Parameterizing the Faroe Bank Channel (FBC) and Denmark Strait (DS) Overflows

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(NCAR)

WHAT HAVE WE DONE ? OWG 07

DOES IT WORK   ?   OWG 07

DOES IT MATTER ???   Today

Uncoupled OGCM (~3 deg)
Coupled CCSM (*) (T31x3)
Experiments

- CON (*) :   200 year, "resolved" overflows

- FBC   :   200 year, parameterized FBC

- DSO (*) :   200 year, parameterized DSO

RESULTS :   (Years 181 - 200)
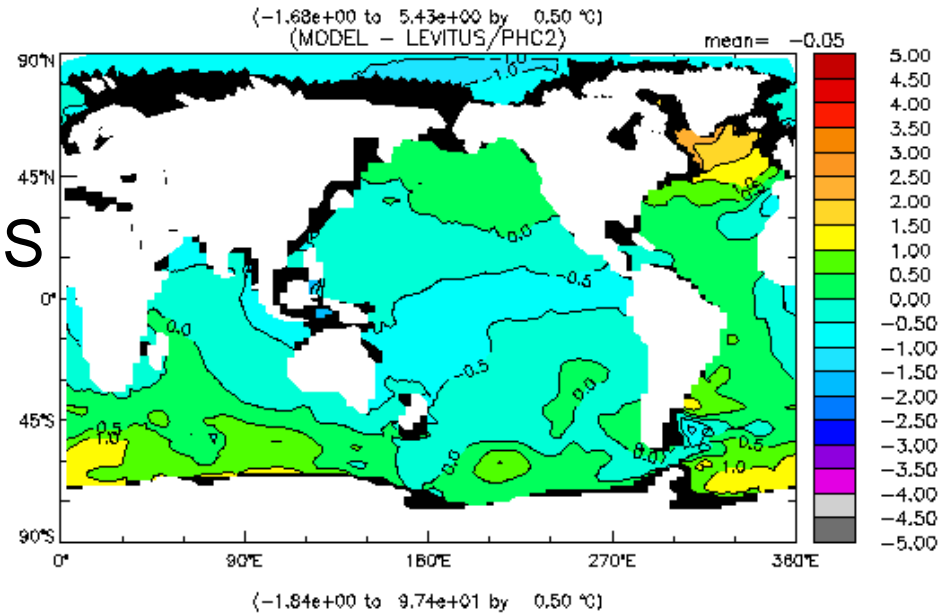

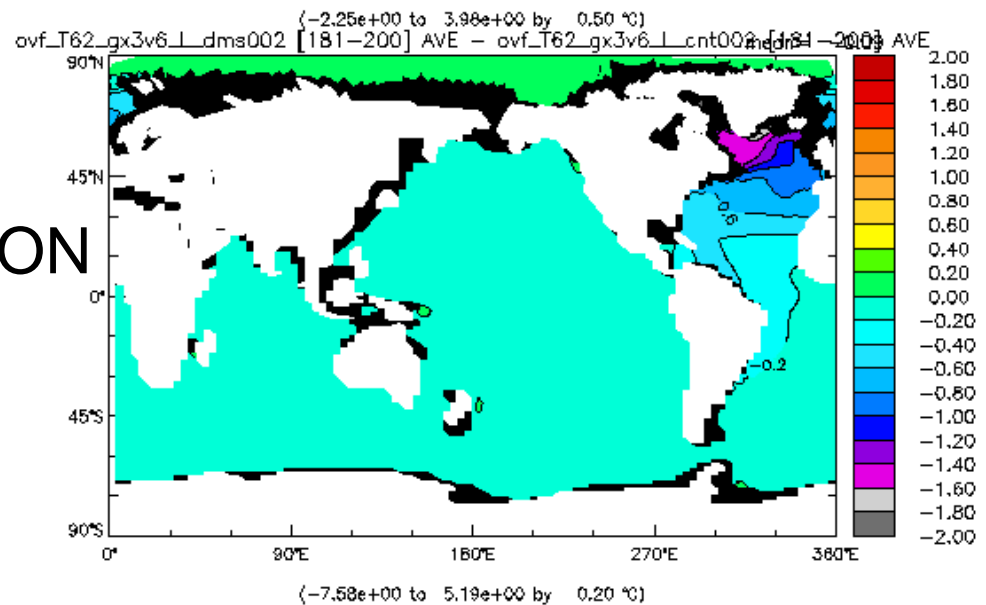   CON (*) - OBS (biases)

           DSO (*) - CON

Matter ?

Temperature at 2000m

CON-OBS

DSO alone removes much of the North Atlantic bias from the Labrador Sea to the South Atlantic
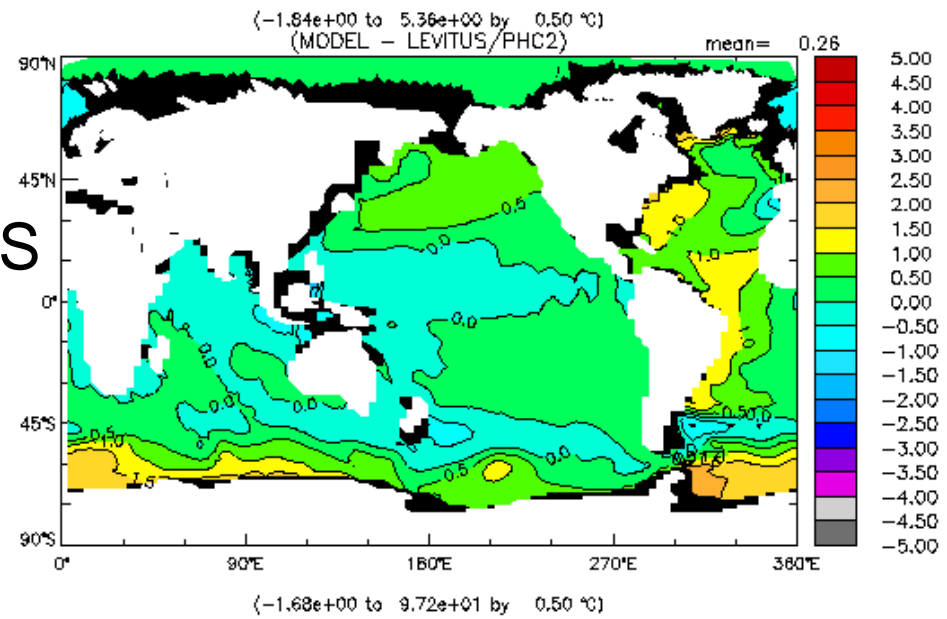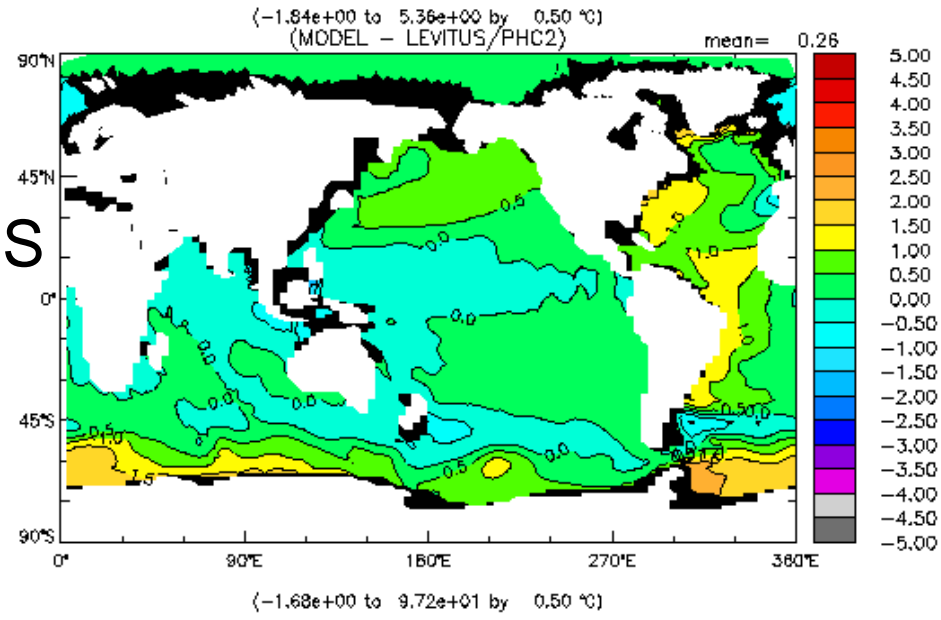

DSO-CON

Matters ? Temperature at 2000m

CON*-OBS

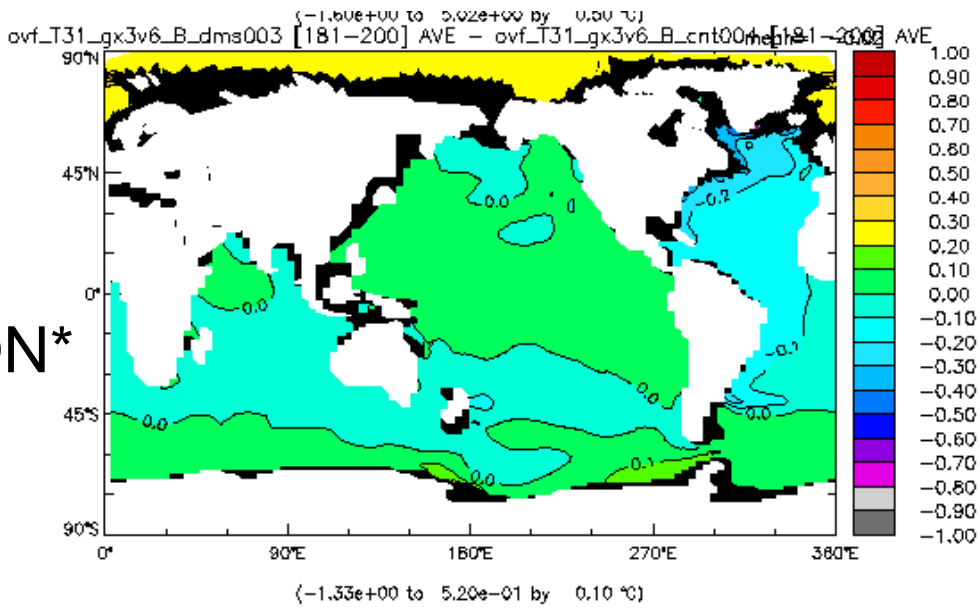CCSM biases much smaller

Matters ? Temperature at 2000m

CON*-OBS
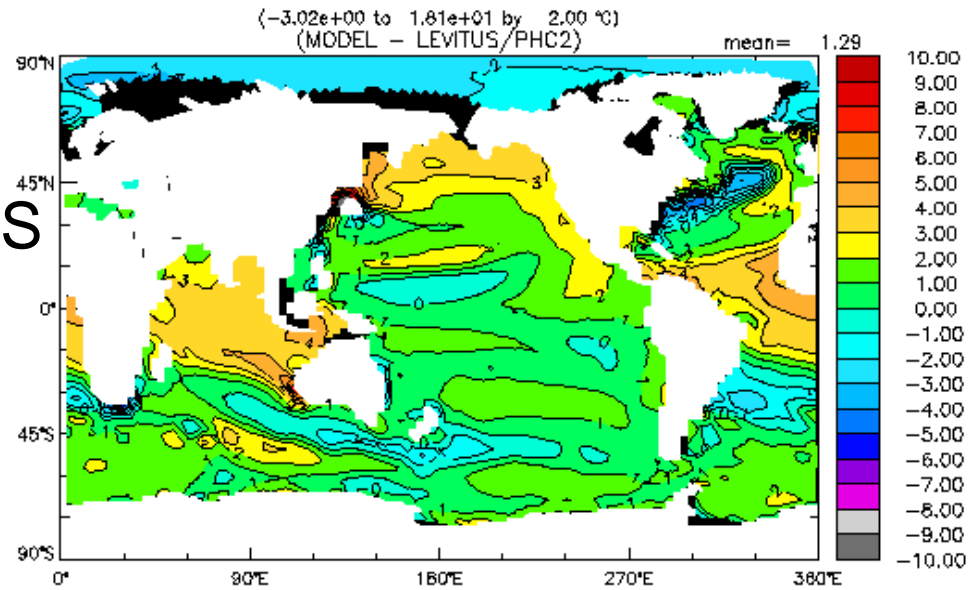
As hoped DSO impact positive, but not too big.
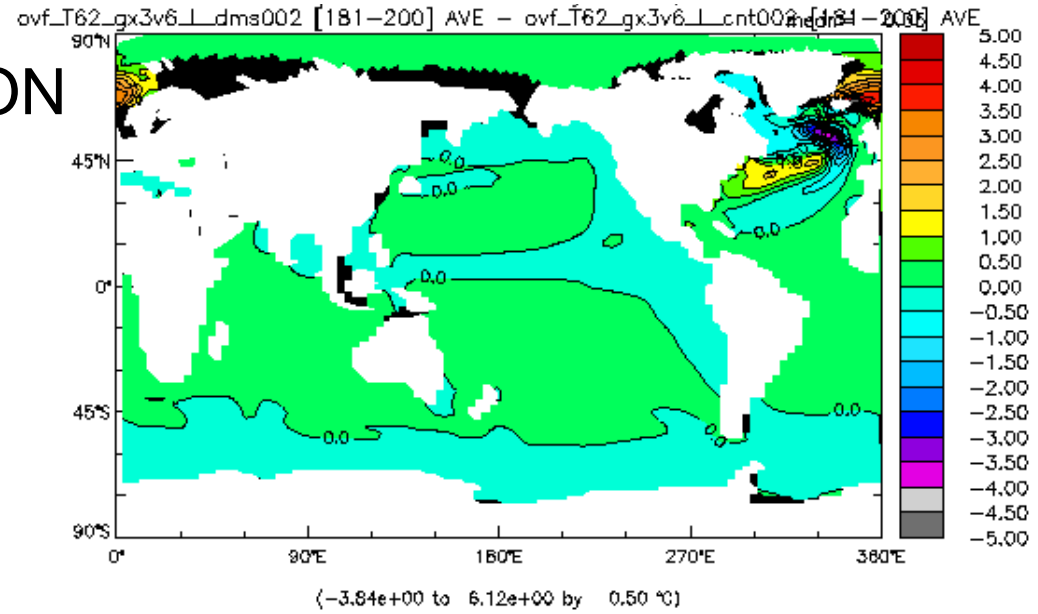
DSO*-CON*

Temperature at 500m

CON-OBS

DSO alone removes much North Atlantic bias between 30 and 75° N .

DSO-CON

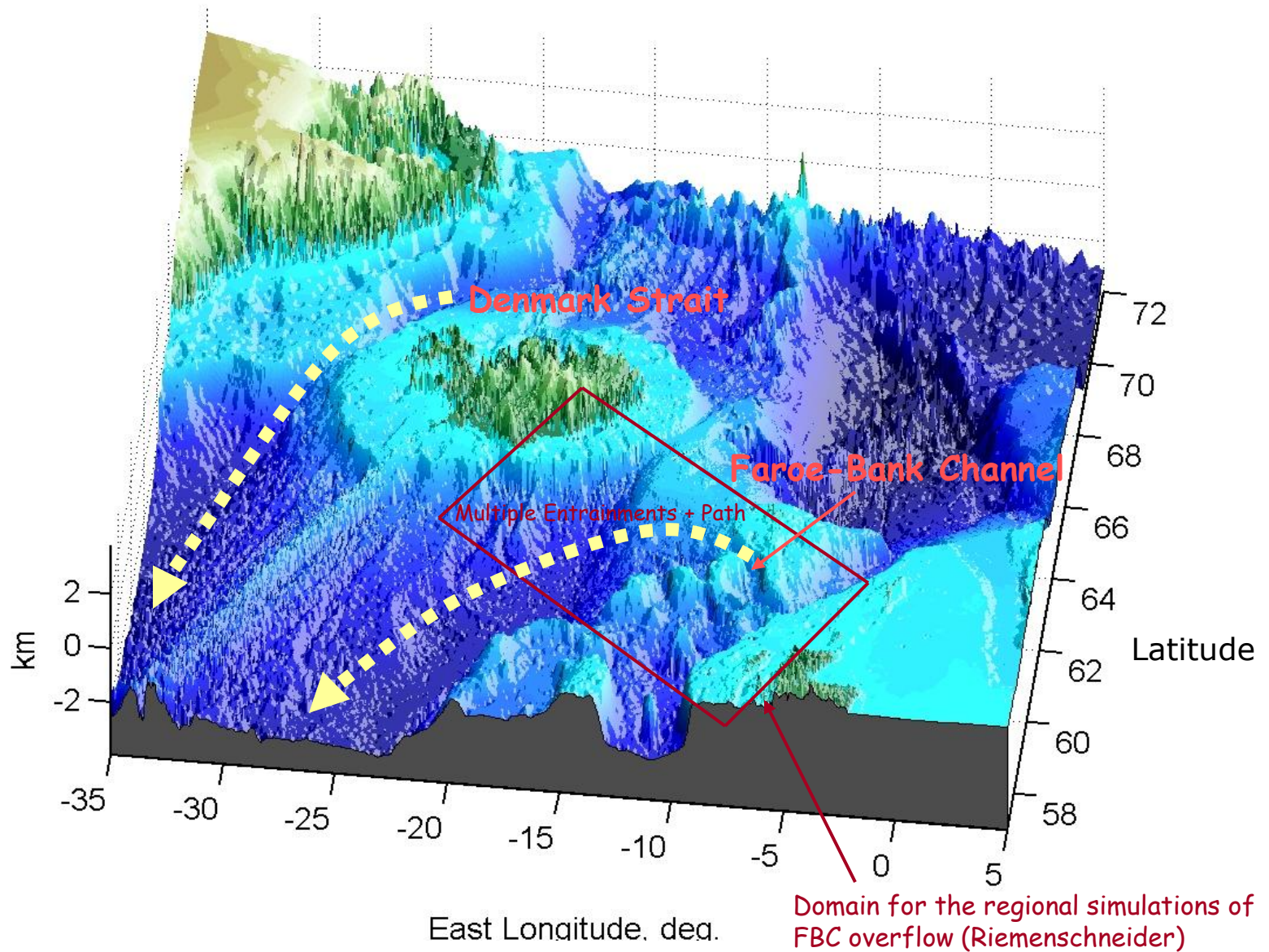Prognostic INFLOW is east of Iceland in N. A. Drift, not locally in Denmark Strait

Conclusion :
These positive results justify ;

- Generalization for multiple overflows, higher resolution, SE standards

- Evaluate coupled climate impact of parameterized overflows by comparing CFC uptake to observations

- Effect on North Atlantic Circulation & Sea-Ice
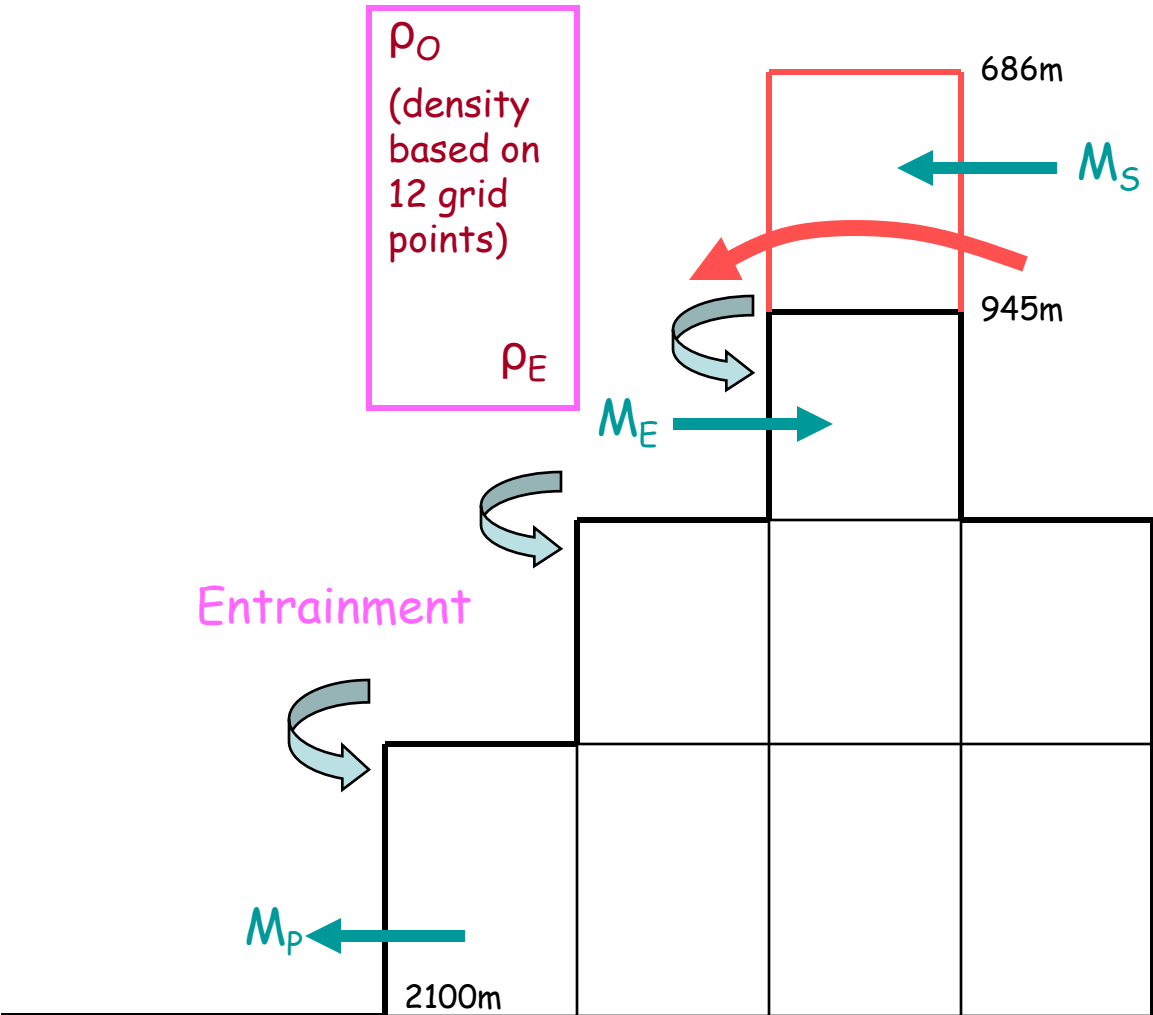
- Include Antarctic shelves

THE   END

Denmark Strait

Faroe-Bank Channel

Multiple Entrainments + Path

Latitude

km

East Longitude, deg.

Domain for the regional simulations of
FBC overflow (Riemenschneider)

from J.Price

ATLANTIC   NORDIC SEAS

Surface

-z

MSBC (Price and Yang)

ρ_O (density based on 12 grid points)

ρ_E

686m

M_S

ρ_S (Source density based on 12 grid points)

945m

M_E

Entrainment

M_P

2100m

BOTTOM TOPOGRAPHY

$g' = g\,(\rho_S - \rho_O)/\rho_{ref}$

$g_E' = g\,(\rho_S - \rho_E)/\rho_{ref}$

$M_S = g'\,(h_S)^2\,/\,2f$
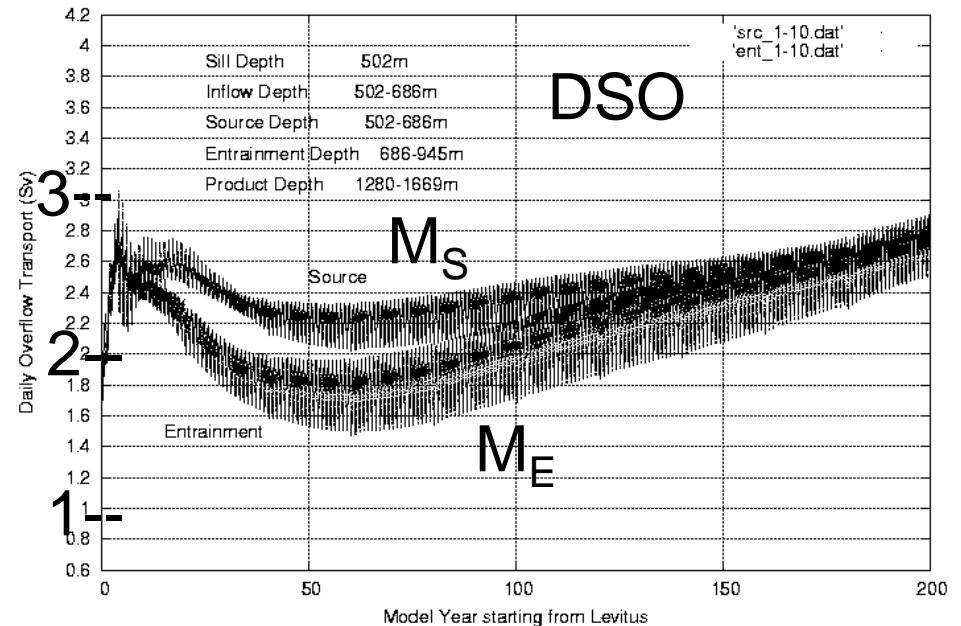
$M_P = M_S + M_E$
+
Heat and salt conservation

Working ?

M_S , M_E (Sv)
200 year Spin Up

Acceptable   drifts

Final assessment
when run together

Ocean Only x3 resolution Faroe Bank Channel Overflow Mass Fluxes (fbc006)

Sill Depth	686m
Inflow Depth	686-945m
Source Depth	686-945m
Entrainment Depth	1280-1669m
Product Depth	1669-2098m

FBC

M_S

M_E

Sill Depth	502m
Inflow Depth	502-686m
Source Depth	502-686m
Entrainment Depth	686-945m
Product Depth	1280-1669m

DSO

M_S

M_E
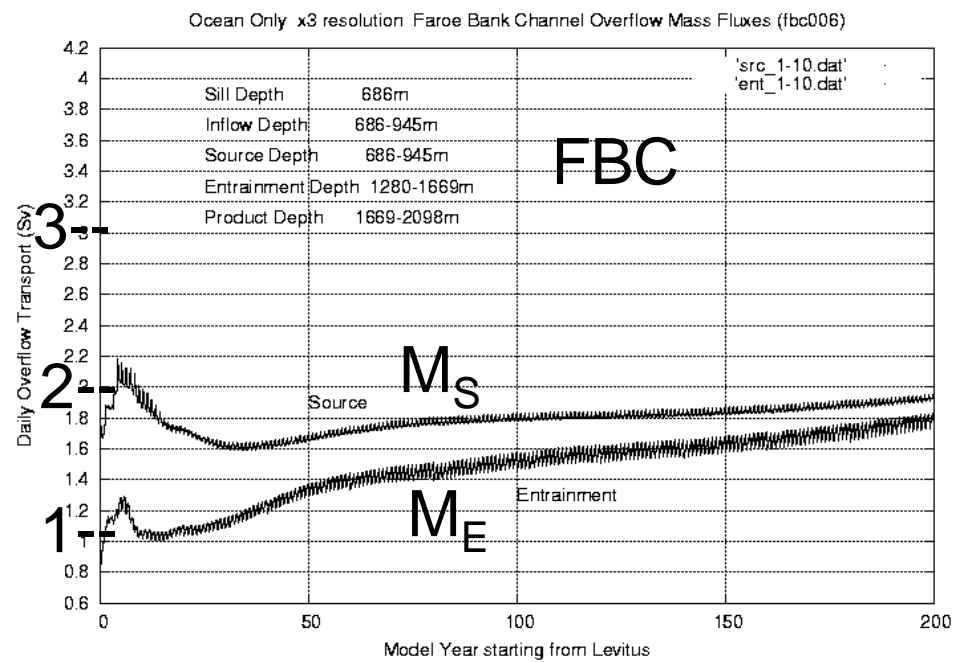
Working ?

North Atlantic
Ideal Age (181-200)
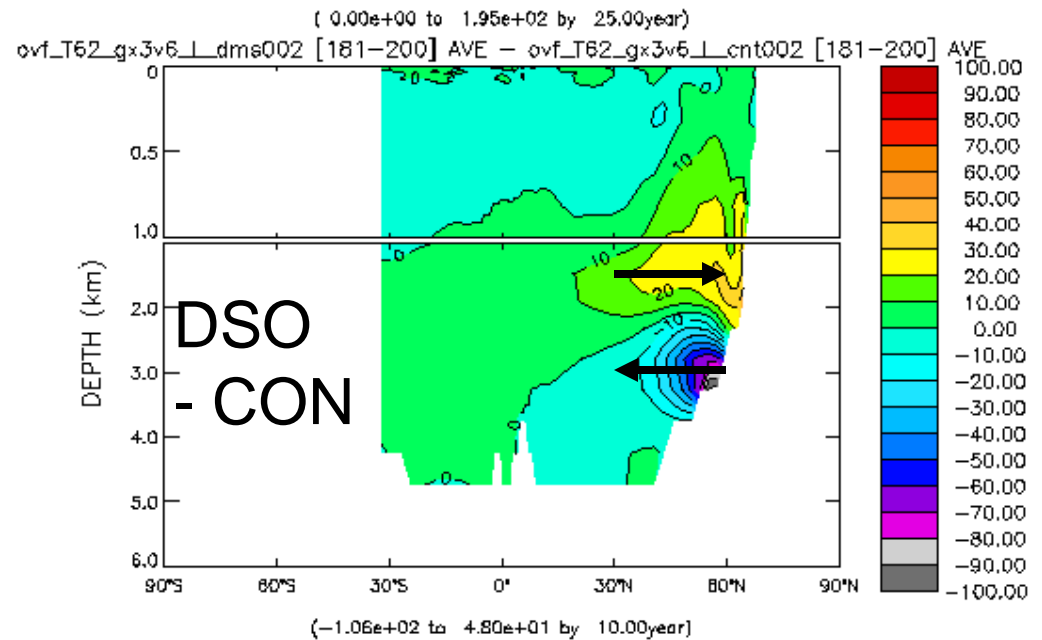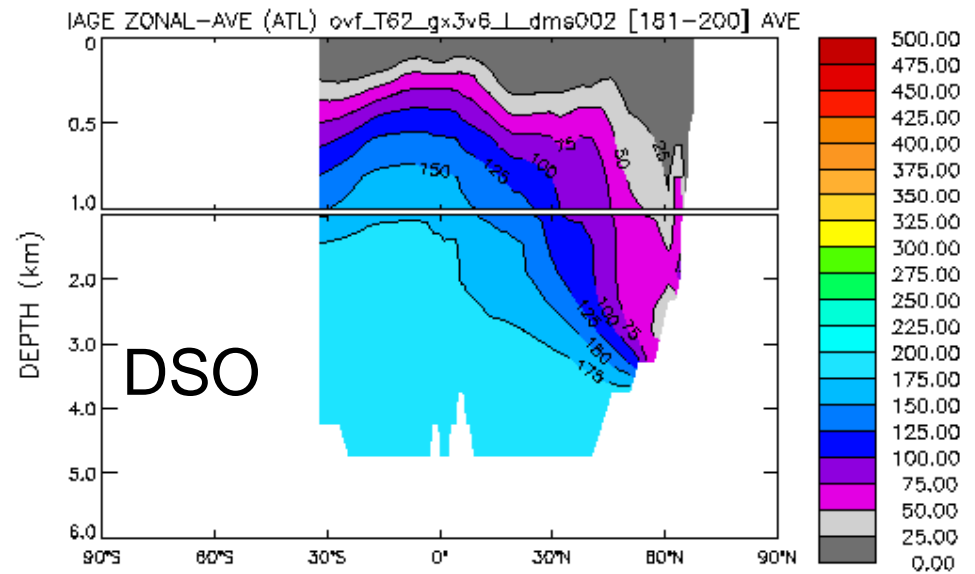
Ocean Model for CCSM4 +:

- Ocean Carbon Cycle (ecosystem)
- Reduced sea ice extent in Arctic margins
- Improved equatorial ocean physics (ENSO)
- Slower Antarctic Circumpolar Current
- Cooler coastal SSTs (eastern boundaries)
- Deeper North Atlantic Overturning
- Warmer North Atlantic SST (Gulf Stream)

Review CCSM3 to CCSM3.5

- Ocean BGC, Carbon-cycle
- Extension of GM90 eddy parameterization to mixed-layers with a strong depth dependency

  (CLIVAR Eddy-Mixed Layer CPT)
- Increase vertical levels from 40 to 60
- Greatly reduced lateral viscosity

  (Key to CCSM3 & FV excess sea-ice problem)

ANN
aice NH

ANN Mean

b30.004 Yrs 0091 - 0100   **t42x1.w01 Yrs 0091 - 0100**

ice area (aggregate)   % ice area (aggregate)   %
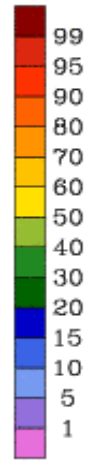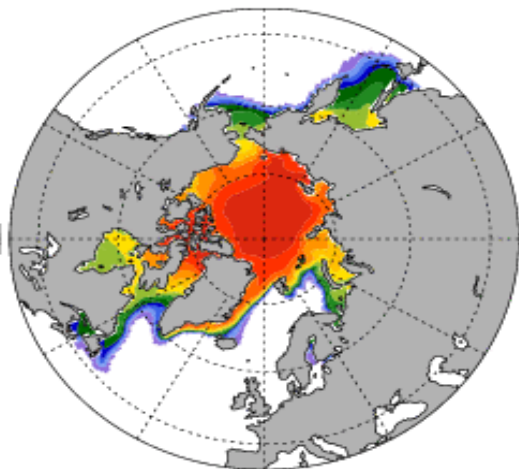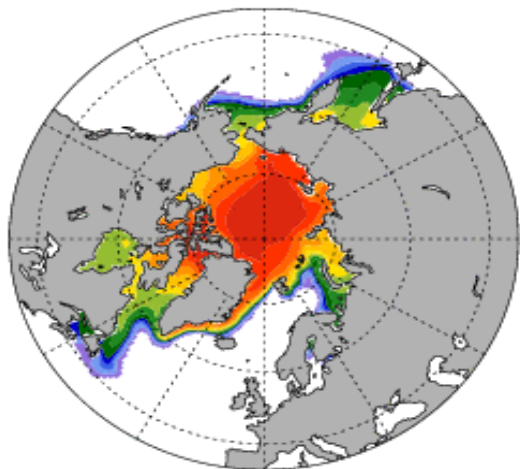
CCSM3   Low Viscosity

b30.004 - t42x1.w01

ice area (aggregate)   %

CCSM3-Low
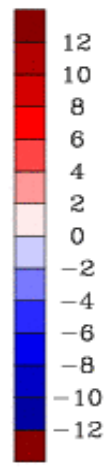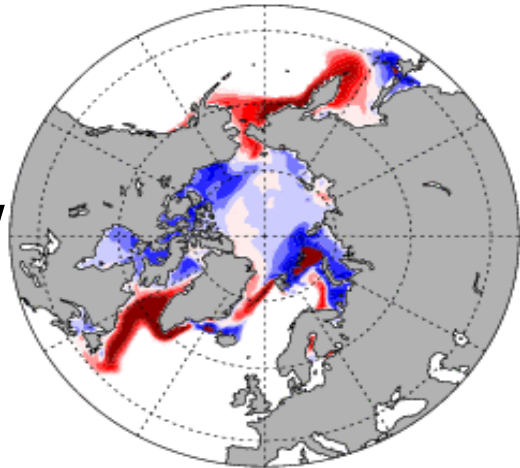
Equatorial physics (coupled)

- Extend observationally based tidal mixing to shallow seas (e.g. Banda Sea)

- Latitudinal dependent internal wave mixing in the ocean interior (1/10 tropics and Arctic), (x10 20-30º)

- Resolved Tropical Instability Waves (viscosity)

COUPLED IMPACTS

Ongoing to CCSM4 and beyond

- Final decisions will depend on CAM (PBL) !!!
- Optimizing 60 levels. 🗎
- Parameterization of sub-mesoscale re-stratification. 🗎
- Consistent PBL (atm, ocn) and flux (air-sea, air-ice, air-land) stability functions. 🗎
- Diurnal cycle of SST.   (prototyped)
- Parameterized deep overflows.   (generalizing)
- Nested regional models (coasts, ITF). (1 way)
- Coastal ecosystems at higher trophic levels. (planning)

BSF and T' @ 175m

Fully coupled

Ocean alone,

60 lvl

Ocean-ice,

60 lvl

Ocean-ice,

100 lvl
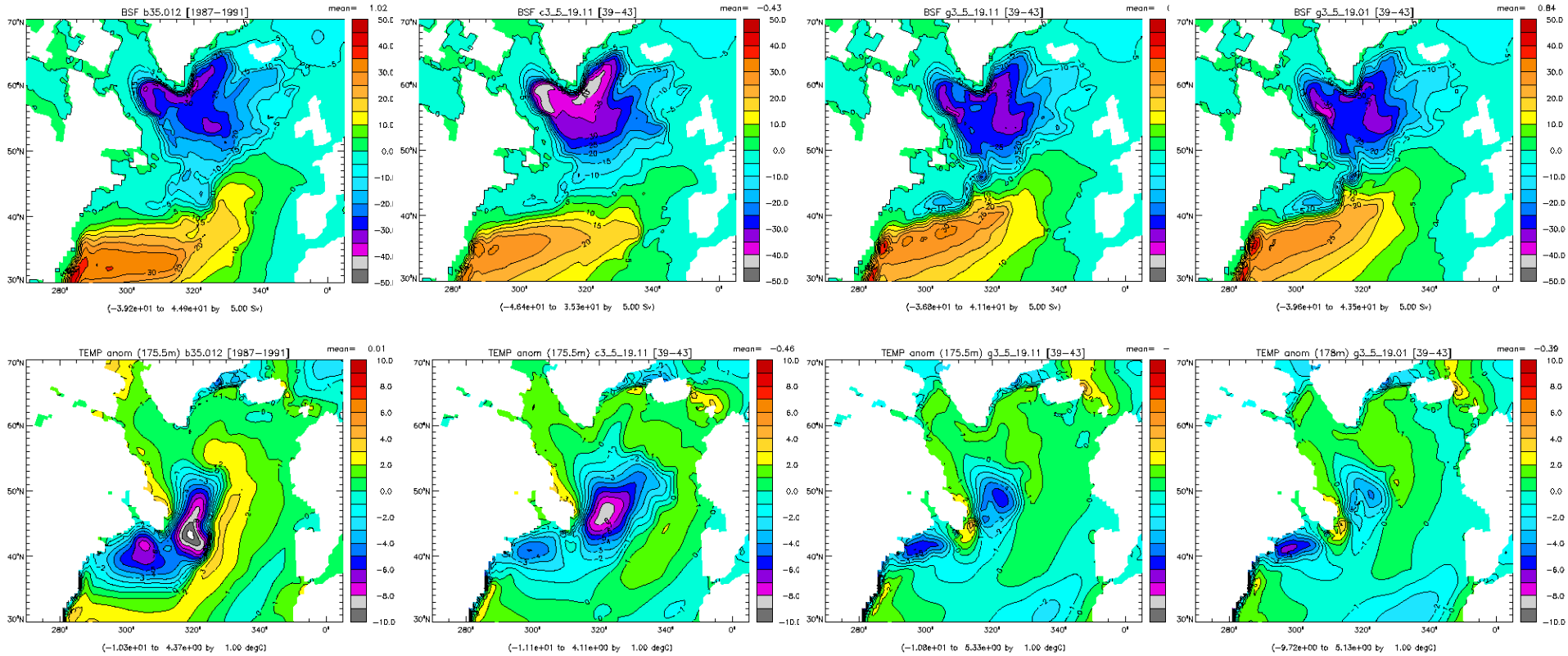
Temperature at 2000m
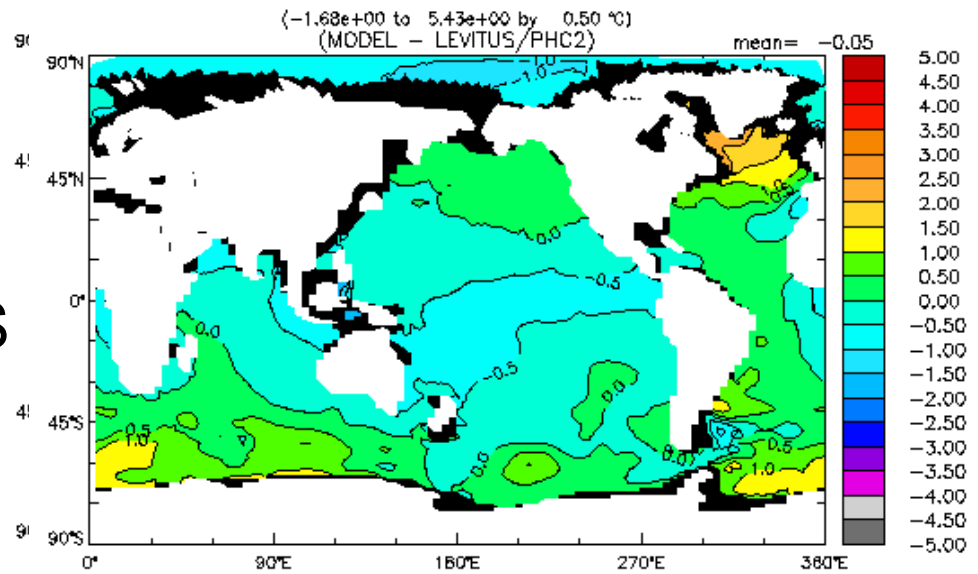
CON-OBS

DSO alone removes much of the North Atlantic bias from the Labrador Sea to the South Atlantic
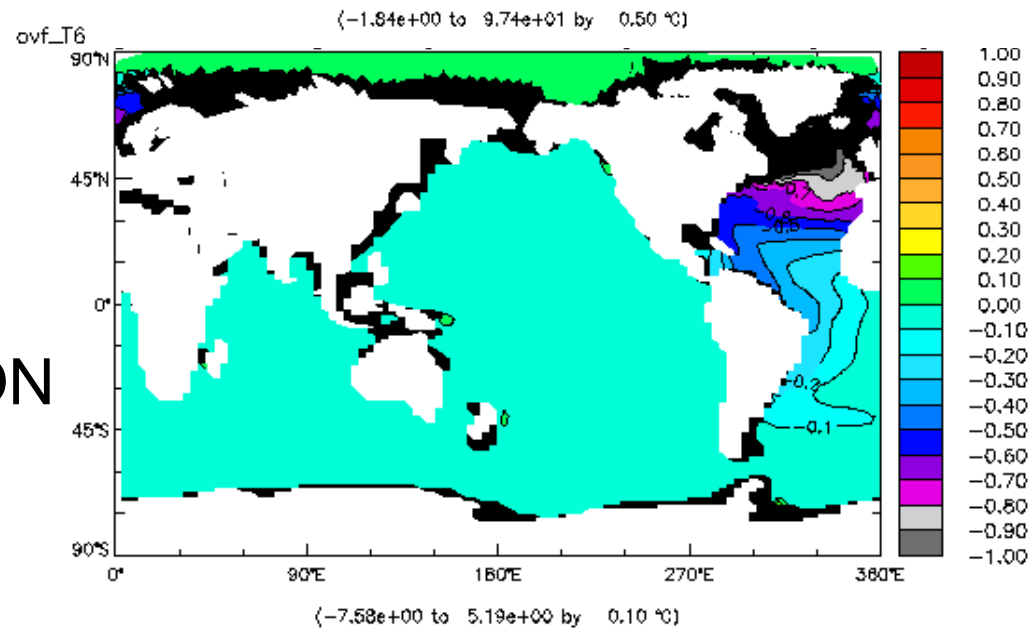
DSO-CON

Temperature at 500m

CON-OBS

DSO alone removes most North Atlantic bias between 30 and 75° N .

DSO-CON
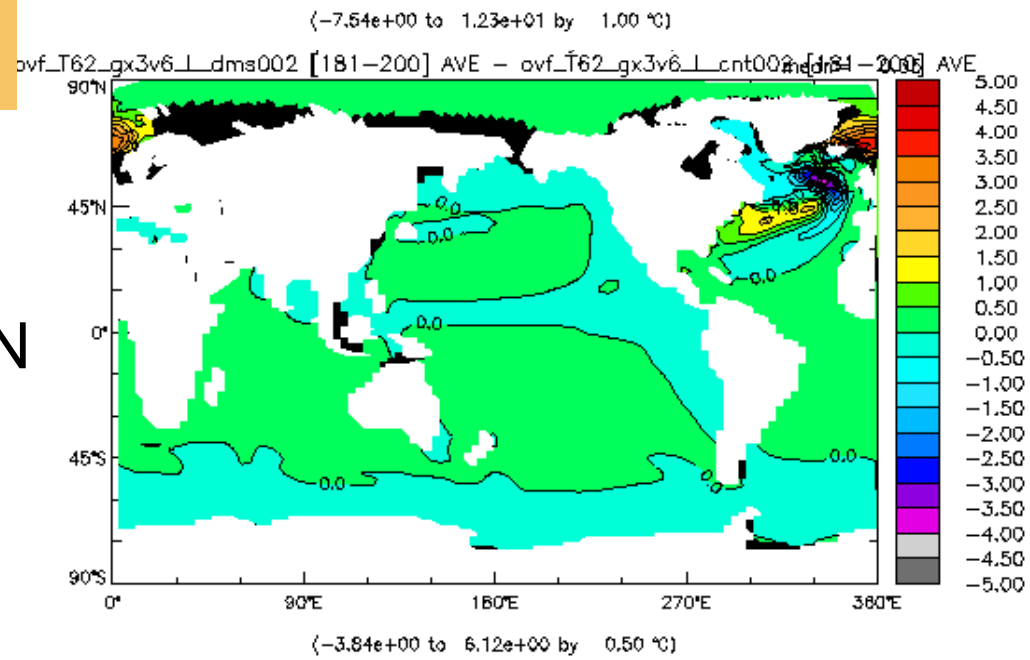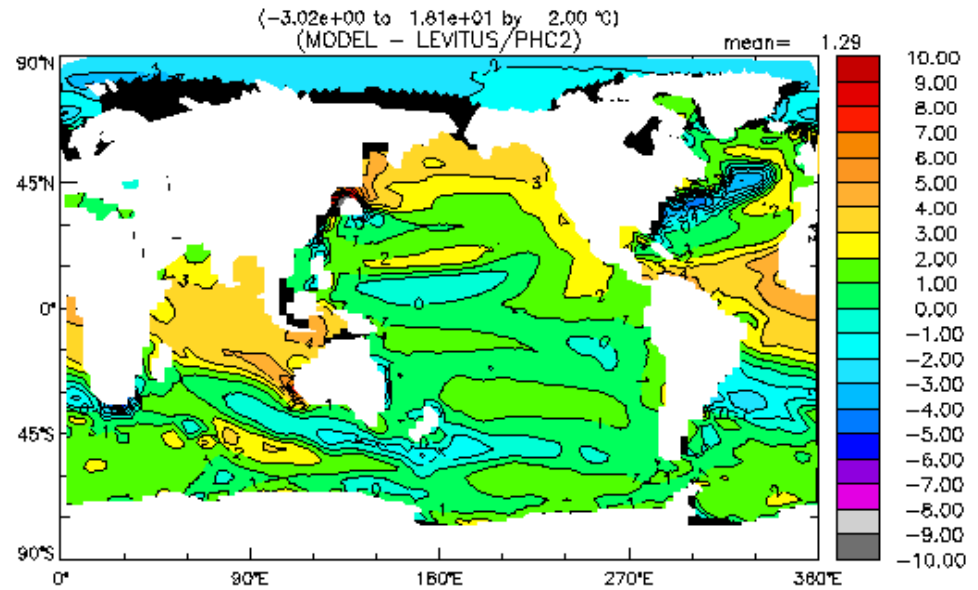
ZONAL WIND STRESS

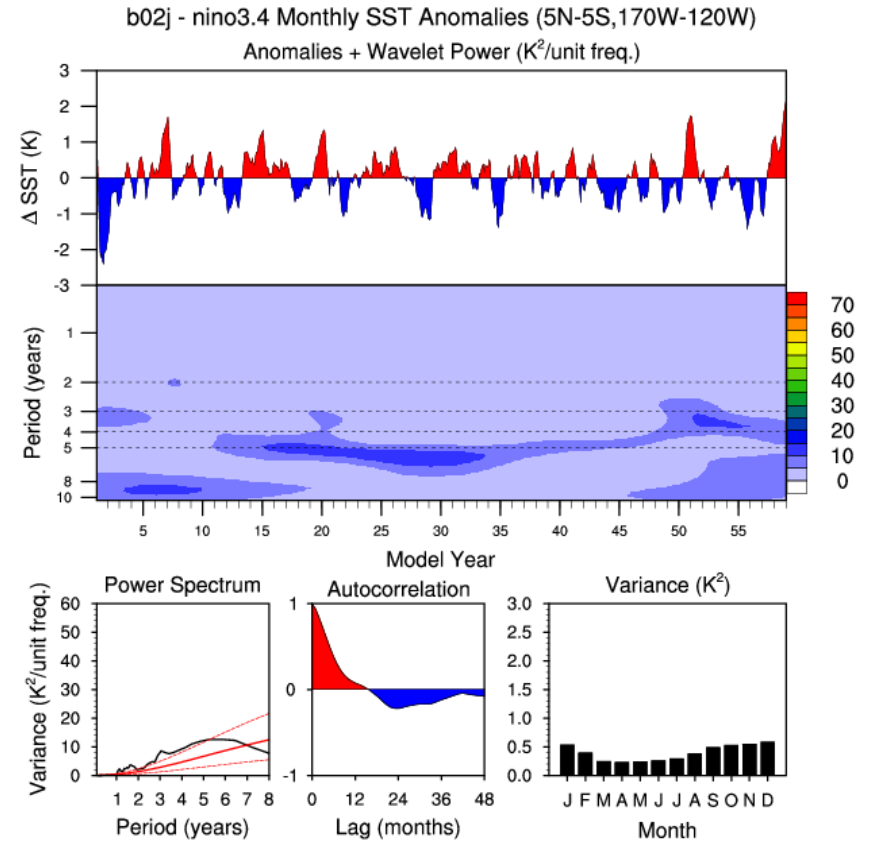## CCSM3.5 (26)

CCSM3.5 (31)

Observed   CCSM3.5 (26)

Observed
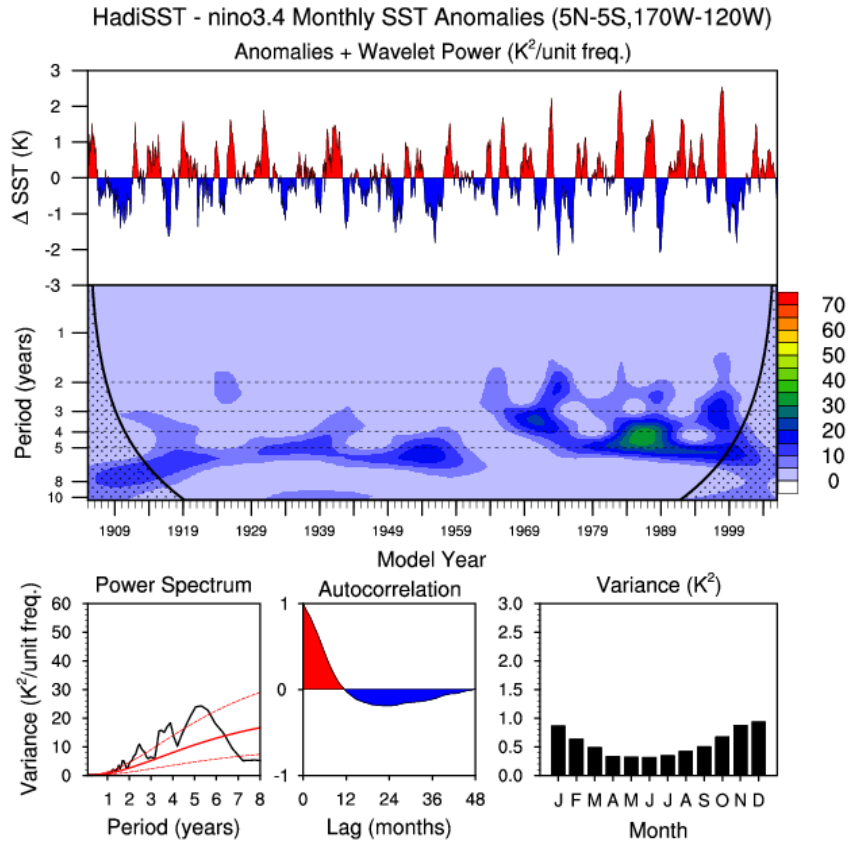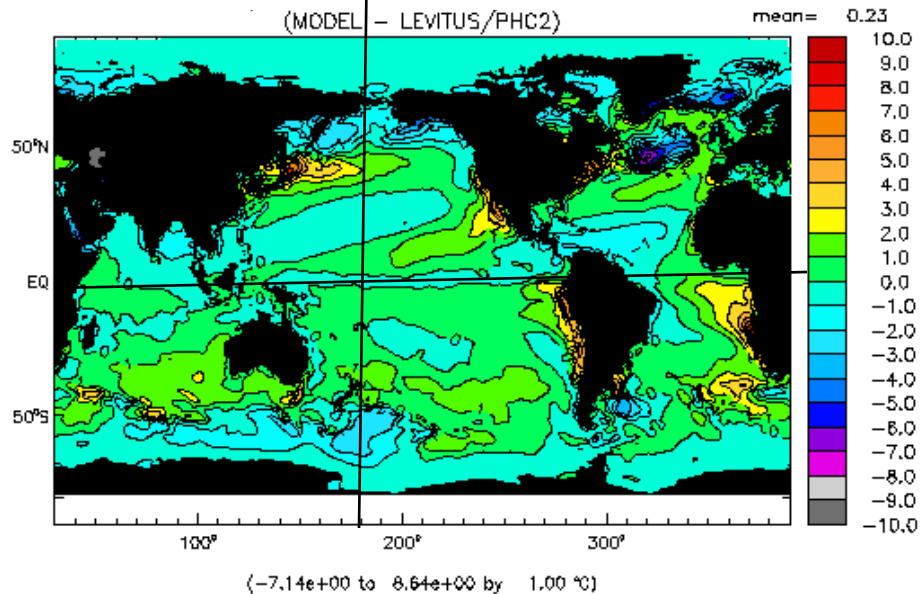
CCSM3.5 (31)

THE   END

Add Monday

- Slides on NAC from Steve

Interior Diffusivity

ΔSST colors

ΔSLP contours

No change to Ocean PBL

SST bias
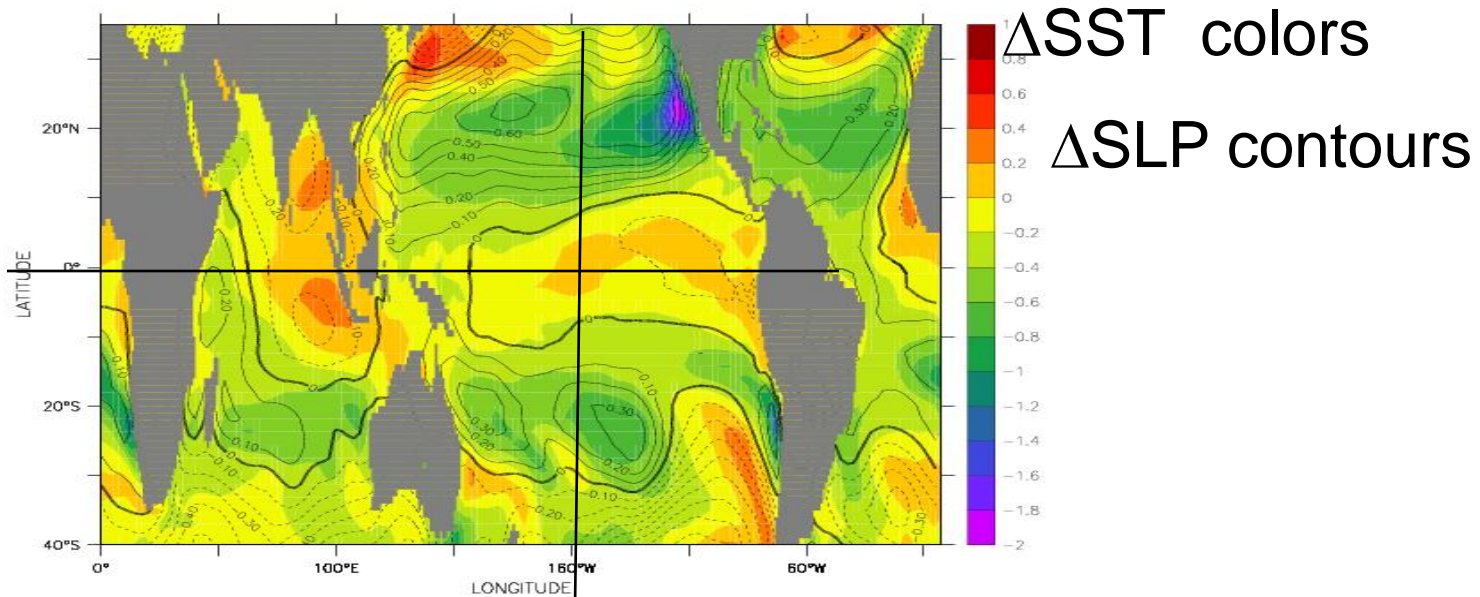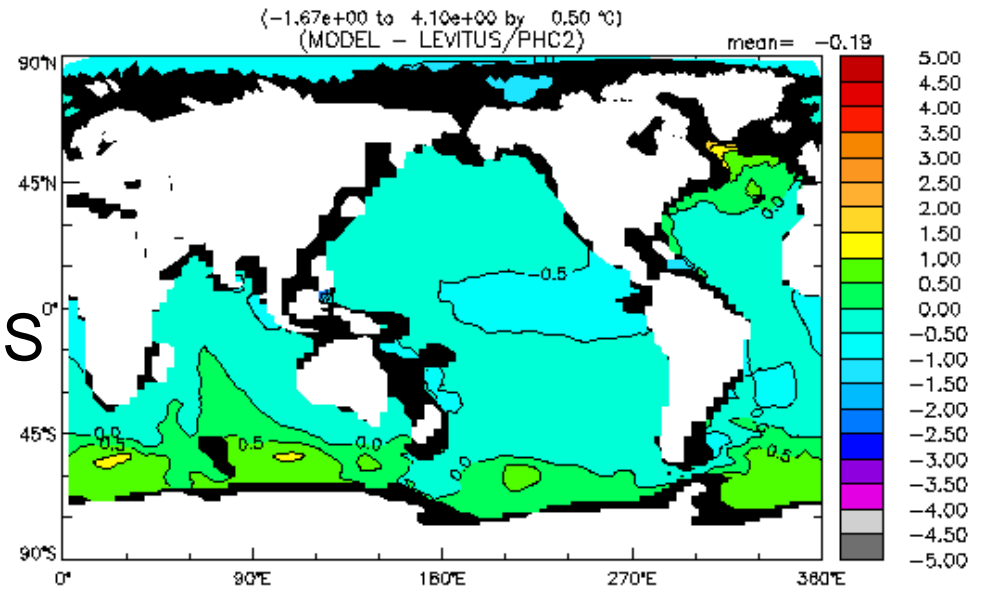
dSST (color) and dPSL (mbar)

Temperature at 3000m

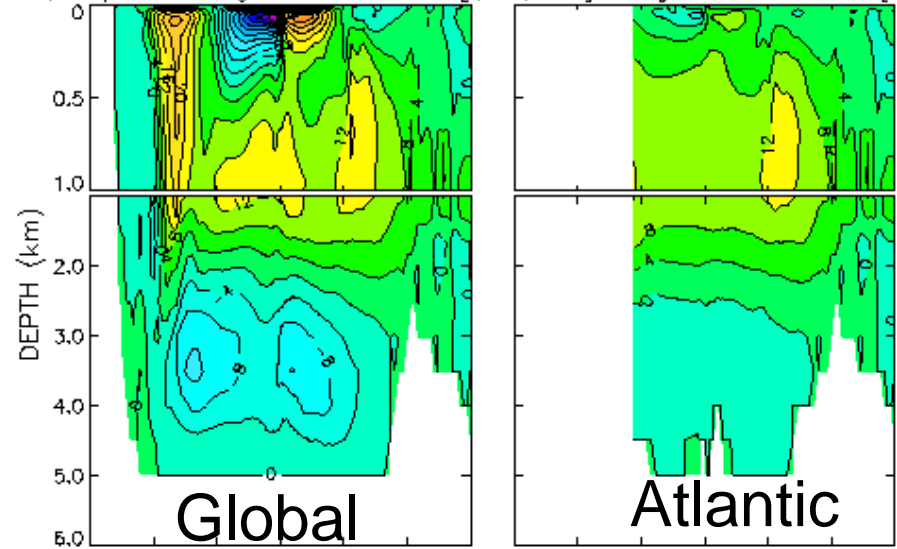CON-OBS

DSO alone reduces North Atlantic biases

DSO-CON
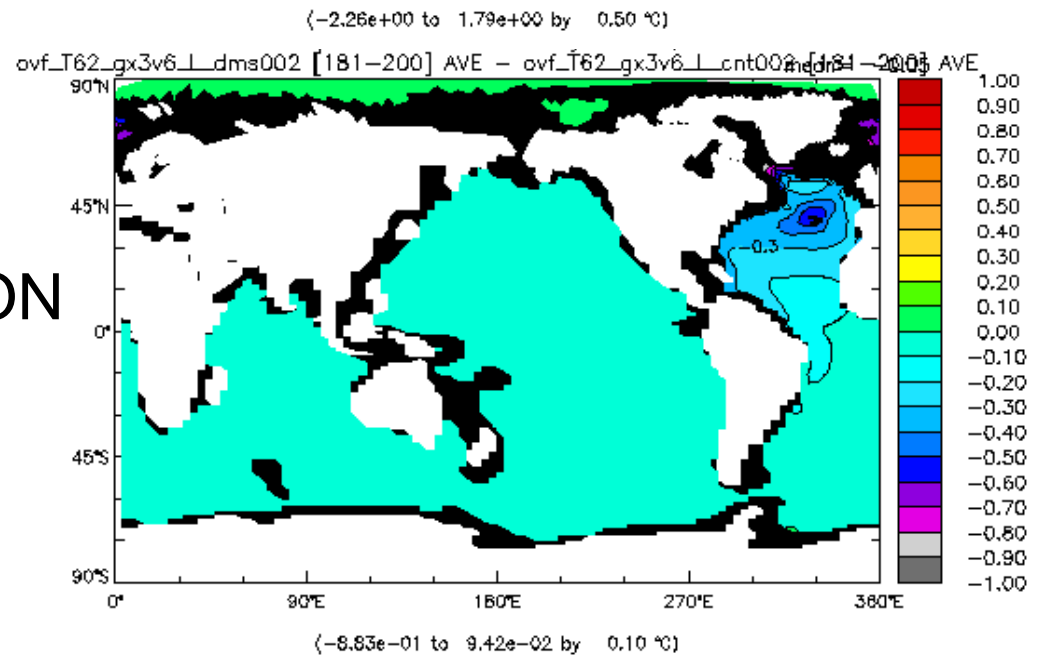
MOC

DSO

Both deep downstream and shallow upstream responses

DSO-CON

Global

Atlantic

b30.081, year 186
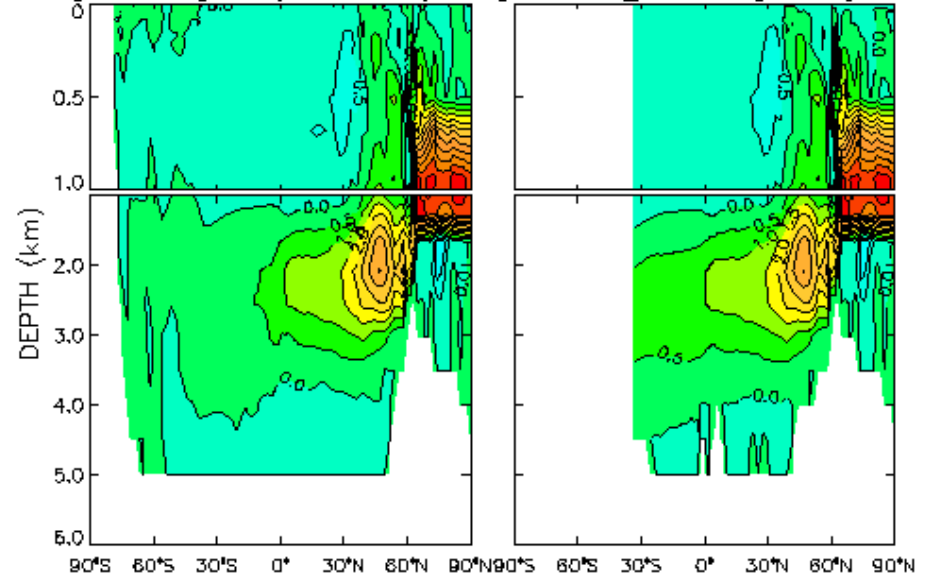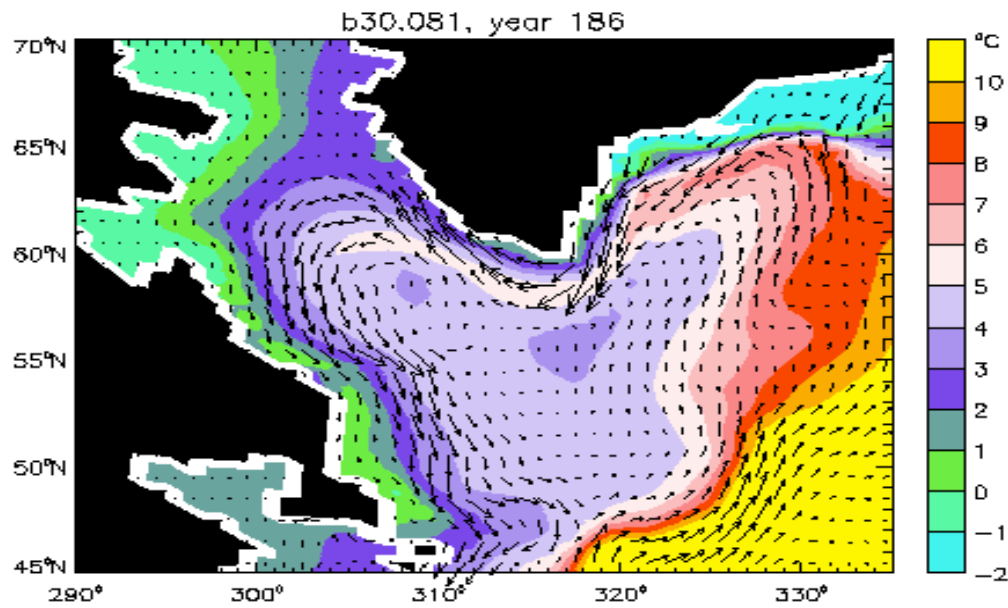
FV2x1

Low Viscosity

b30.021, year 186
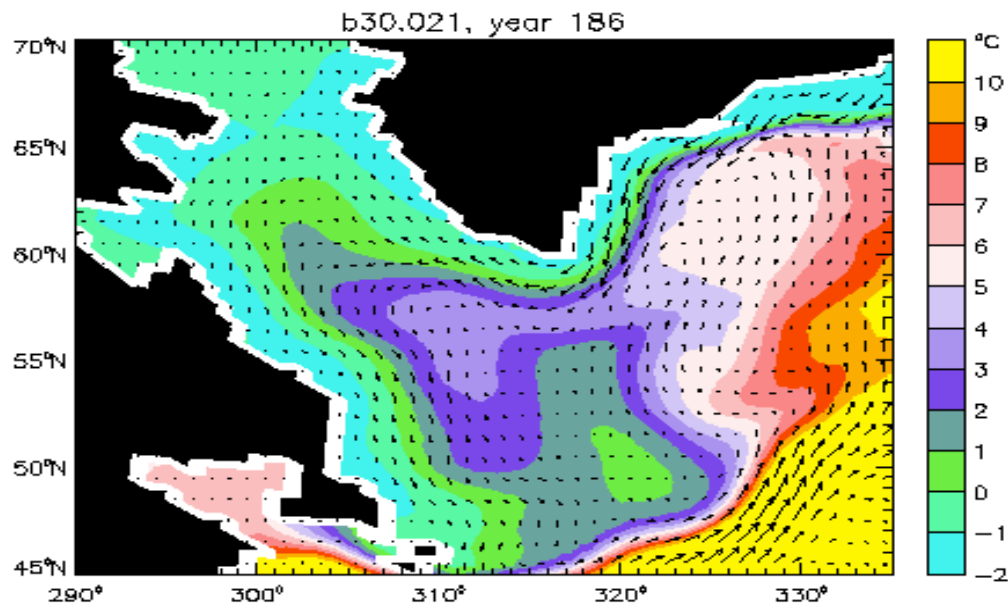
Higher Viscosity

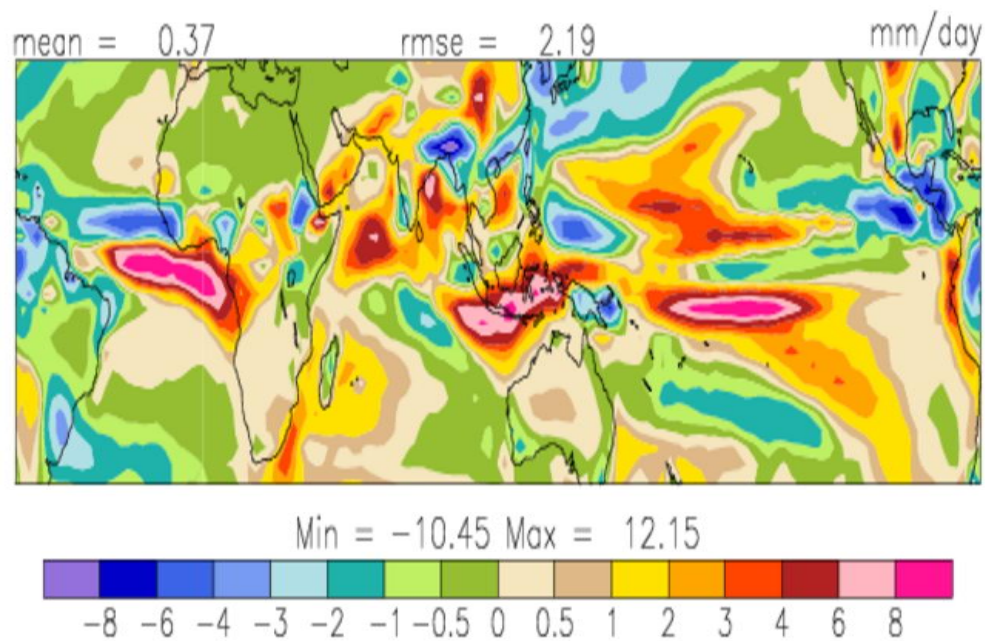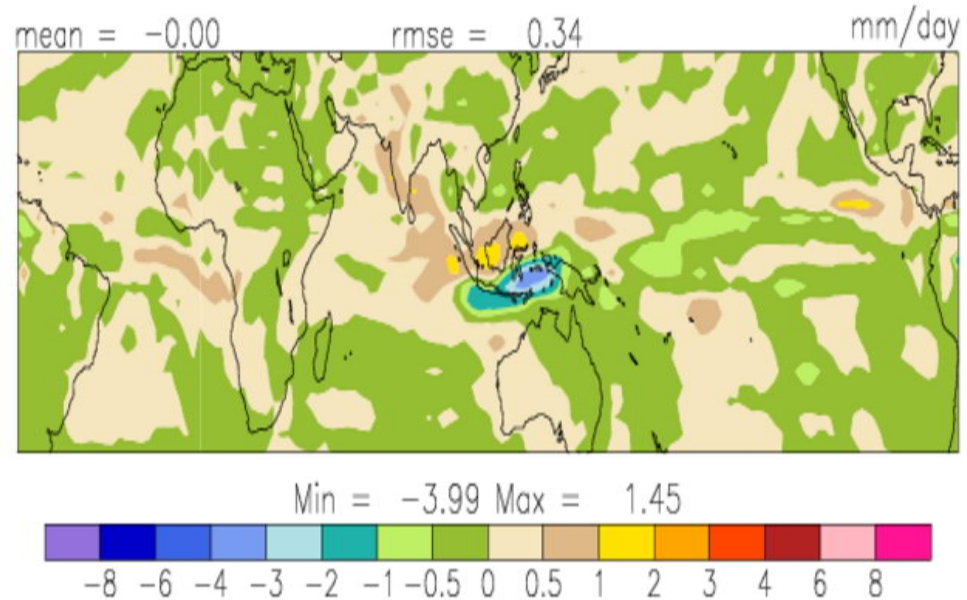T & velocity at 96.9241m

Tropical rainfall
biases in T42x1.

Min = −10.45 Max = 12.15

mean = 0.37   rmse = 2.19   mm/day

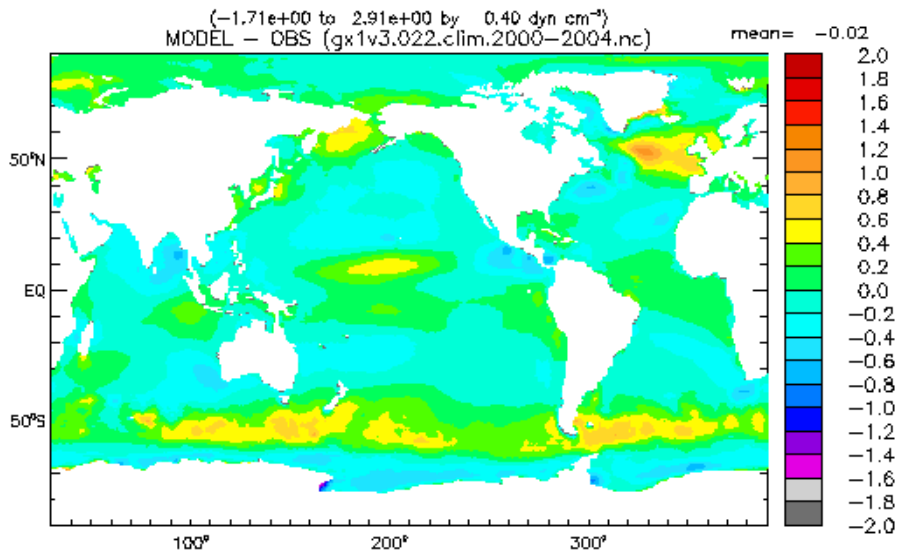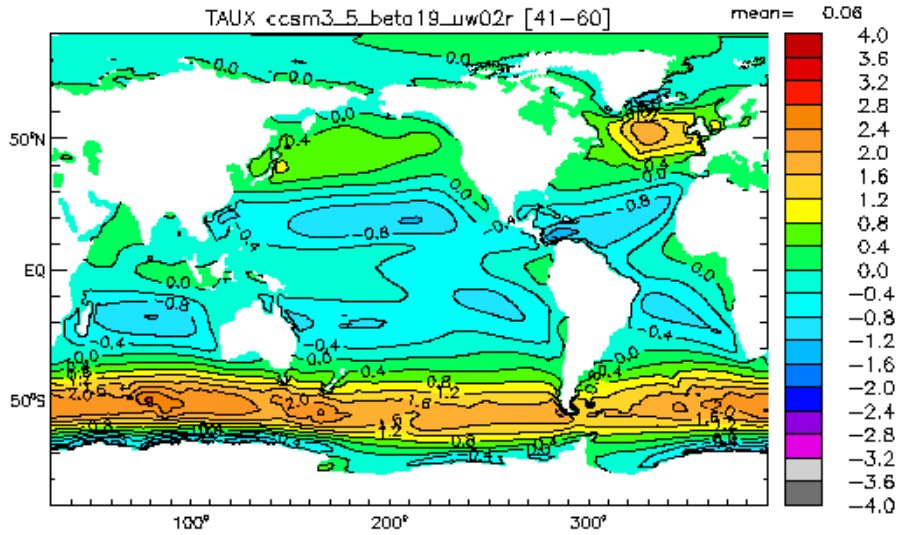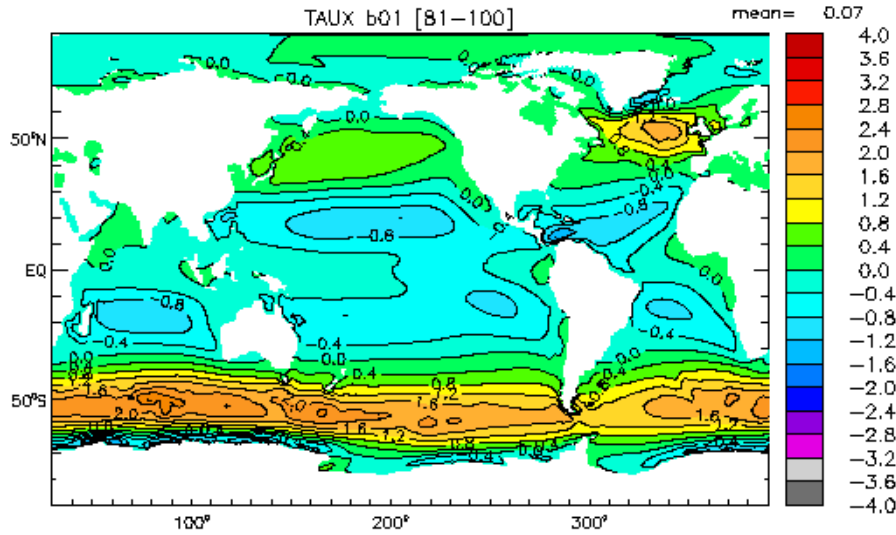|															
−8	−6	−4	−3	−2	−1	−0.5	0	0.5	1	2	3	4	6	8	

Difference in
rainfall between
high mixing and
control.

mean = −0.00   rmse = 0.34   mm/day

Min = −3.99 Max = 1.45

−8	−6	−4	−3	−2	−1	−0.5	0	0.5	1	2	3	4	6	8	

ZONAL WIND STRESS

CCSM3.5 (26)

UW (30)

TAUX b01 [81-100]   mean= 0.07

(−1.71e+00 to 2.81e+00 by 0.40 dyn cm⁻²)
MODEL − OBS (gx1v3.022.clim.2000−2004.nc)   mean= −0.01
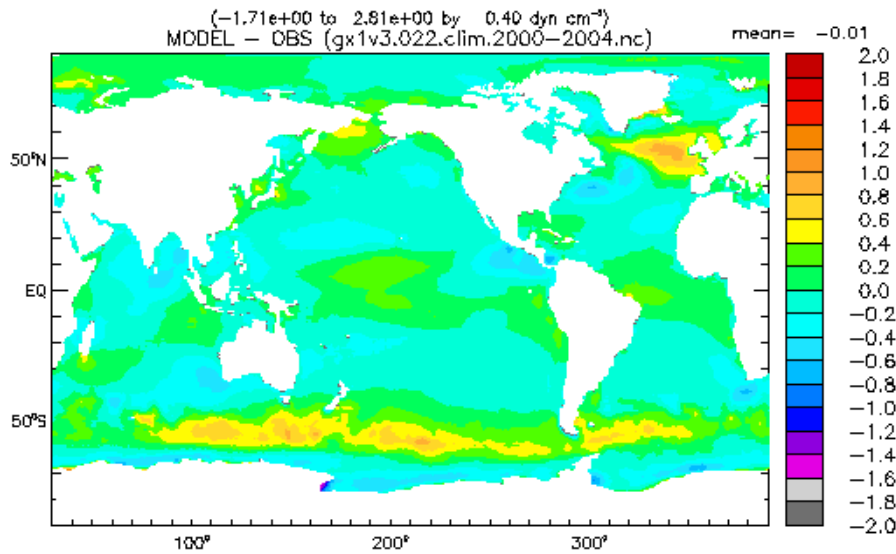
(−1.57e+00 to 1.47e+00 by 0.20 dyn cm⁻²)

TAUX ccsm3_5_beta19_uw02r [41-60]   mean= 0.06

(−1.71e+00 to 2.91e+00 by 0.40 dyn cm⁻²)
MODEL − OBS (gx1v3.022.clim.2000−2004.nc)   mean= −0.02

(−1.53e+00 to 1.54e+00 by 0.20 dyn cm⁻²)
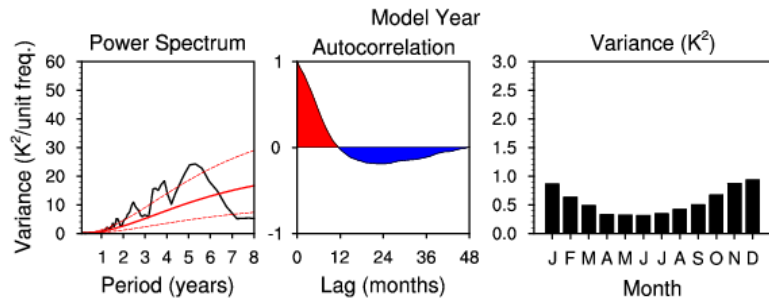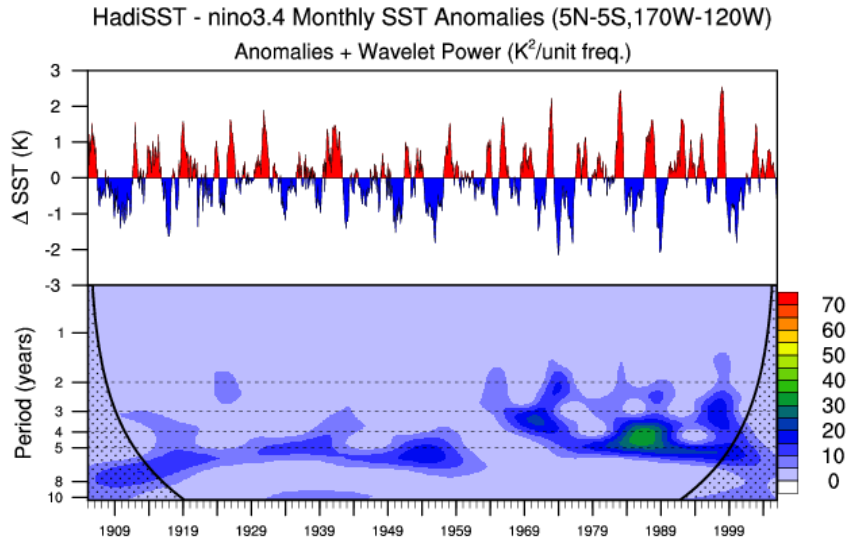
Observed — UWpbl (30)

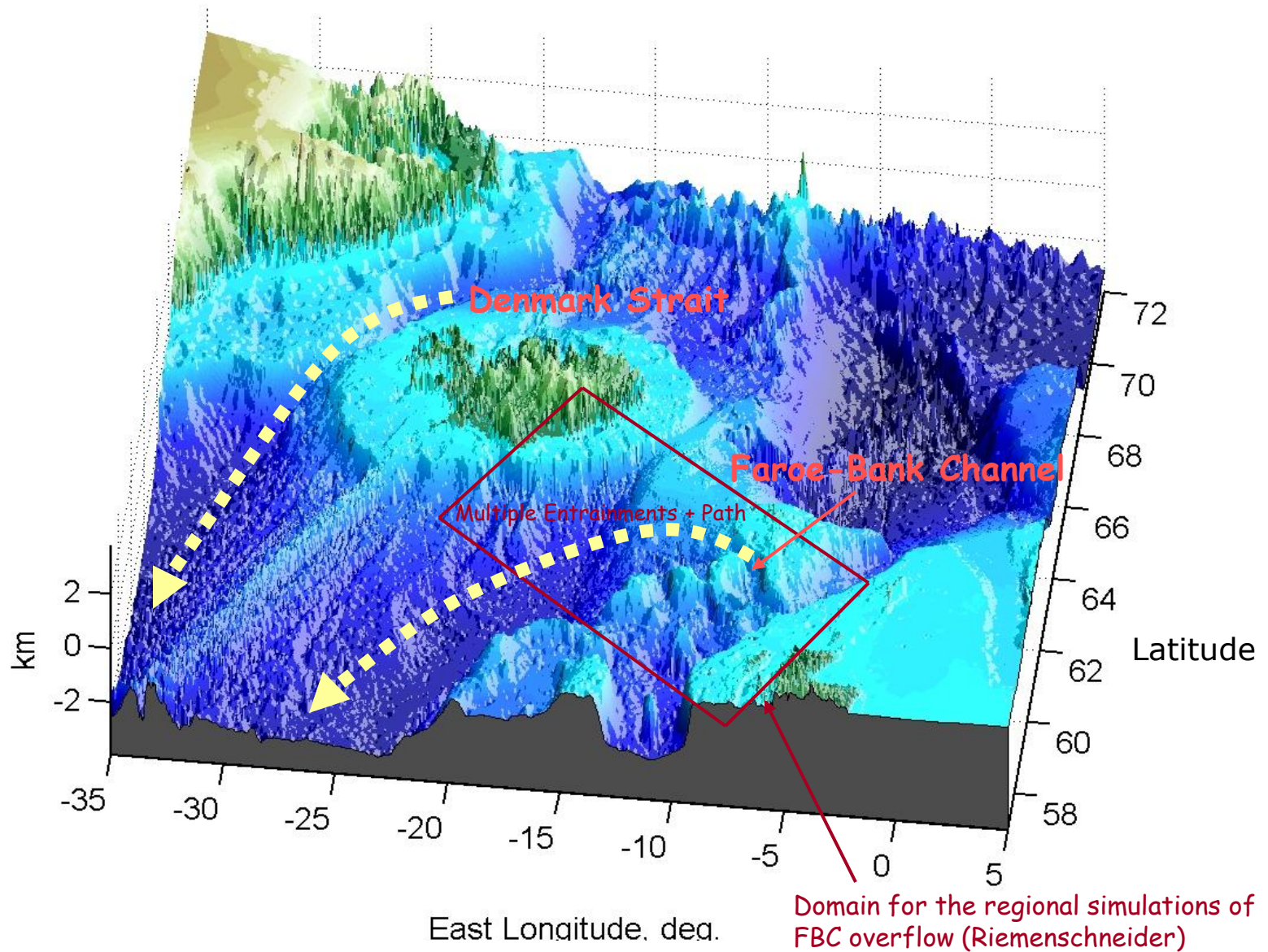# Parameterized Overflows

from J.Price
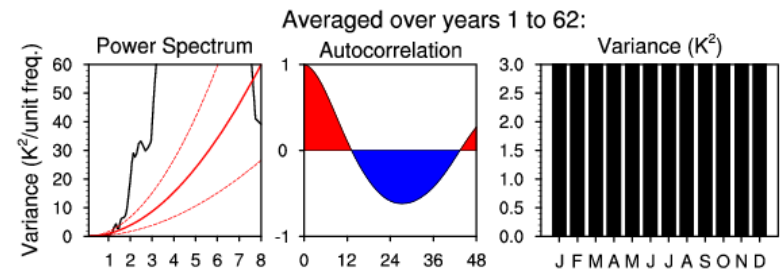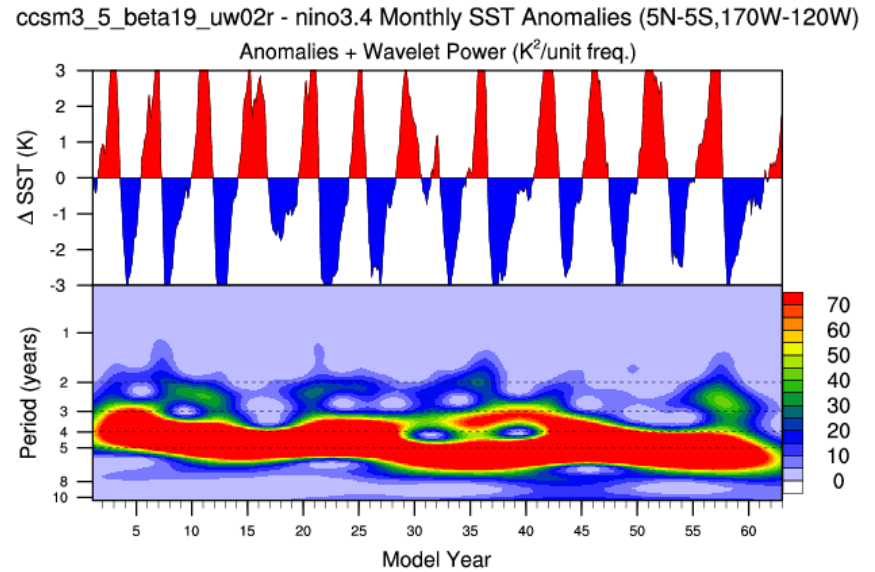
Ideal Age (181-200)

DSO

Young DSO water goes deeper to 4000m

DSO - CON