MESOSCALE AND SUBMESOSCALE PARAMETERIZATIONS

Implementations of the near-surface eddy flux (NSEF) parameterization (Ferrari & McWilliams, 2008) and the vertically varying tracer diffusivities and their impacts on our ocean-only simulations have been documented in two recent papers:

- Danabasoglu, Ferrari, & McWilliams, 2008, J. Climate (in press),

- Danabasoglu & Marshall, 2007, Ocean Modelling, v18, 122-141 for K(z).

OUTLINE:

- Implementation of the submesoscale eddy parameterization (Fox-Kemper, Ferrari, & Hallberg, 2008) and its impacts in ocean-only simulations (SM),

- Preliminary climate impact simulations with NSEF and K(z) in CCSM3.5,

- Future plans.

SUBMESOSCALE EDDY PARAMETERIZATION
(Fox-Kemper, Ferrari, and Hallberg 2008)

The associated streamfunction is given by

$$\boldsymbol{\Psi} = C_e \mu(z) \frac{H^2 \nabla \overline{\mathbf{b}} \times \mathbf{z}}{\sqrt{f^2 + 1/t^2}} \max\left[\left(\frac{\min(\Delta x, 1^\circ)}{L} \right), 1 \right]$$

where

C_e: efficiency factor (0.06-0.08),

μ: quartic shape function,

H: mixed layer depth,

b: buoyancy vertically averaged over H,

f: Coriolis parameter,

t: time scale (1 day – 1 week),

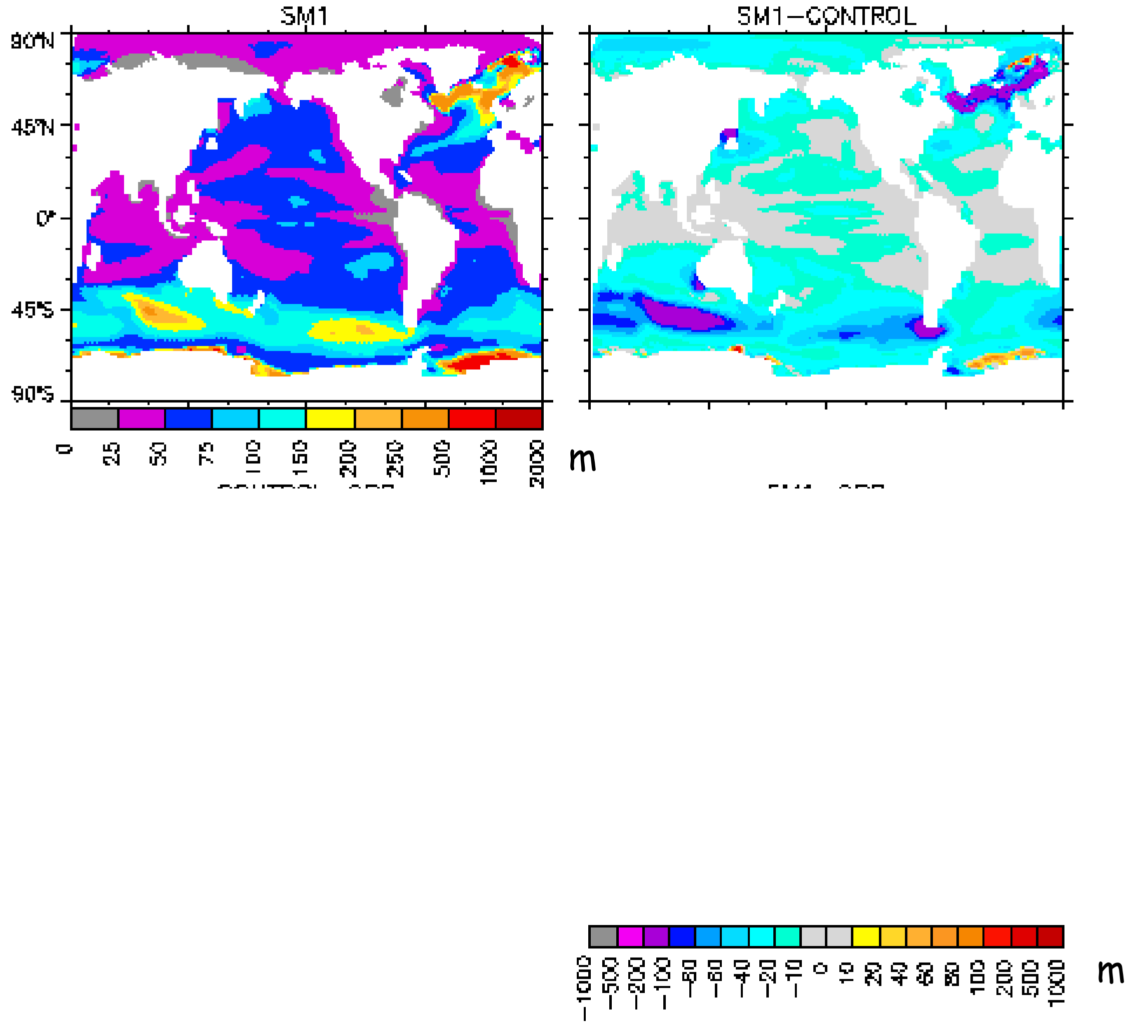
Δx: model grid resolution,

L: length scale

$$L = \max\left(\frac{|\nabla \overline{\mathbf{b}}| H}{f^2}, \frac{NH}{|f|}, L_{\min} \right)$$ with L_{min} = 1-10 km

We use the nominal 3° resolution version of the CCSM ocean model, forced with the CORE normal-year data sets. The NSEF scheme is included. The results are from 100 year simulations. Cases SM1 and SM5 use L_{min} values of 1 and 5 km, respectively.

ANNUAL-MEAN MIXED LAYER DEPTH (density change of 0.125 Kg m^{-3})

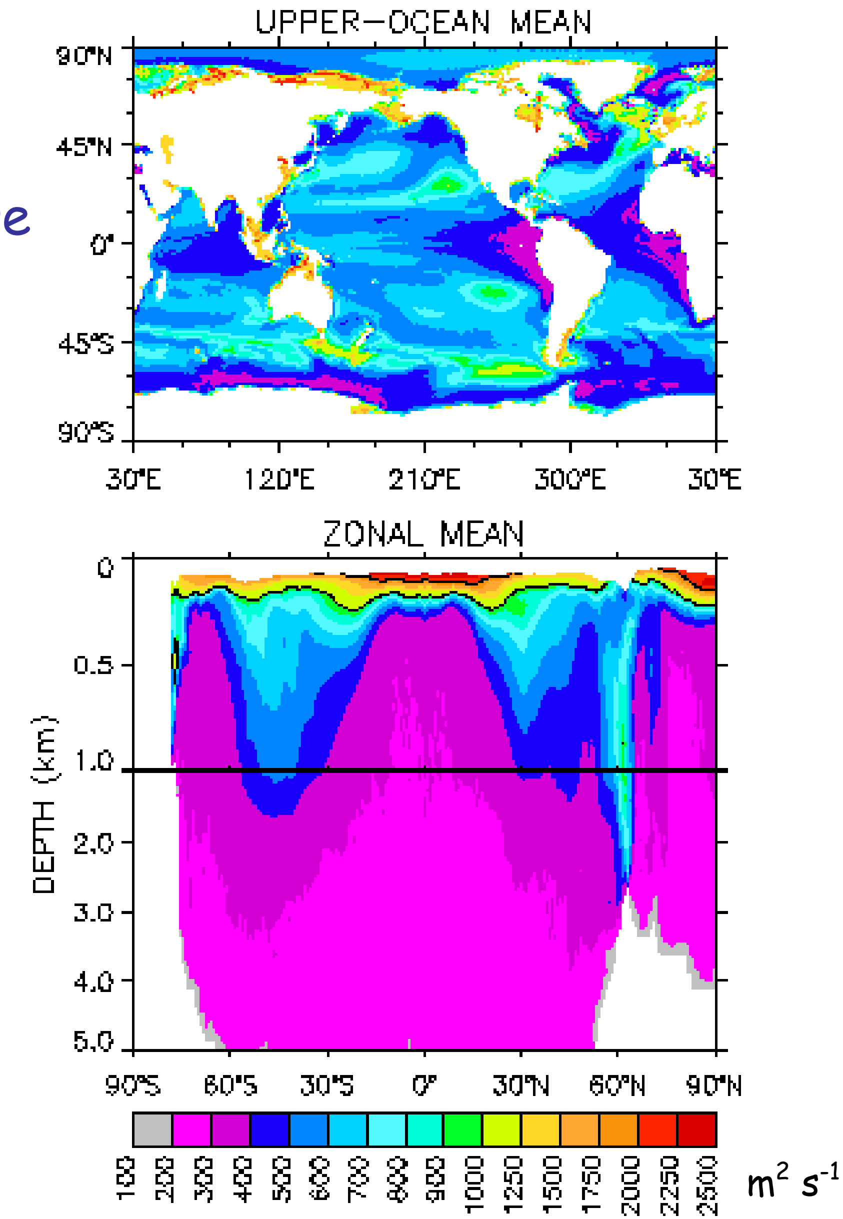


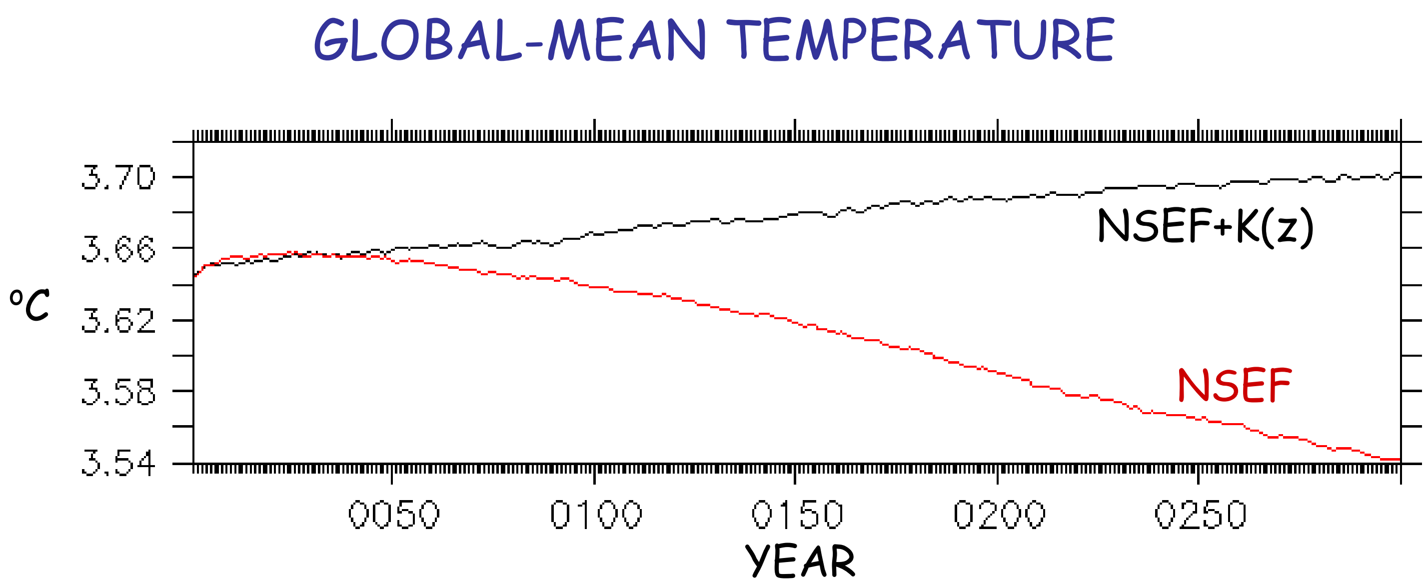
PRELIMINARY CLIMATE IMPACT SIMULATIONS WITH CCSM3.5

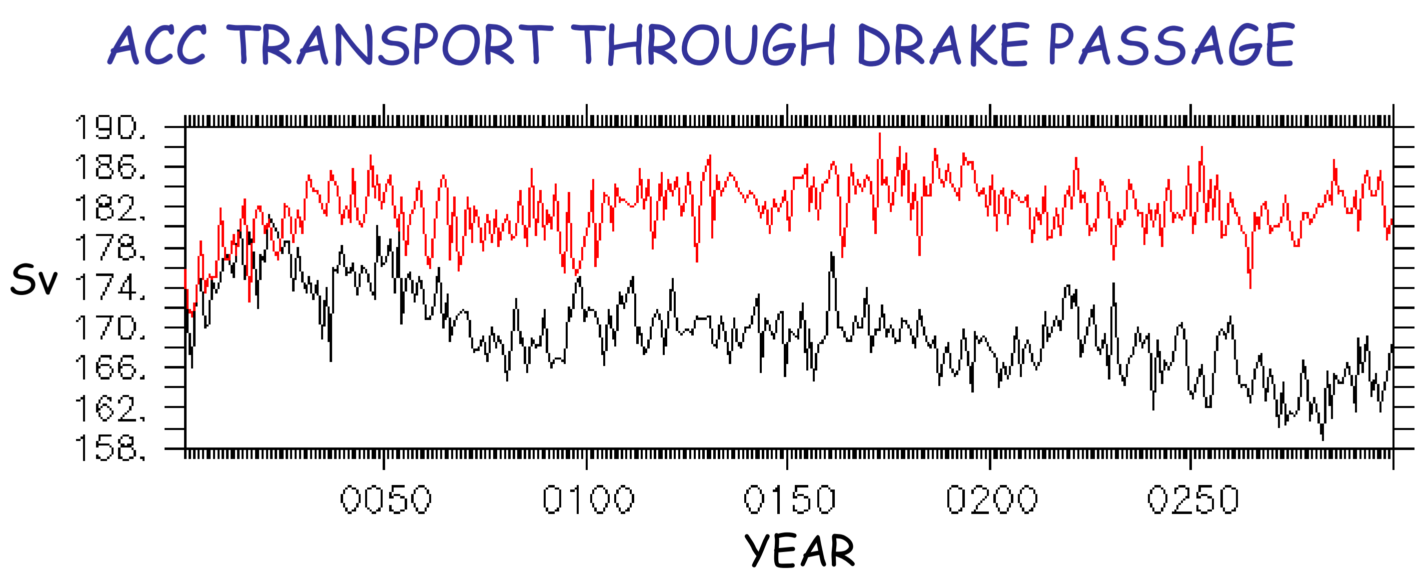
These are fully coupled 300-year simulations, using an early version of CCSM3.5. The atmosphere has a FV core with about 2° resolution. The nominal 1° resolution version is used for the ocean model. I have only two cases so far:

- NSEF ($K = 600\ m^2\ s^{-1}$),
- NSEF + K(z).

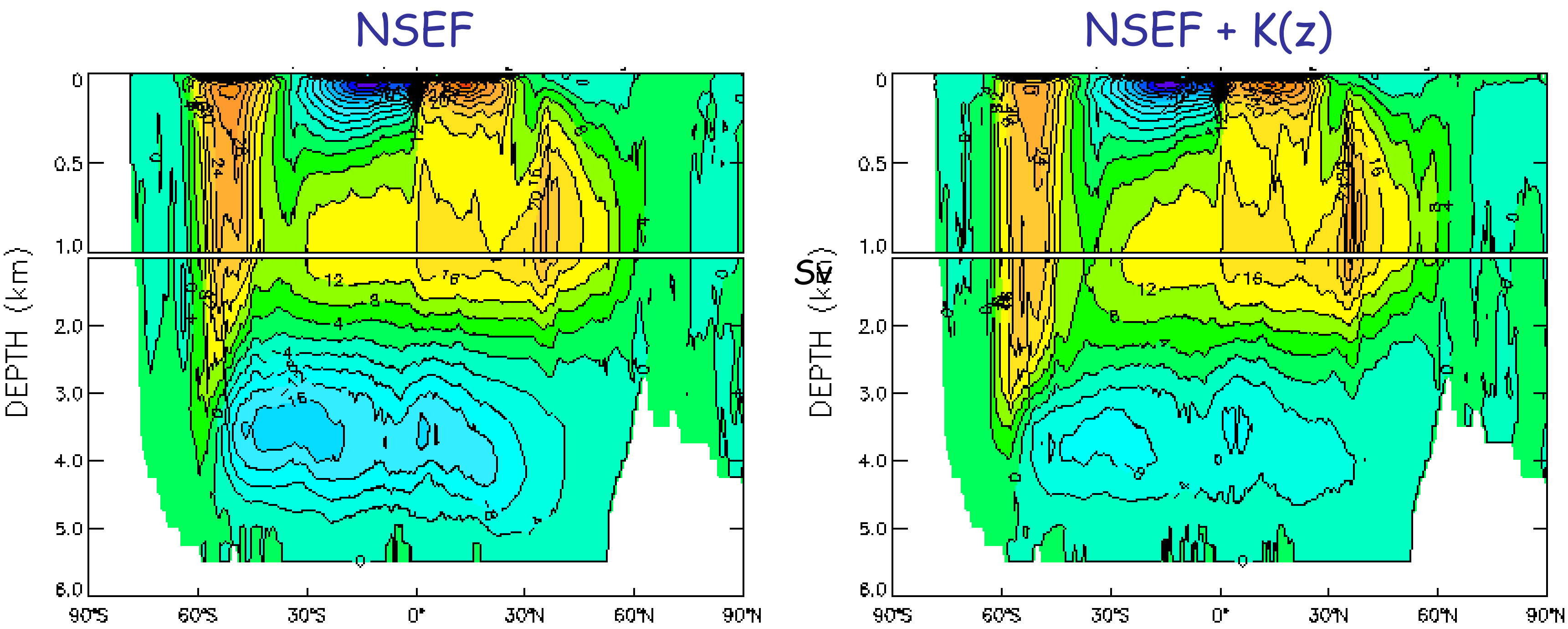
THICKNESS DIFFUSIVITY DISTRIBUTIONS



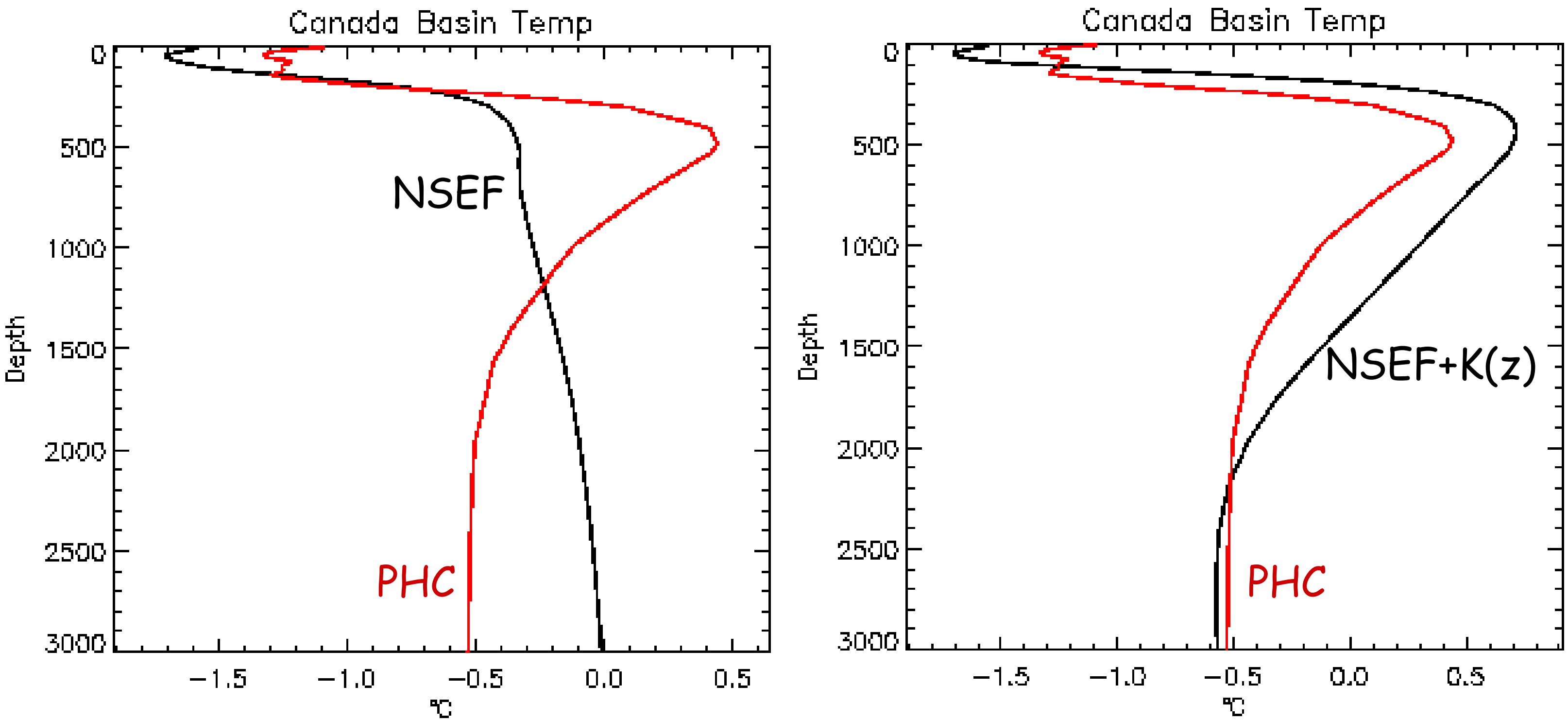

GLOBAL-MEAN TEMPERATURE
3.70
3.66
°C
3.62
3.58
3.54
0050
0100
0150
0200
0250
YEAR
NSEF+K(z)
NSEF


ACC TRANSPORT THROUGH DRAKE PASSAGE
190.
186.
182.
178.
Sv
174.
170.
166.
162.
158.
0050
0100
0150
0200
0250
YEAR

GLOBAL MOC (TOTAL)



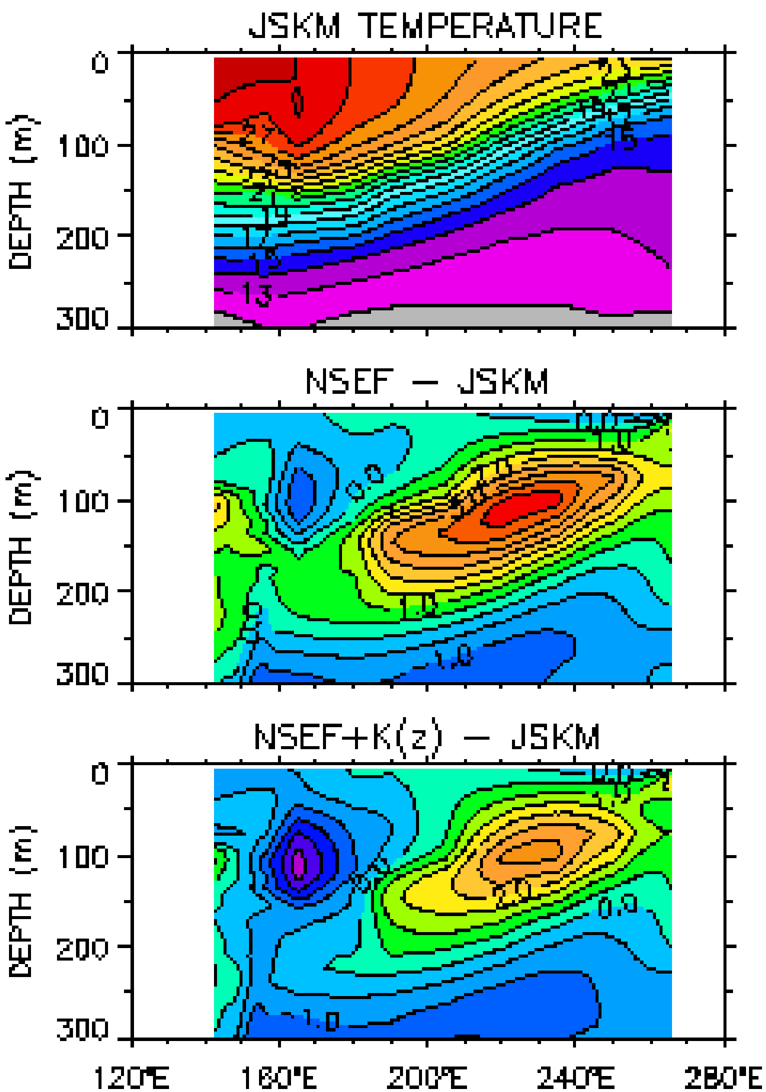
CANADIAN BASIN TEMPERATURE PROFILES



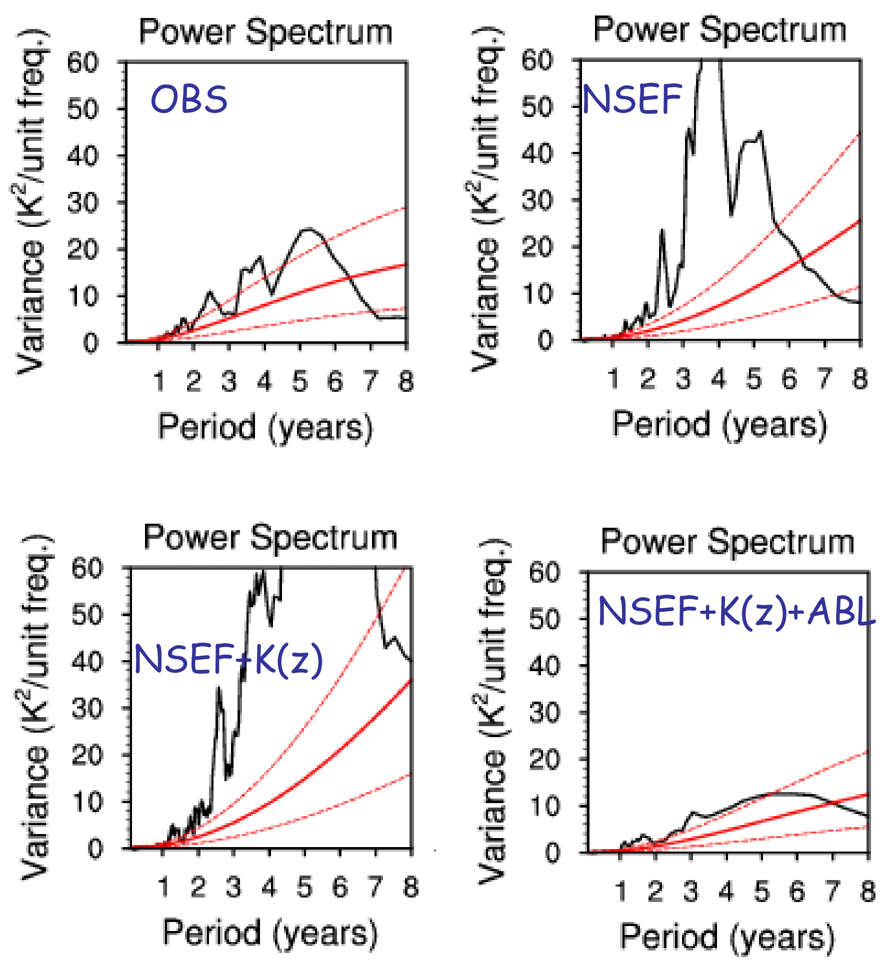
FUTURE WORK

- The NSEF formulation currently implemented does not necessarily guarantee that the mean potential energy is lost everywhere within the surface diabatic layer. To address particularly this issue, there is a new version of the NSEF scheme (Ferrari, McWilliams, et al. 2008). This new version will be implemented.
- Additional ocean-only experiments with the SM parameterization using the 1° model.
- CCSM3.5/4 simulations with the new NSEF, K(z), and SM schemes to document sensitivities and climate impacts (2° and 1° atmospheric and ocean model resolutions, respectively).

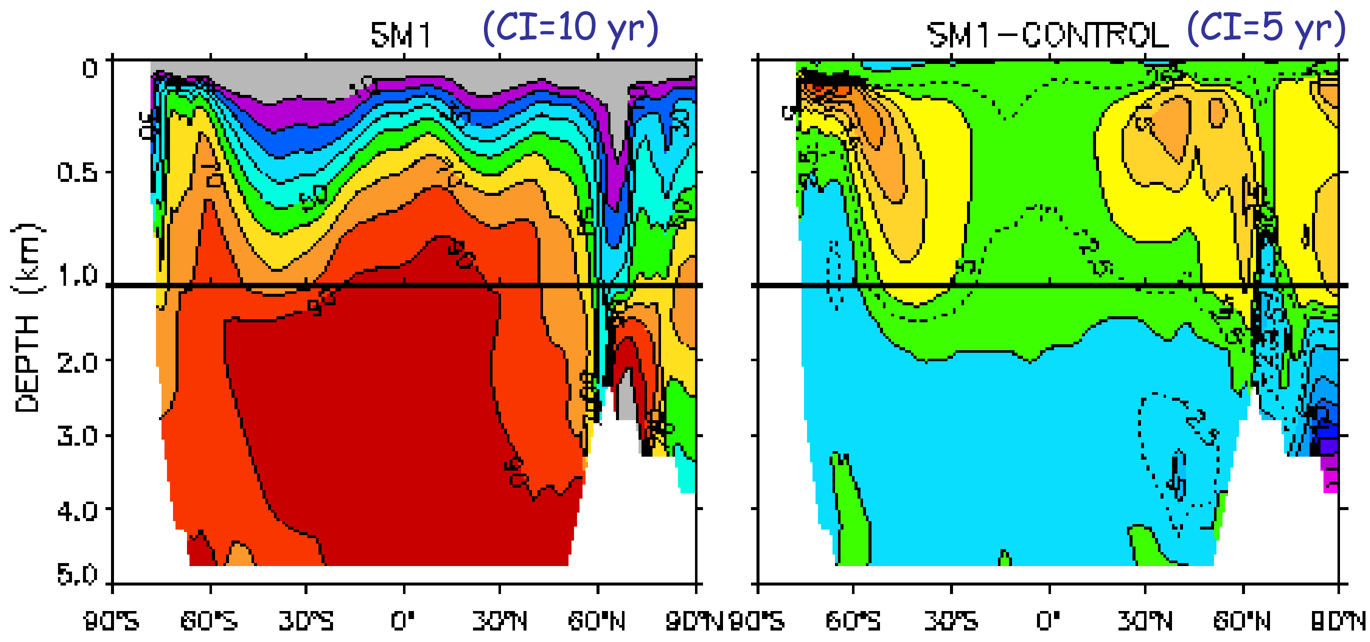
EQUATORIAL PACIFIC TEMPERATURE



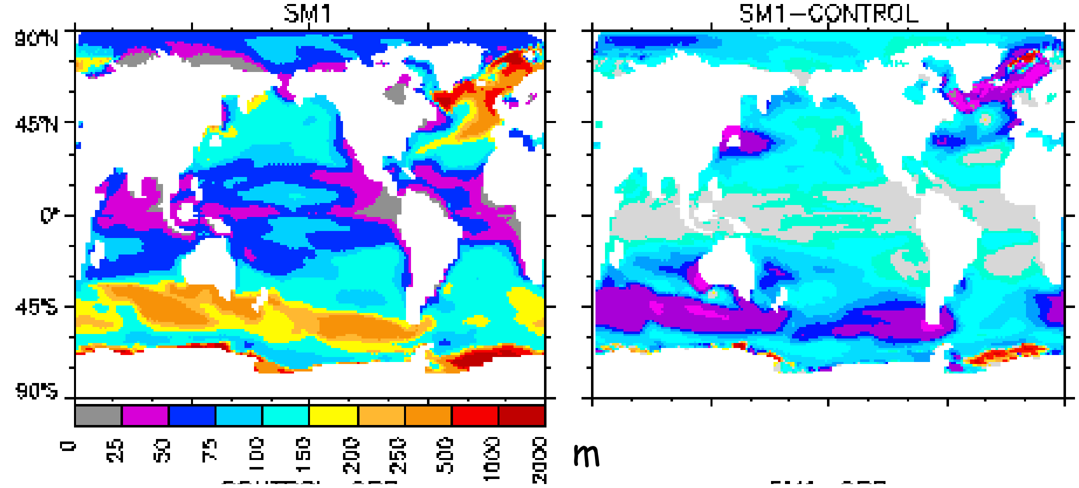
ENSO 3.4 POWER SPECTRA



ZONAL-MEAN IDEAL AGE

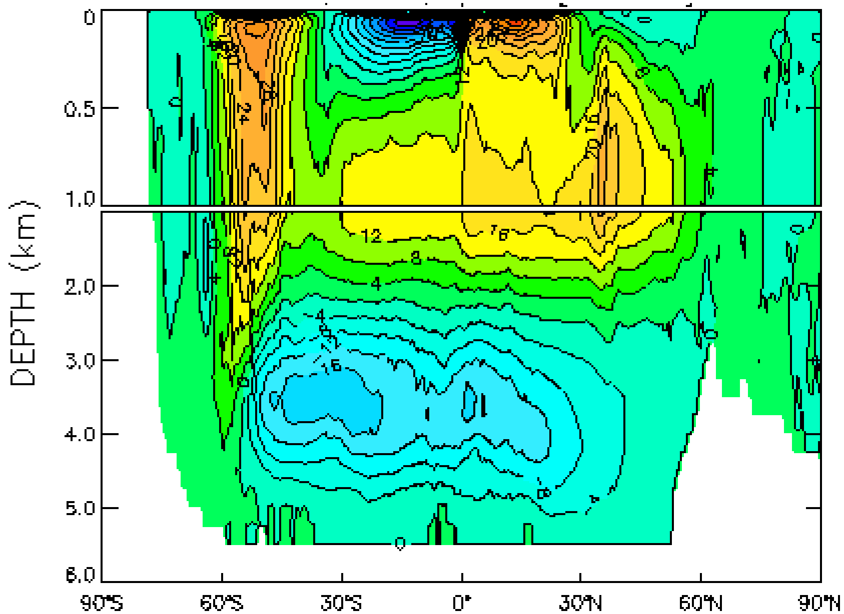


WINTER-MEAN MIXED LAYER DEPTH (density change of 0.125 Kg m^{-3})

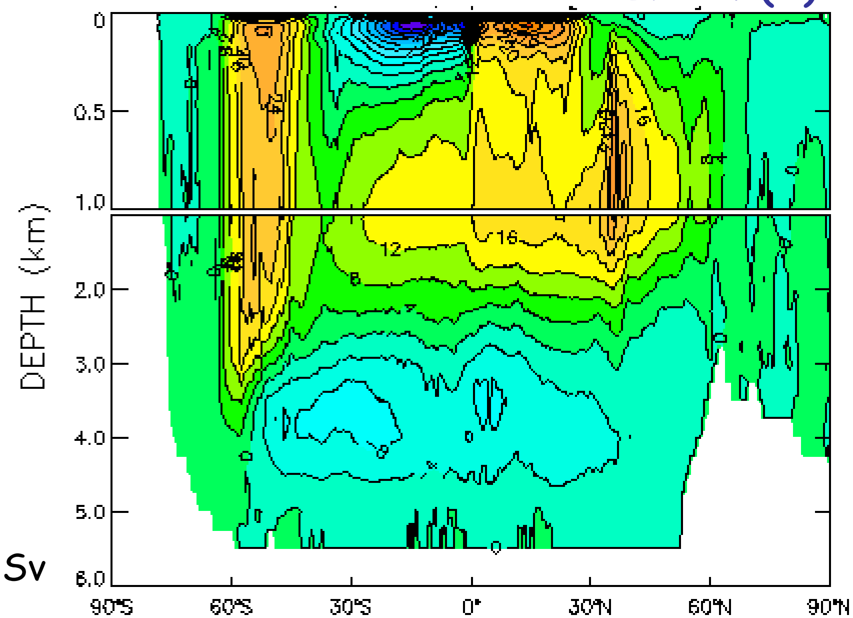


GLOBAL MOC (TOTAL)

NSEF



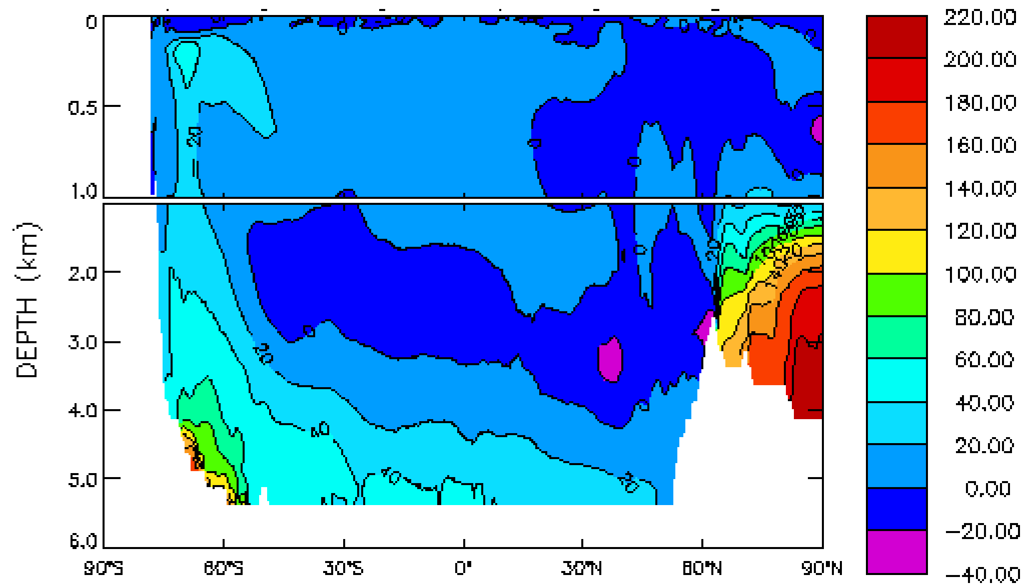
NSEF + K(z)



Sv

ZONAL-MEAN IDEAL AGE DIFFERENCE

([NSEF+K(z)]-[NSEF])



Year

CFC SIMULATIONS WITH NSEF AND K(z) PARAMETERIZATIONS

We use the nominal 1° resolution version of the CCSM ocean model, forced with the CORE inter-annual data sets.

NSEF scheme uses an extrapolation of the vertical gradients of the interior isopycnal slopes to determine the circulation within the surface diabatic layer. If not treated properly, sharp interior gradients may lead to an instability that produces large changes in model tracers within a time step.

MONTHLY TIME SERIES OF MAX TEMPERATURE CHANGE IN ONE TIME STEP