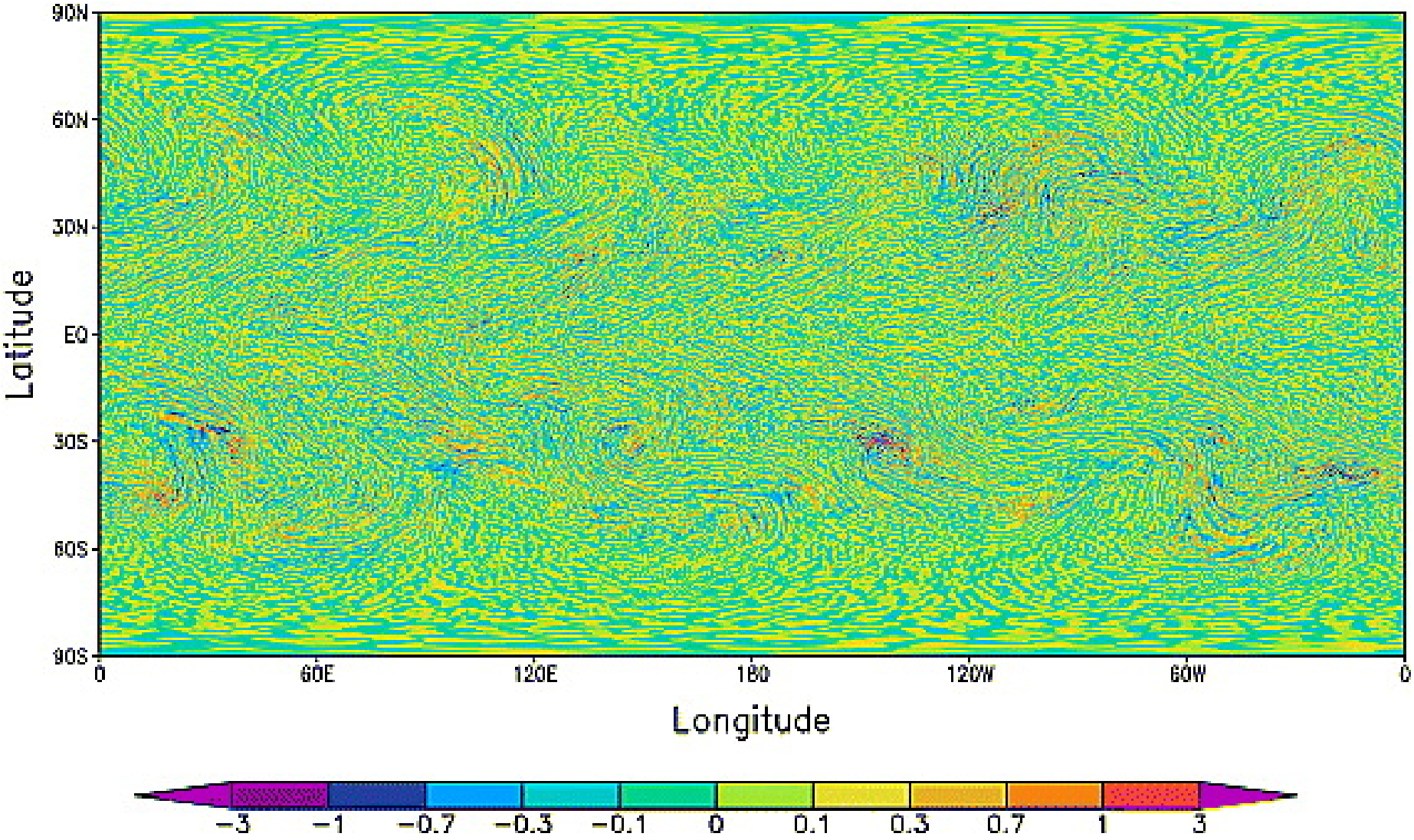
T639 Version Control, 200 hPa divergence snapshot



T639 Aquaplanet



T639 Dry Dynamical Core



NICAM

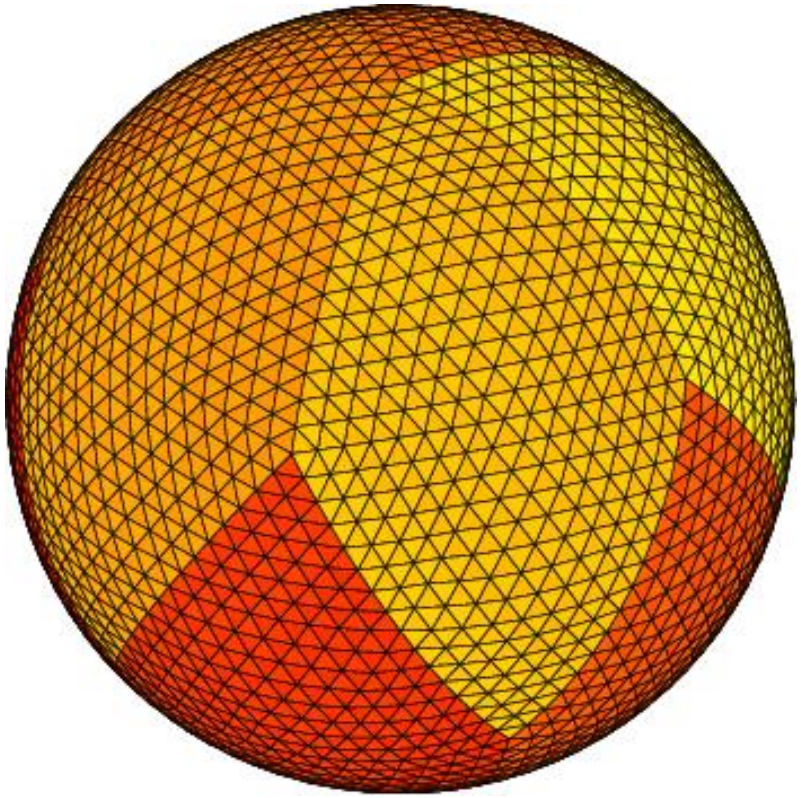
- **N**on-hydrostatic **Ic**osahedral Global **A**tmospheric **M**odel
- Horizontal resolution determined by number of bisections of an icosahedron

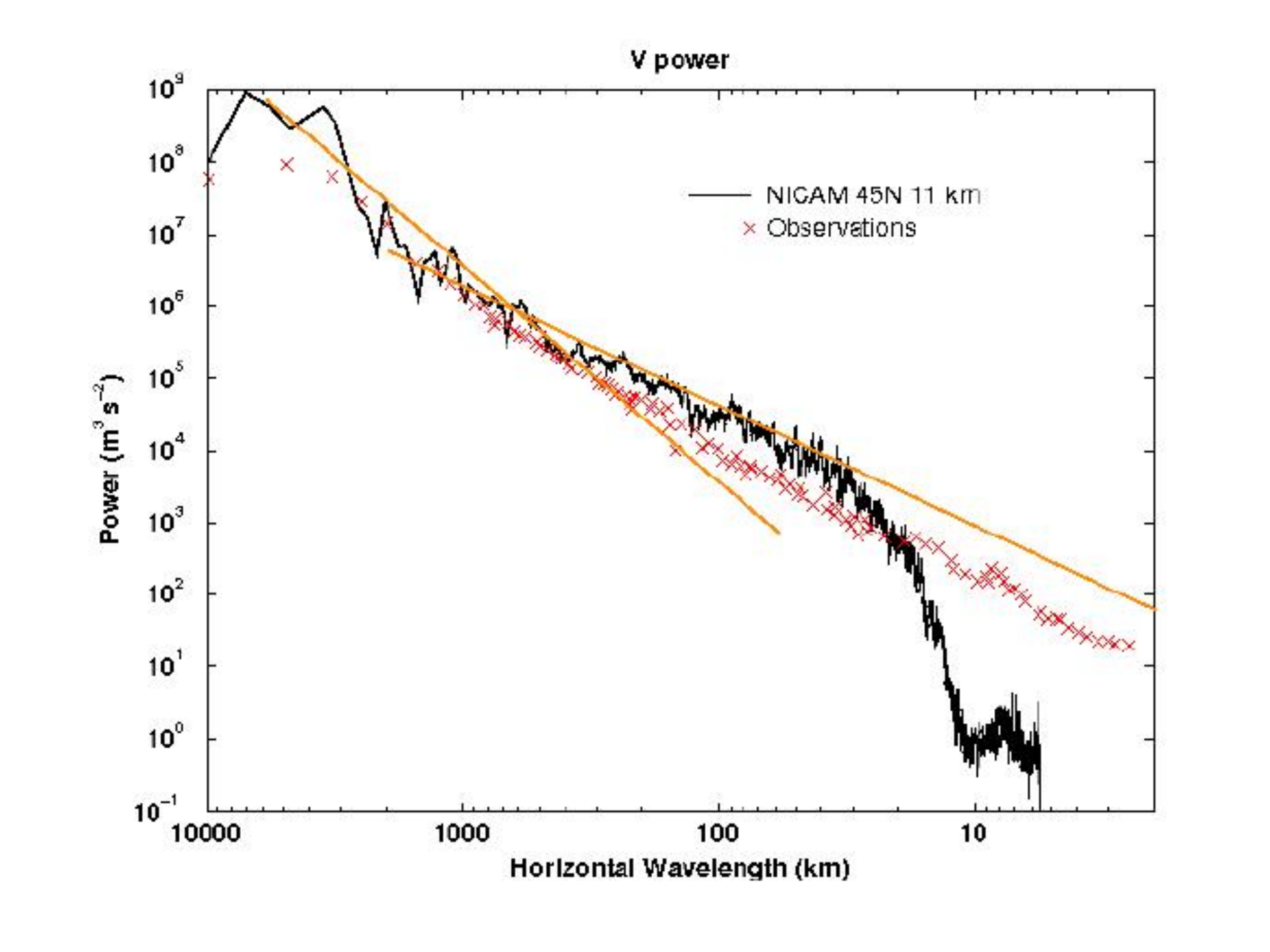
G11 ∆x~3.5 km

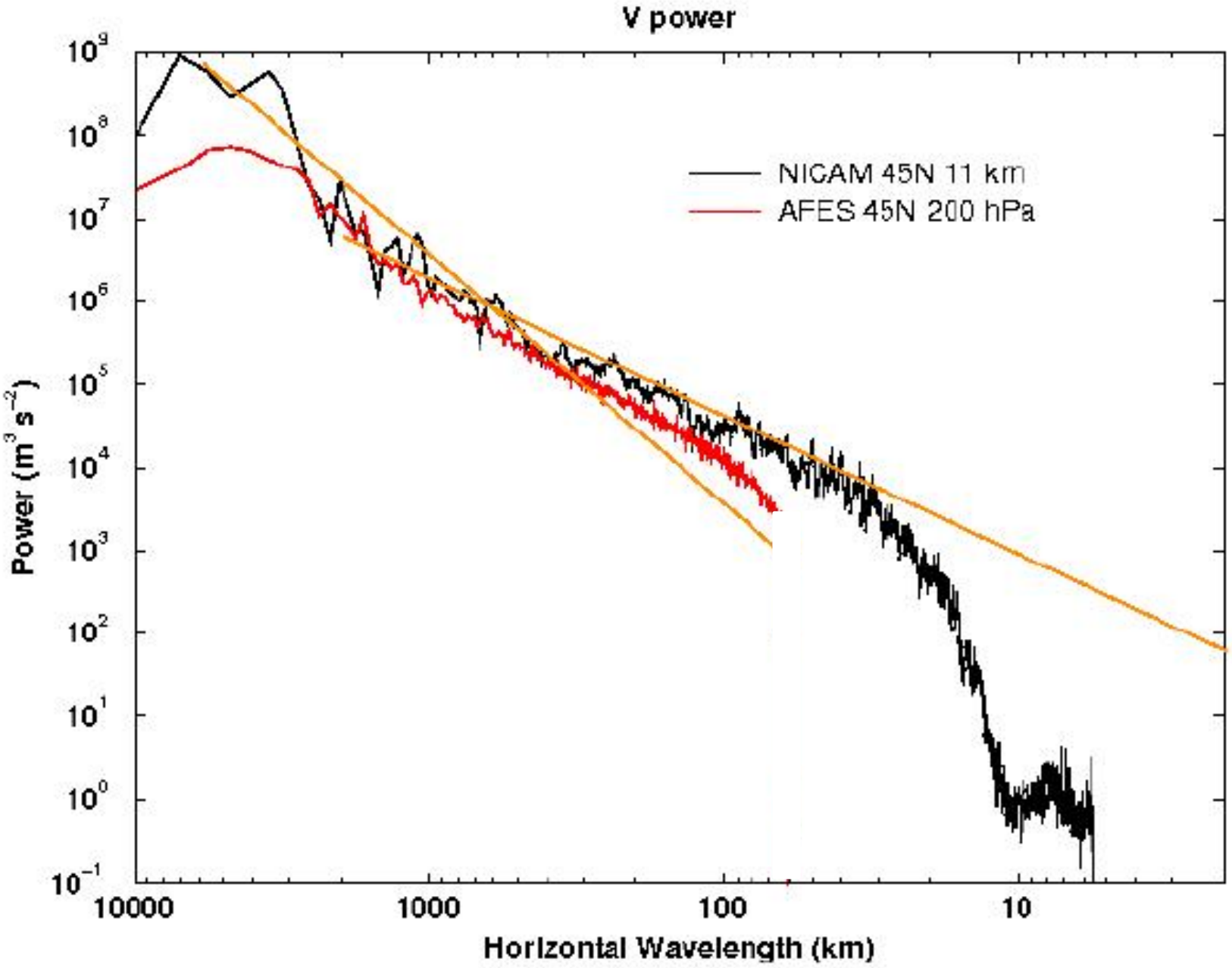
G10 ∆x~7 km

G9 ∆x~14

- 40 levels to z=40 km

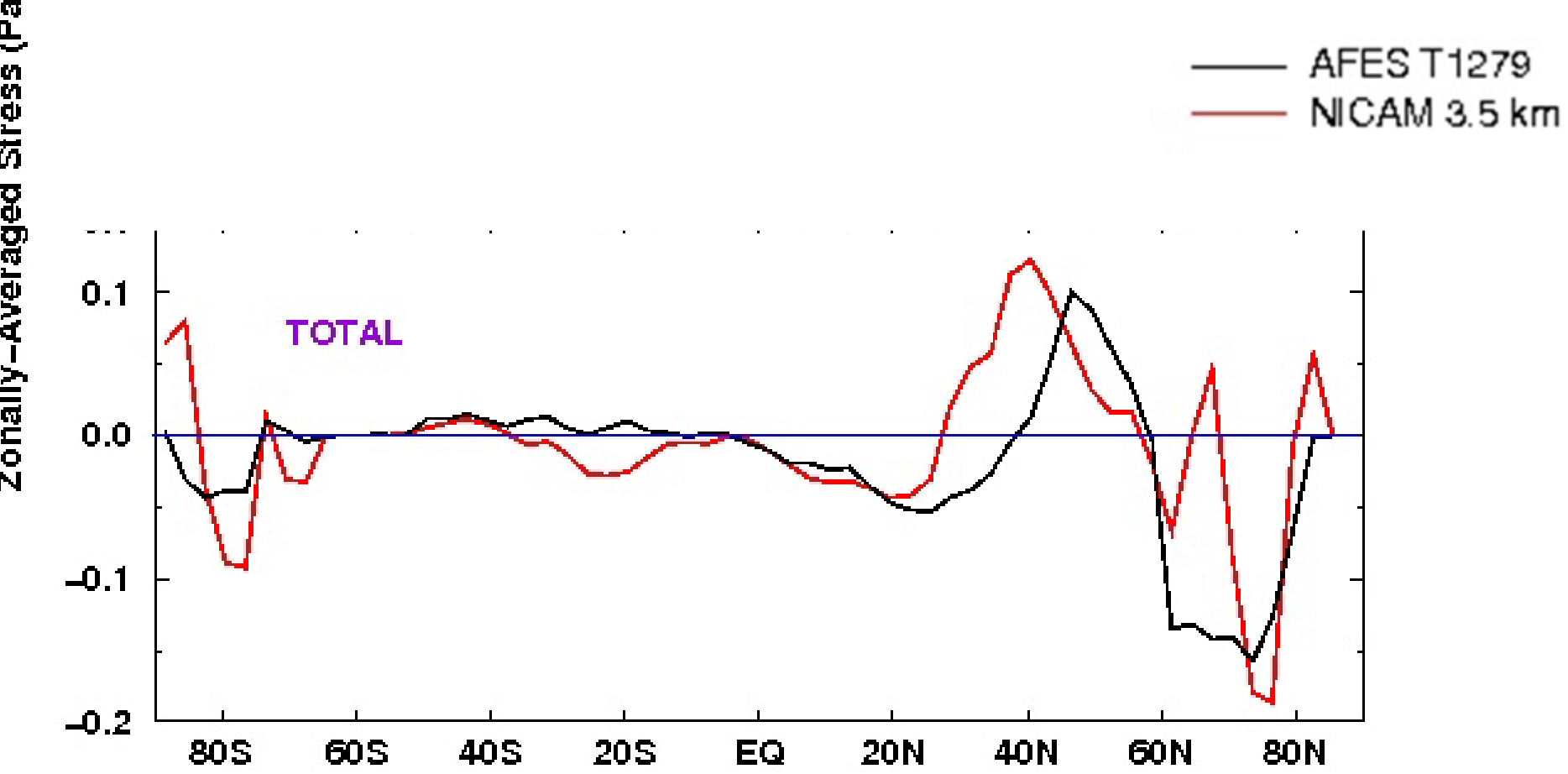


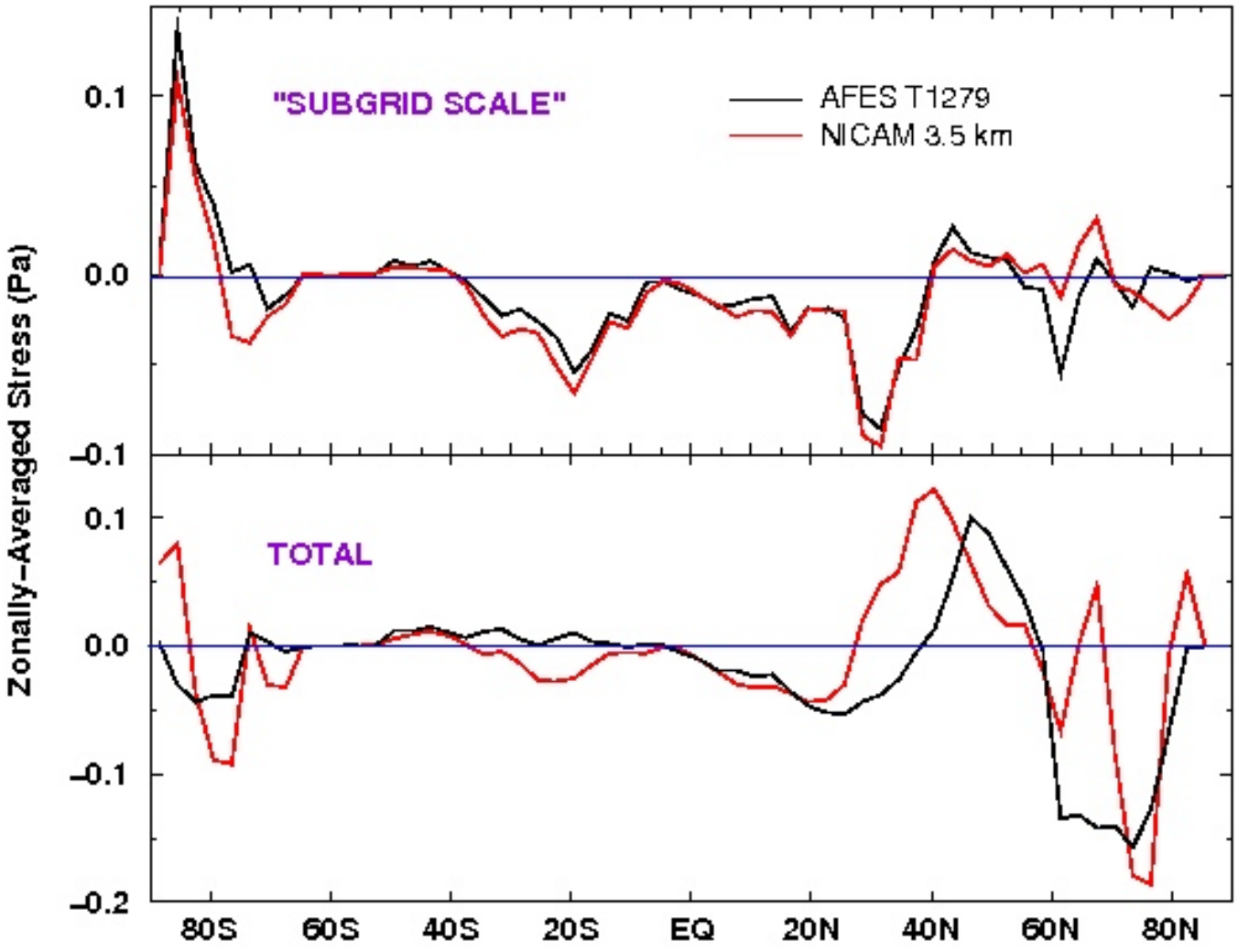

V power
NICAM 45N 11 km
Observations
Power (m^3 s^-2)
Horizontal Wavelength (km)
10000
1000
100
10

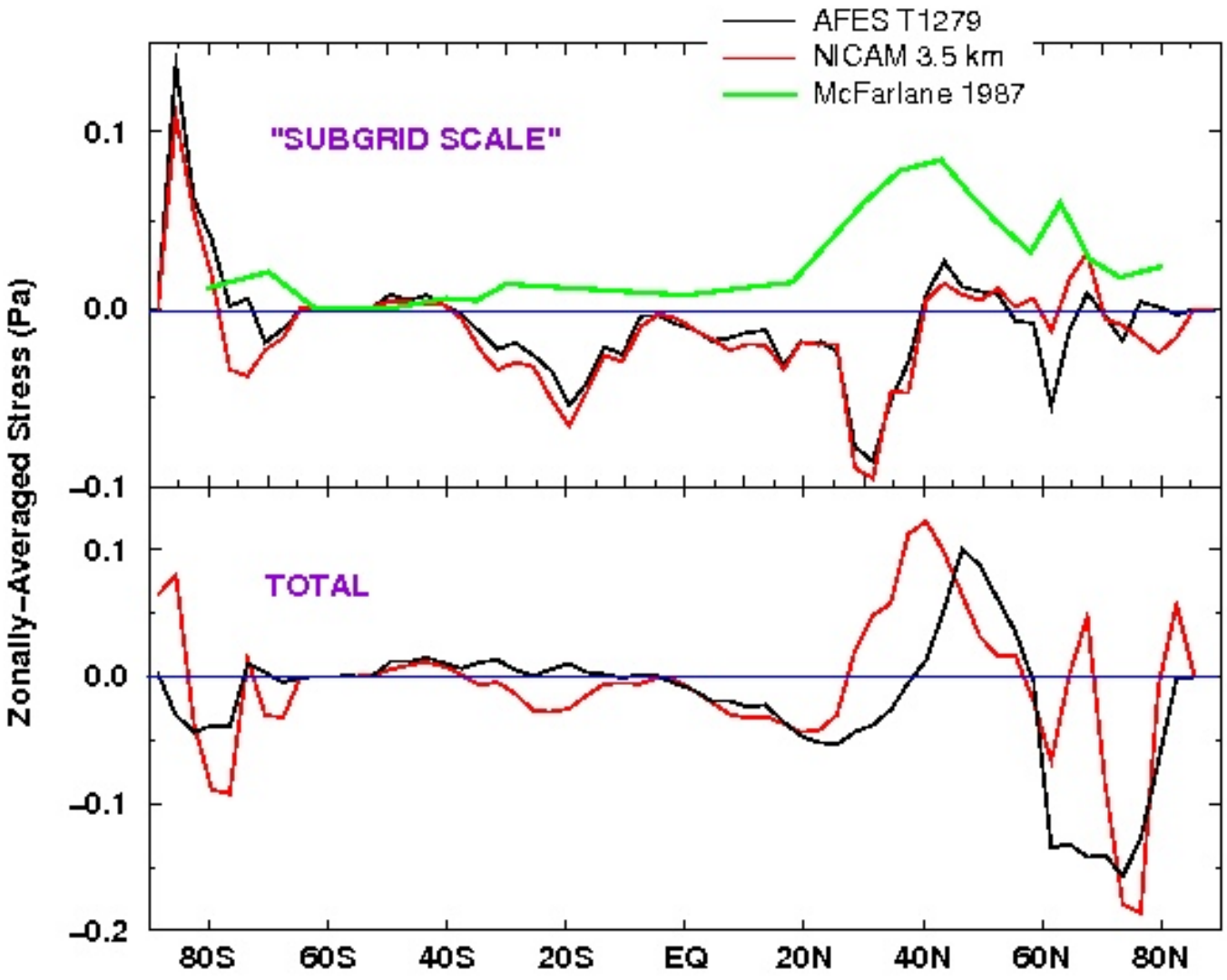

V power
NICAM 45N 11 km
AFES 45N 200 hPa
Power (m^3 s^-2)
Horizontal Wavelength (km)
10000
1000
100
10

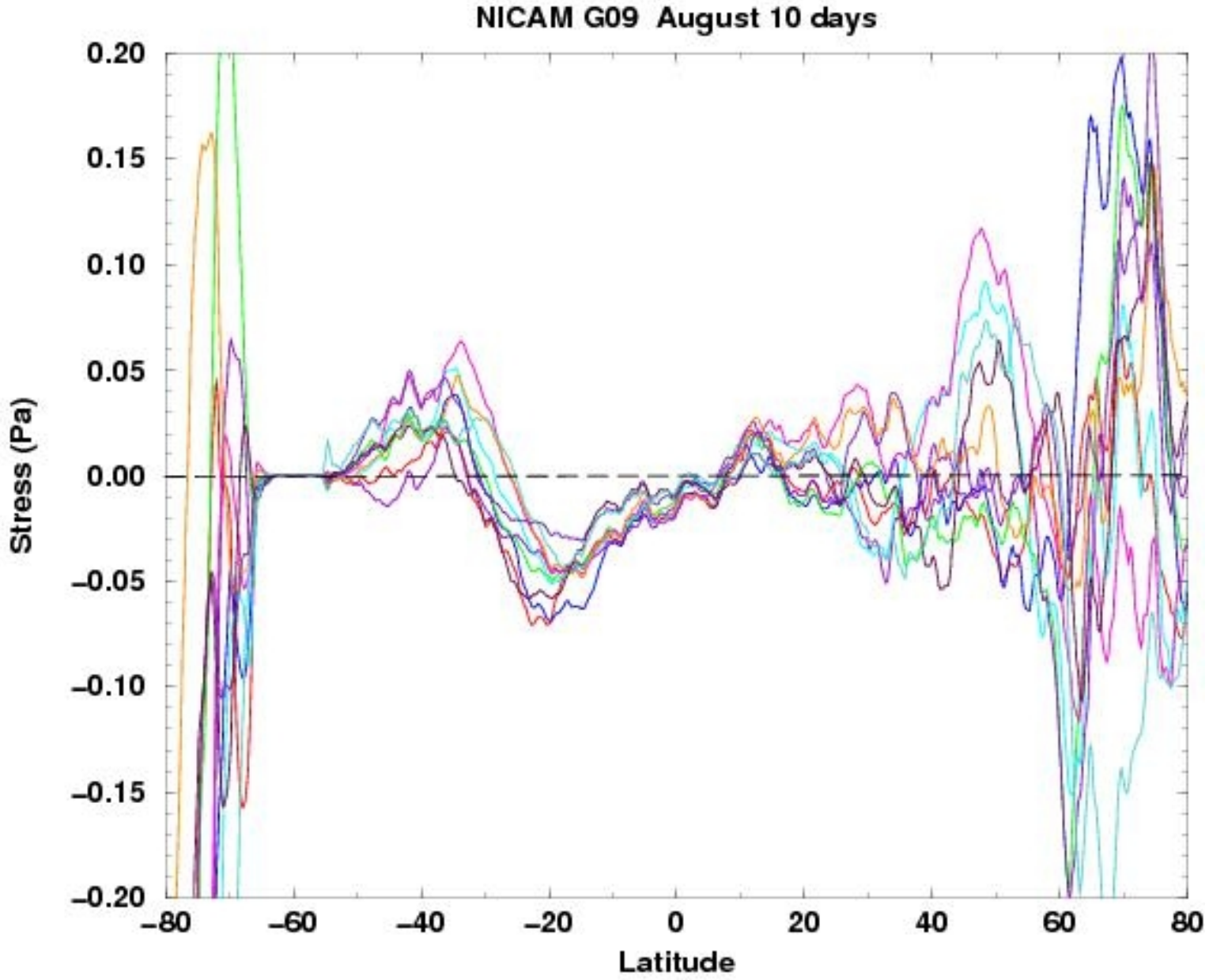
Dec-Jan Results

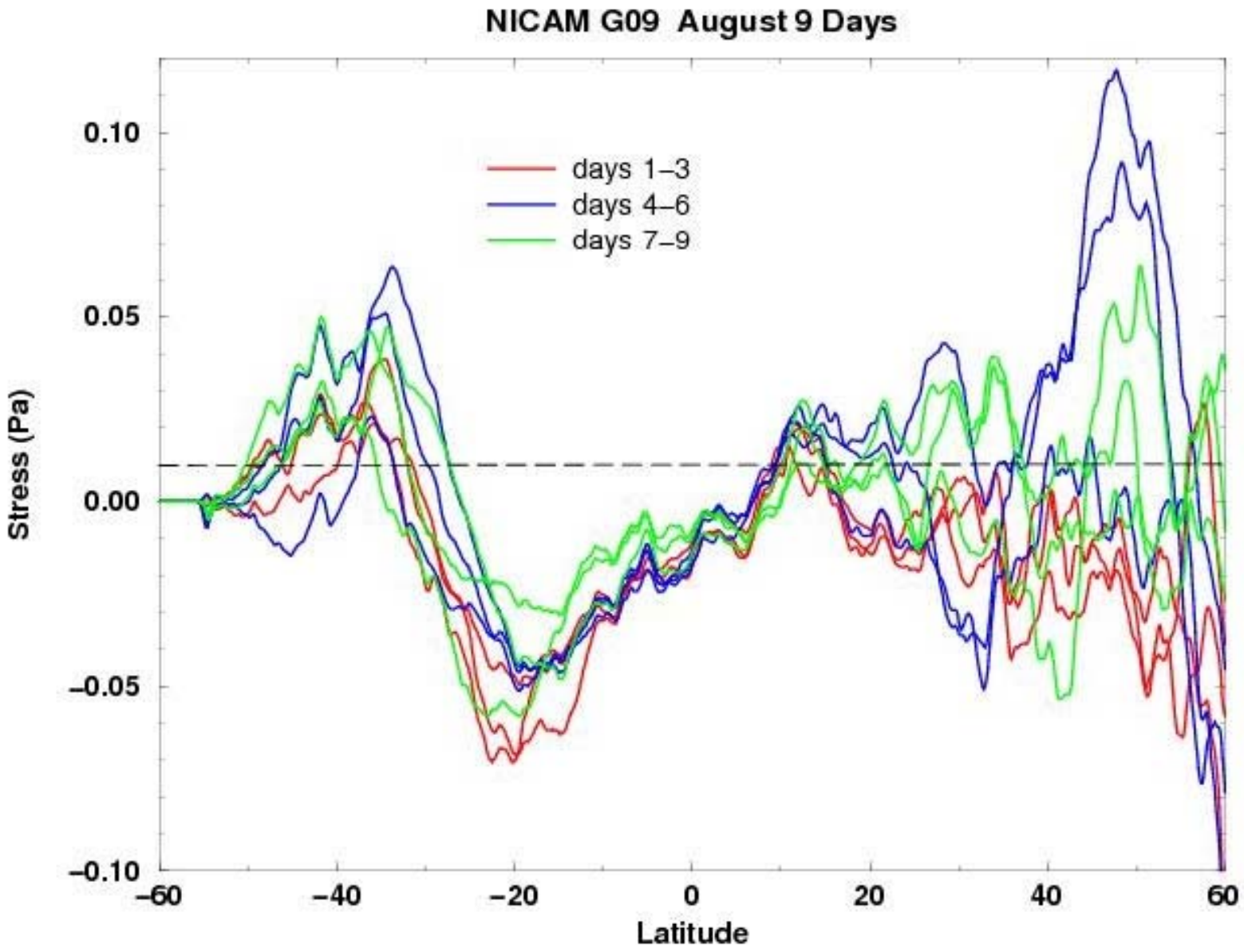
- **4 days of 90-minute mean values of *p* from NICAM December run**
- **7 days of 3-hourly samples of *p* from AFES January run**
- **Compare total zonal-mean topographic stress, stress computed with *p* and *Z* smoothed to ~3-degree resolution & difference**
- **Compare with McFarlane's January mean stress from parameterization (CCC model, 1987)**


AFES T1279
NICAM 3.5 km
Zonally-Averaged Stress (Pa
TOTAL
0.1
0.0
−0.1
−0.2
80S
60S
40S
20S
EQ
20N
40N
60N
80N


"SUBGRID SCALE"
AFES T1279
NICAM 3.5 km
TOTAL
Zonally-Averaged Stress (Pa)
0.1
0.0
-0.1
0.1
0.0
-0.1
-0.2
80S
60S
40S
20S
EQ
20N
40N
60N
80N

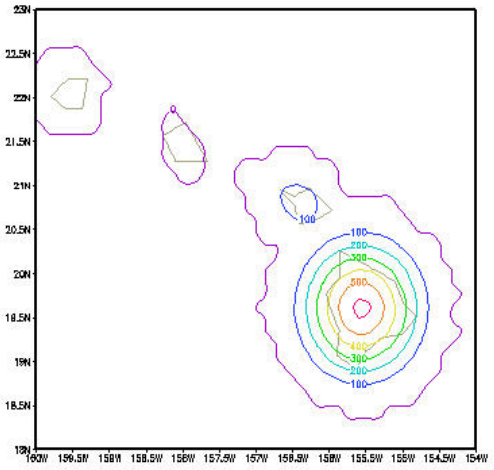

AFES T1279
NICAM 3.5 km
McFarlane 1987
"SUBGRID SCALE"
TOTAL
Zonally-Averaged Stress (Pa)
0.1
0.0
-0.1
0.1
0.0
-0.1
-0.2
80S
60S
40S
20S
EQ
20N
40N
60N
80N


NICAM G09 August 10 days
Stress (Pa)
0.20
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
−0.20
−80
−60
−40
−20
0
20
40
60
80
Latitude


NICAM G09 August 9 Days
days 1–3
days 4–6
days 7–9
0.10
0.05
0.00
–0.05
–0.10
Stress (Pa)
–60
–40
–20
0
20
40
60
Latitude

For 17N-20N, 204-207E mean stress in NICAM is -0.11 Pa

McFarlane $10^{-7} h_e^2 V$



To Do List

Compare G09, G10, G11.

Compare with parameterizations for both zonal mean and “local” stress.

Derive/tune a “parameterization” from the explicit results with statistical techniques.

Compare surface drag with wave stress above surface.

Mahalo Nui Loa!

(Thank you very much!)



Ancient Waikiki