POP Vertical Grids for CCSM 4.0

- Suite of uncoupled & coupled vertical grid sensitivity experiments will help inform the choice of CCSM4 POP vertical grid(s)
- facilitated by new topography_opt = ‘bathymetry’ option (runtime vertical grid selection)
- Test beds:

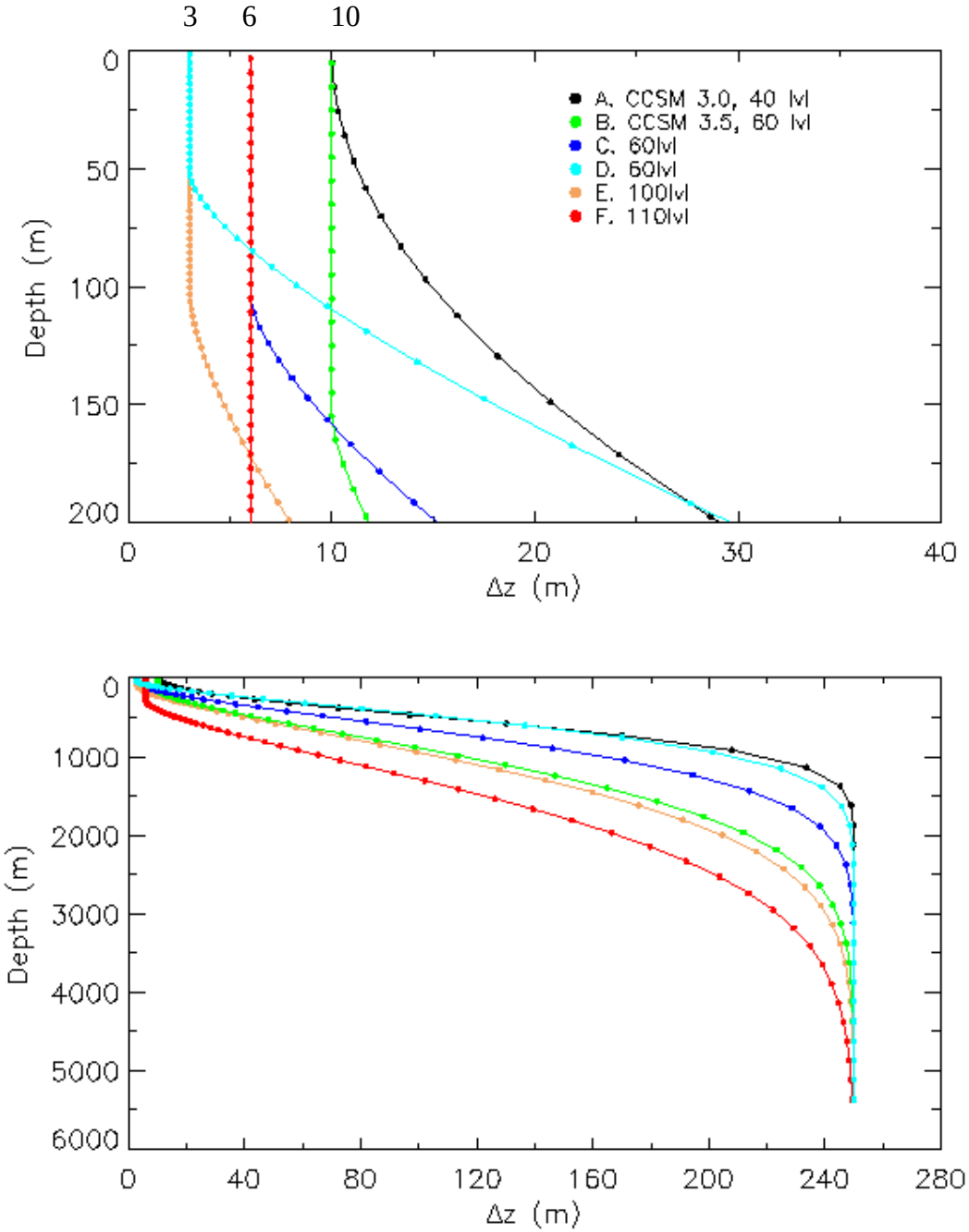
I. Ocean alone: 1° POP forced with repeat 2000 NCEP/GISS/0.5°QSCAT

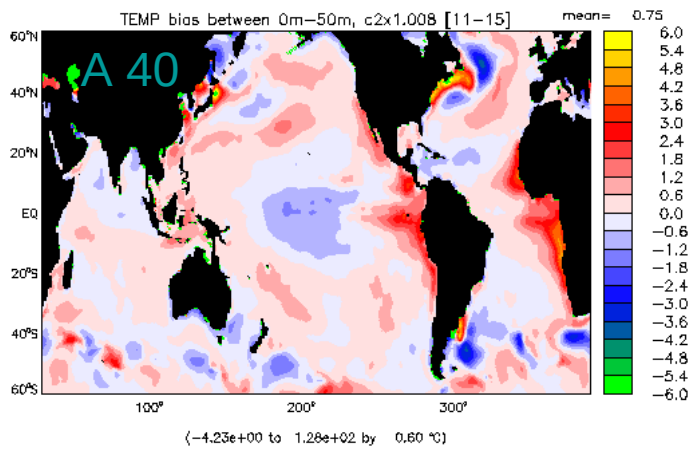
II. Fully coupled (ccsm3_5_beta12)

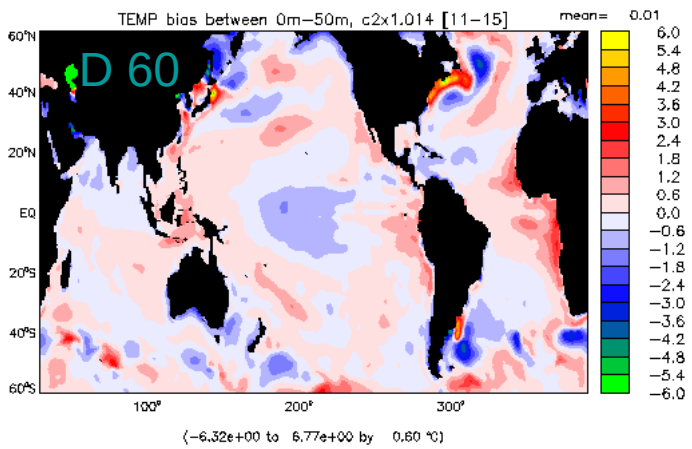
III. Ocean alone with BGC

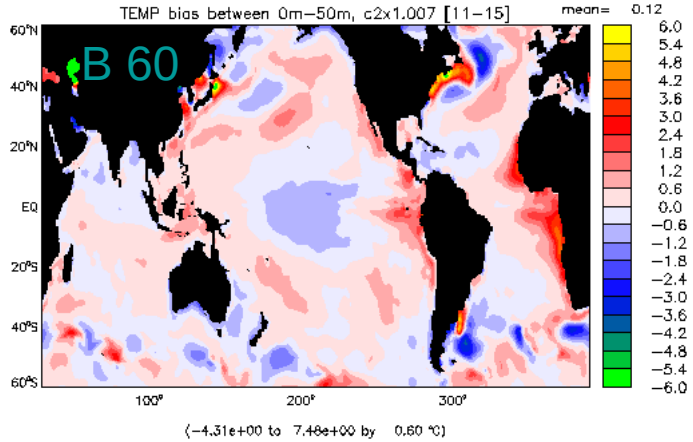
IV. Fully coupled with BGC

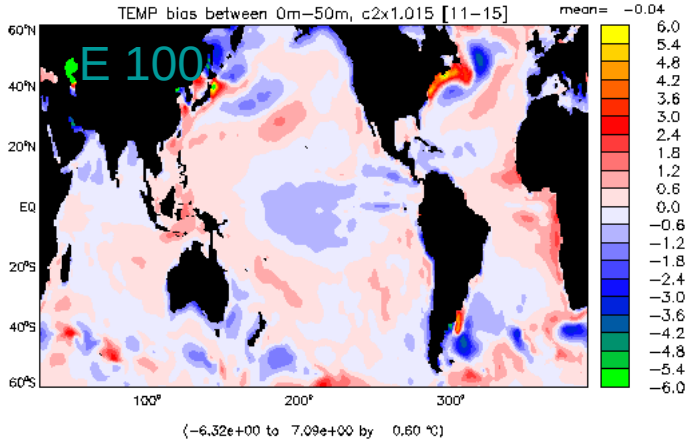
Vertical Grid

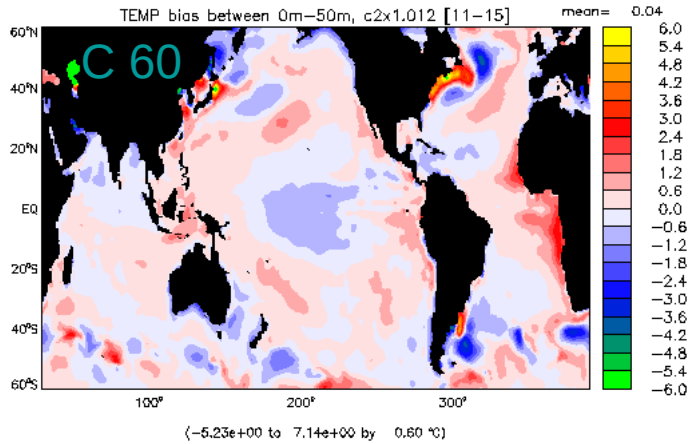


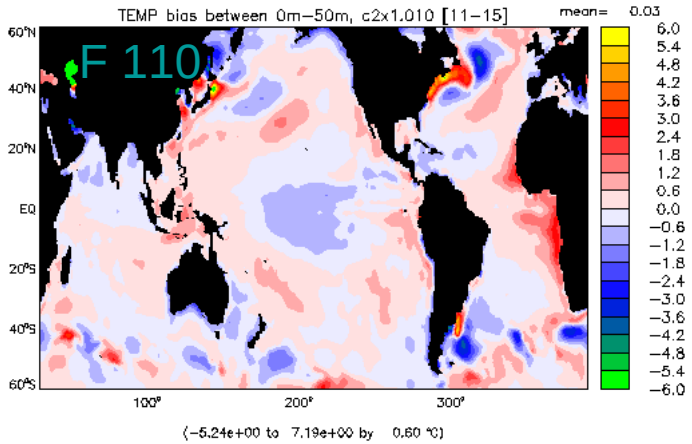




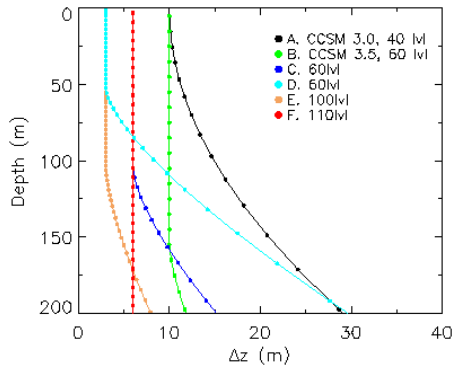




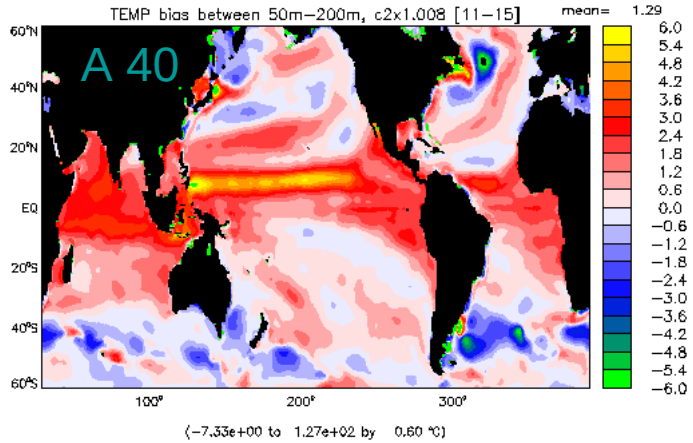


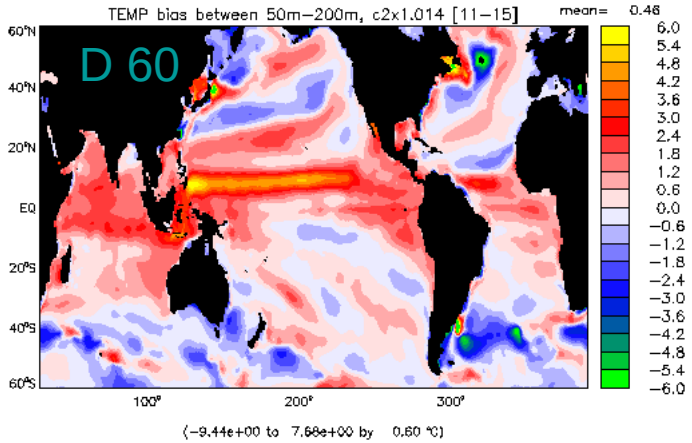


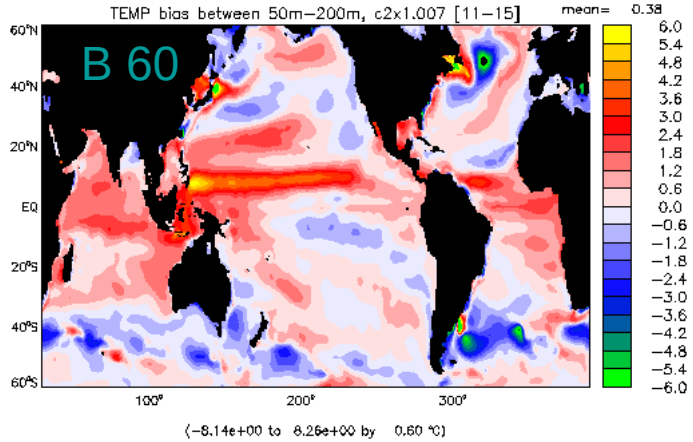
Mean T' 0m-50m

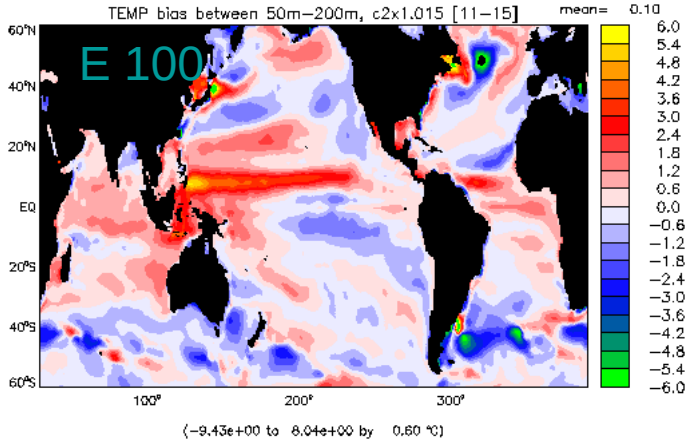


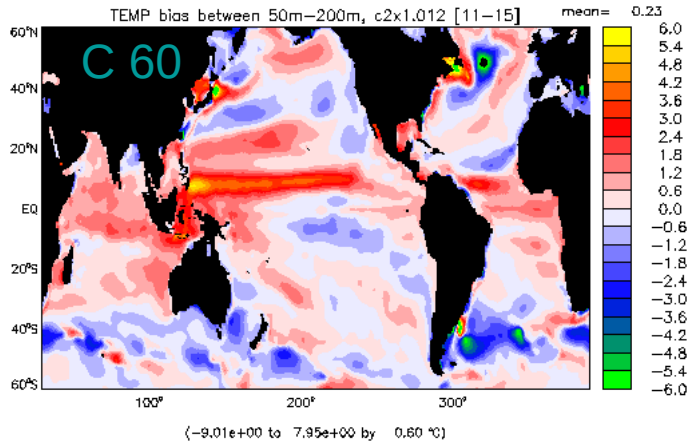
1. E 100
2. F 110, C60, D 60
3. B 60
4. A 40

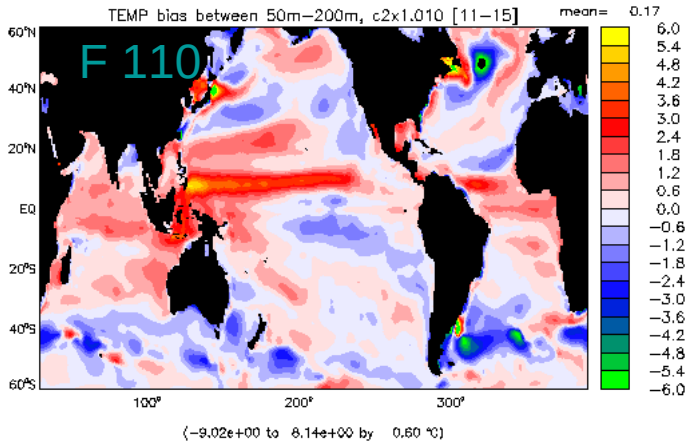




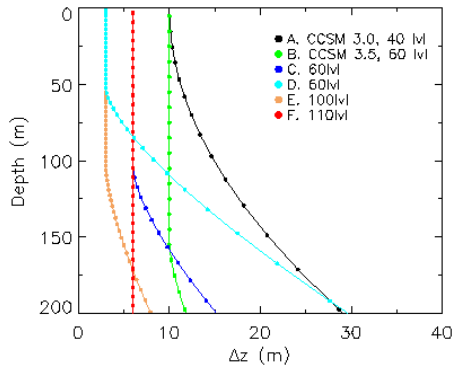




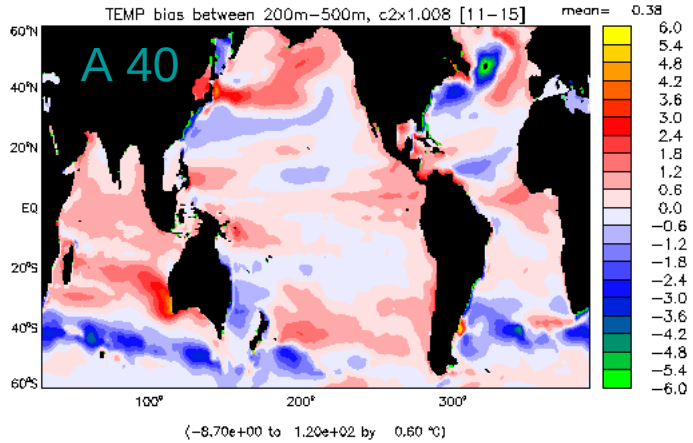


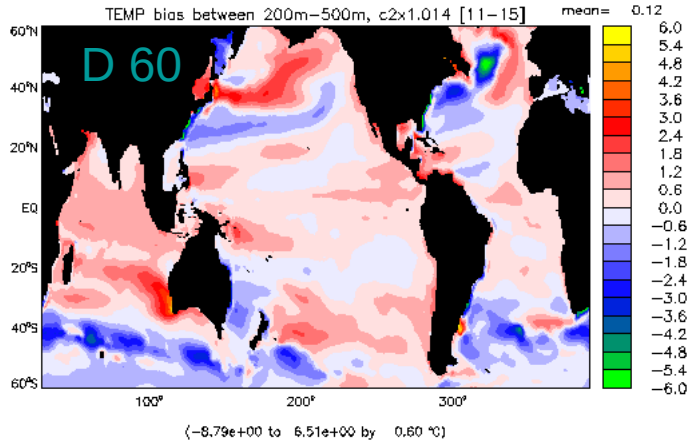


Mean T’ 50m-200m

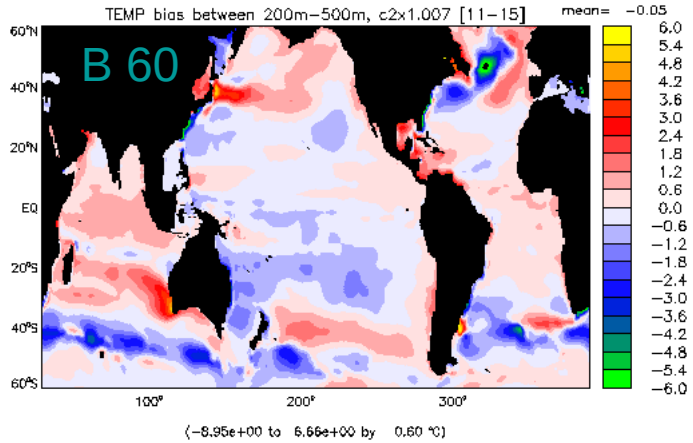


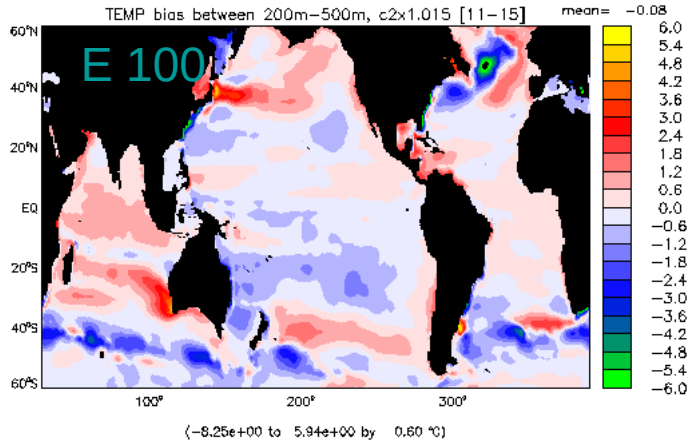
1. E 100, F 110
2. C60
3. B 60
4. D 60
5. A 40

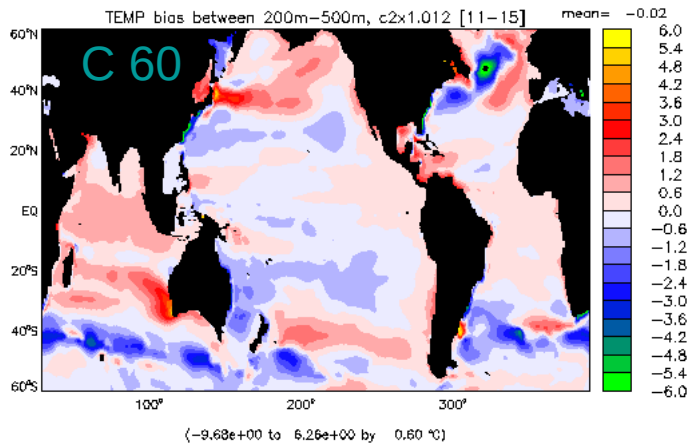


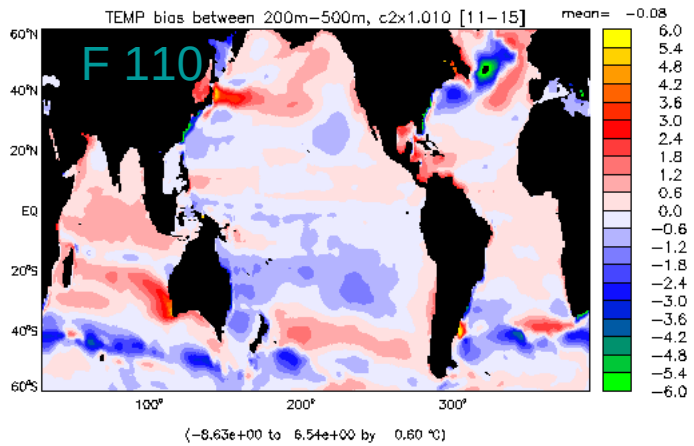


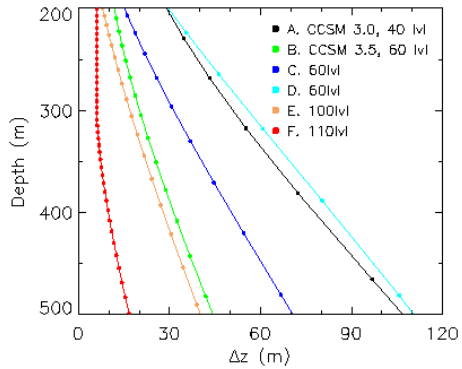
Mean T' 200m-500m





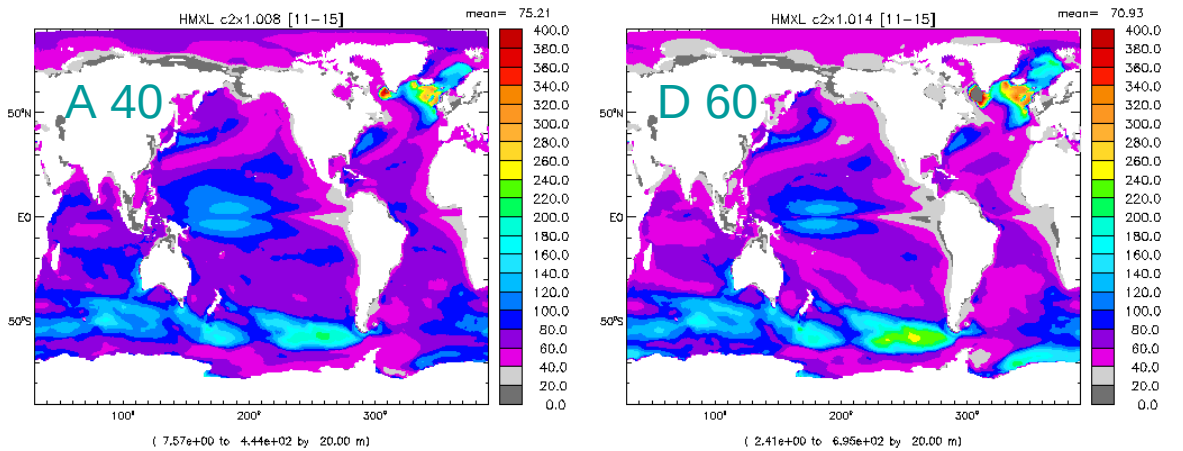


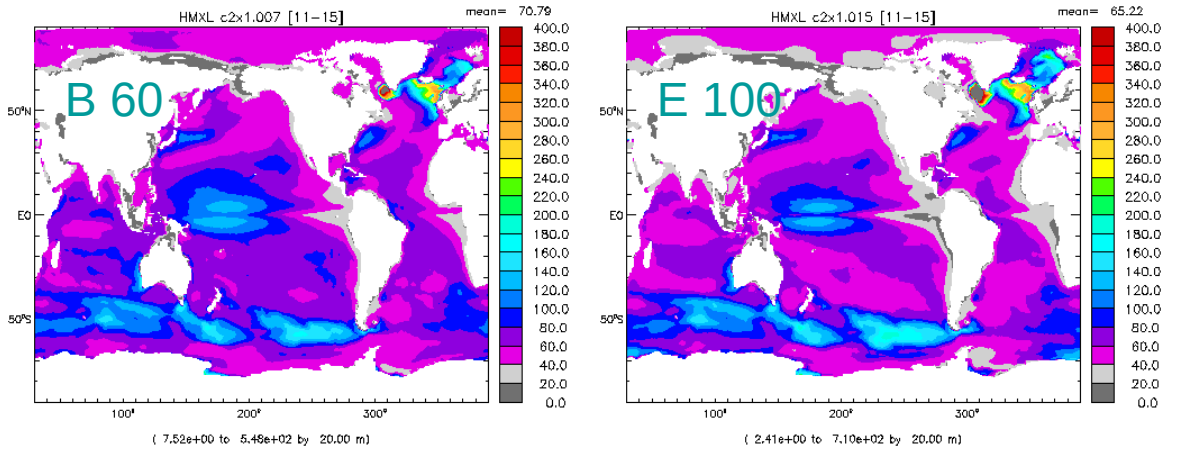


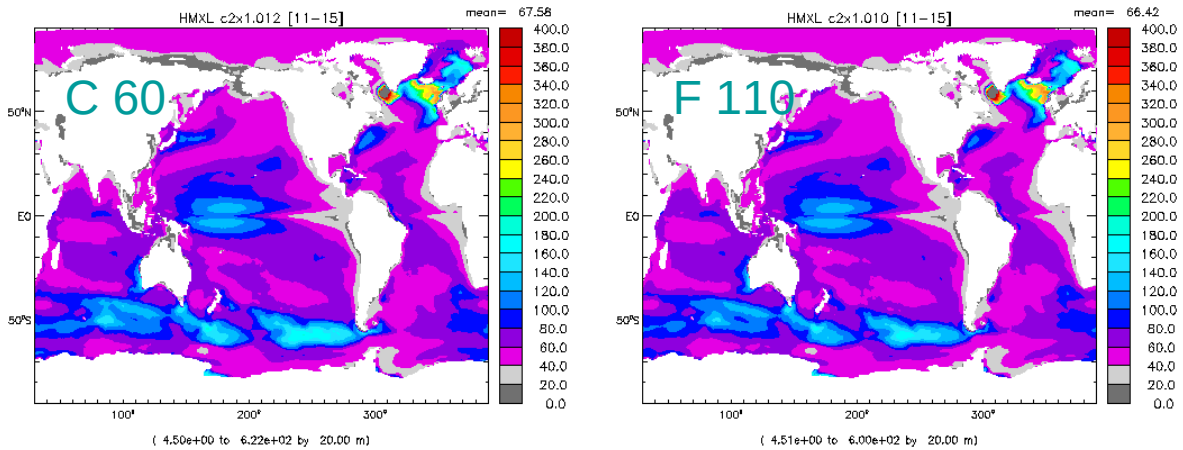


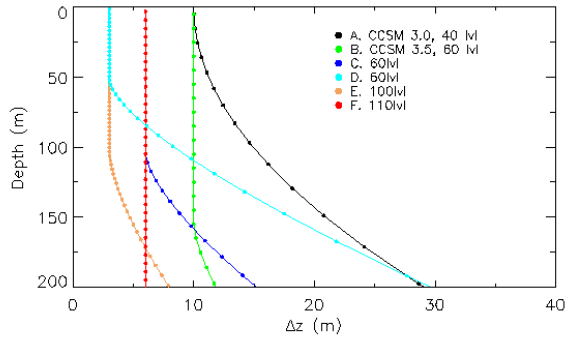
1. F 110,
   E 100,
   C 60,
   B60
2. D 60, A 40

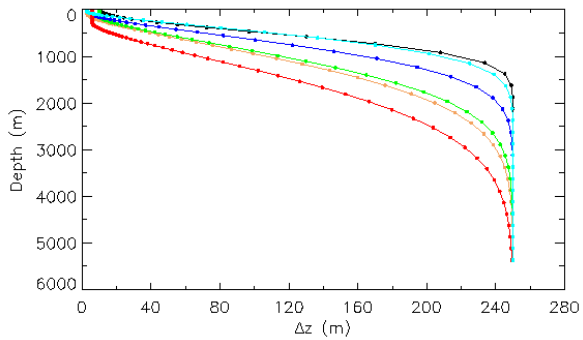
MLD



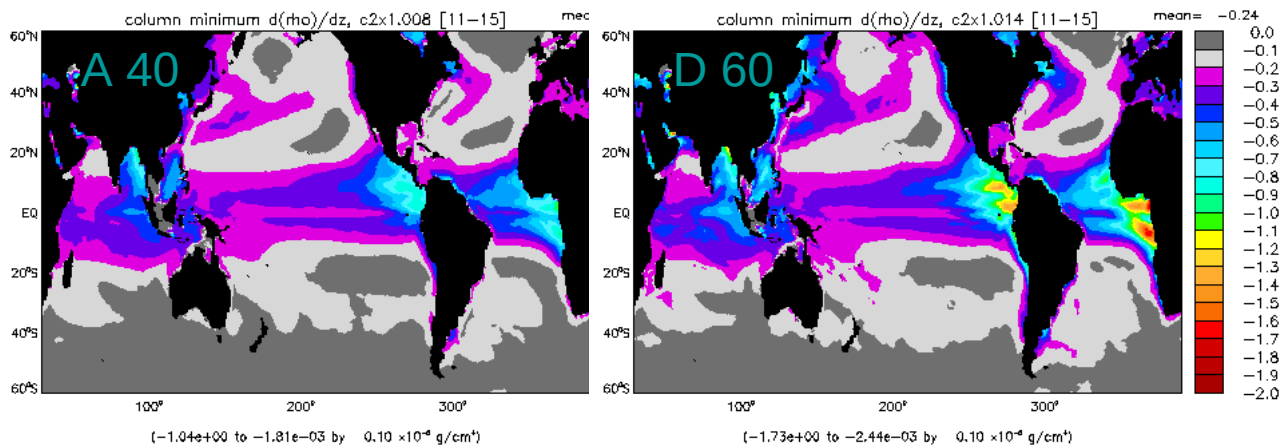


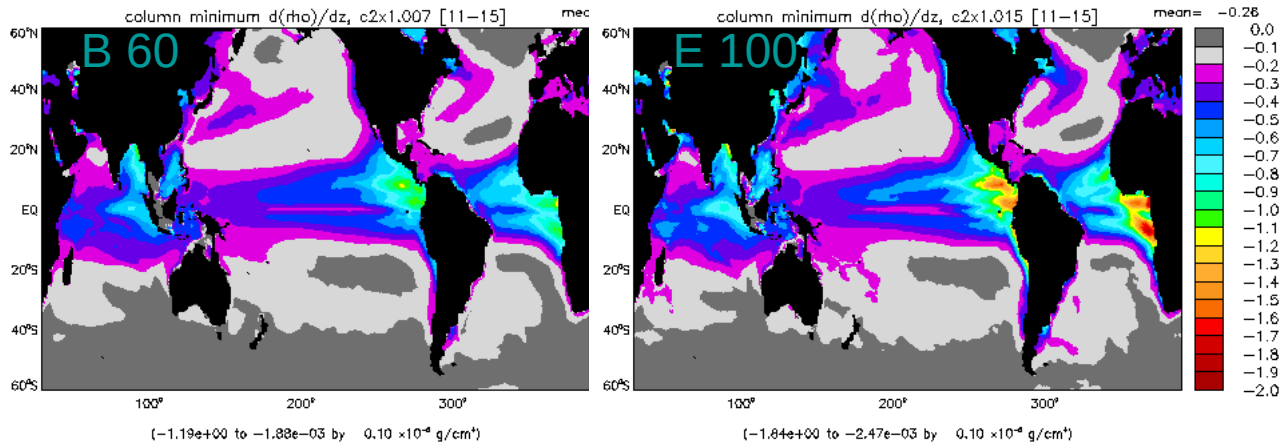


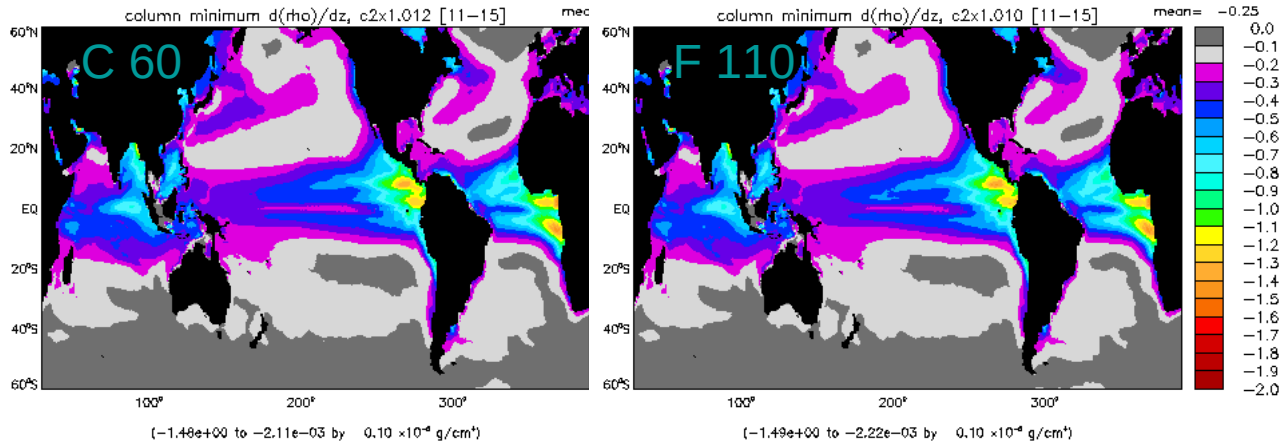




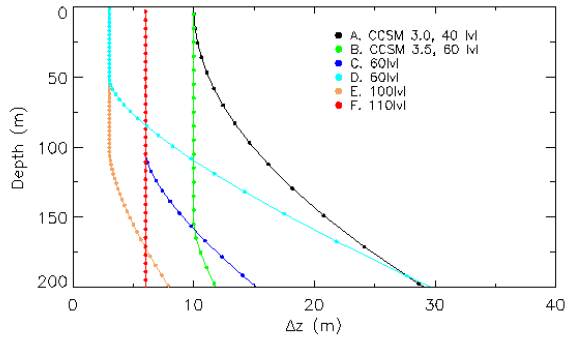
- Shallower mixing in Tropics
- Enhanced deep water formation

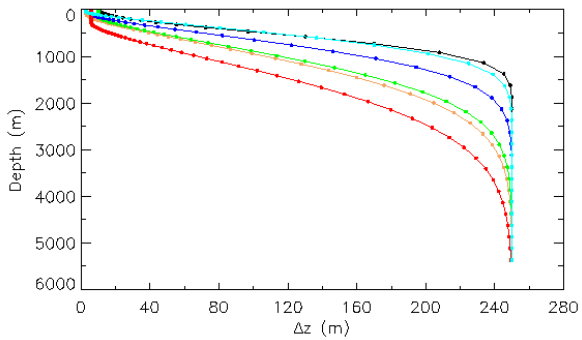




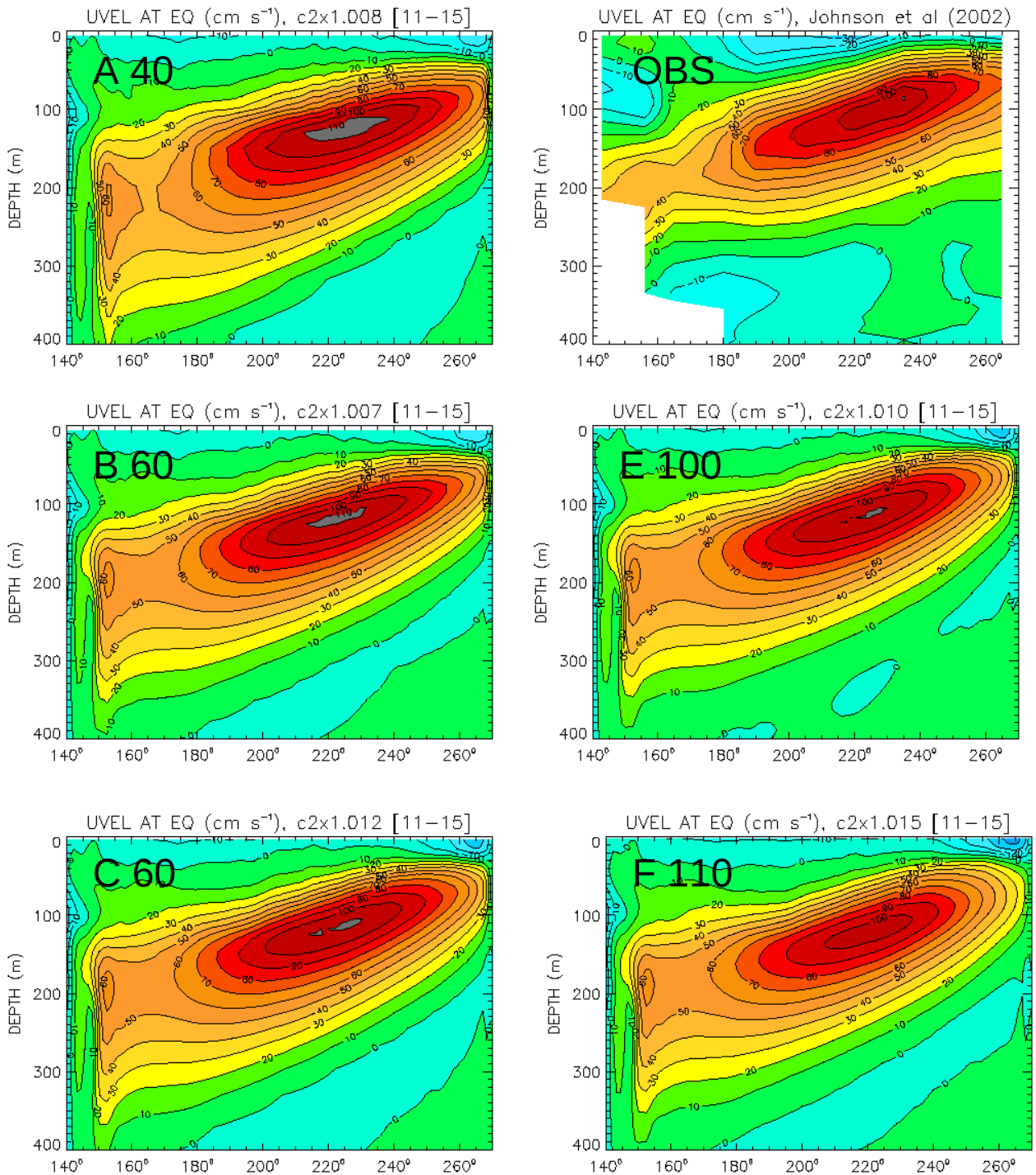


Min(dρ/dz)





- Enhanced stratification (esp E. Pac, E. Atl, Ind)

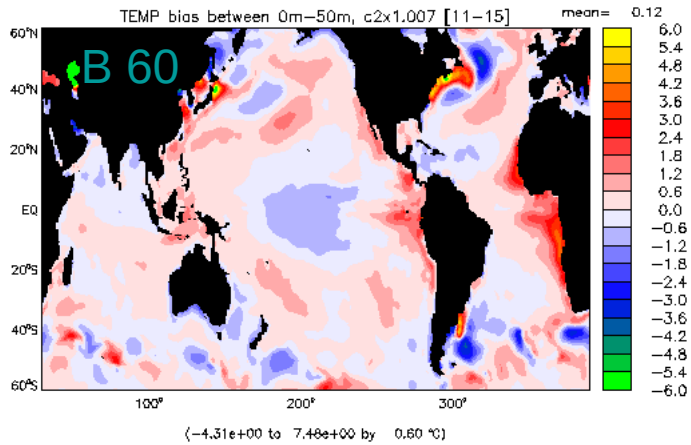


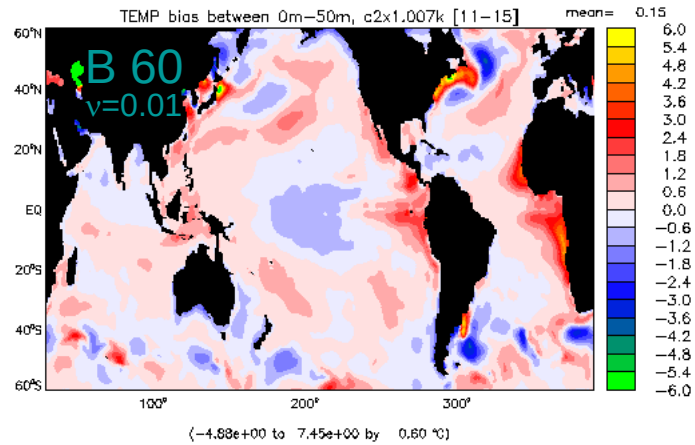
U @ Eq

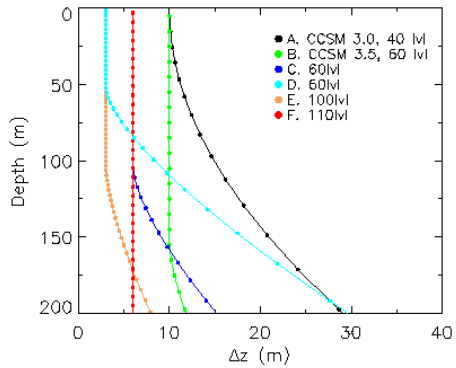
- Tighter undercurrent

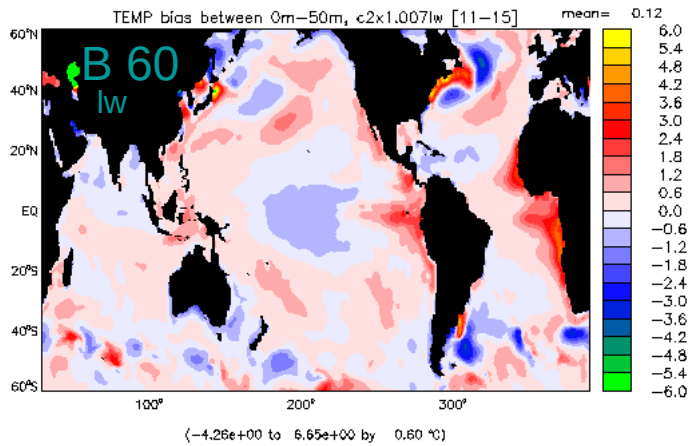
Comparative sensitivities

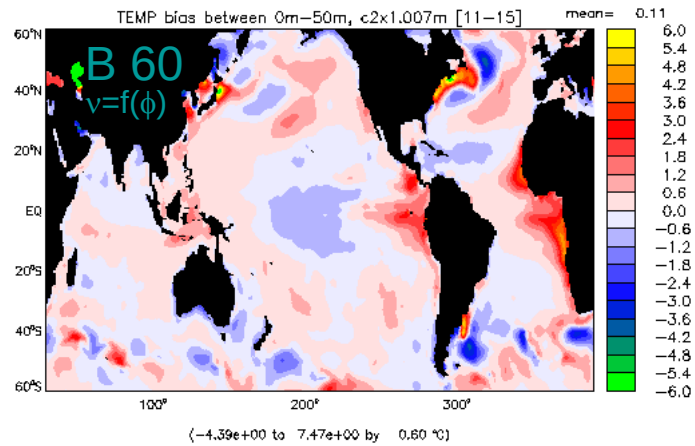
Mean T' 0m-50m





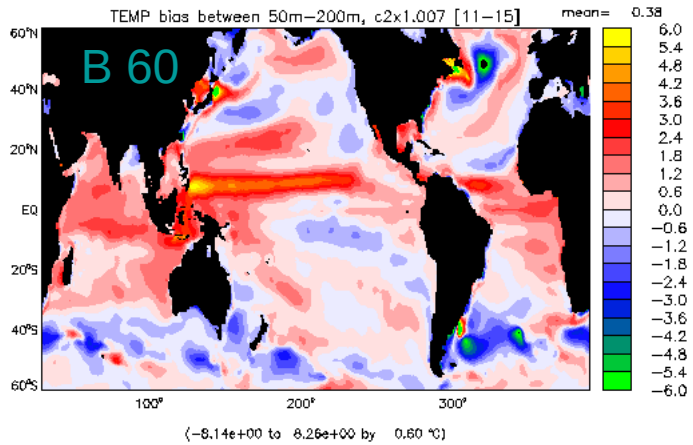


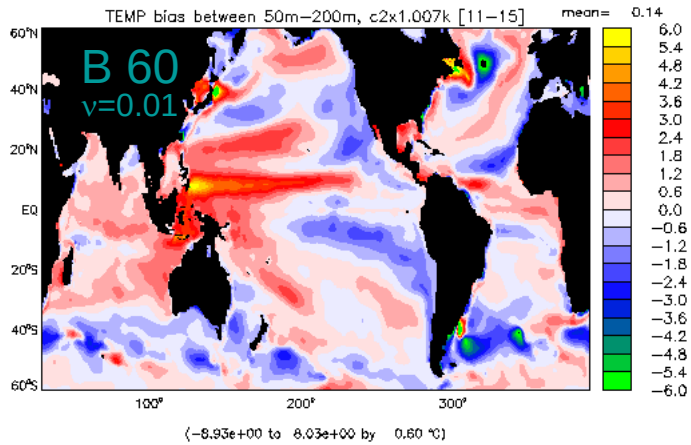


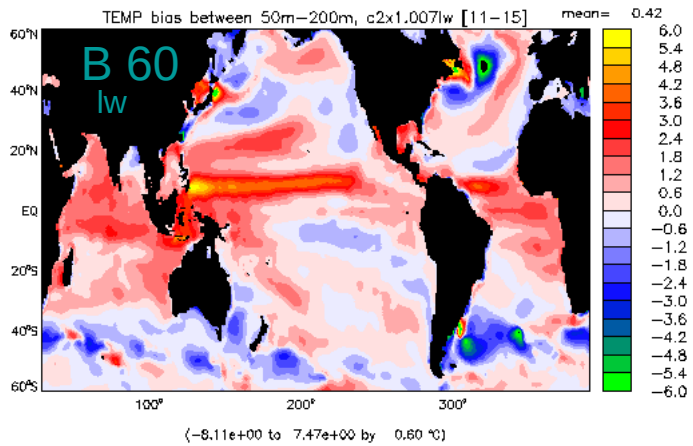


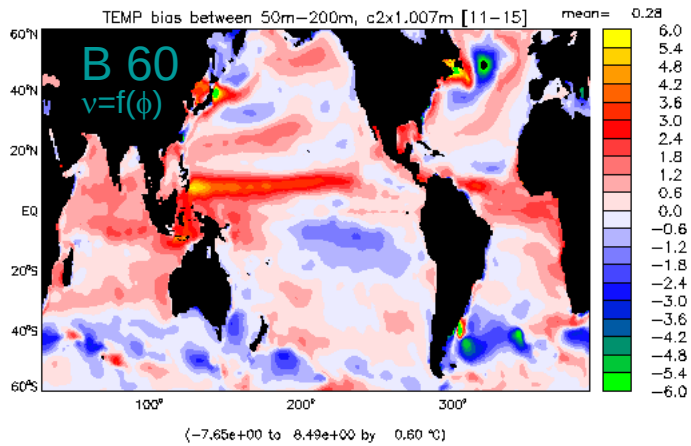
Comparative sensitivities

Mean T' 50m-200m



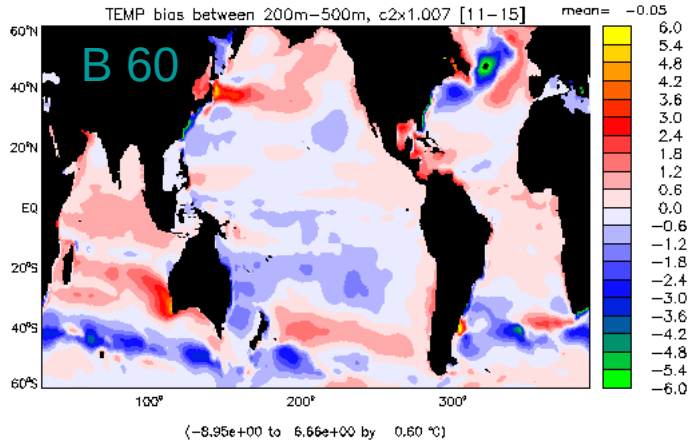


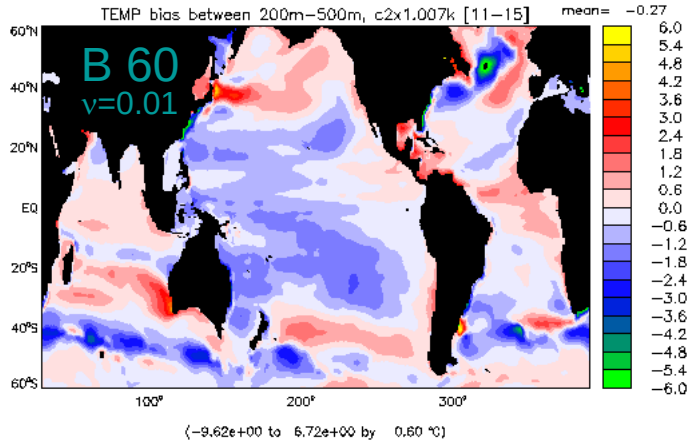


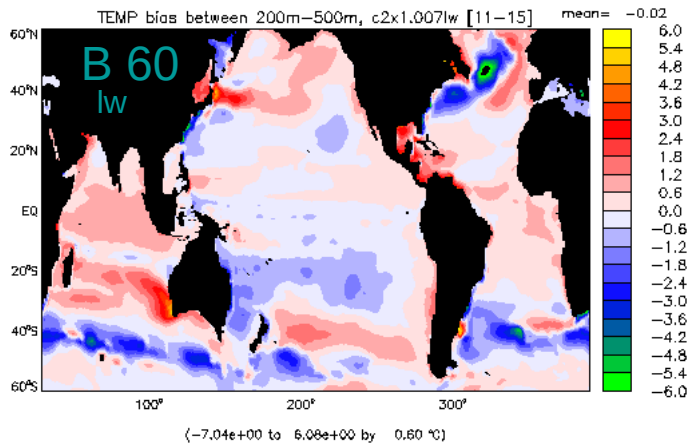


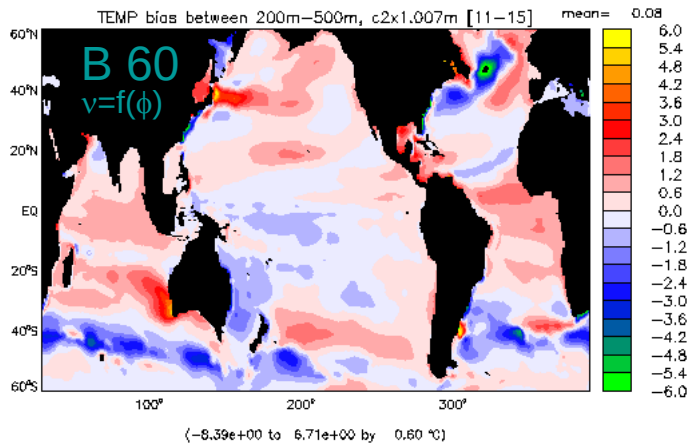
Comparative sensitivities

Mean T’ 200m-500m



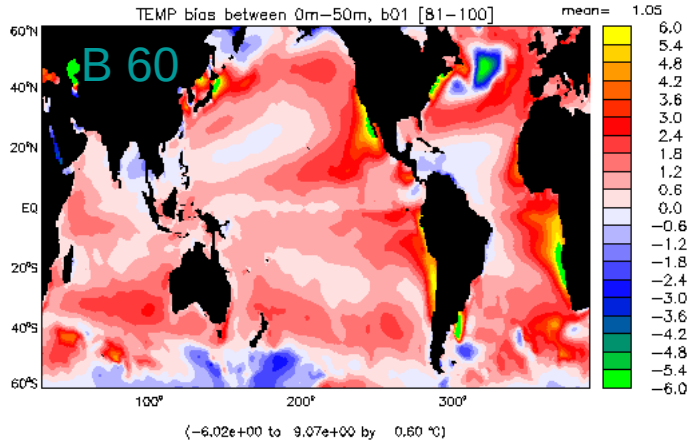


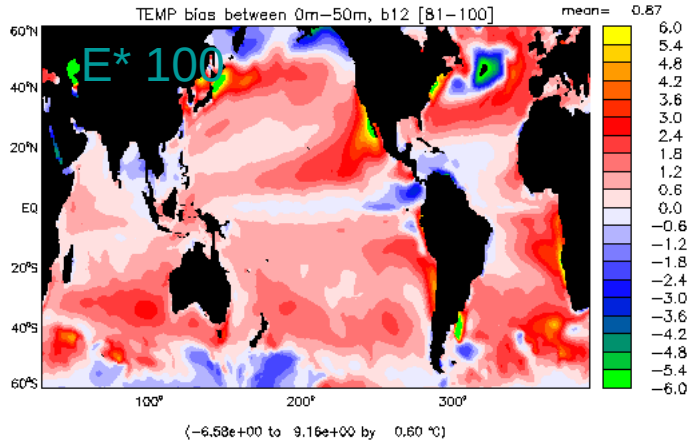


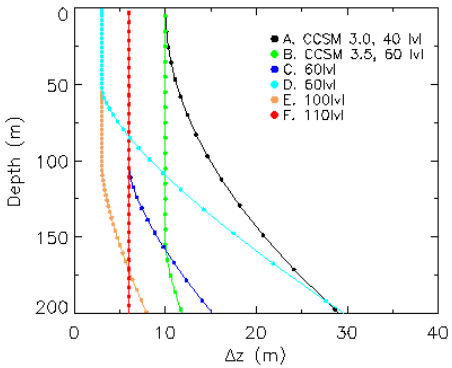


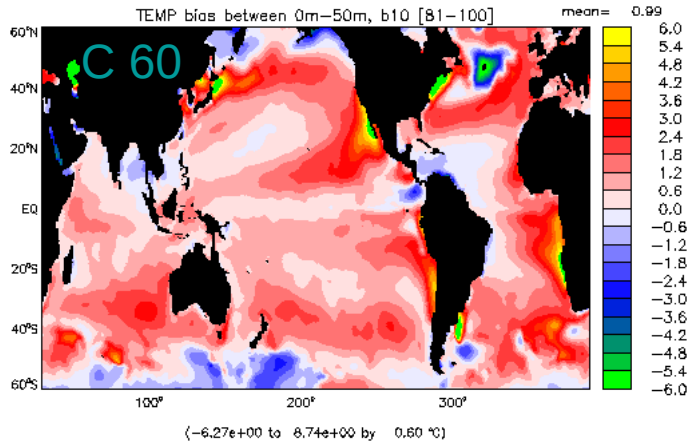
II. Fully Coupled

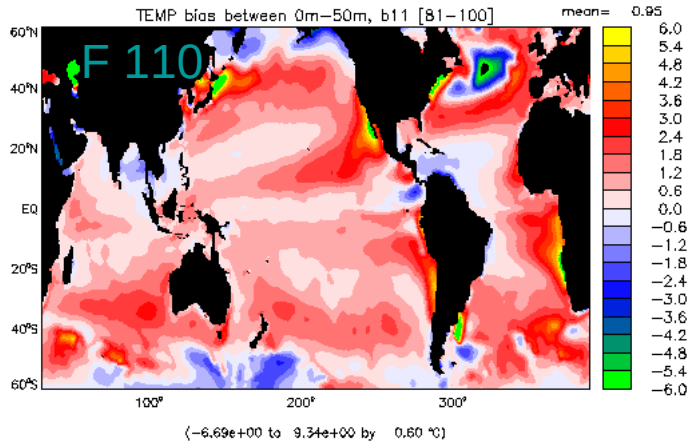
Mean T' 0m-50m





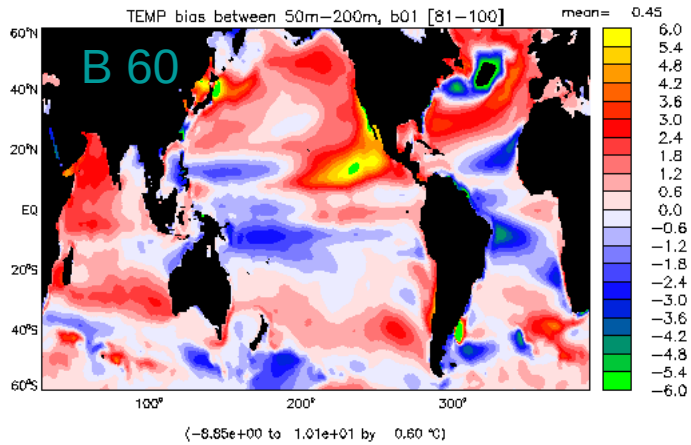


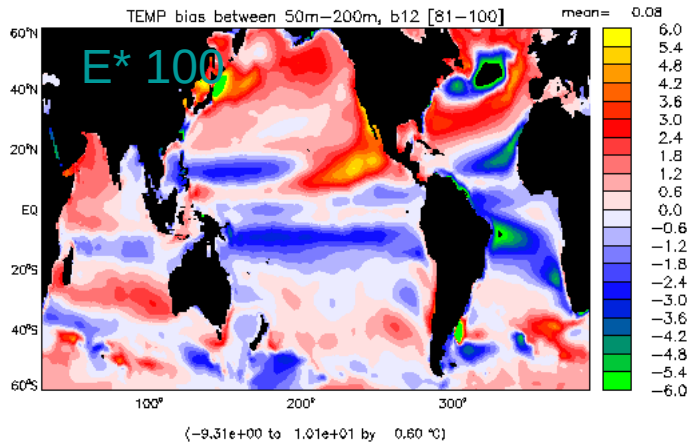


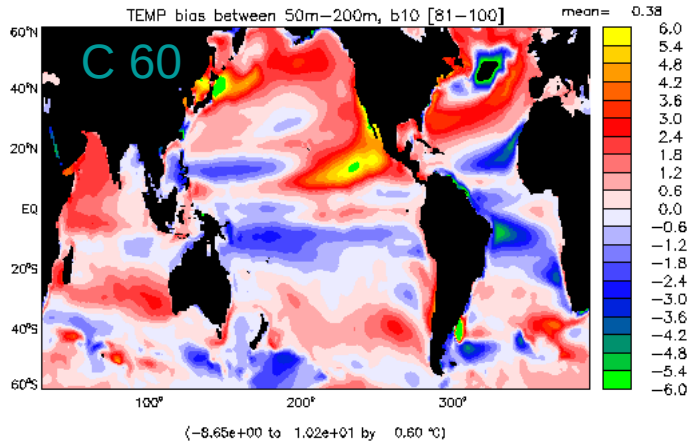


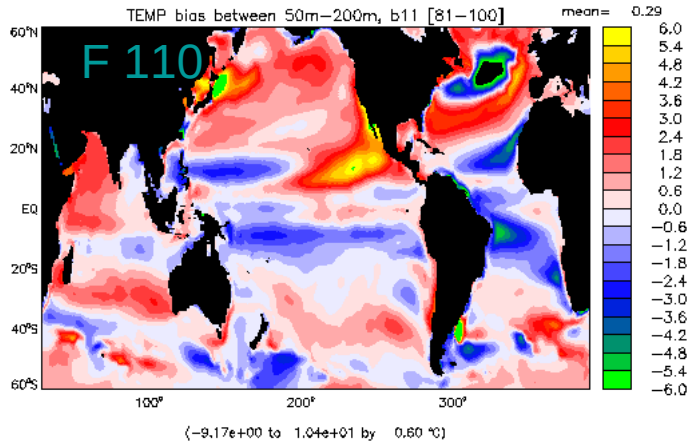
II. Fully Coupled

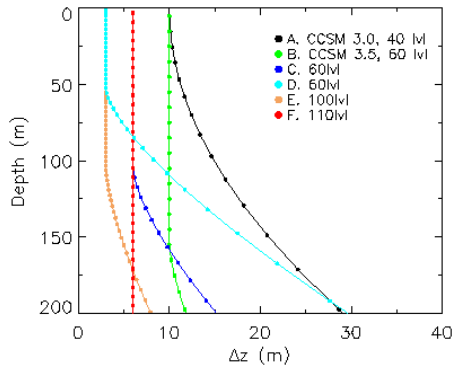
Mean T' 50m-200m

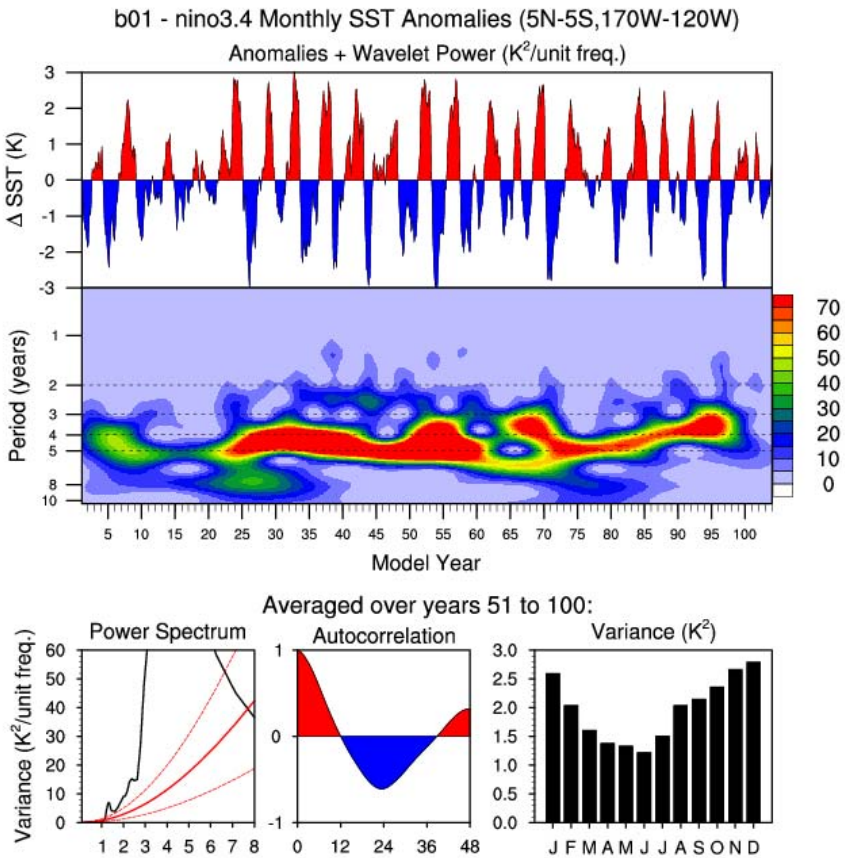




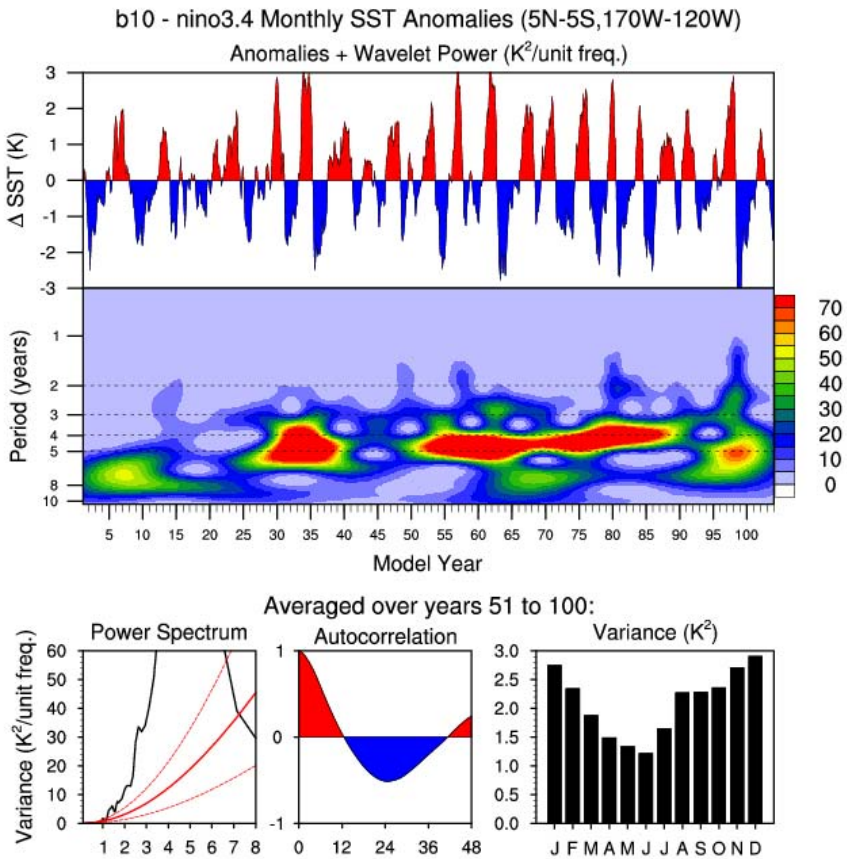




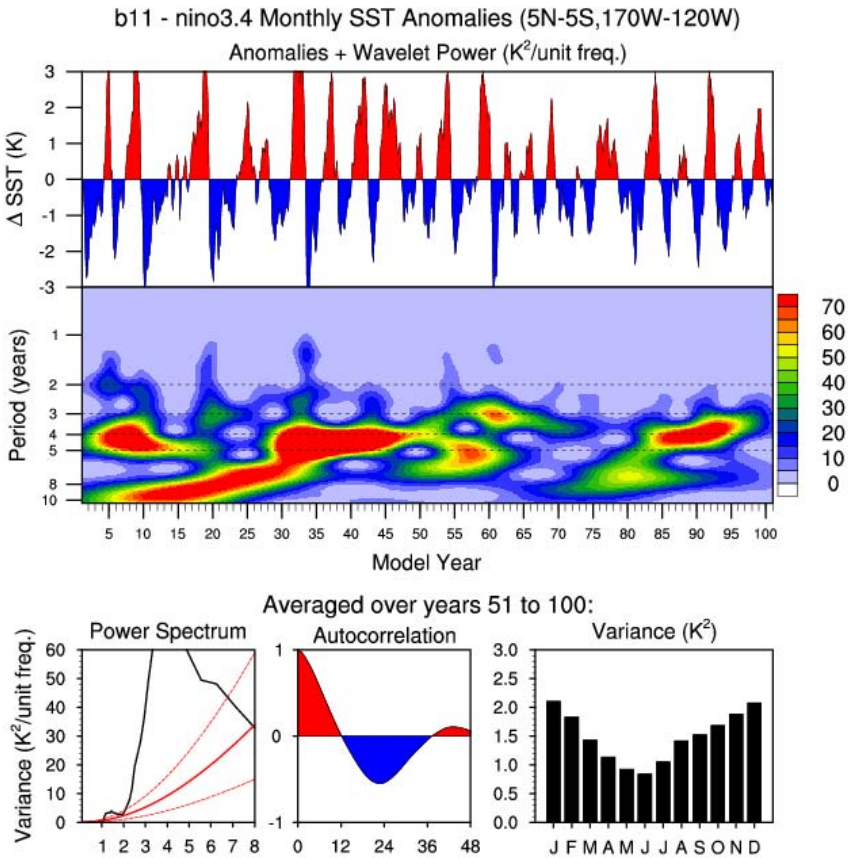



b01 - nino3.4 Monthly SST Anomalies (5N-5S,170W-120W)
Anomalies + Wavelet Power (K²/unit freq.)
Δ SST (K)
Period (years)
Model Year
Averaged over years 51 to 100:
Power Spectrum
Autocorrelation
Variance (K²)
Variance (K²/unit freq.)
J F M A M J J A S O N D

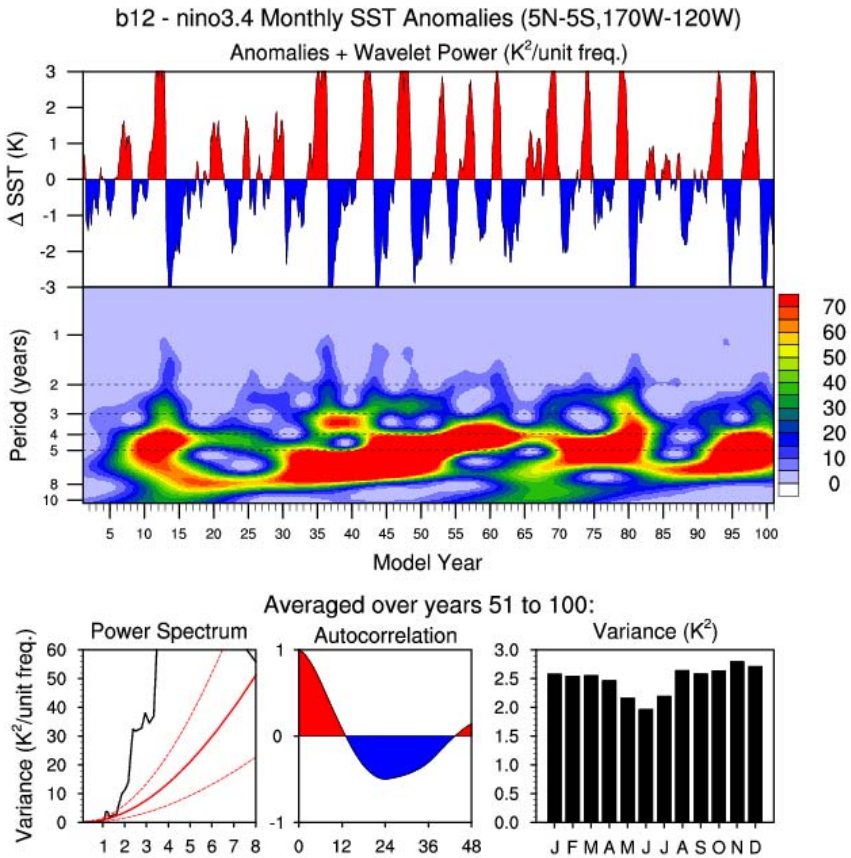
B 60


b10 - nino3.4 Monthly SST Anomalies (5N-5S,170W-120W)
Anomalies + Wavelet Power (K²/unit freq.)
Δ SST (K)
Period (years)
Model Year
Averaged over years 51 to 100:
Power Spectrum
Autocorrelation
Variance (K²)
Variance (K²/unit freq.)
J F M A M J J A S O N D

C 60


b11 - nino3.4 Monthly SST Anomalies (5N-5S,170W-120W)
Anomalies + Wavelet Power (K²/unit freq.)
Δ SST (K)
Period (years)
Model Year
Averaged over years 51 to 100:
Power Spectrum
Autocorrelation
Variance (K²)
Variance (K²/unit freq.)
J F M A M J J A S O N D

F 110


b12 - nino3.4 Monthly SST Anomalies (5N-5S,170W-120W)
Anomalies + Wavelet Power (K²/unit freq.)
Δ SST (K)
Period (years)
Model Year
Averaged over years 51 to 100:
Power Spectrum
Autocorrelation
Variance (K²)
Variance (K²/unit freq.)
J F M A M J J A S O N D

E* 100

Conclusions

- To minimize upperocean biases associated with numerical effects:

$\Delta z < 6m$	above ~75m	(E100)
$\Delta z < 10m$	above ~150m	(E100, F110, C60)
$\Delta z < 60m$	above ~500m	(B60, C60, E100, F110)

- Upperocean biases are reduced more by vertical grid than background diffusivity or advection scheme (at least at B60!)

- Good candidate grids for uncoupled CCSM4.0 are C60 (60 level from 6m$\rightarrow$250m), E100 (100 level from 3m$\rightarrow$250m), and F110 (110 level from 6m $\rightarrow$250m).

- 6m surface Δz may help reduce CCSM4.0 fully coupled biases

Vertical Grid	Timestep (min)
A40	63 (63)
B60	63 (63)
C60	63 (48)
D60	36 min
E100	36 (41)
F110	63 (41)

Conclusions

- Have used T' as a proxy for excessive upper ocean numerical mixing, but it may be worth exploring new POP diagnostics which explicitly quantify numerical vs. physical mixing (eg, Burchard and Rennau 2007)
- Recommend C60 (60 level from 6m$\rightarrow$250m) for default CCSM4.0; E100 (100 level from 3m$\rightarrow$250m) for ocean standalone experiments.