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Grid Scale Oscillations in MICOM*

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Model Characteristics

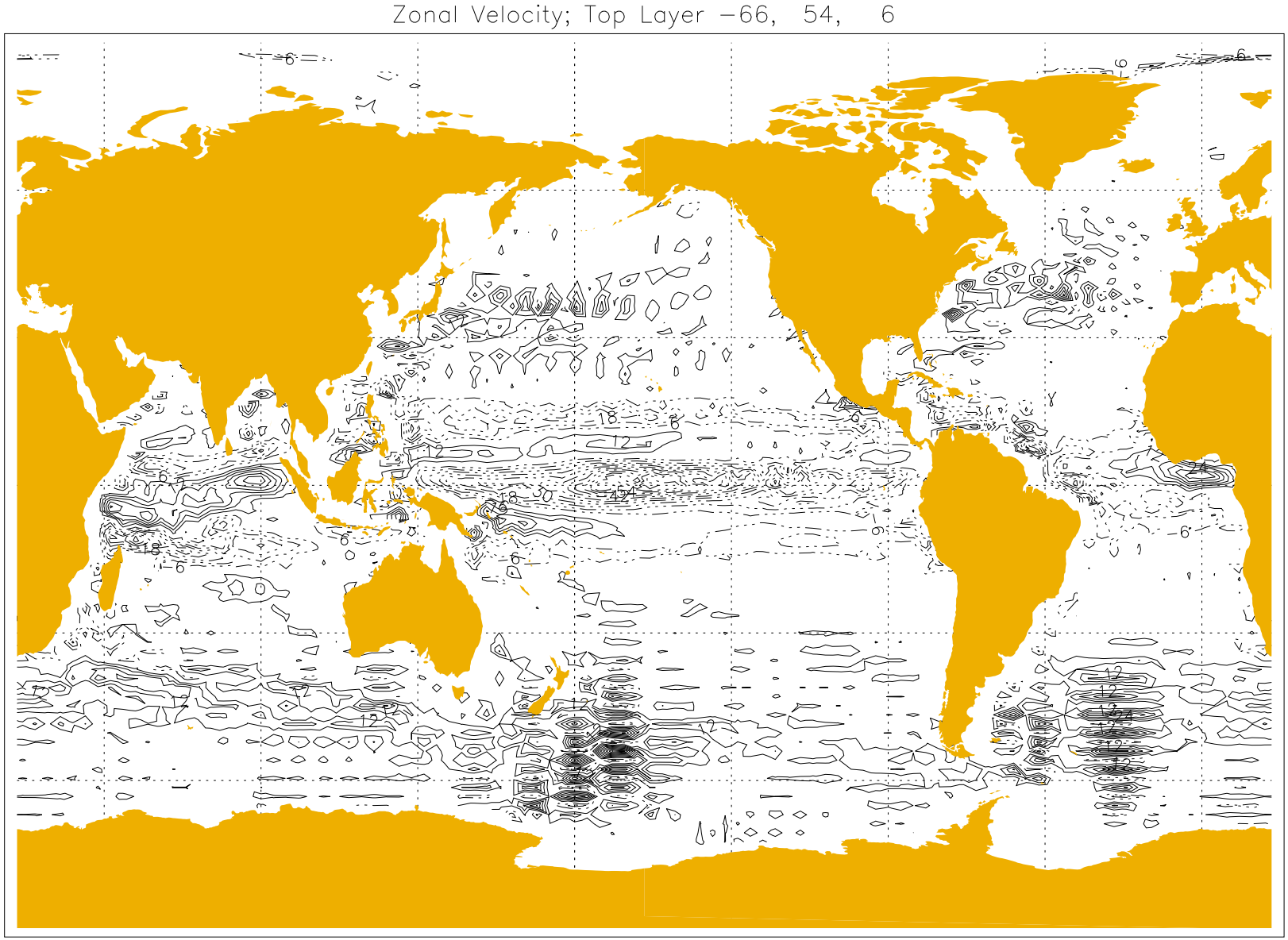
- Miami Isopycnal Coordinate Ocean Model
- 3^{o} displaced pole grid. 16 layers
- Kraus-Turner Bulk Mixed Layer
- Explicit diapycnal-mixing based on McDougall and Dewar (1998).
- Simple thermodynamic ice model with
  no brine rejection for first 3 years
  or
  Diagnosed ice (Shea-Trenberth-Reynolds SST climatology)
- Topography derived from ETOPO5

Forcing and Initial Conditions

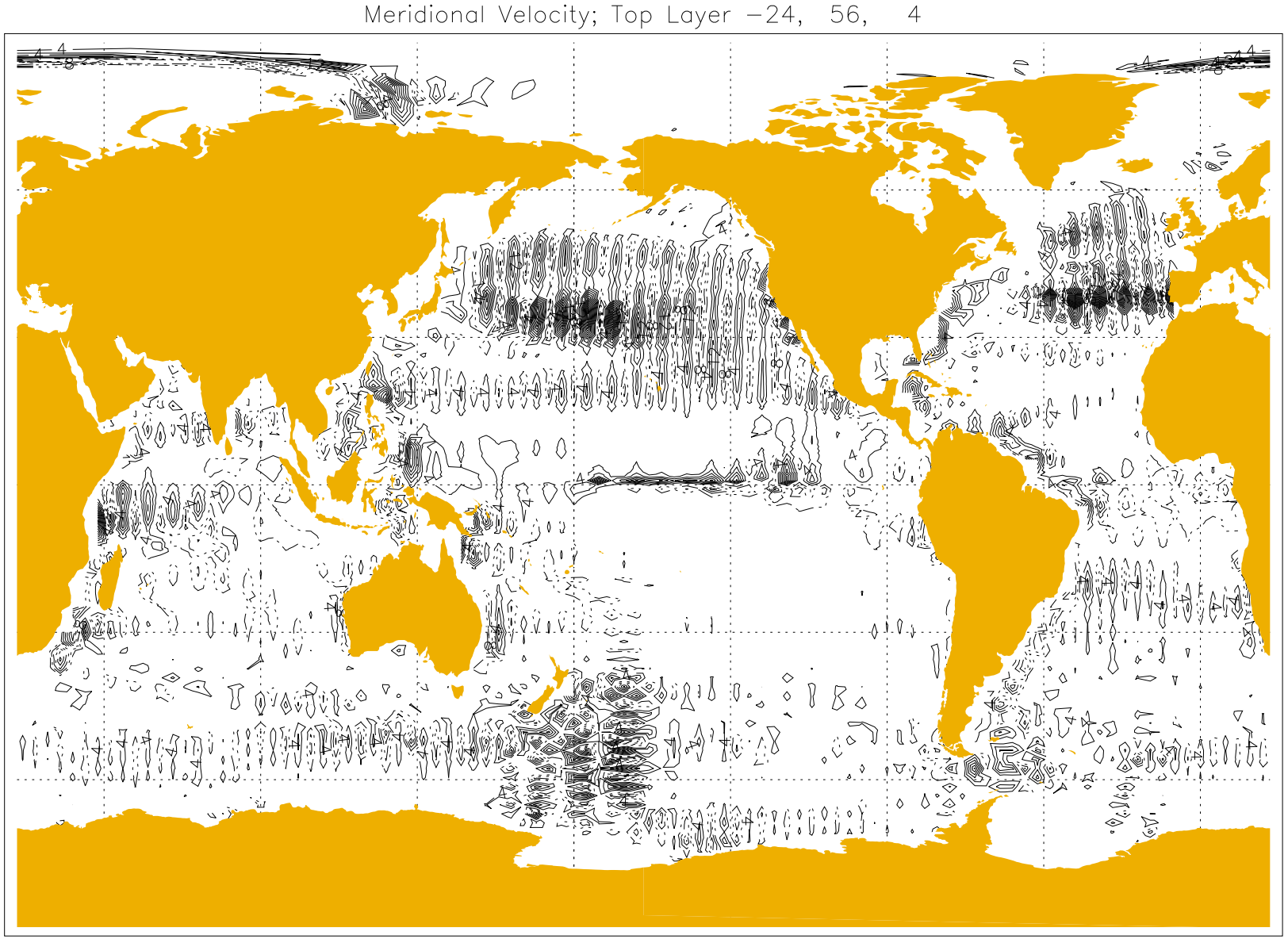
- Specified Monthly Climatalogy of Atmosphere
  - NCEP Reanalysis: Wind, Humidity, Temperature
  - ISCCP (Sat. Cloud Clmt): Shortwave radiation, Cloud fraction
  - Fung et al.: Longwave radiation
  - MSU/Xie-Arkin: Precipitation
- Model SST + Bulk Forcing (Large et al.) $\Rightarrow$ Surface Flux of Heat and Freshwater

Forcing and Initial Conditions (cont'd)

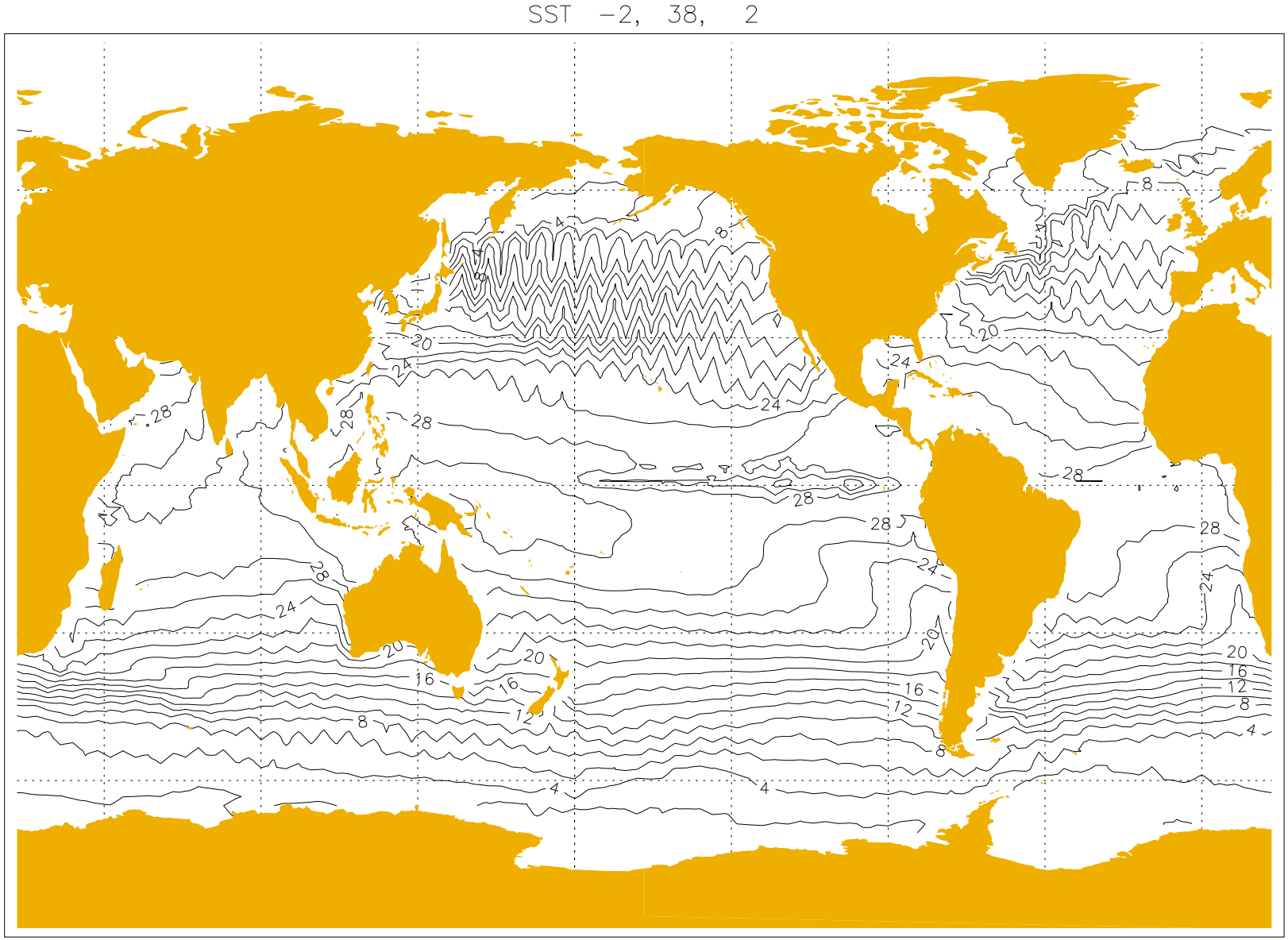
- NO RESTORING TO CLIMATOLOGY
- Precipitation adjustment
- Initial Condition based on Levitus '82



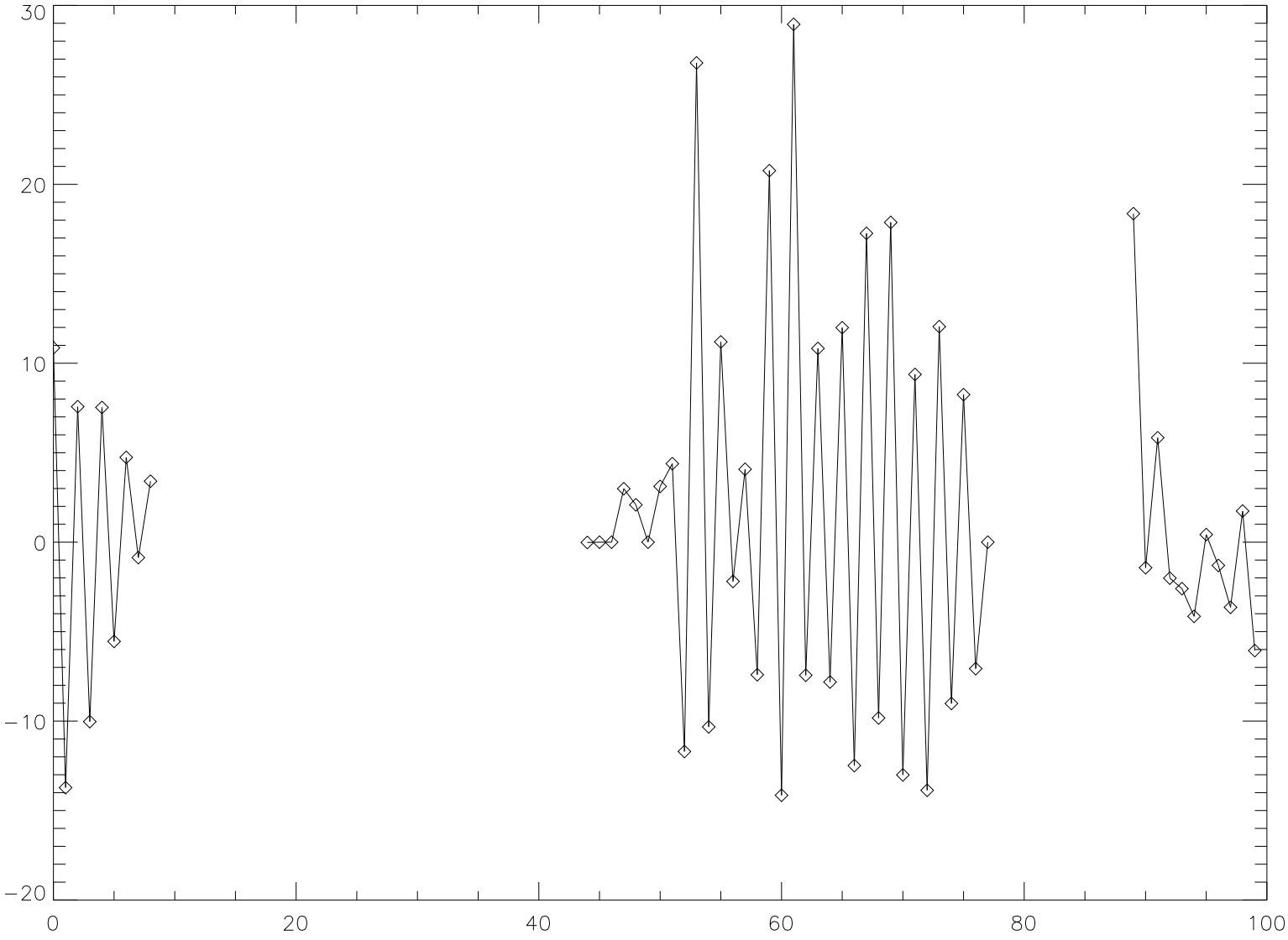
Zonal vel: $2\Delta y$ noise (veldff=2cm/s; t=450 days)



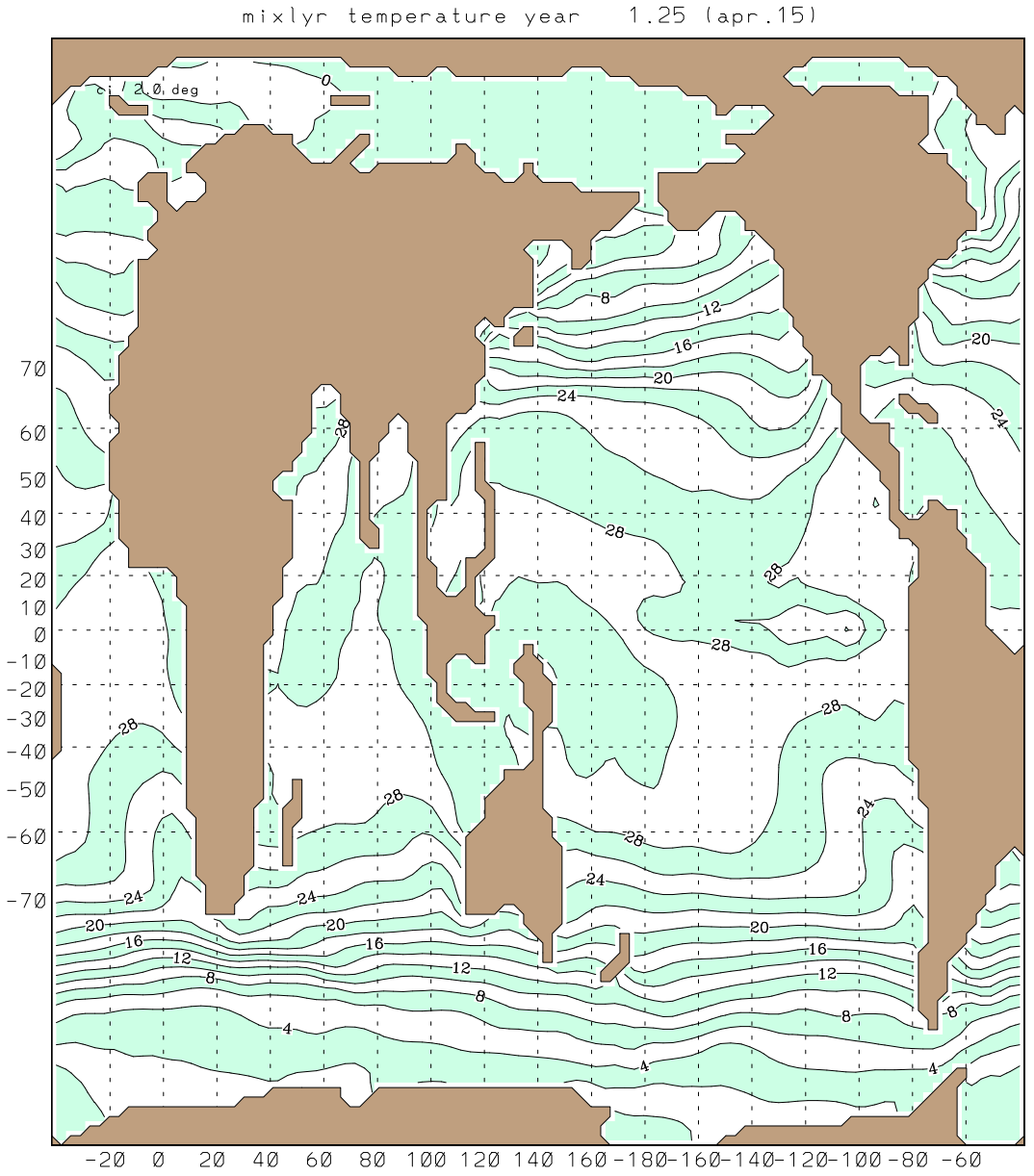
Meridional vel: 2Δx noise (veldff=2cm/s; t=450 days)



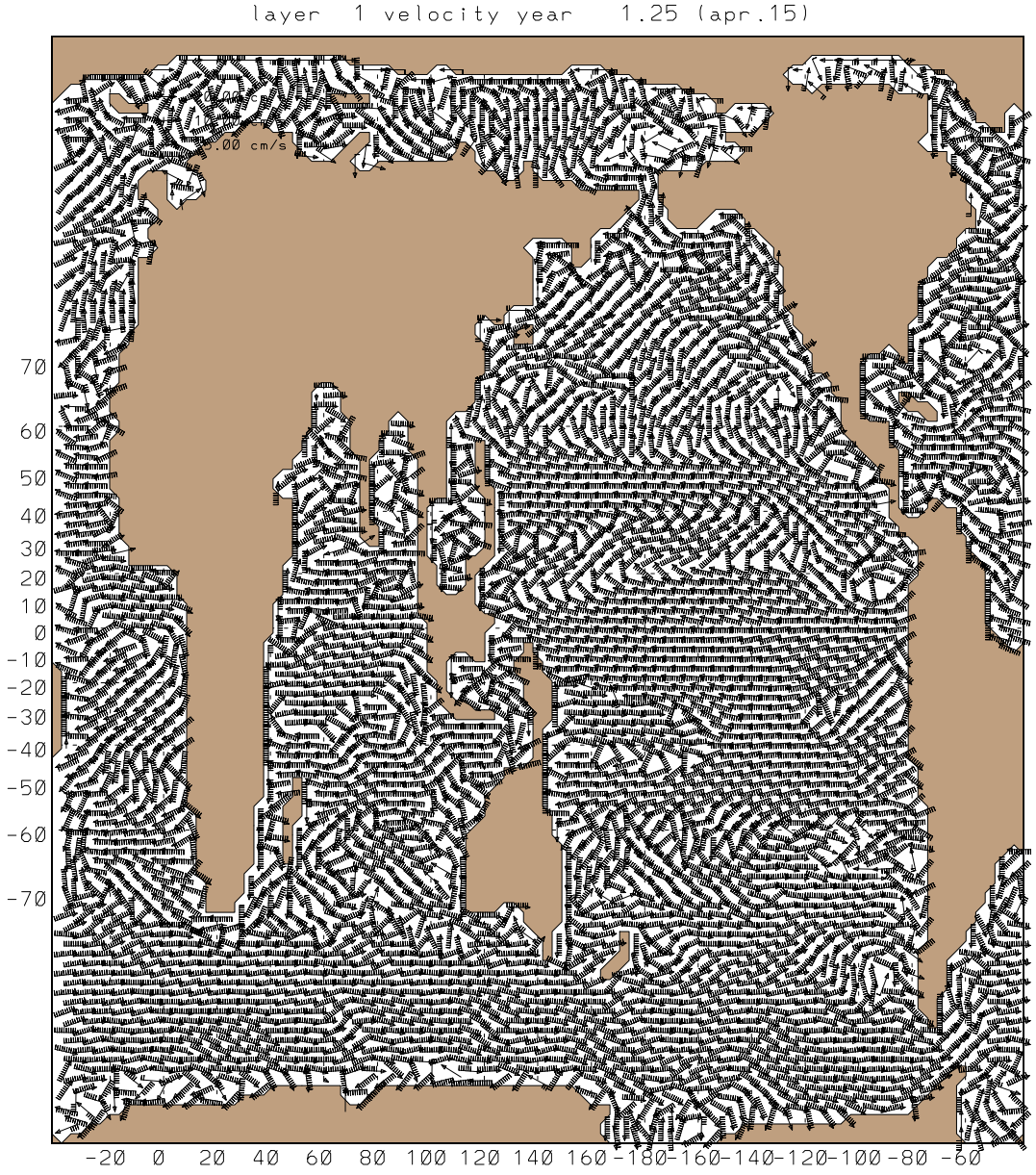
SST: 2Δx noise (veldff=2cm/s; t=450 days)



Meridional vel. along 35.7^{o} N (veldff=2cm/s; t=450 days)



SST *à la* micomproc (veldff=2cm/s; t=450 days)



Velocity *à la* micomproc (veldff=2cm/s; t=450 days)

Possible Sources of Grid Scale Oscillations

- Non Resolution of Important Length Scales
  - Viscous boundary layer scale
  - Inertial boundary layer scale
  - Grid Reynolds Number
  - Topography induced viscous scale
  - Rough Topography, layers intersecting topography
  - Boundary Conditions

Possible Sources (contd.)

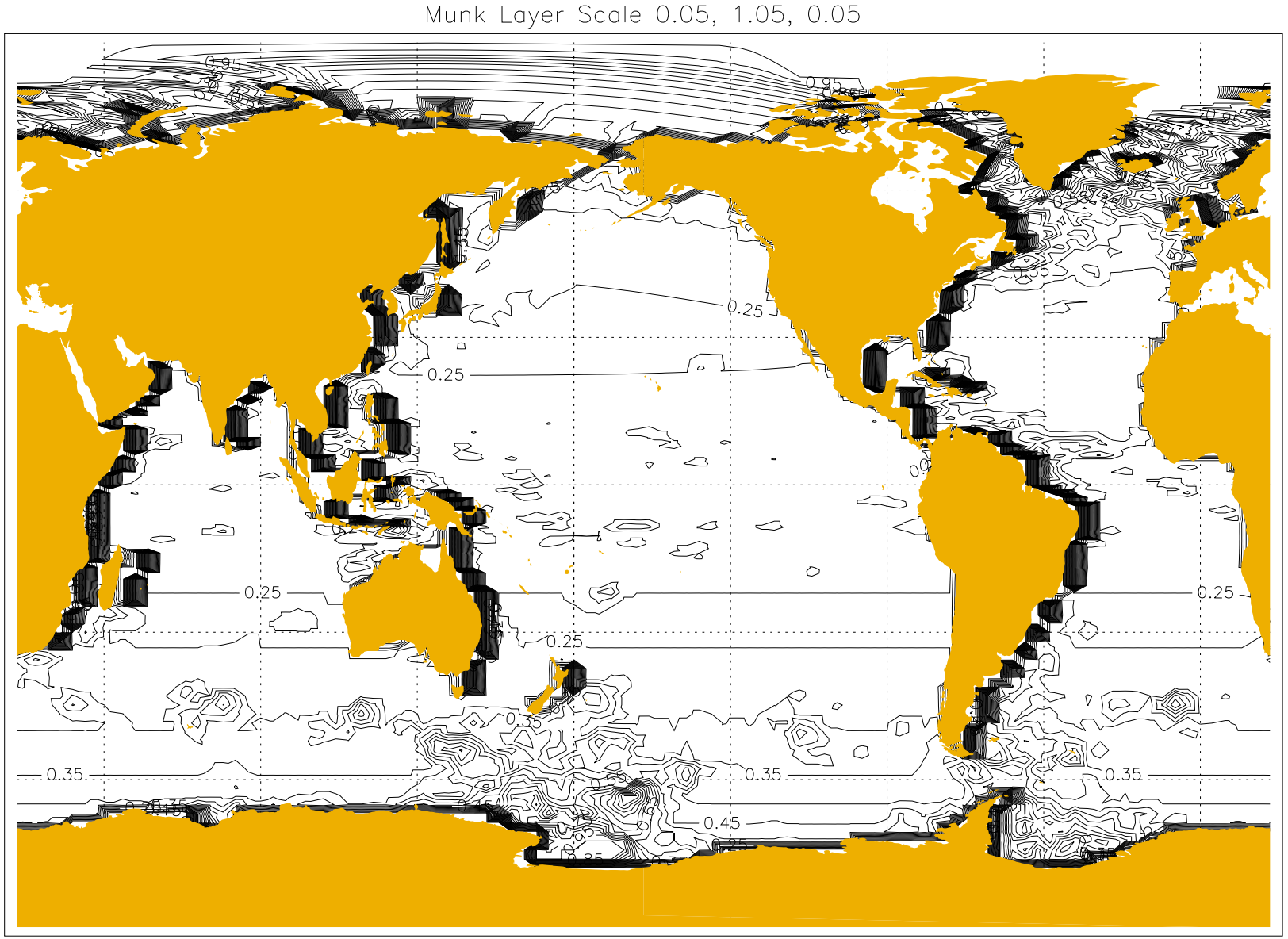
- Null Space of Differential Operators
- Averaging in Coriolis Terms (C-grid)
- Barotropic-baroclinic splitting

Time Step, Grid Re, Munk Scale

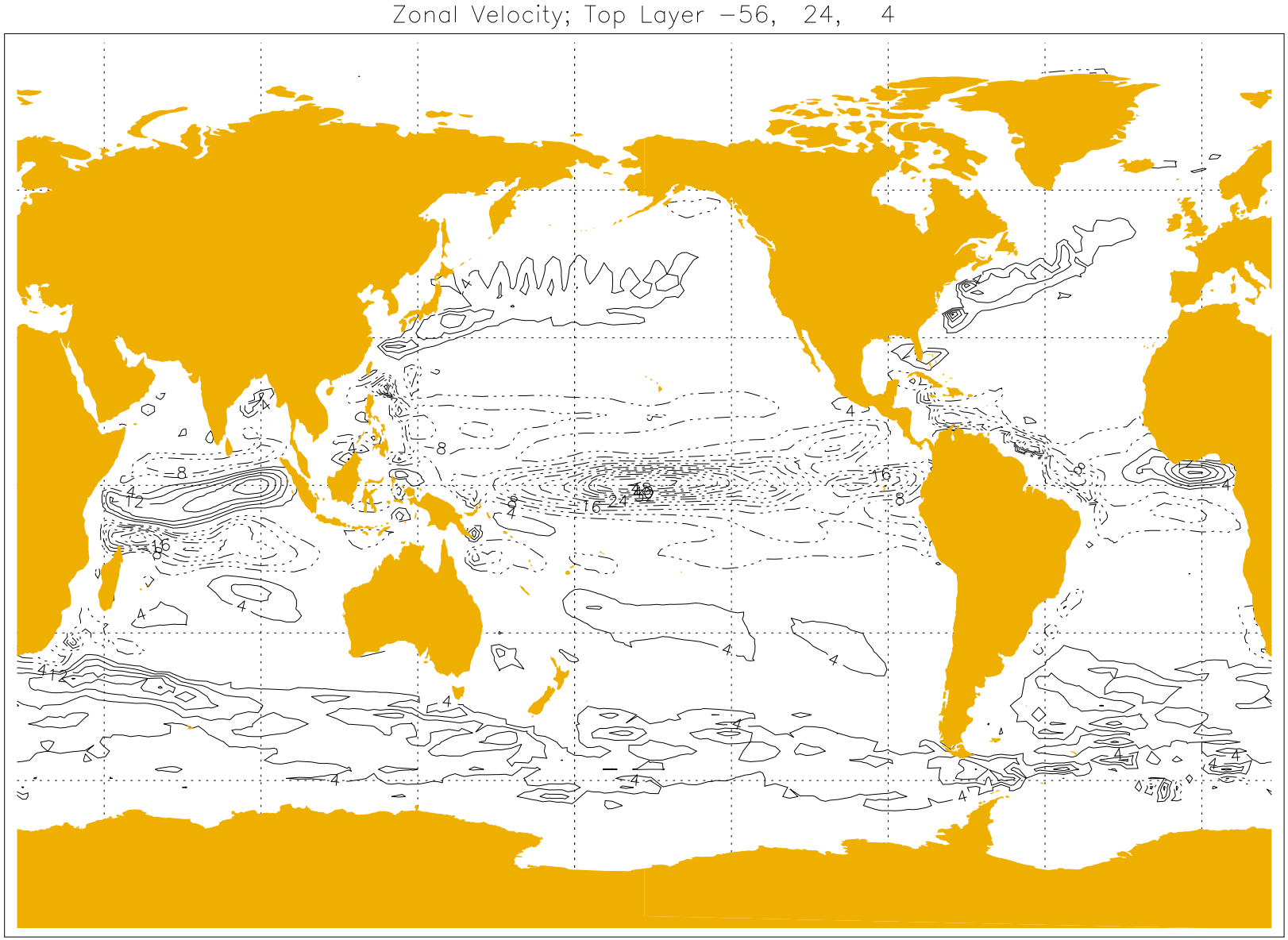
$$CFL\# = \frac{\Delta t}{\Delta x \Delta y}((2u_\nu + |u|)\Delta x + (2v_\nu + |v|\Delta y))$$

$$Re_g = \max\left(\frac{|u|}{u_\nu}, \frac{|v|}{v_\nu}\right)$$

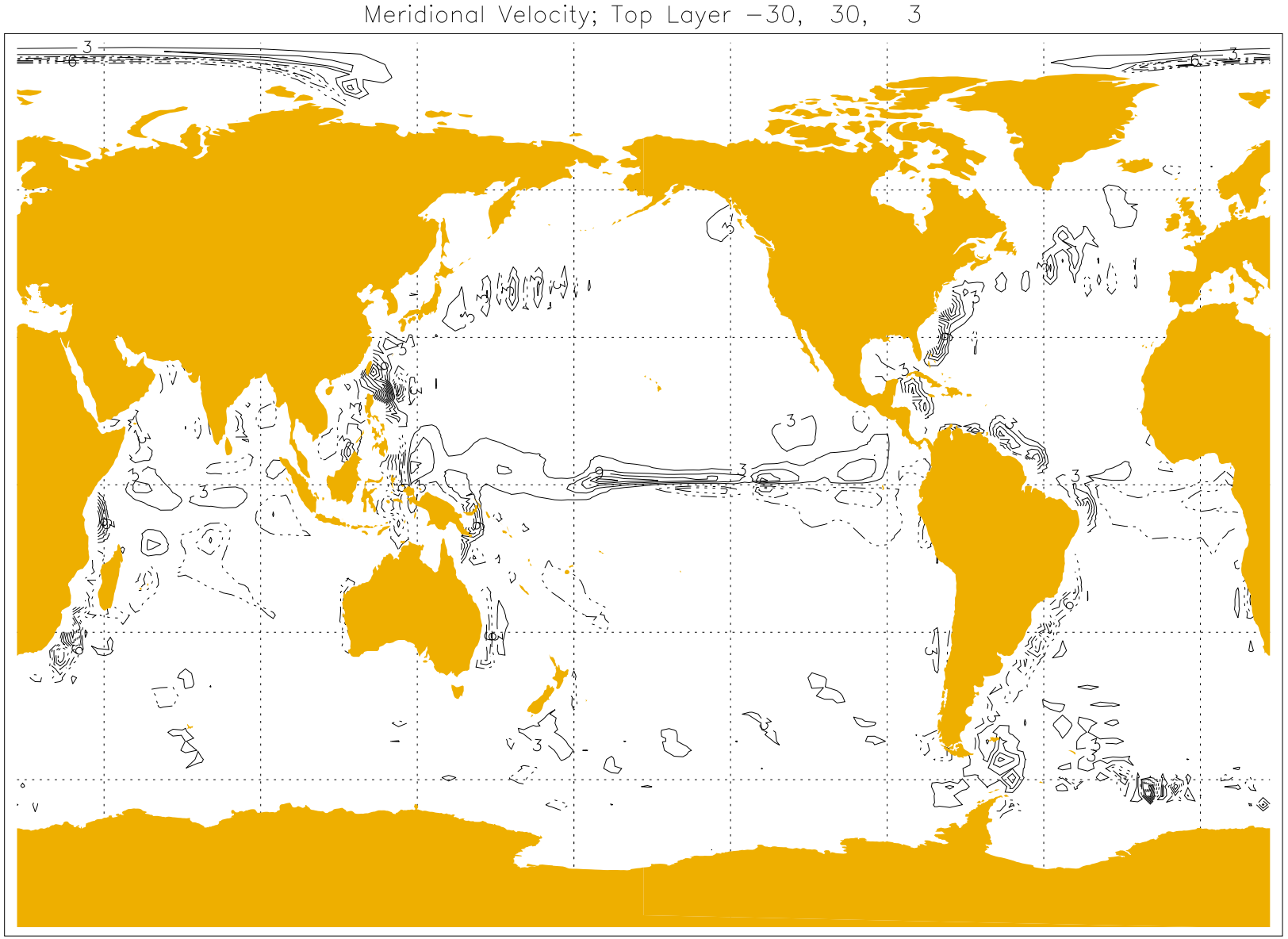
$$\frac{L_m}{\Delta x} = \left(\frac{u_\nu \Delta x + v_\nu \Delta y}{2\beta(\Delta x \Delta y)^{\frac{3}{2}}}\right)^{\frac{1}{3}}$$



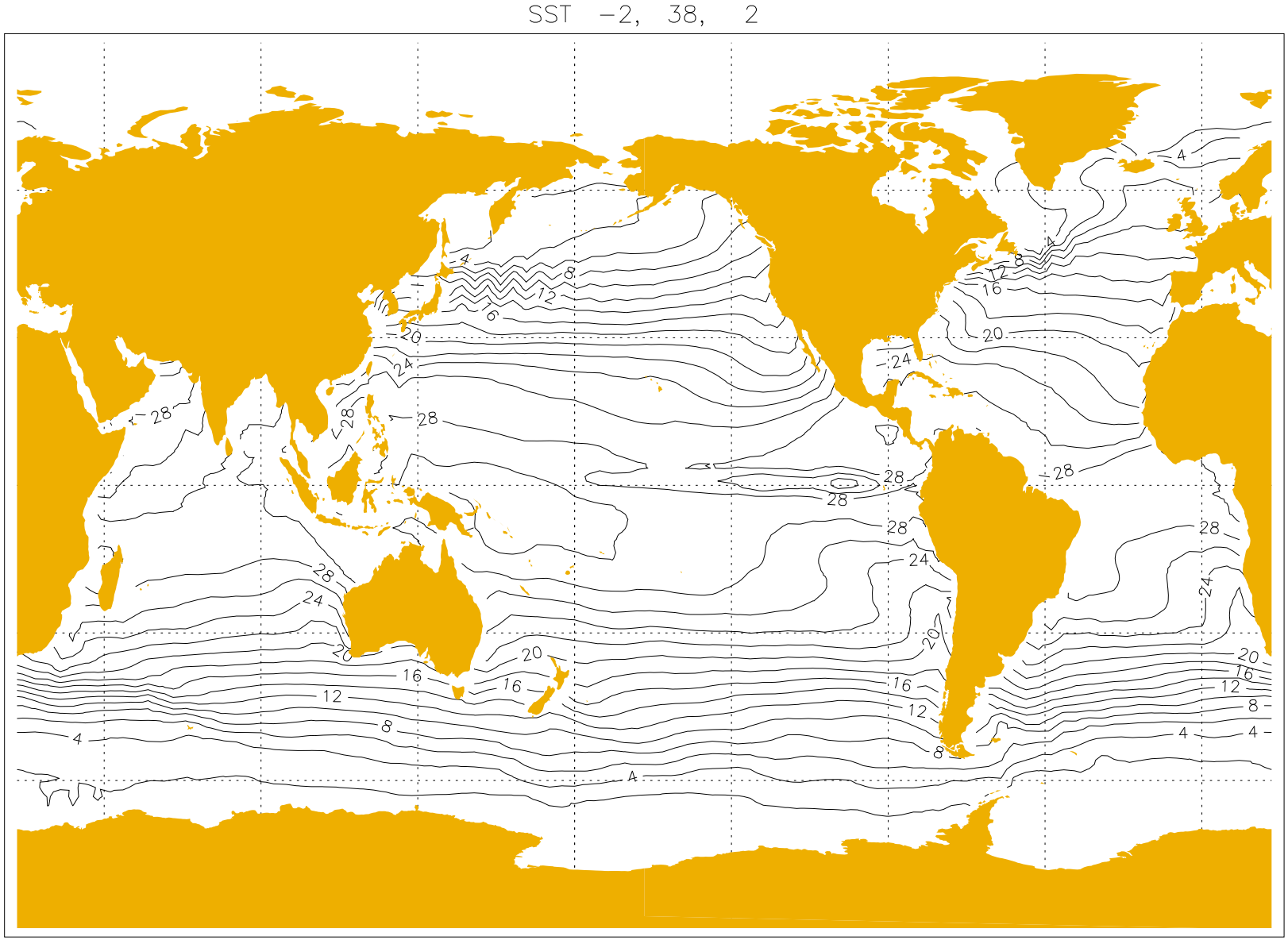
Munk Layer Thickness (veldff=2cm/s; t=450 days)



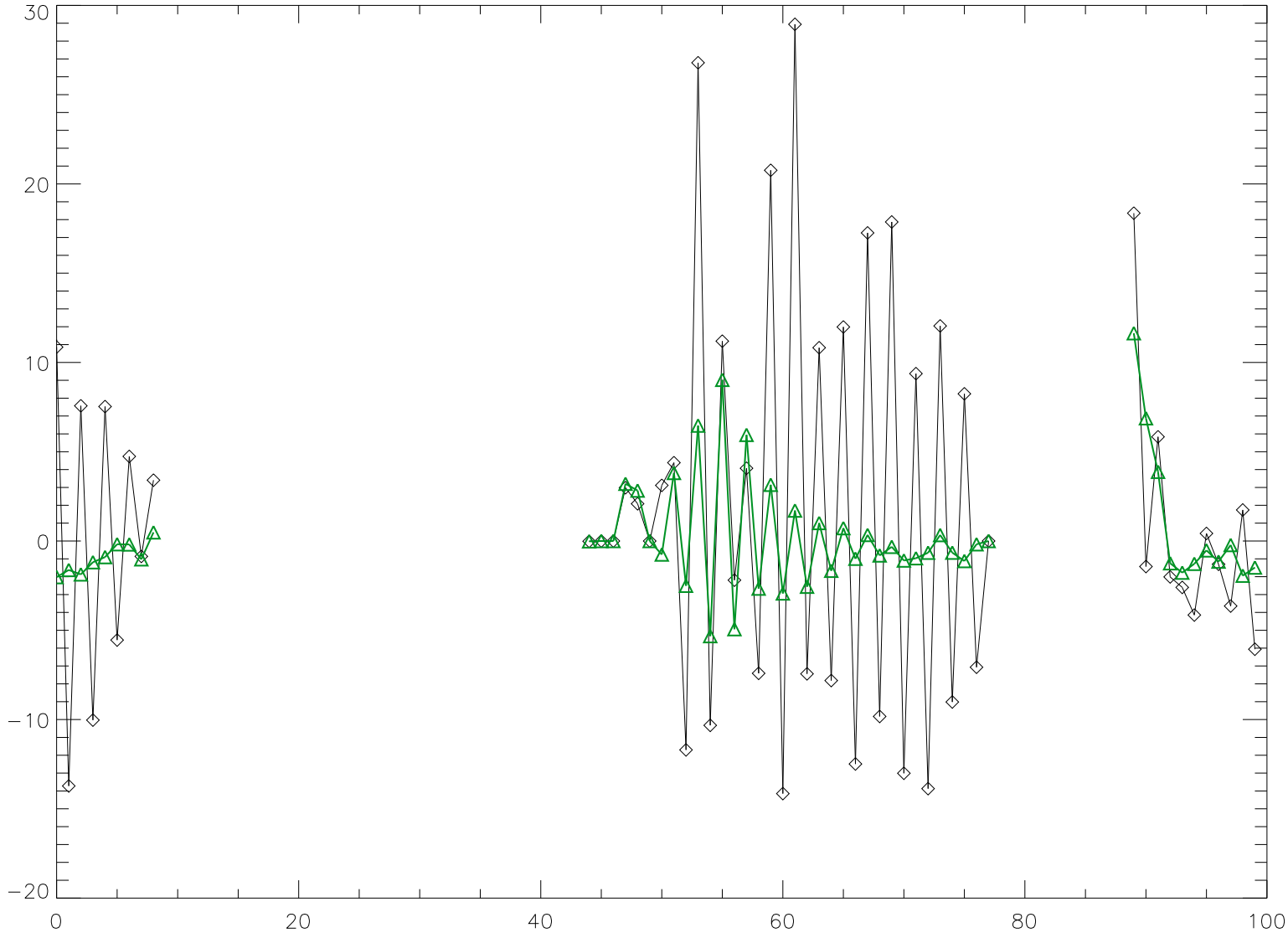
Zonal vel. (veldff=40cm/s; t=450 days)



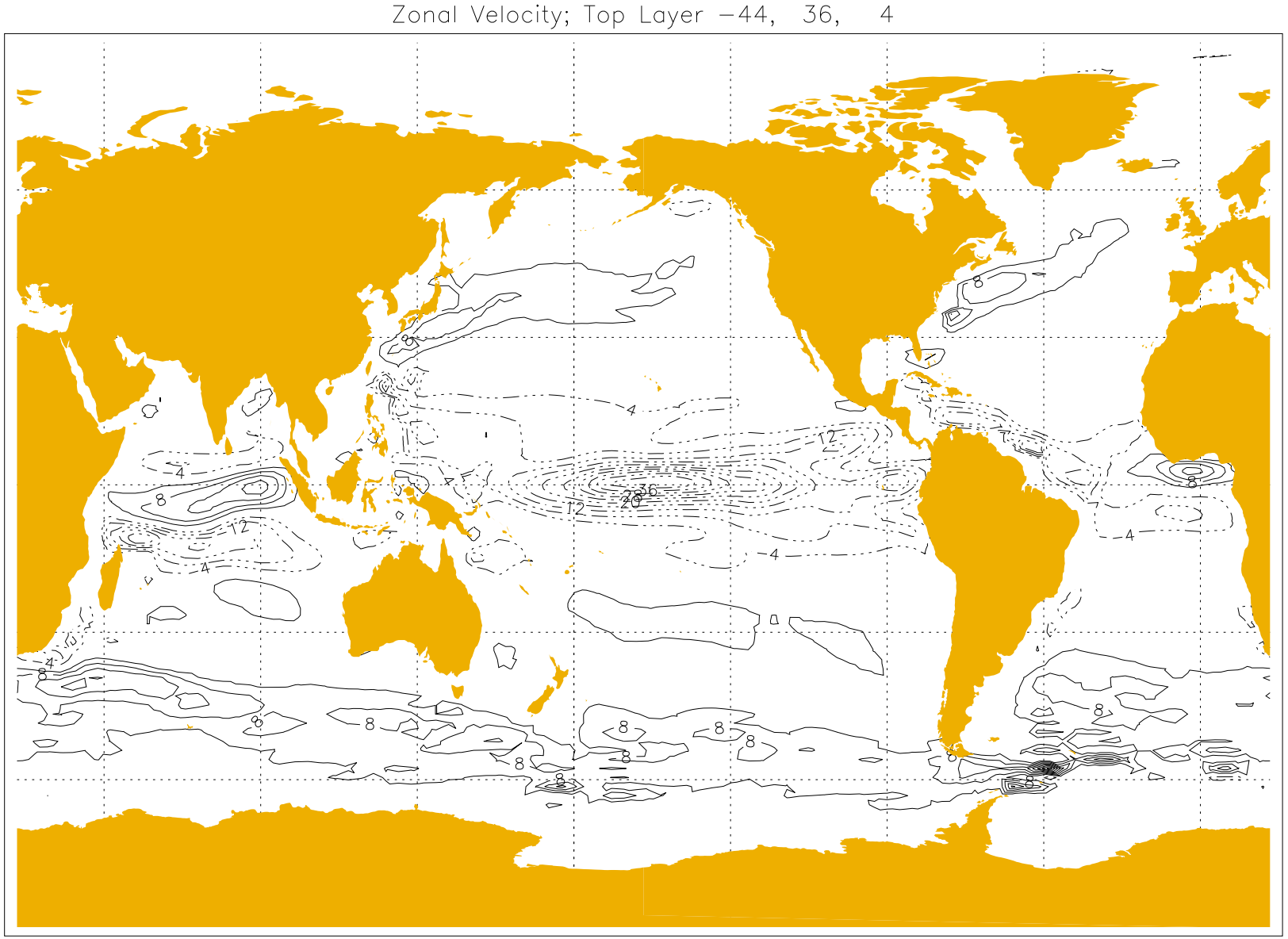
Meridional vel. (veldff=40cm/s; t=450 days)



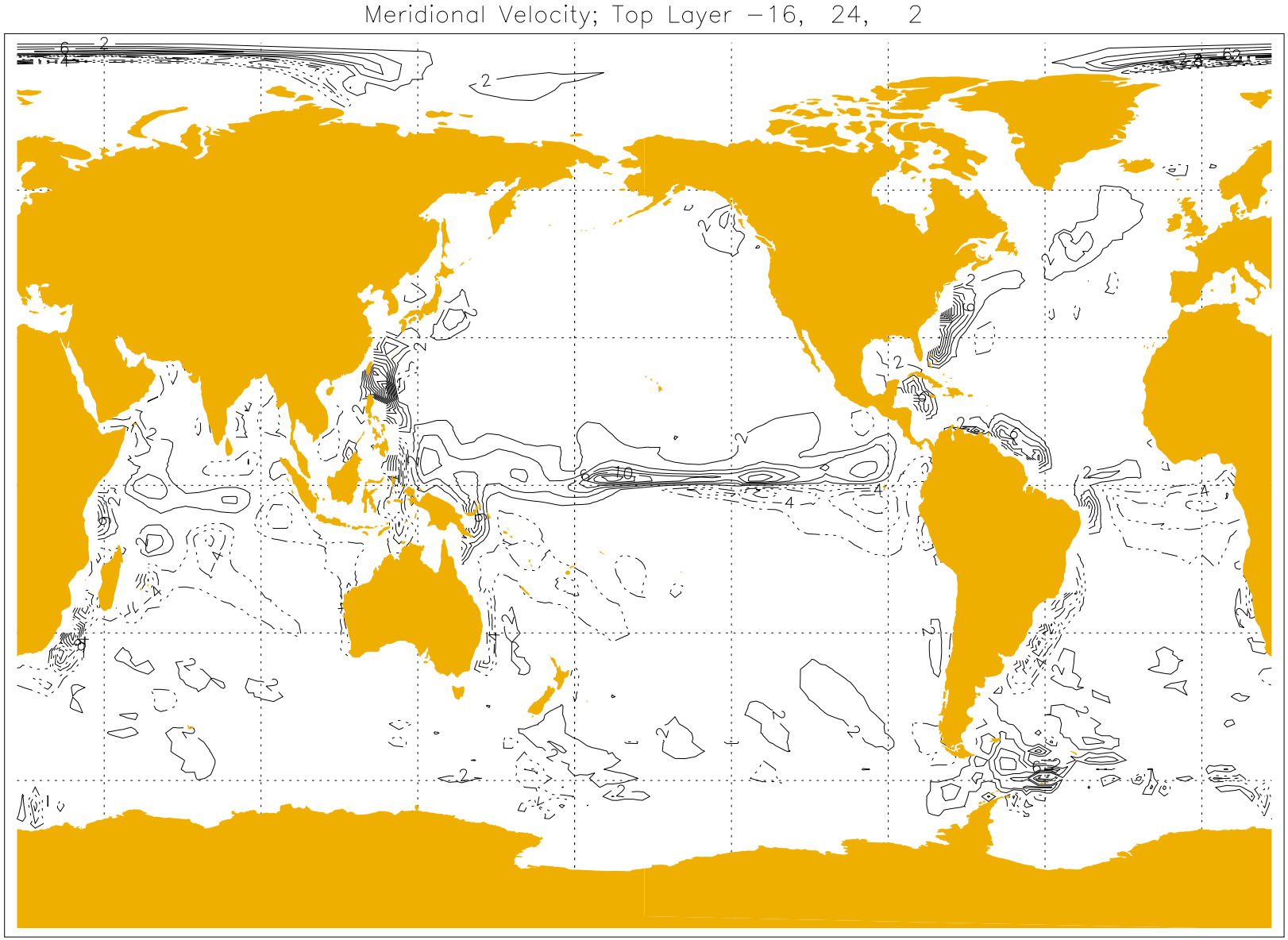
SST: Reduced 2Δx noise (veldff=40cm/s; t=450 days)



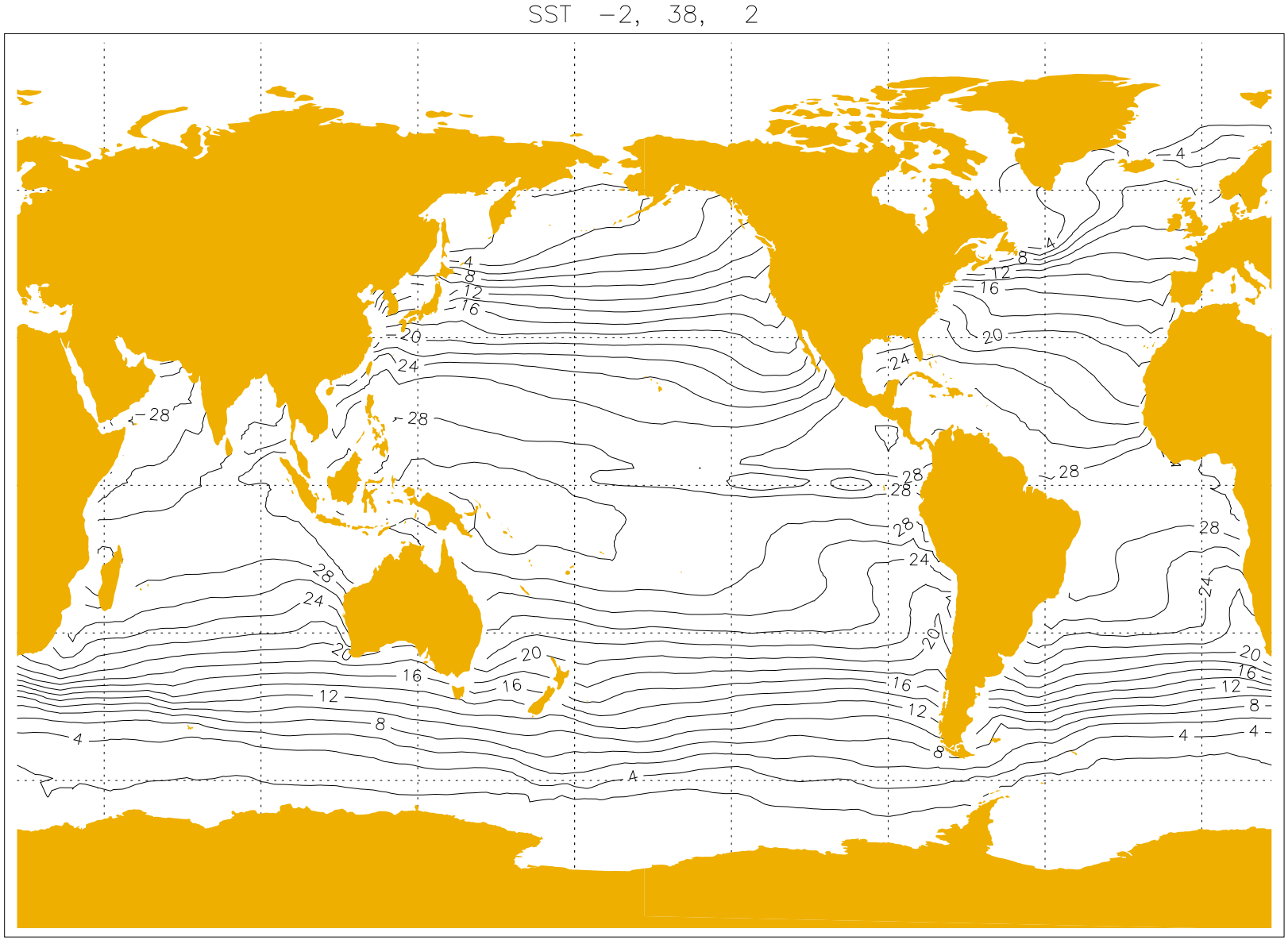
Meridional vel along 35.7^{o} N (veldff=2cm/s and 40cm/s; t=450 days)



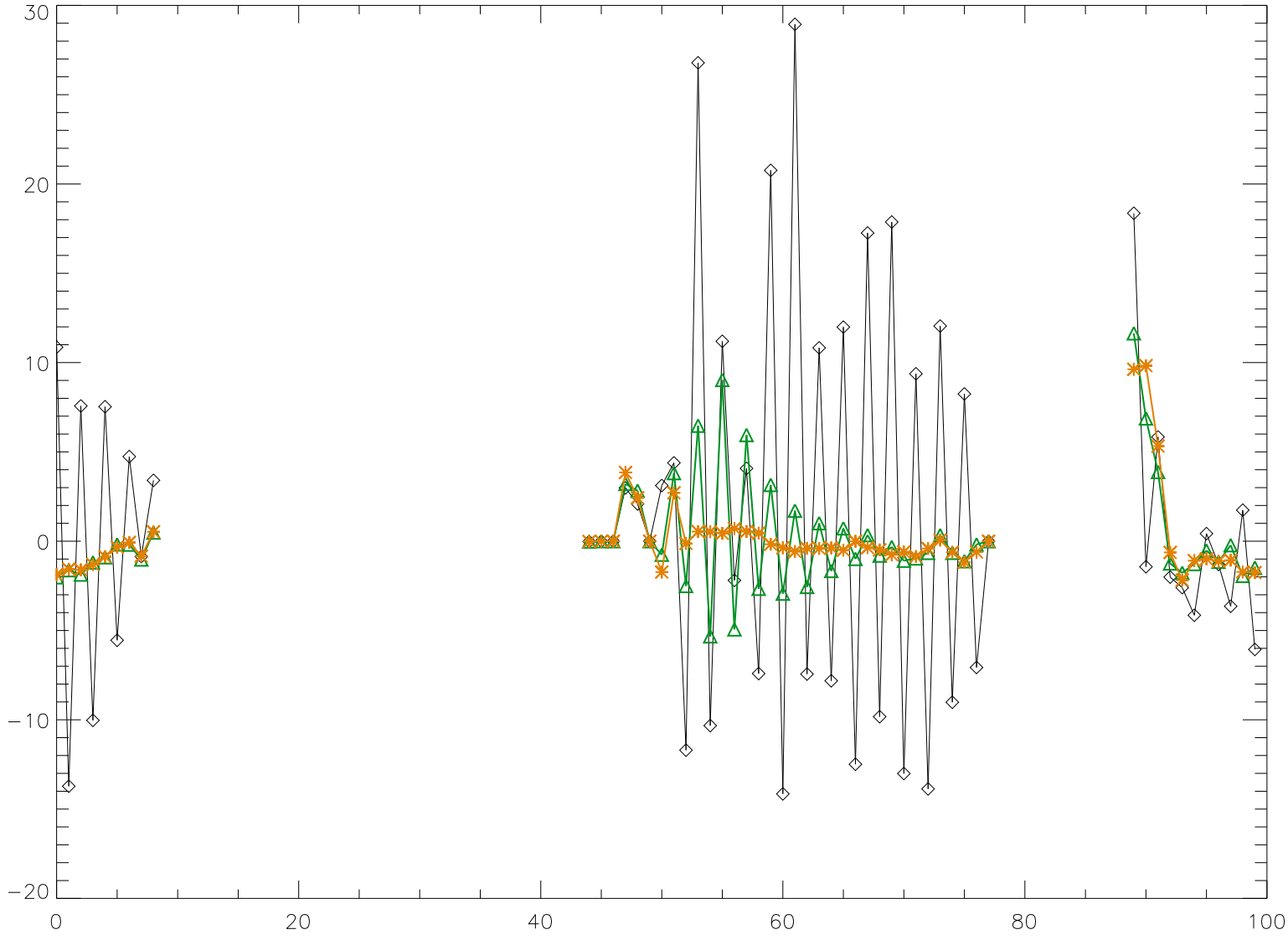
Zonal vel: 2Δy noise (veldff=80cm/s; t=450 days)



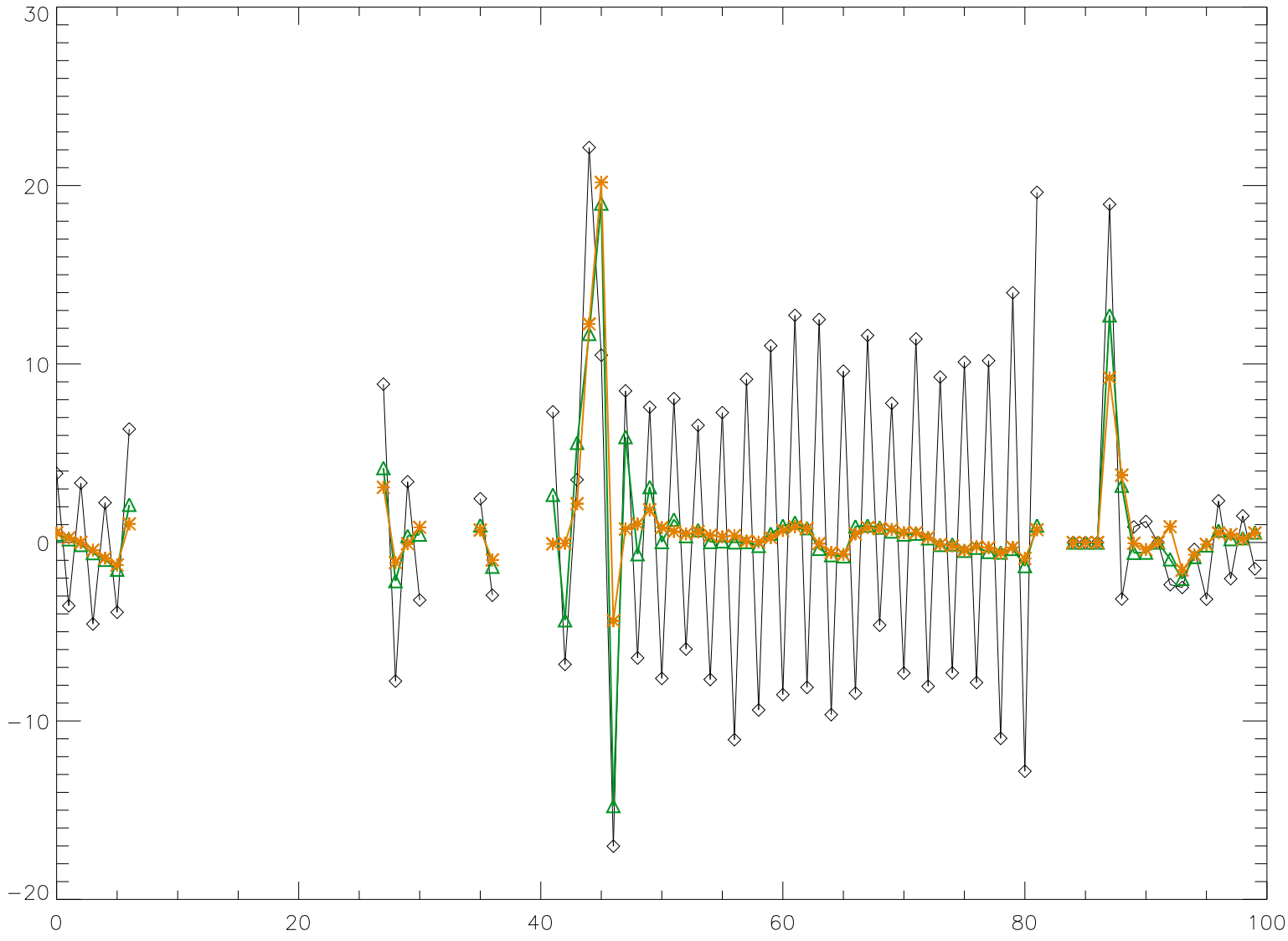
Meridional vel. (veldff=80cm/s; t=450 days)



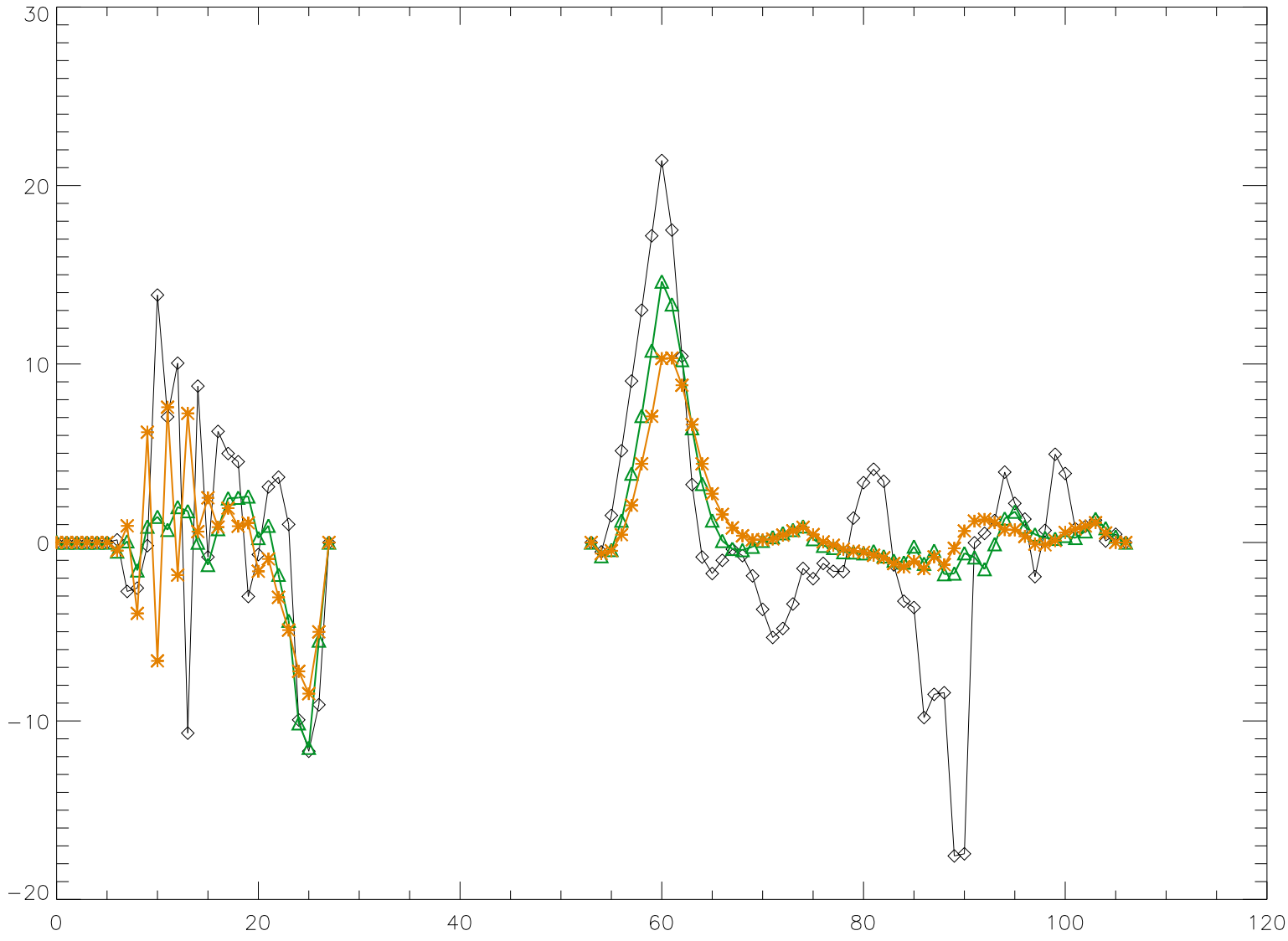
SST: No grid scale osc. (veldff=80cm/s; t=450 days)



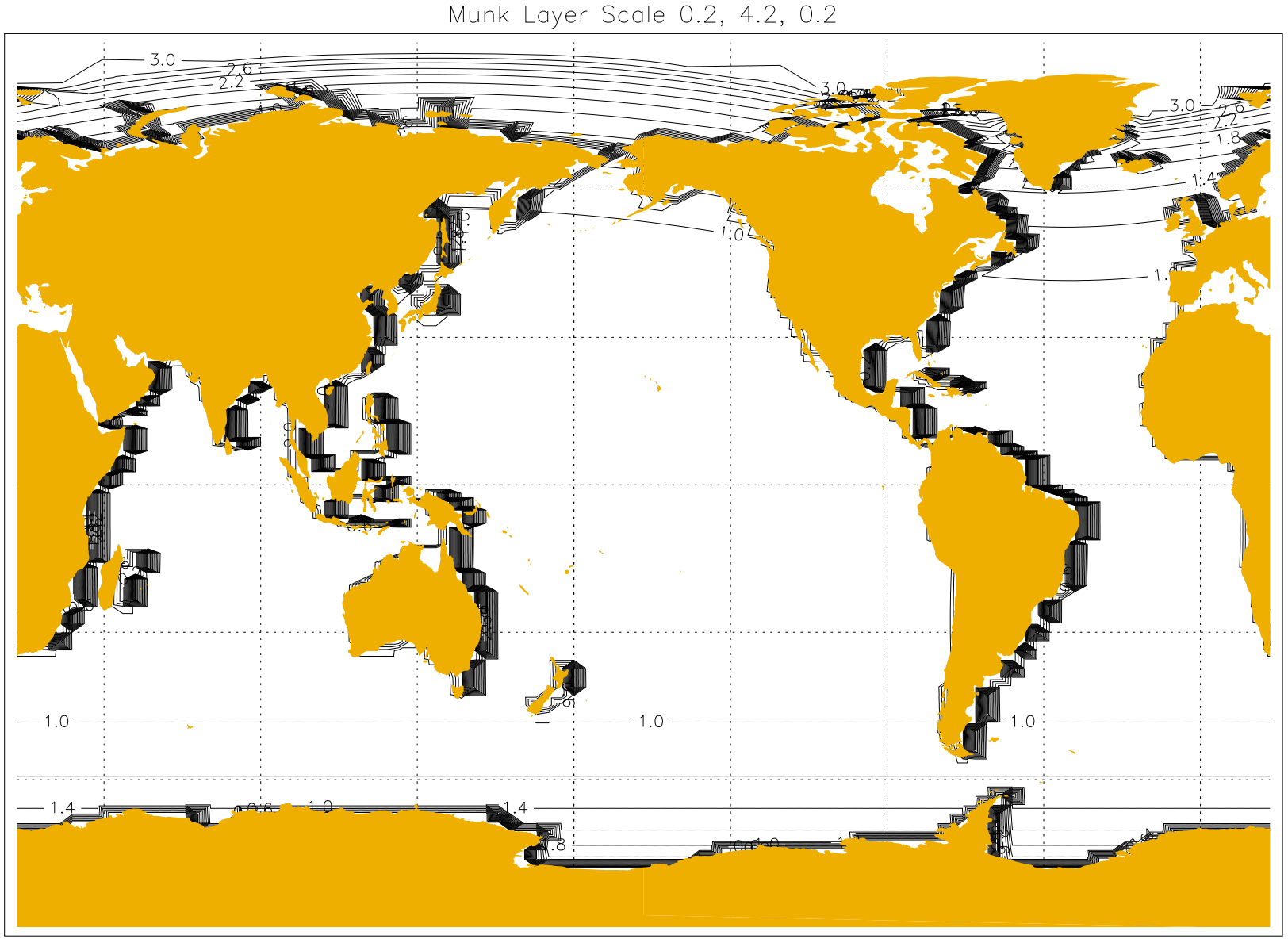
Merid. vel along 35.7^{o} N (veldff=2, 40, and 80cm/s; t=450 days)



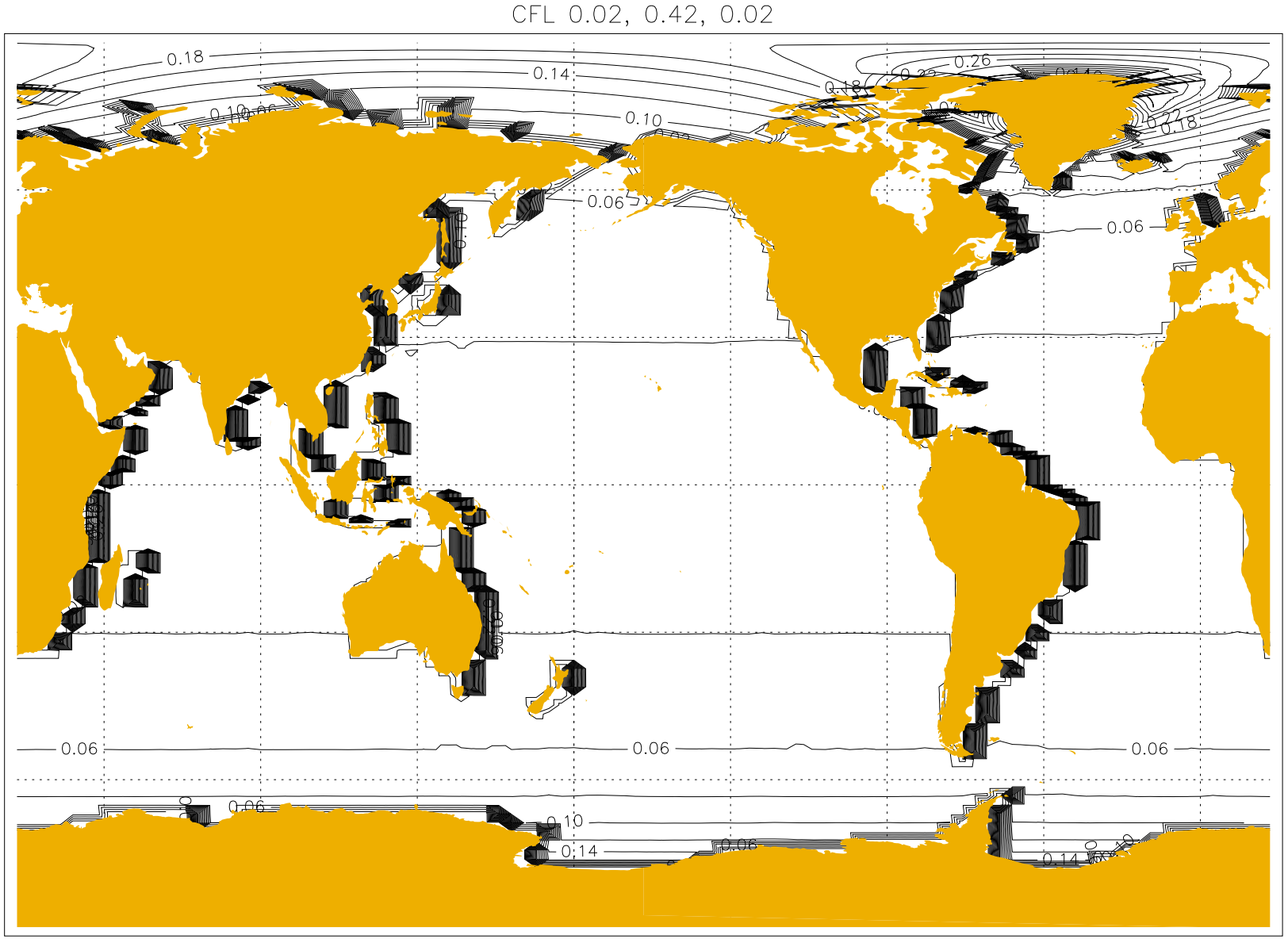
Merid. vel along 19.3^{o} N (veldff=2, 40, and 80cm/s; t=450 days)



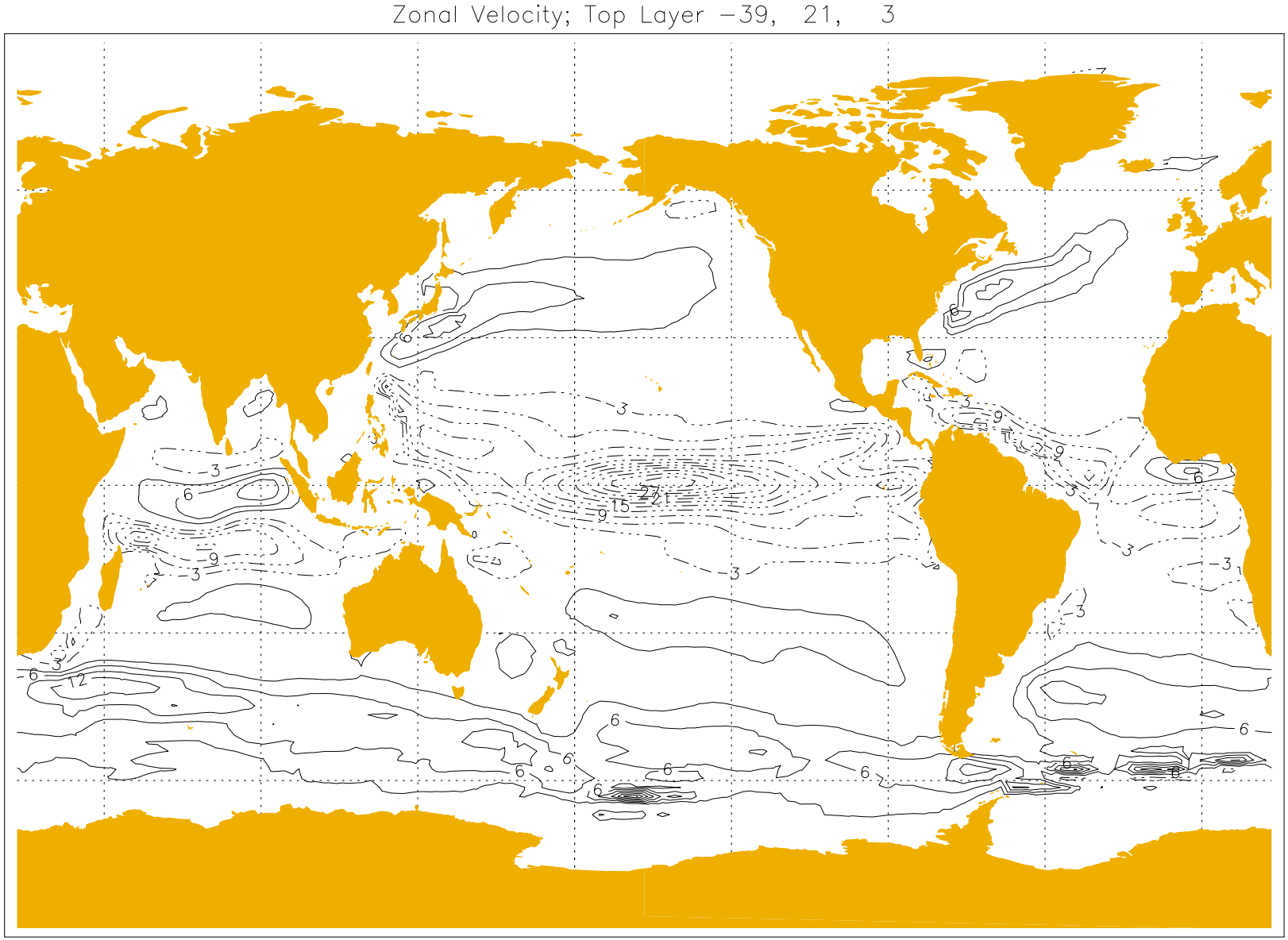
Merid. vel along 313.6^{o} long. (veldff=2, 40, and 80 cm/s; t=450 days)



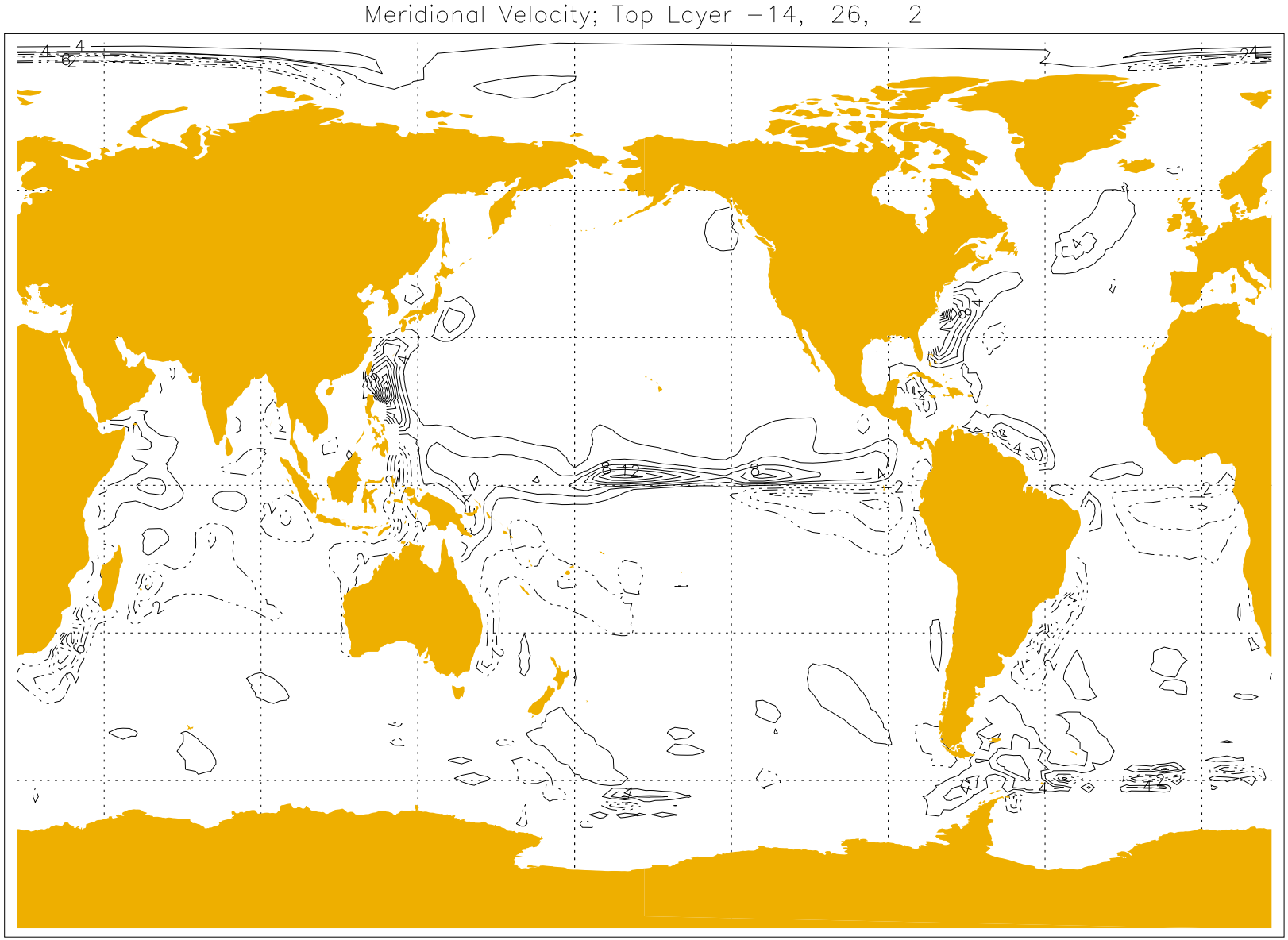
Munk Layer Scale (veldff=80 cm/s; t=450 days)



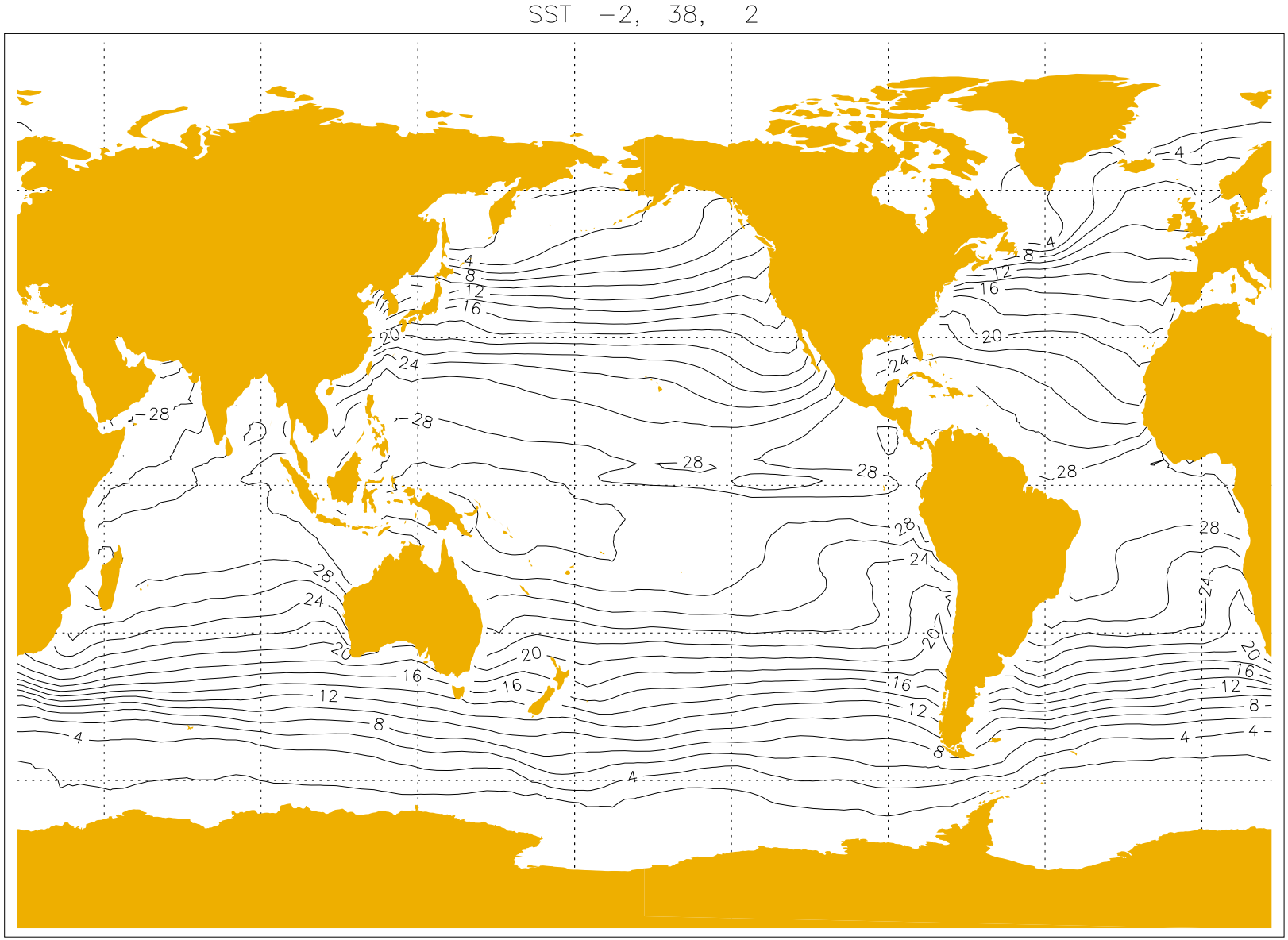
CFL No. (veldff=80 cm/s; t=450 days)



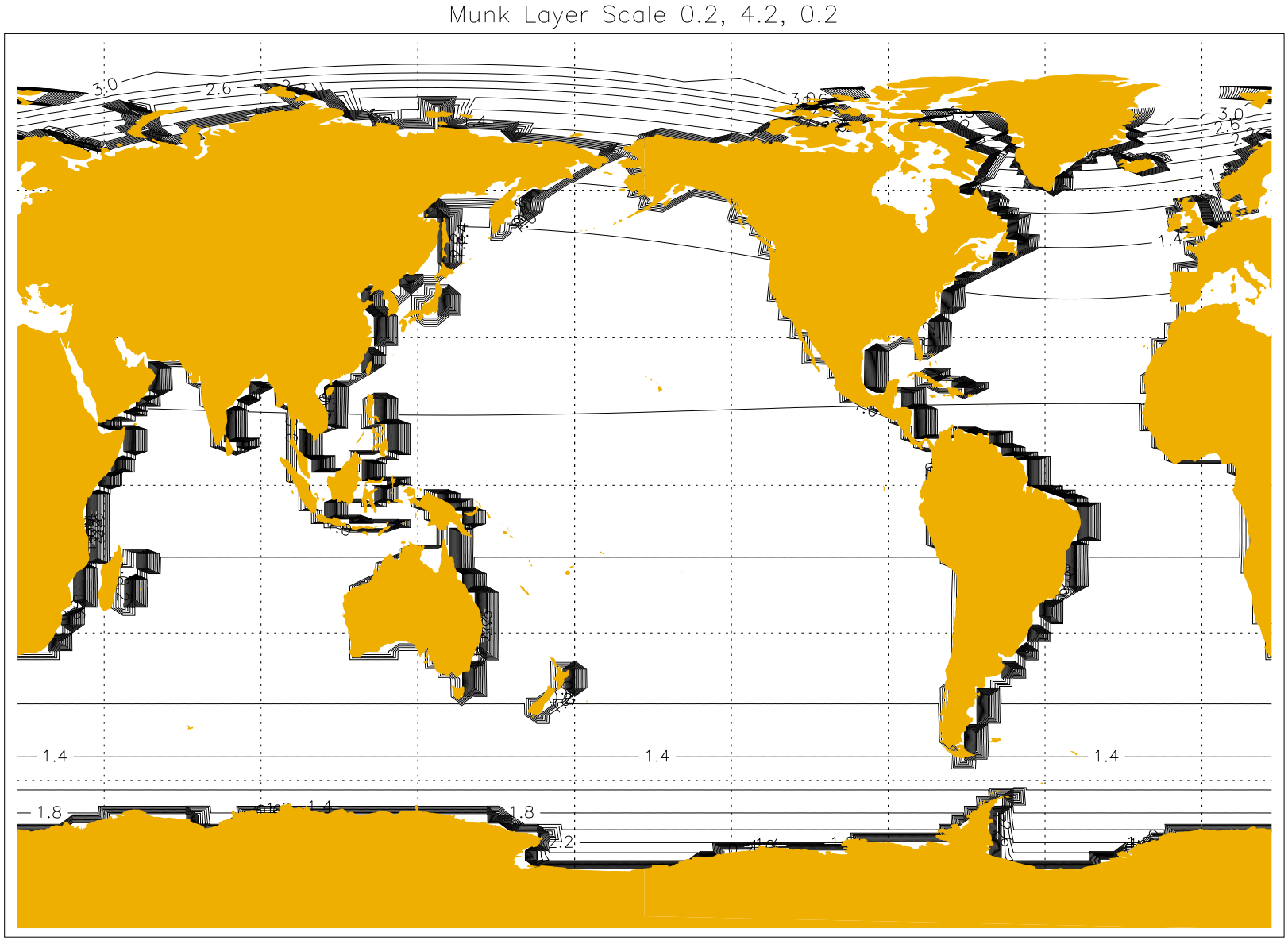
Zonal vel (veldff=160cm/s; t=450 days)



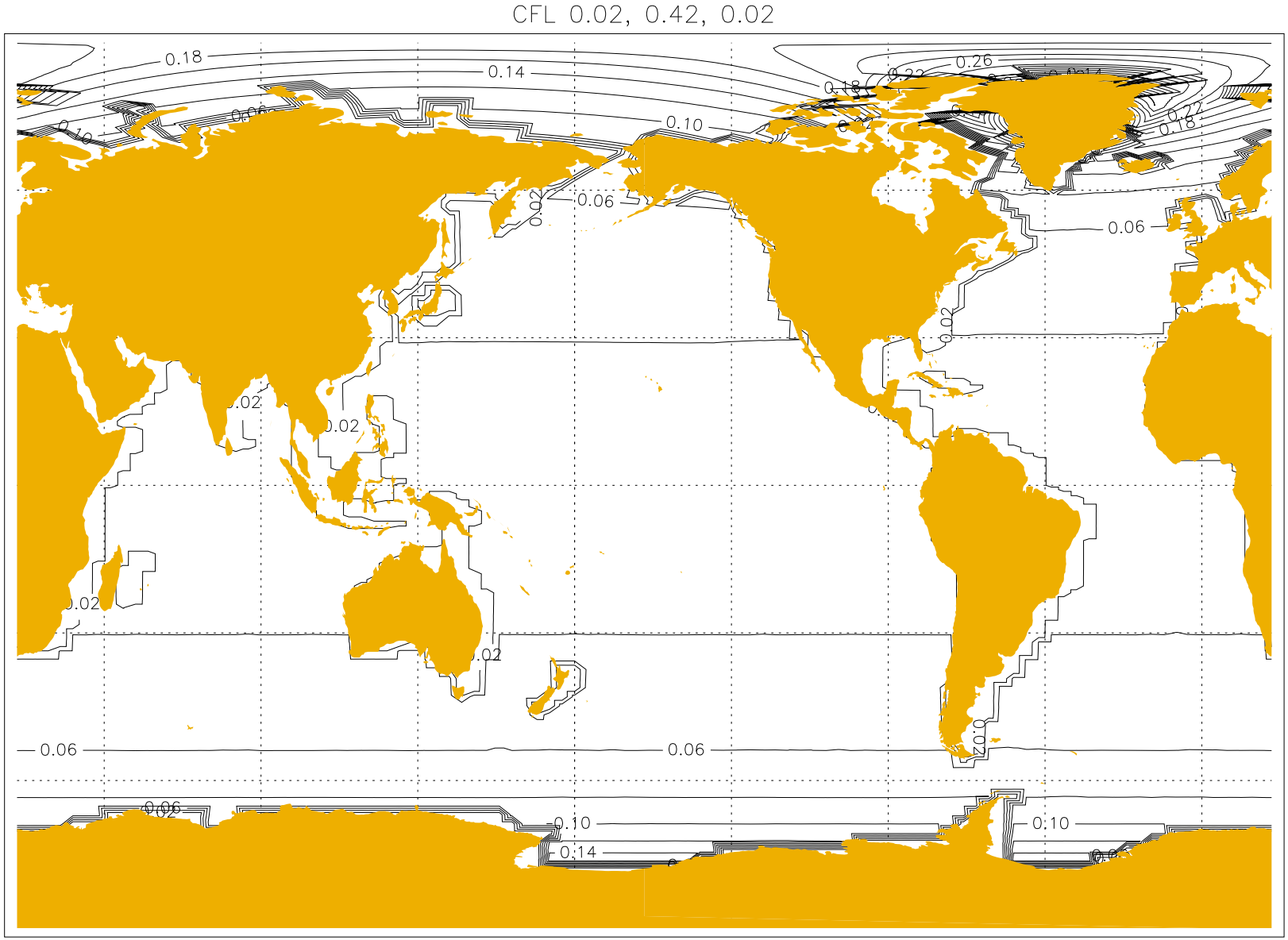
Meridional vel. (veldff=160cm/s; t=450 days)



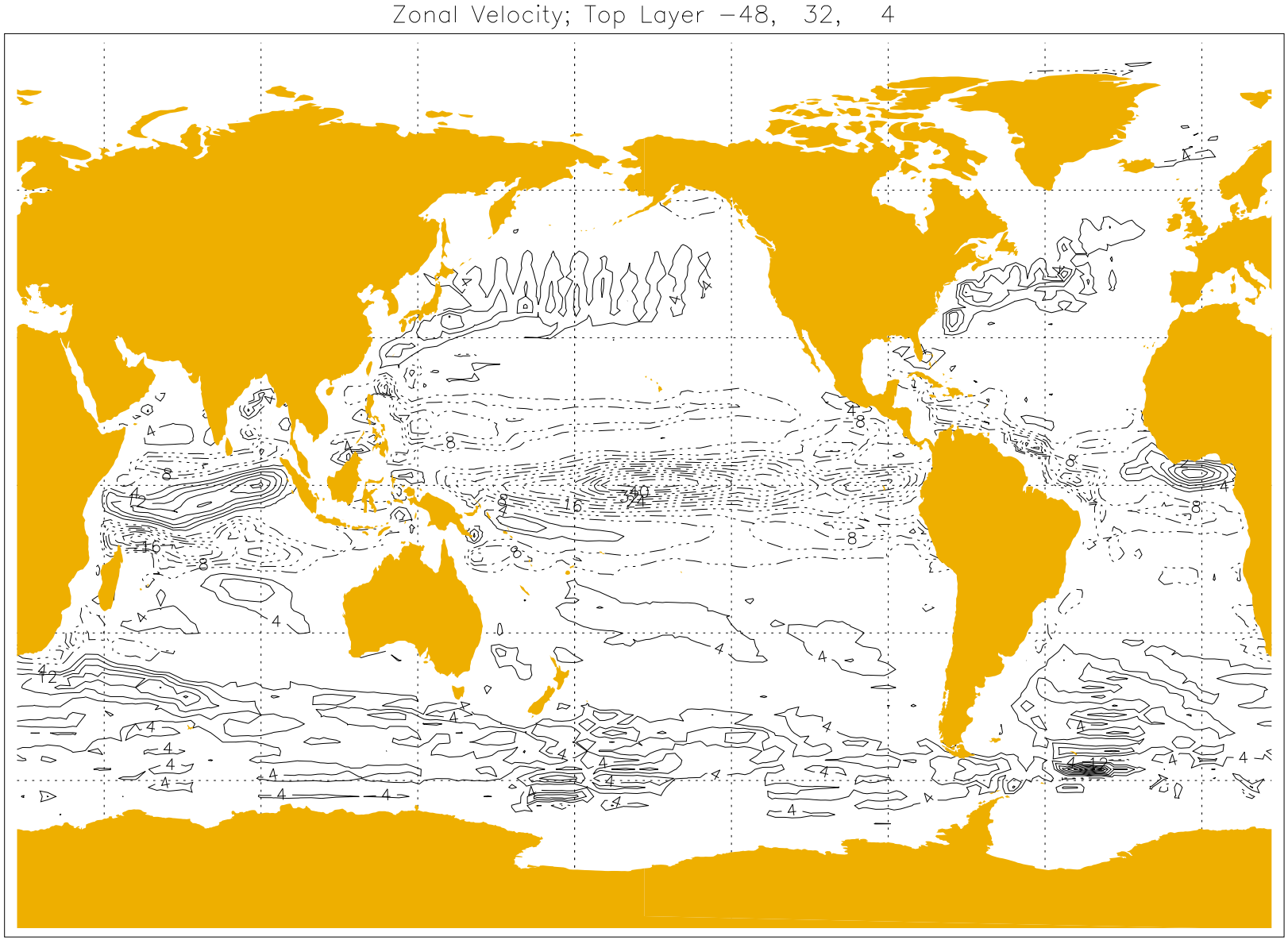
SST: No grid scale osc. (veldff=160cm/s; t=450 days)



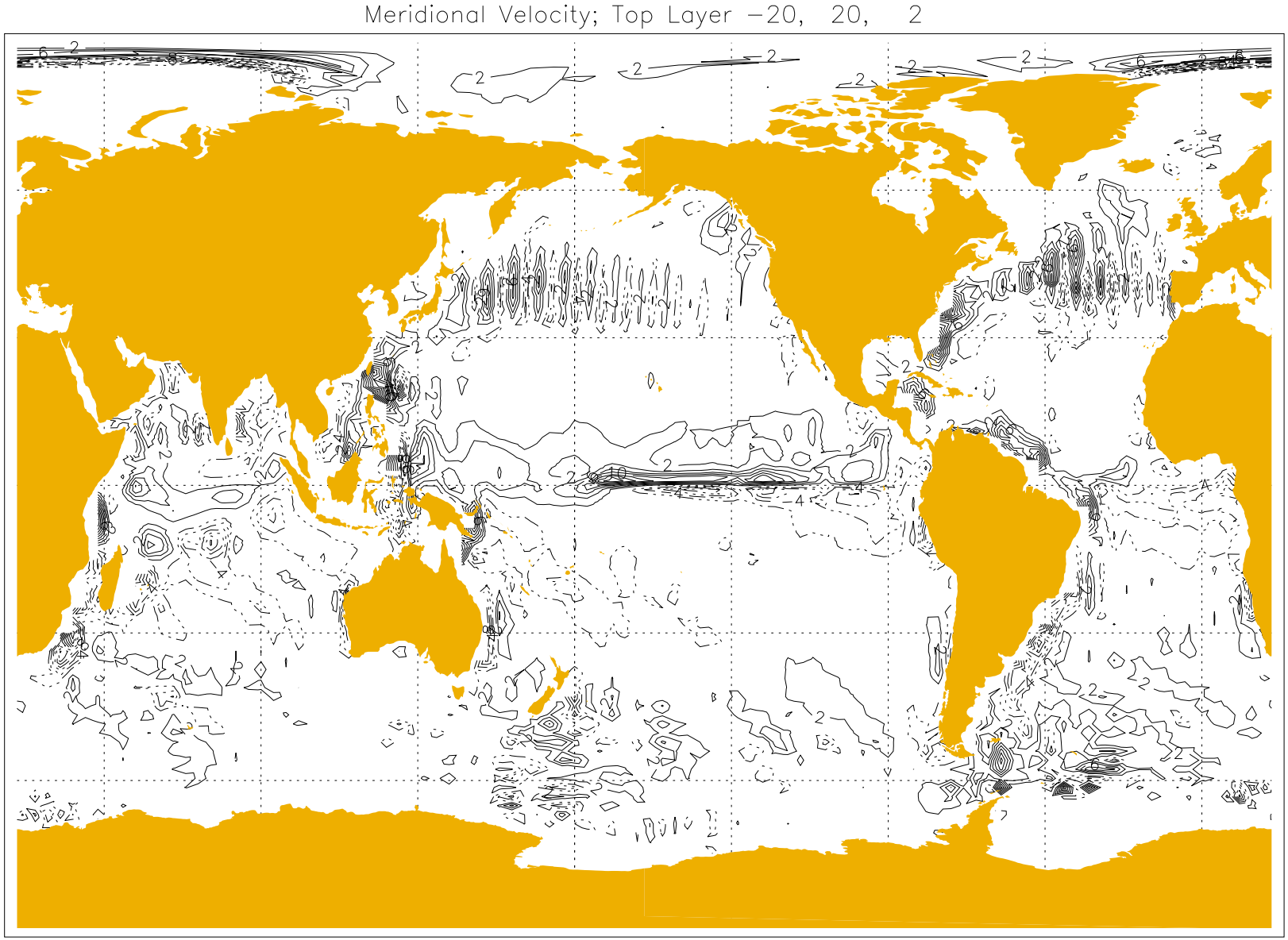
Munk Layer Scale (veldff=160 cm/s; t=450 days)



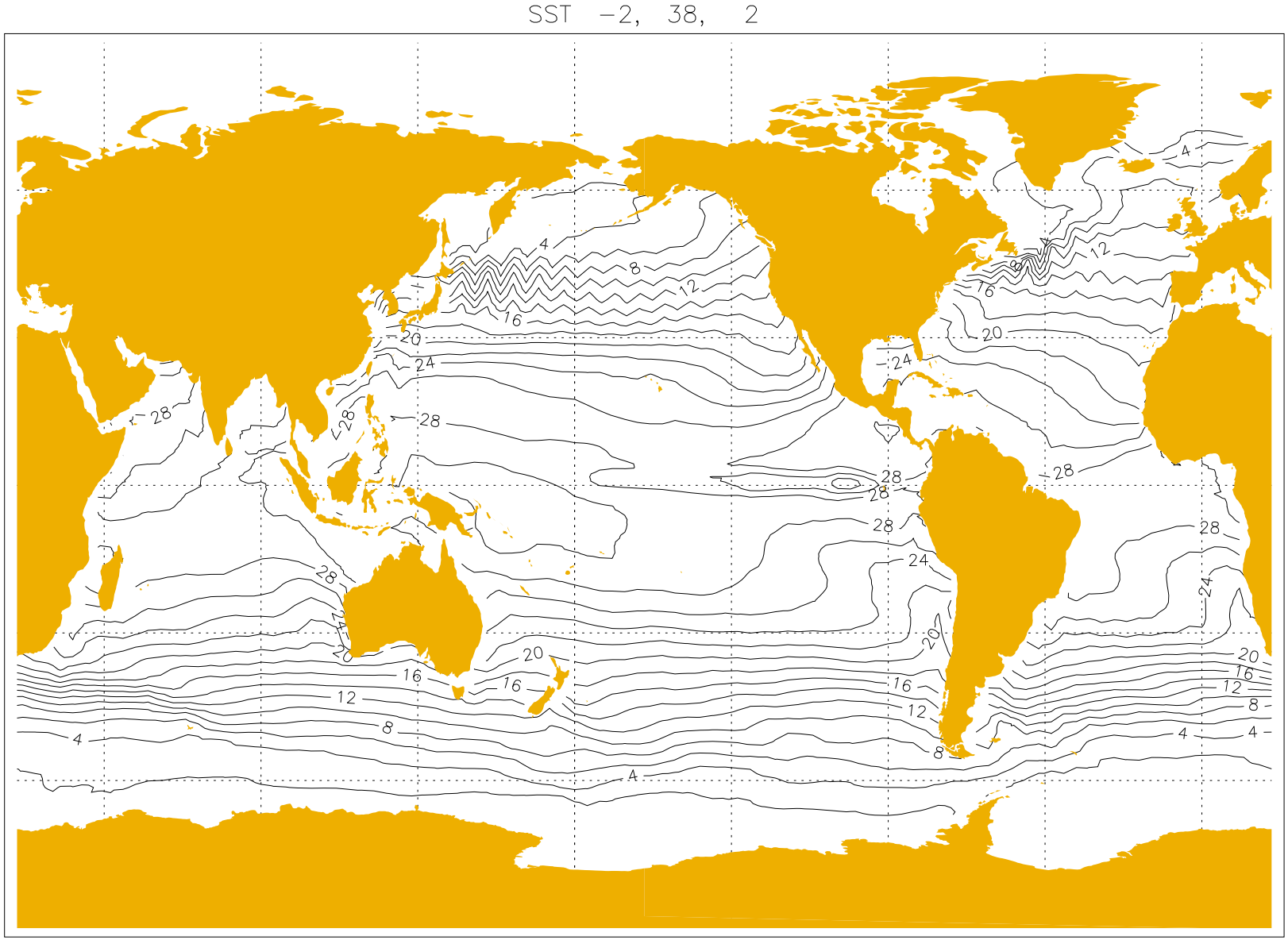
CFL No. (veldff=160 cm/s; t=450 days)



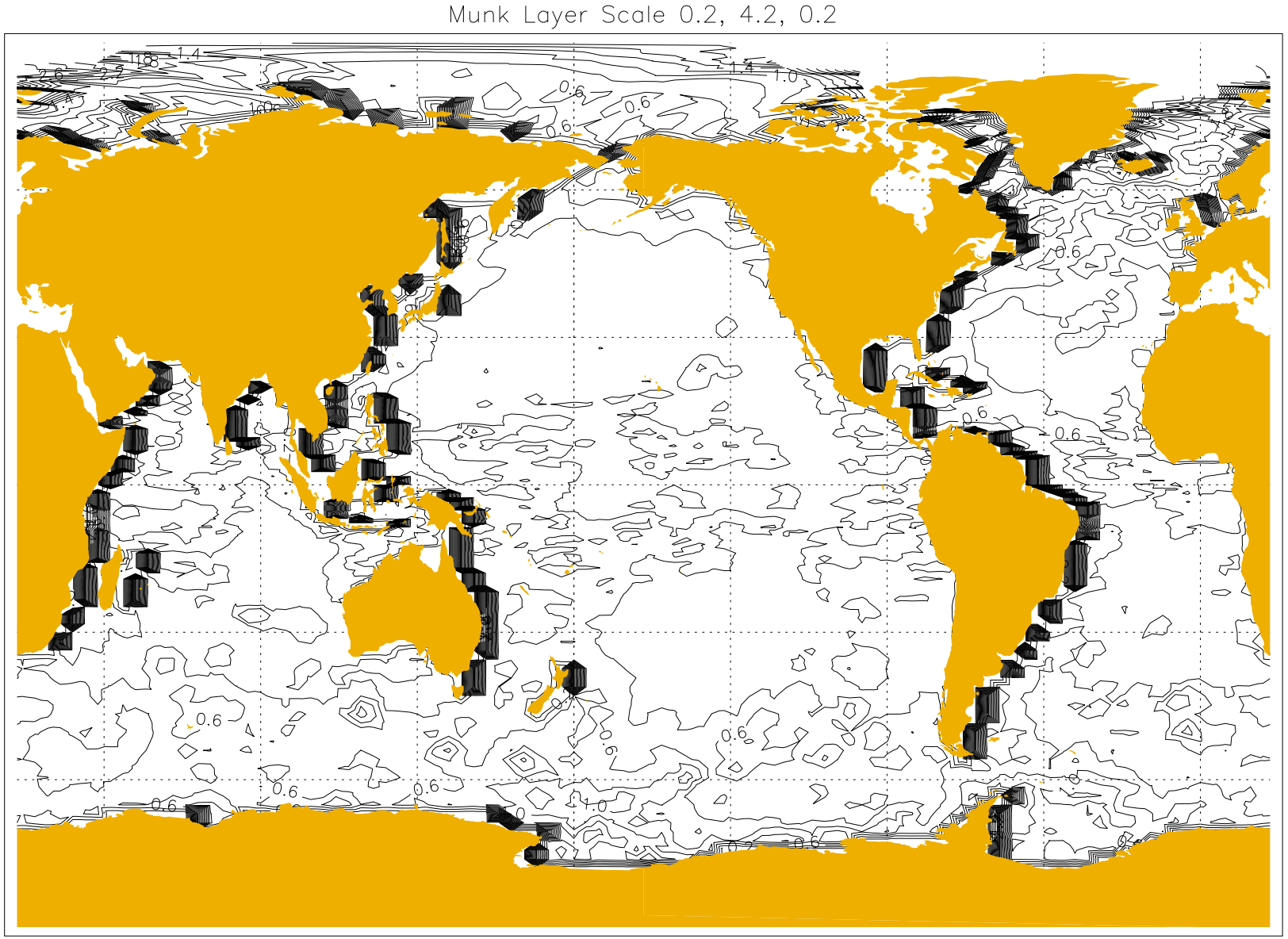
Zonal vel: 2Δy noise (viscos=3.0; t=450 days)



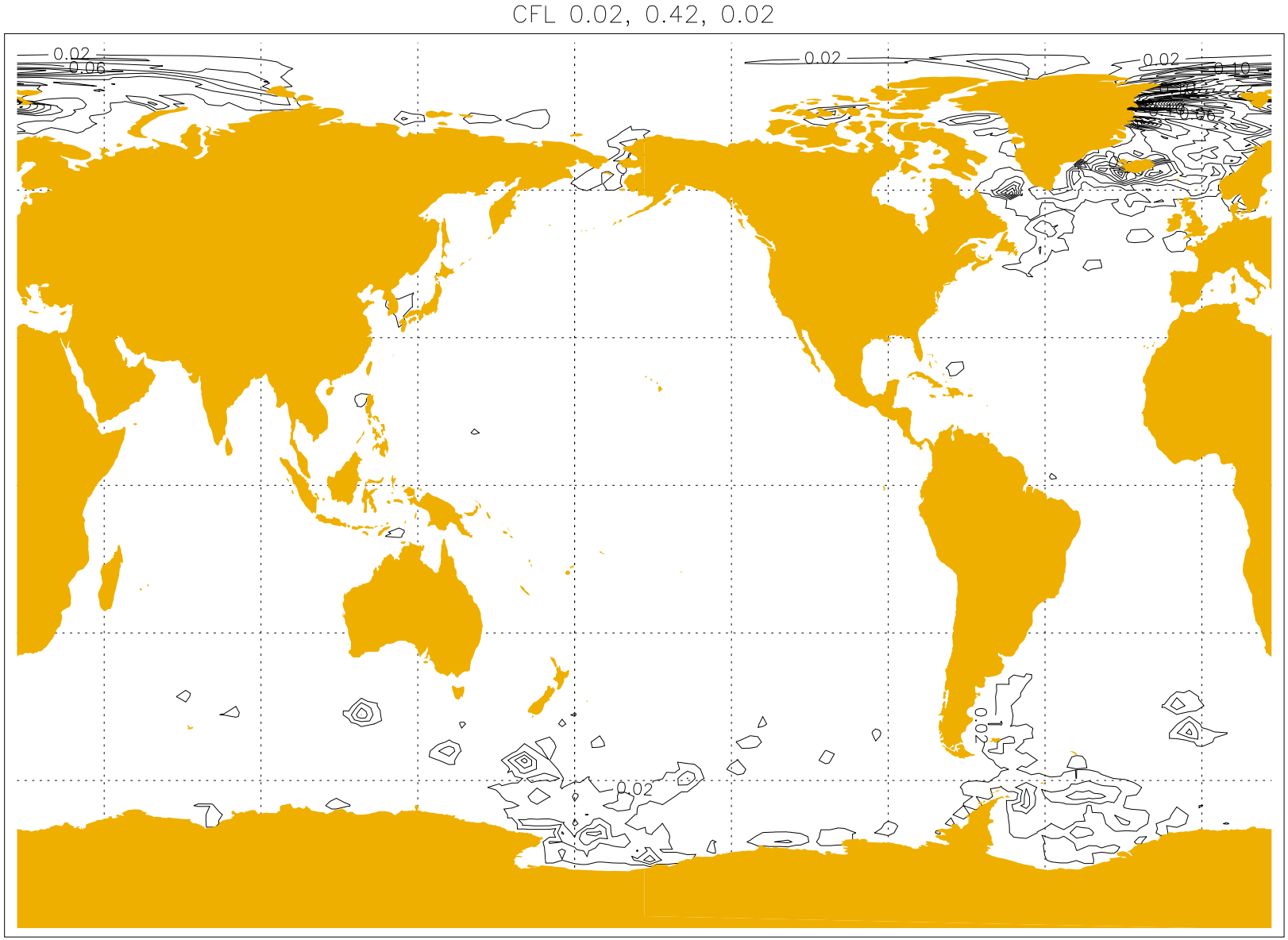
Meridional vel. (viscos=3.0; t=450 days)



SST. (viscos=3.0; t=450 days)



Munk Layer Scale (viscos=3.0; t=450 days)



CFL No. (viscos=3.0; t=450 days)

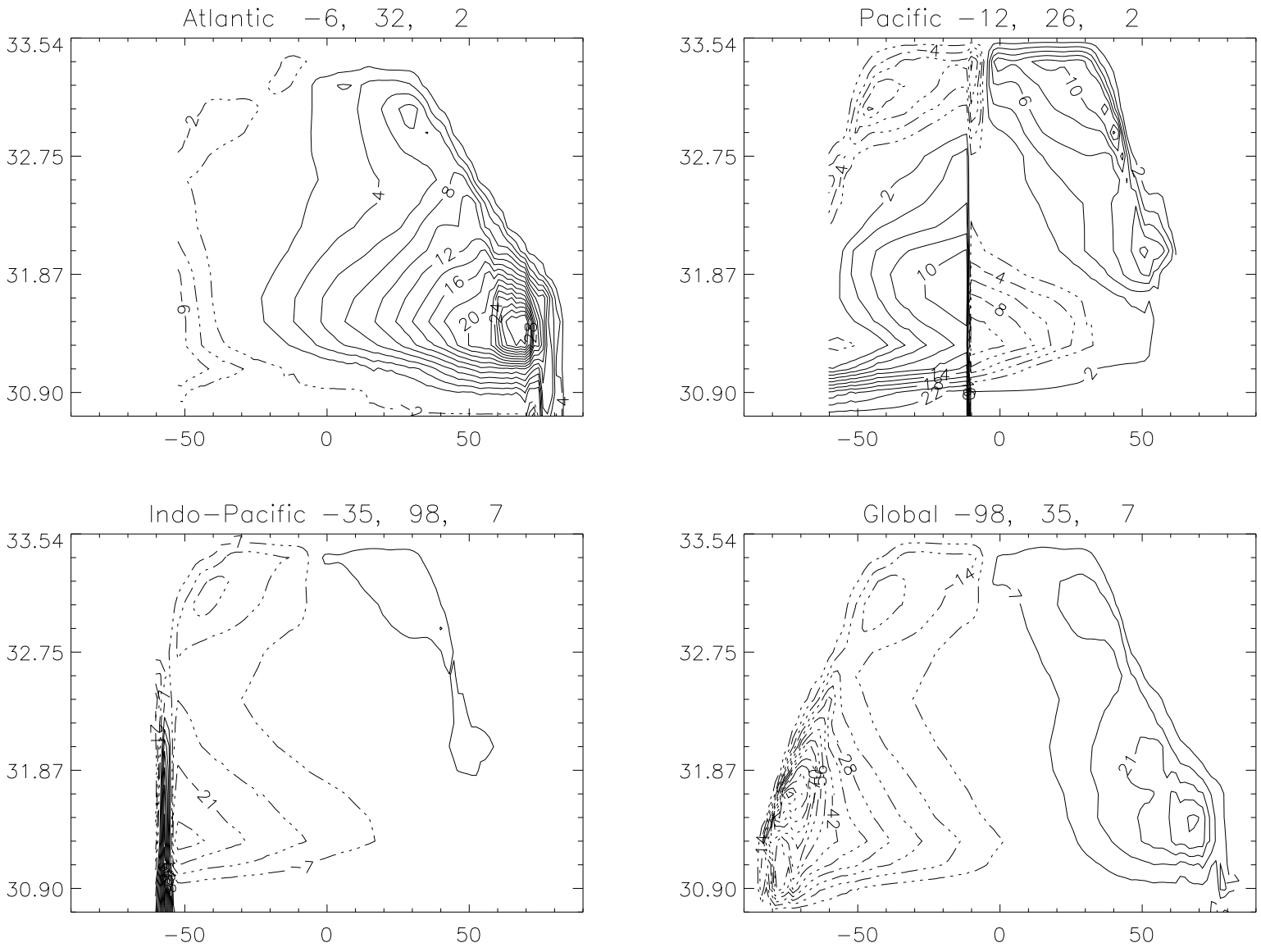
veldff (cm/s)	2	40	80	160	2
viscos	0.3	0.3	0.3	0.3	3.0
CFL #	0.15	0.36	0.36	0.35	0.47
Re_g	6.5	1.2	0.5	0.2	1.4
$\frac{L_M}{\Delta x}$	0.24	0.64	0.81	1.01	0.24

Summary

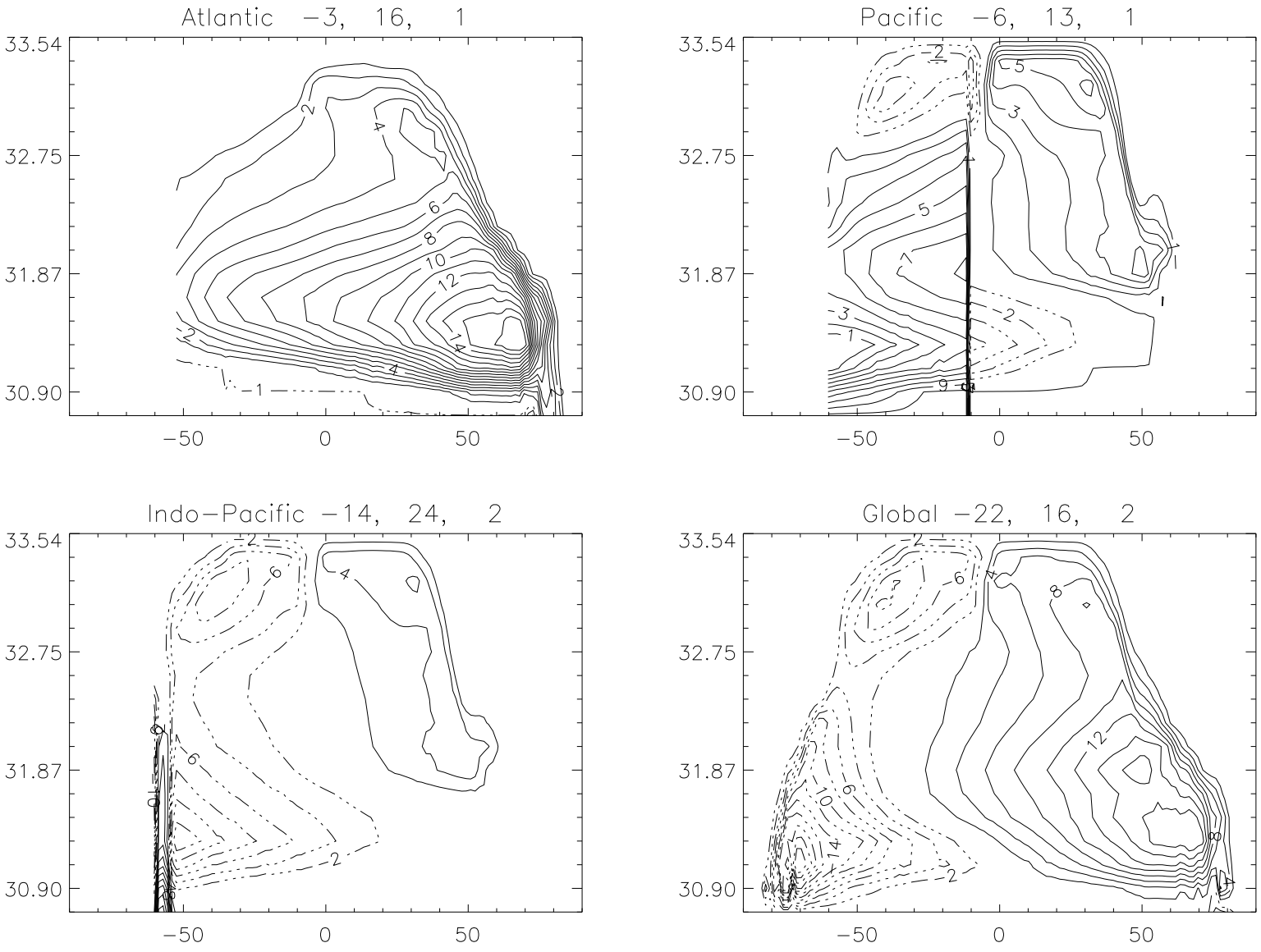
- Investigating sources of grid scale oscillations in MICOM (HYCOM dynamical core similar to that of MICOM)
- Major contributor: Non-resolution of viscous boundary layer
- Increasing viscosity with concomitant decreases in Δt works
- Increasing Smagorinsky coefficient does not seem to work

Summary

- What is causing the remnant grid scale oscillation?
  - Topography
  - Null Space of Differential Operators
  - Averaging in Coriolis Terms (C-grid)
  - Barotropic-baroclinic splitting
- What are the implications of the grid scale oscillation on
  - Surface Fluxes that drive THC
  - Heat transport
  - Meridional overturning circulation



veldff=2 cm/s. Noisy SST



veldff=80 cm/s. MOC more realistic