

AMOC Perturbation Experiments a.k.a. Hosing



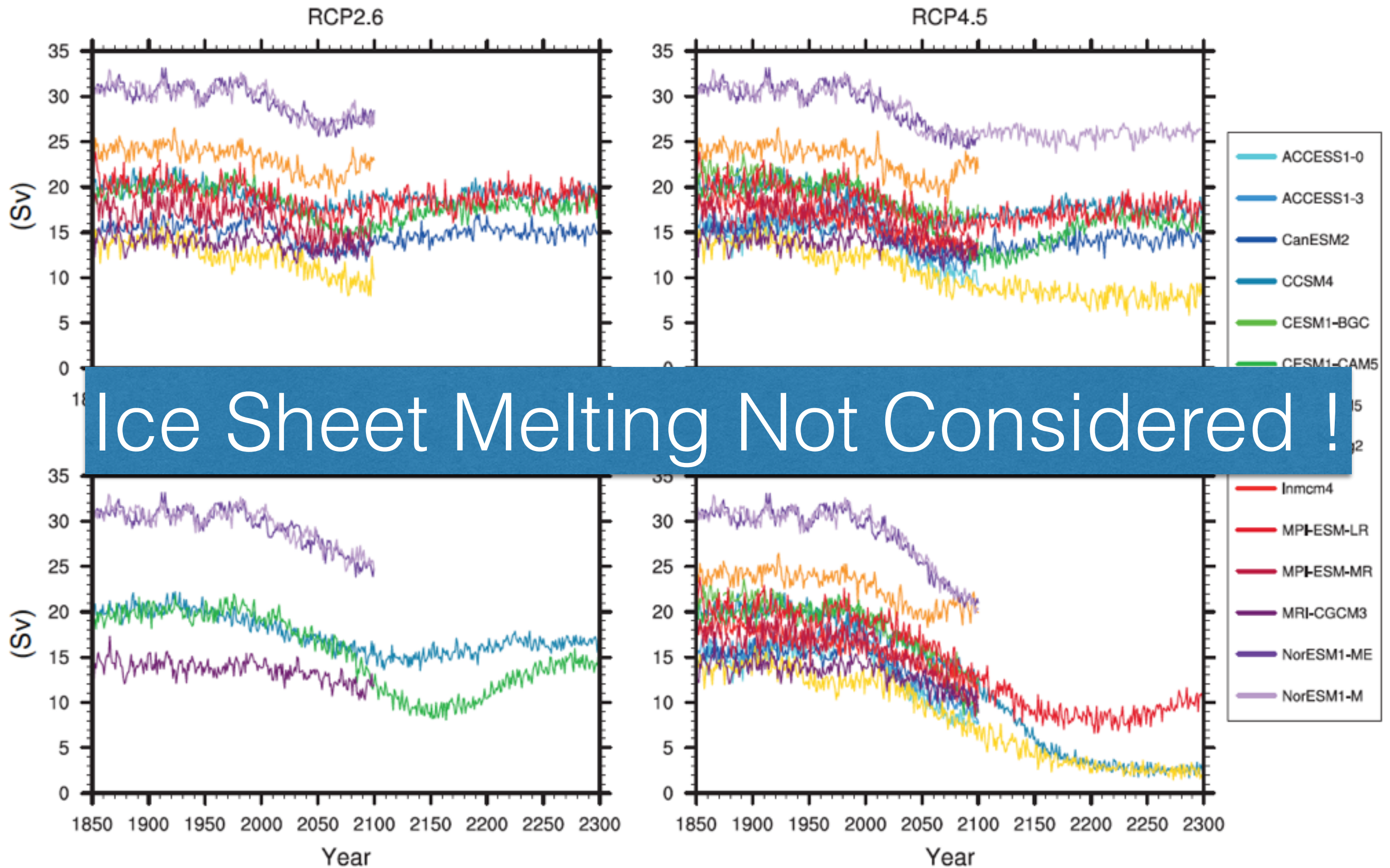
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North Atlantic Planning Workshop, April 15, 2014

Atlantic Meridional Overturning Circulation at 30°N



Atlantic Meridional Overturning Circulation Model Intercomparison Project (AMOCMIP)

Modeling Effects of Greenland Ice Sheet Melting on AMOC Variability and Predictability

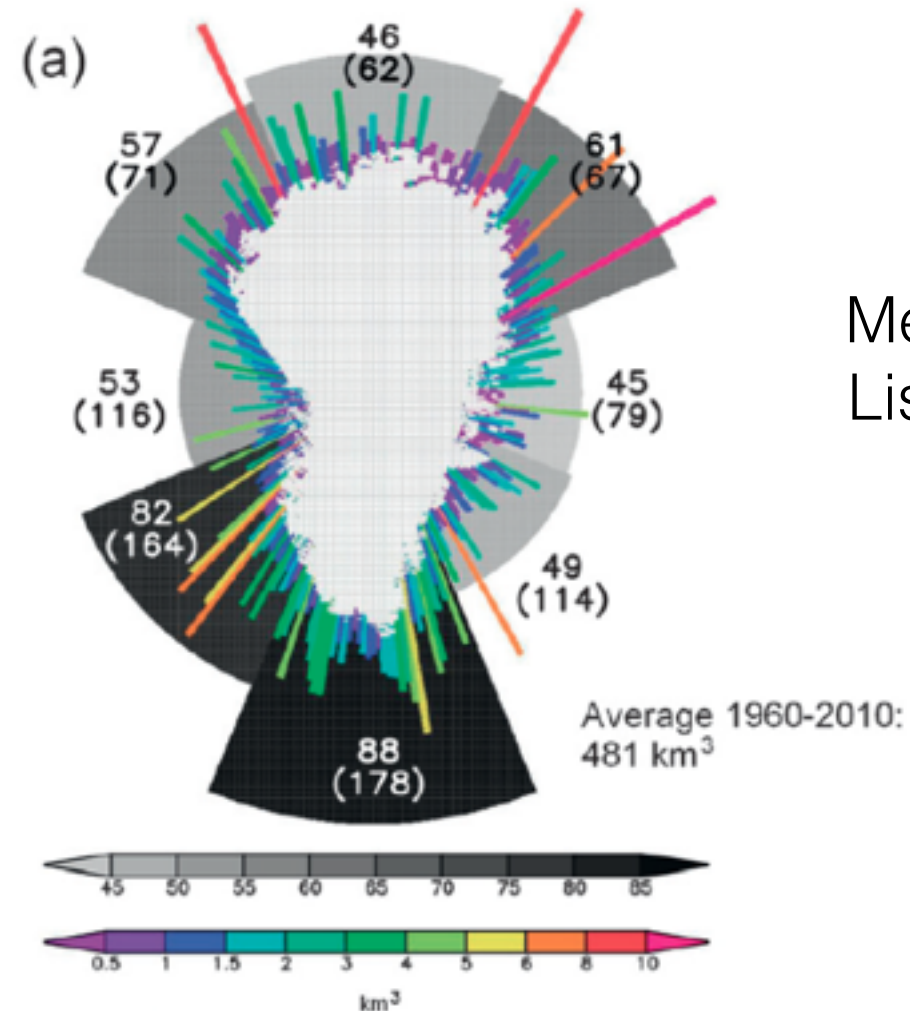


<http://people.oregonstate.edu/~schmita2/Projects/AMOC/>

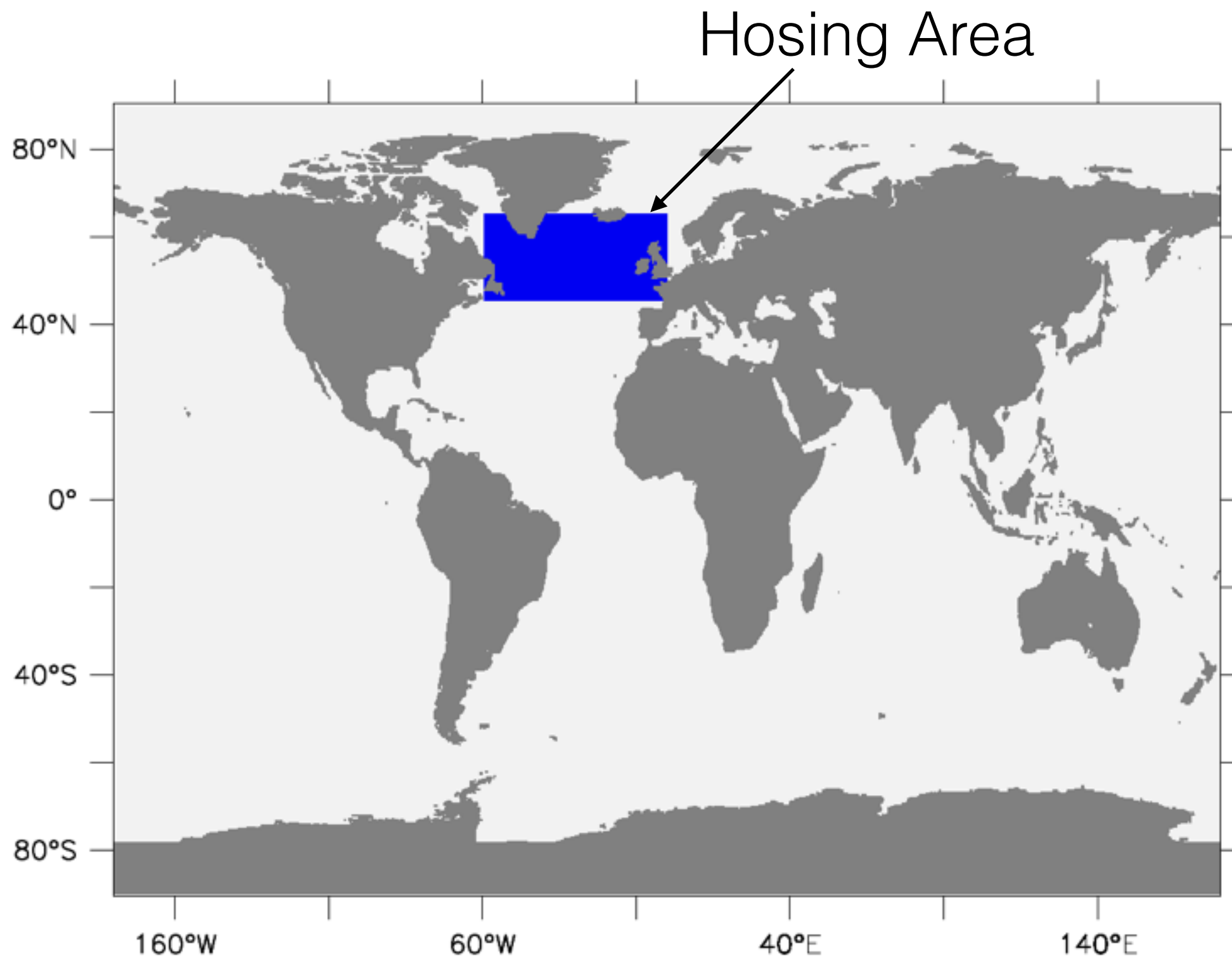


Modeling Groups:

ACCESS
BCC
CCCMA
CSIRO Mk3L
FGOALS
GFDL
HadGEM
IPSL
KNMI
MIROC
MPI
NCAR

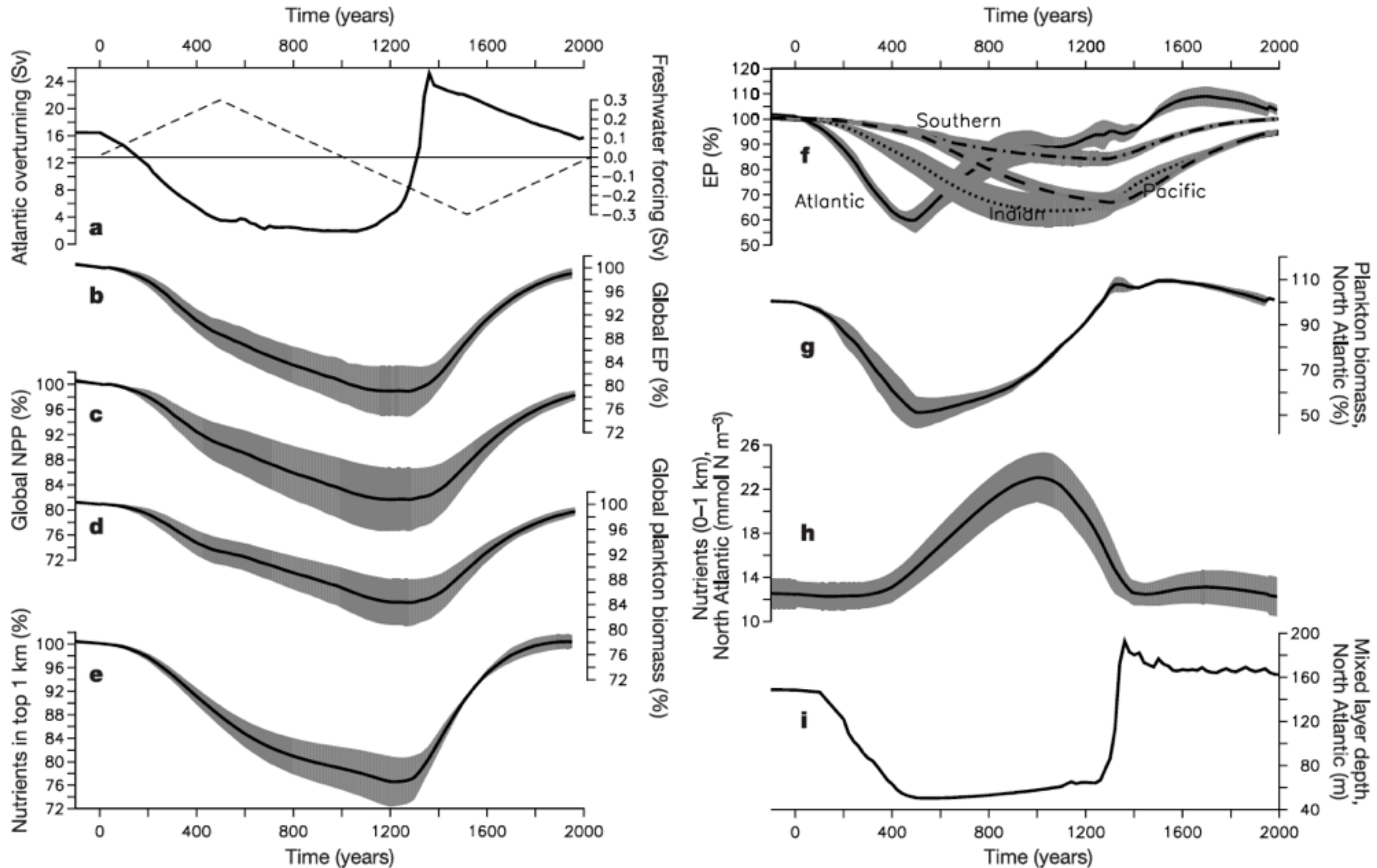


Mernhild and
Liston (2012)

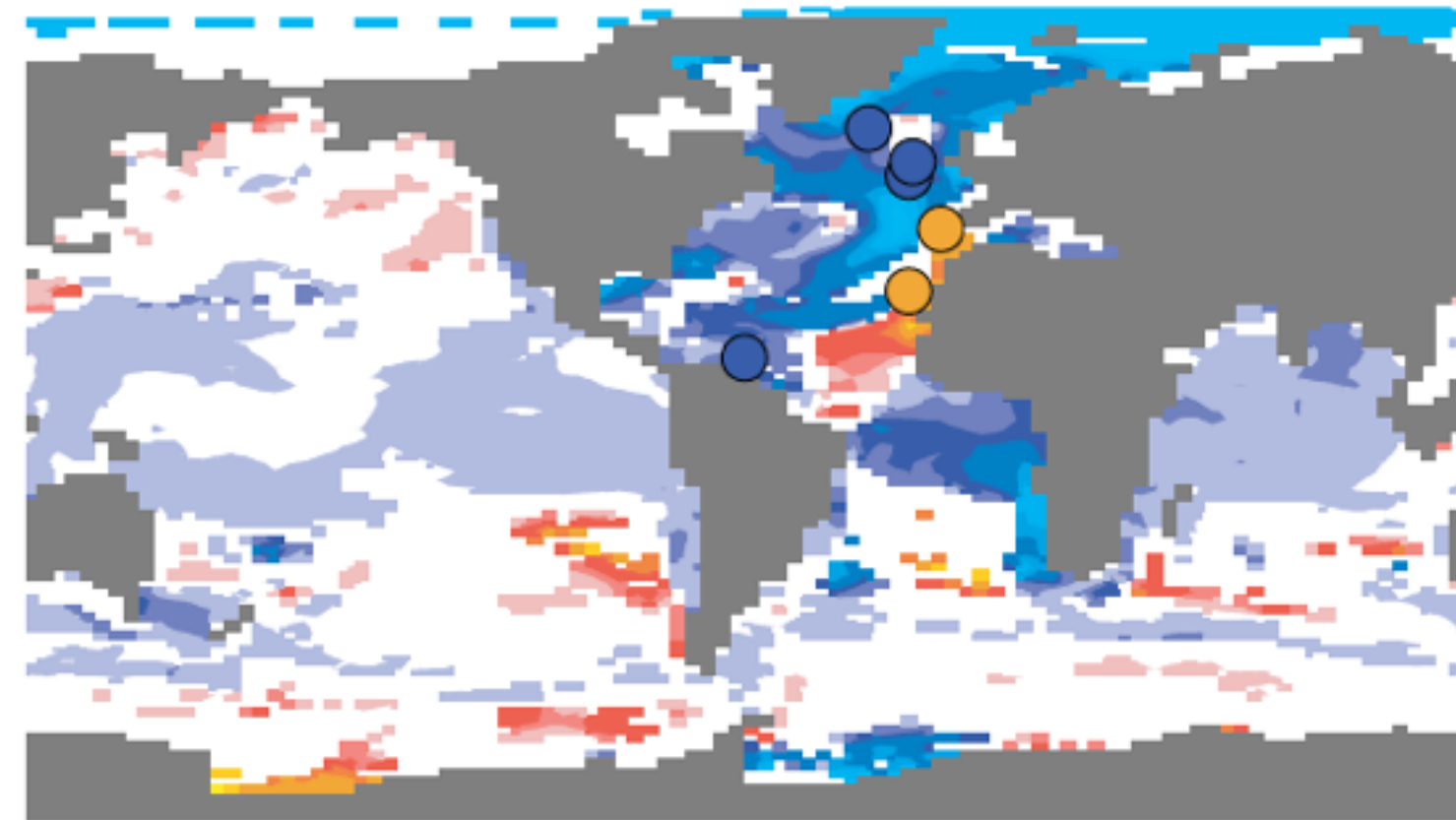
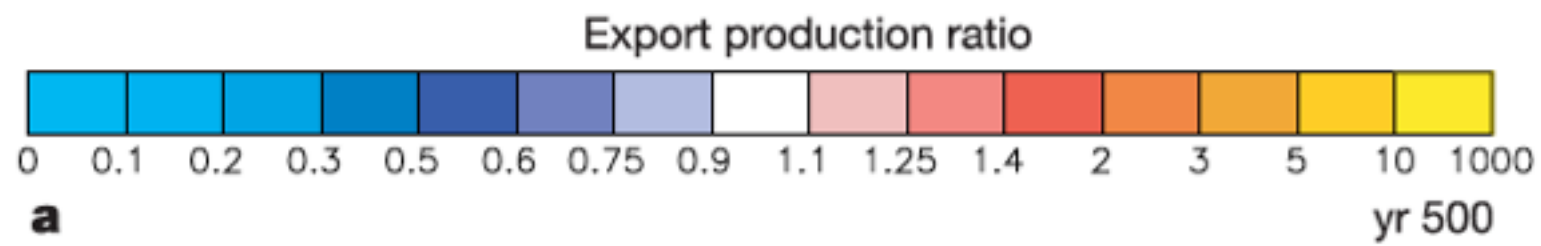


Freshwater Flux ~ 0.1 Sv ~ 1 cm/yr sea level rise

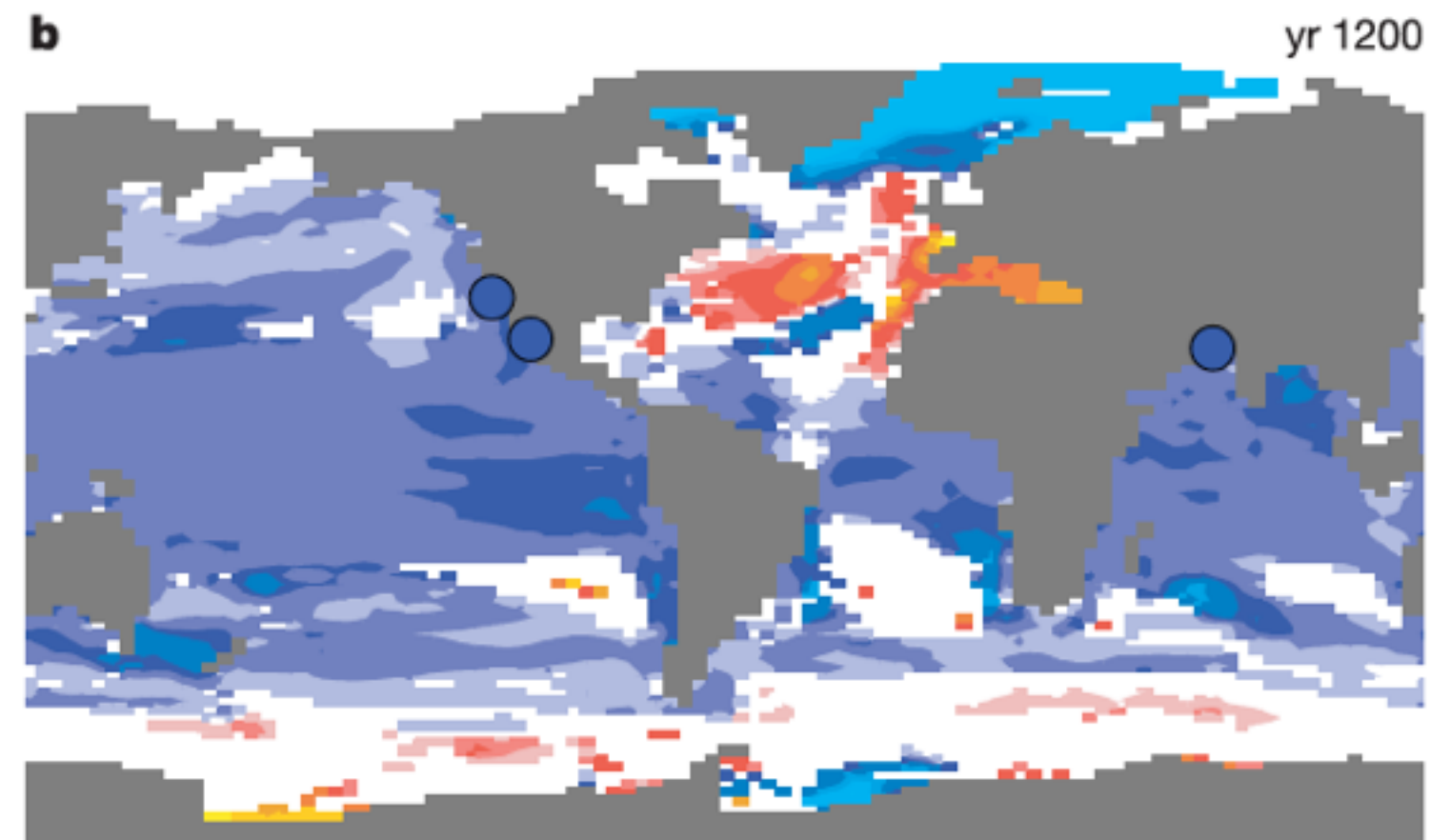
Effects on Nutrient Cycling and Productivity



Schmittner (2005) Nature



Reduced North Atlantic productivity due to shoaling of mixed layer depth

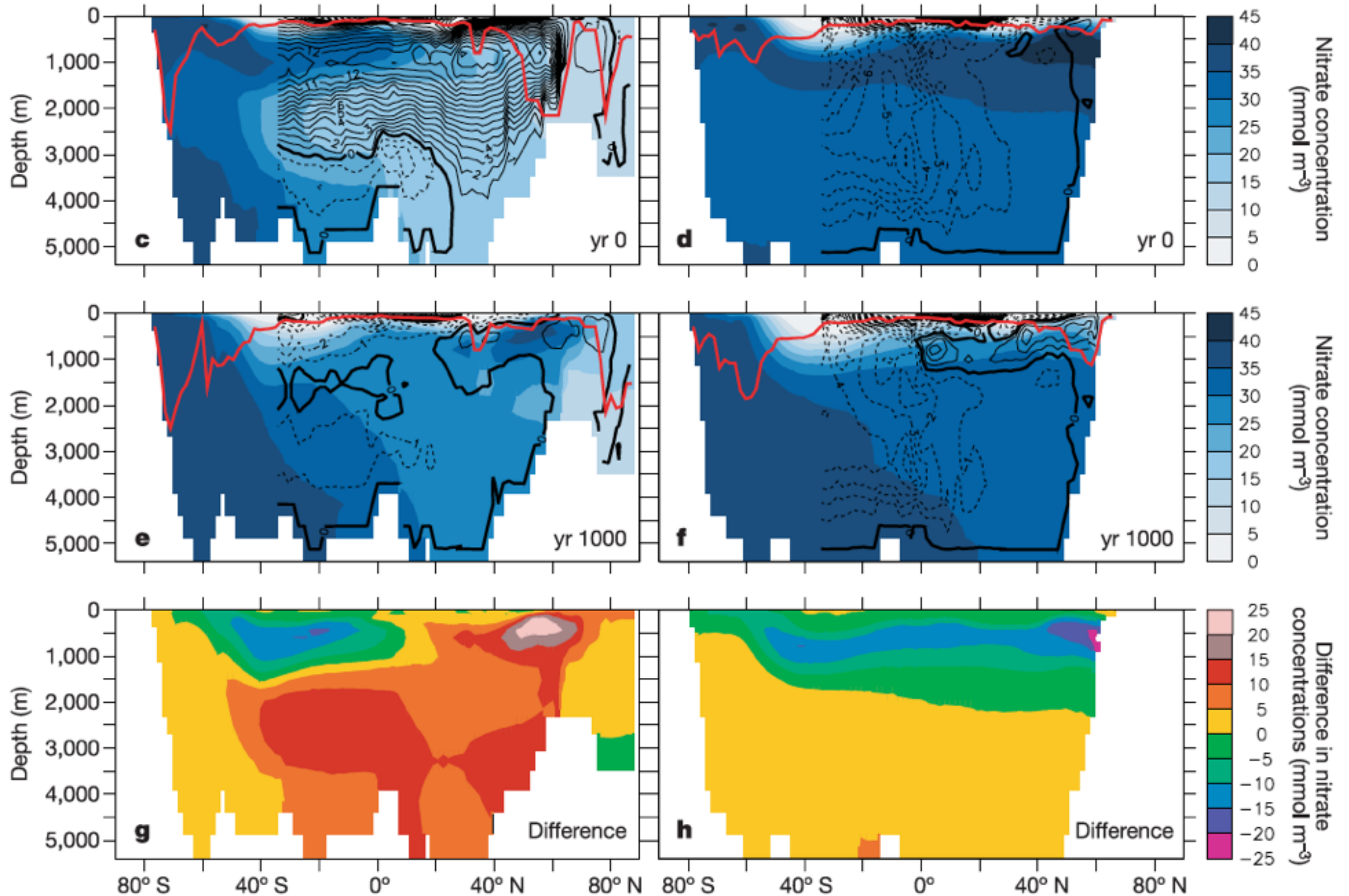


Reduced productivity in Indian and Pacific oceans due to nutricline deepening caused by reduced upwelling

Schmittner (2005) Nature

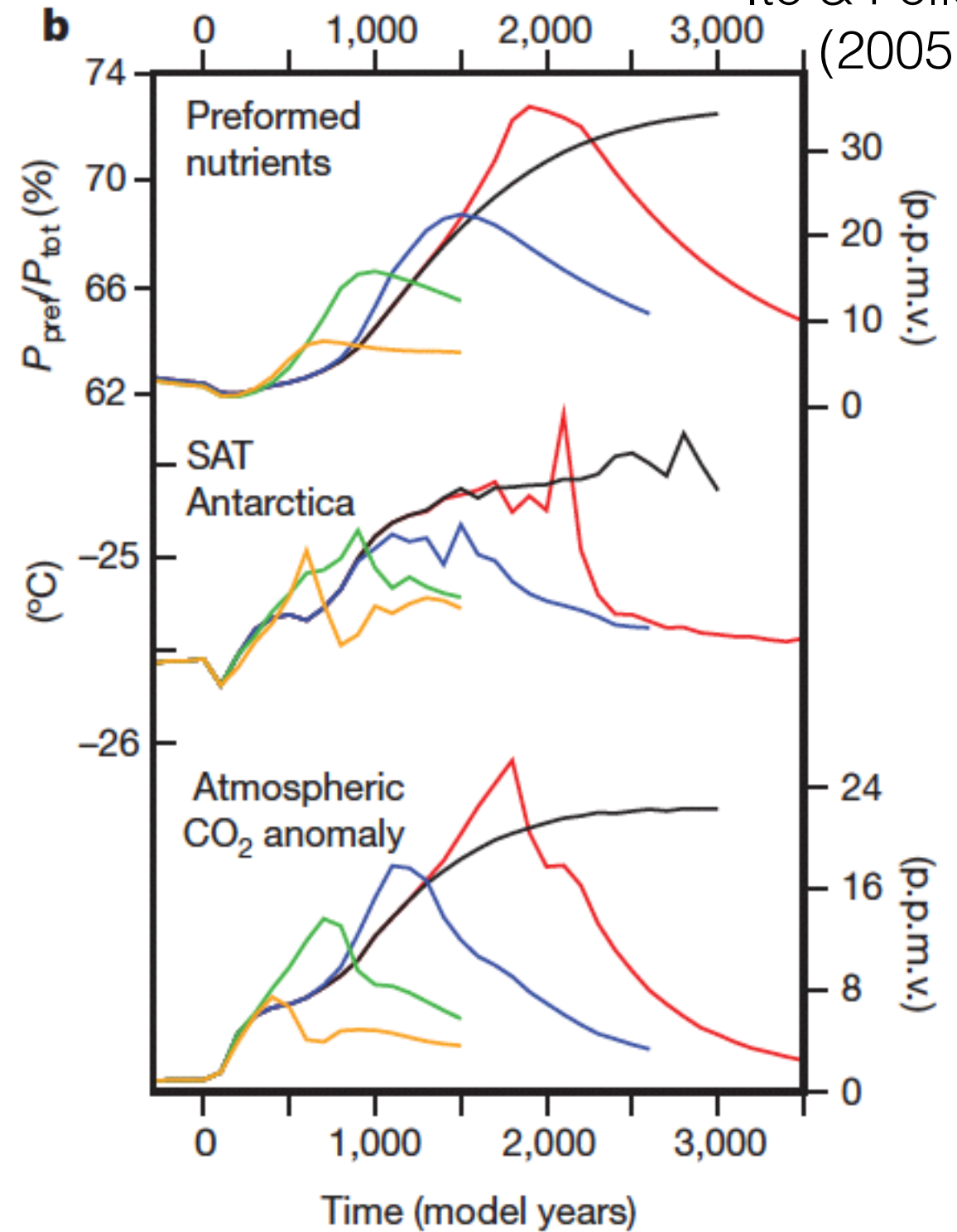
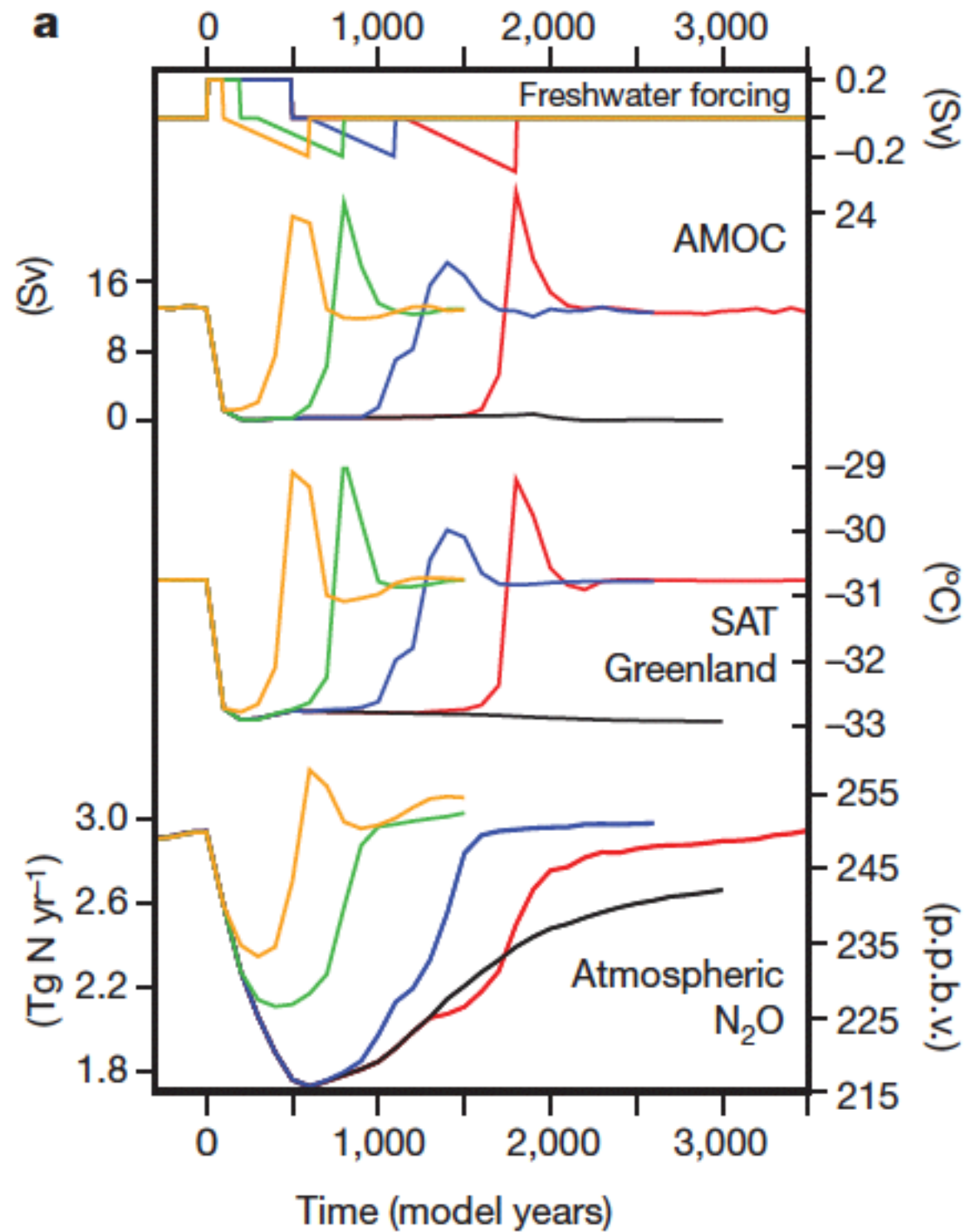
Atlantic

Pacific



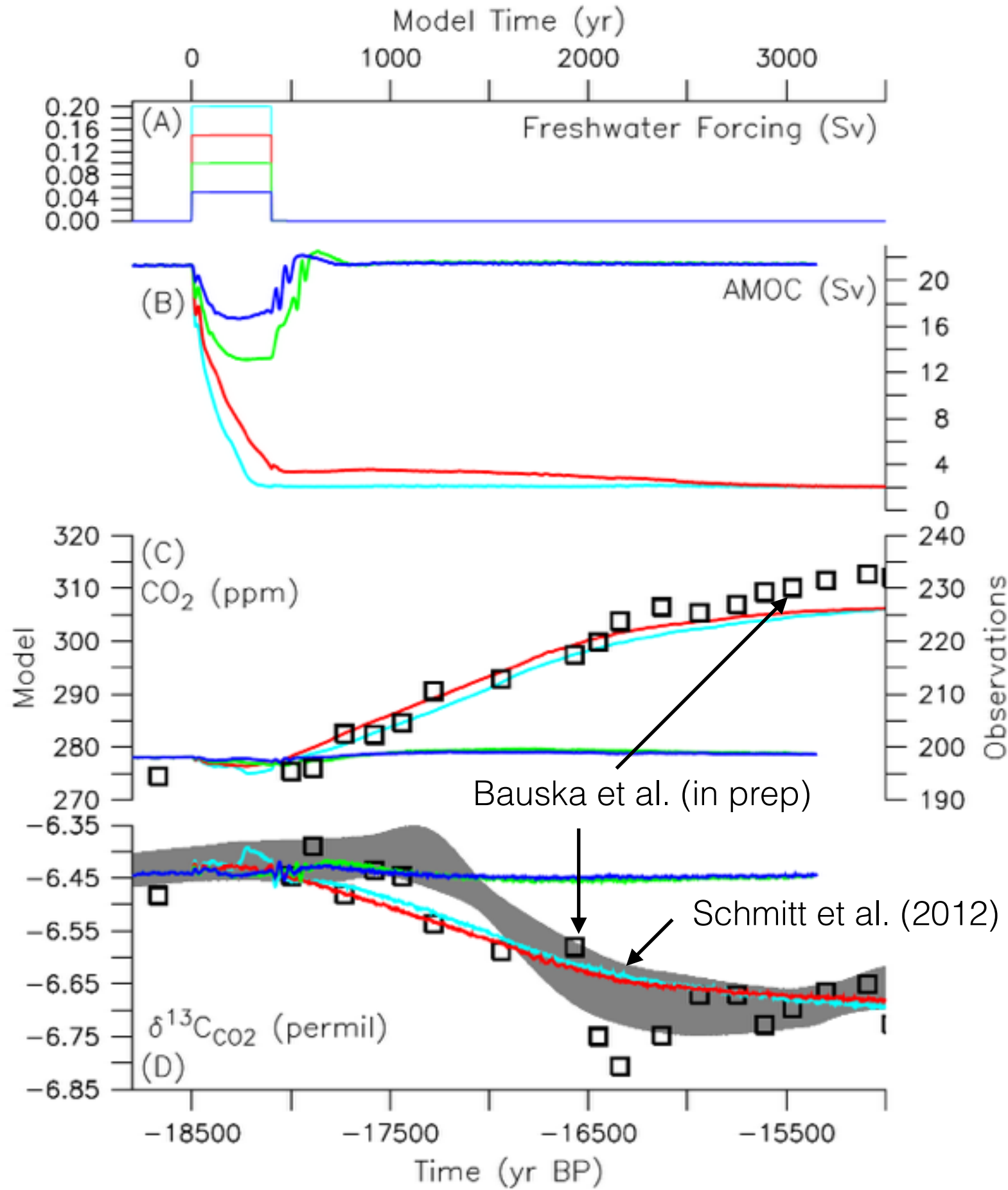
Effects on Carbon Cycling

Ito & Follows
(2005)



Schmittner and Galbraith (2008) Nature

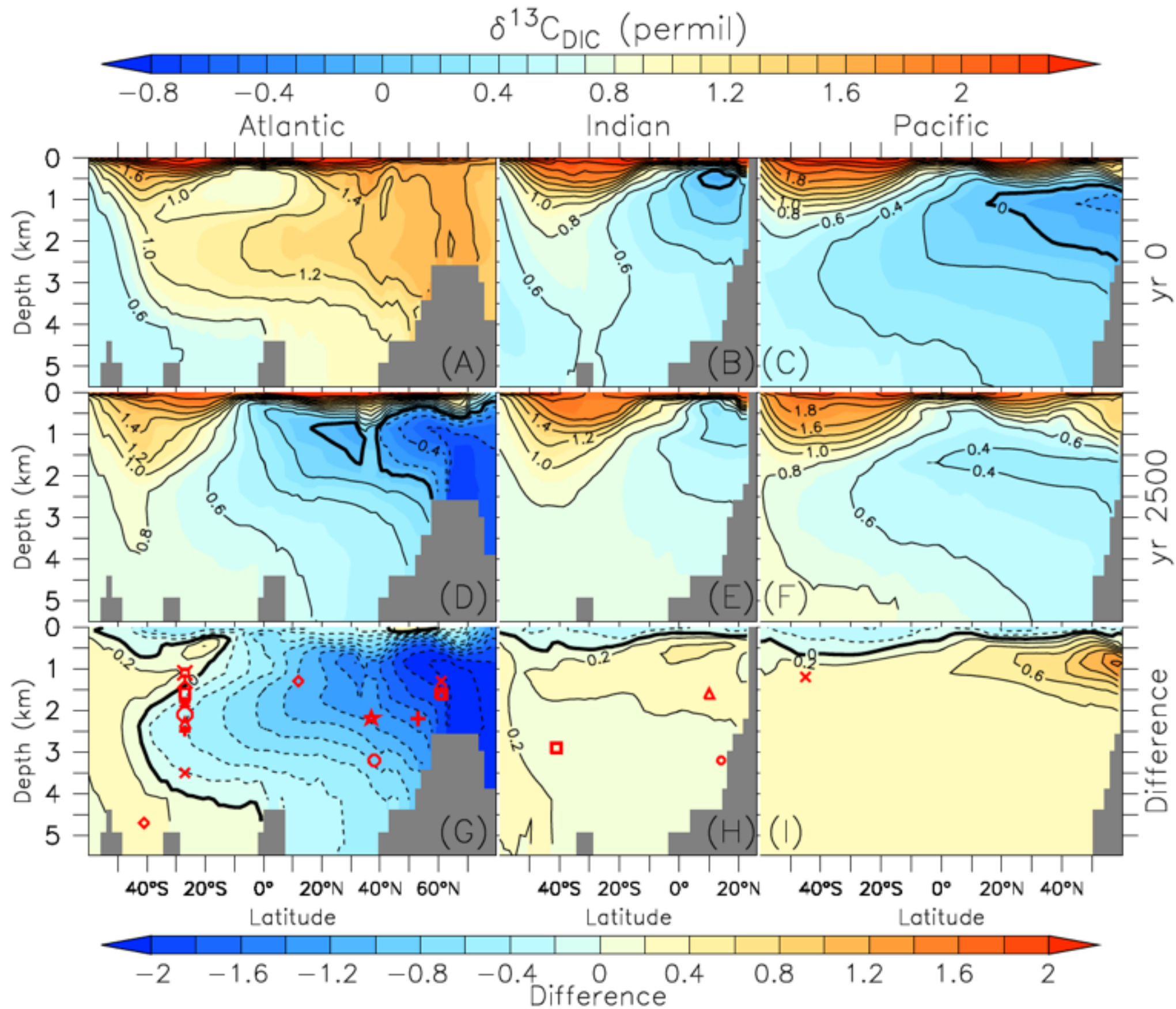
Effects on Carbon Isotopes



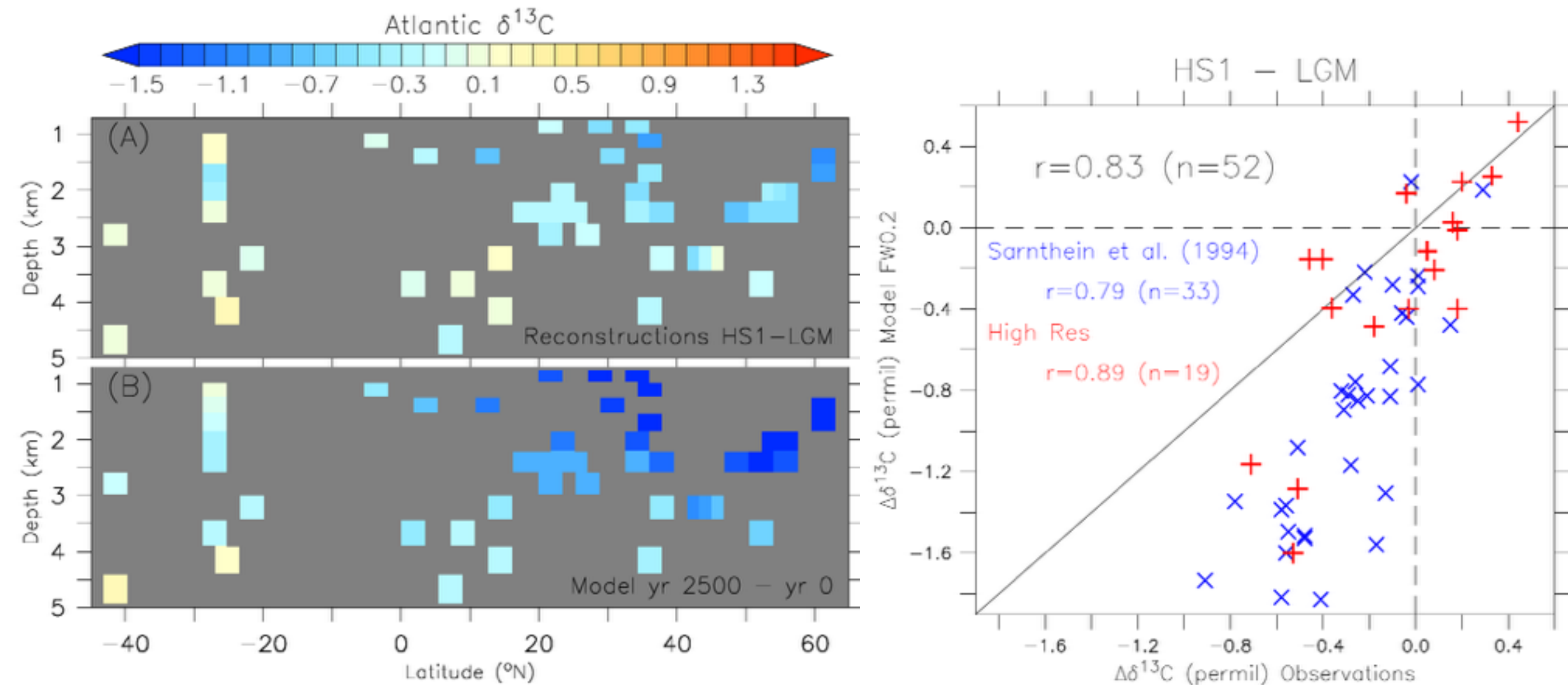
Reduced efficiency of biological pump leads to increase in atmospheric CO₂

Release of respired (low $\delta^{13}\text{C}$) carbon leads to decrease in atmospheric $\delta^{13}\text{C}_{\text{CO}_2}$ consistent with ice core data

Impact on Ocean Carbon Isotopes



Comparison with Carbon Isotope Reconstructions



Reasons for larger model amplitude:

- AMOC reductions were smaller
- Initial conditions
- Smoothing/age model errors in reconstructions

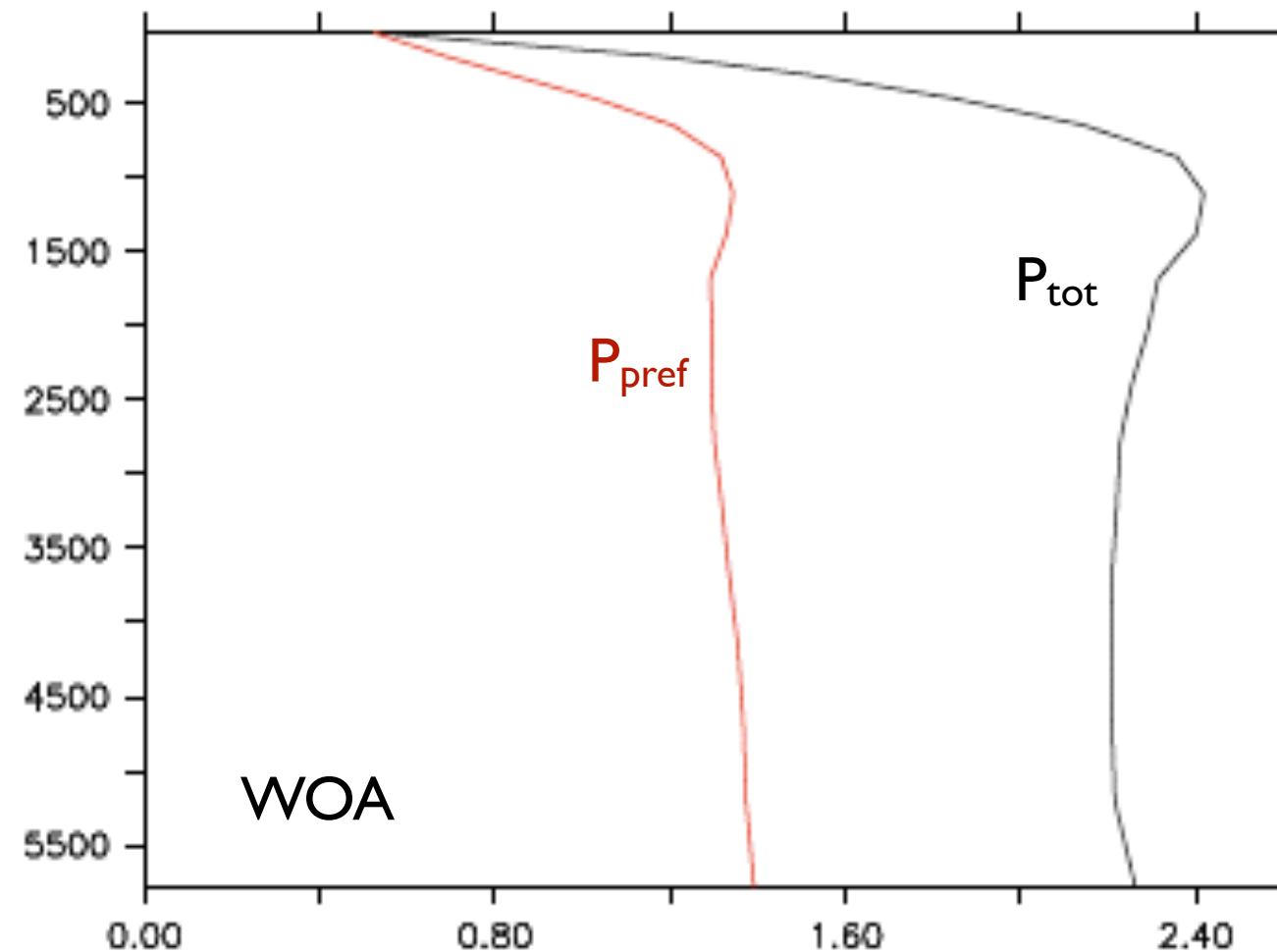
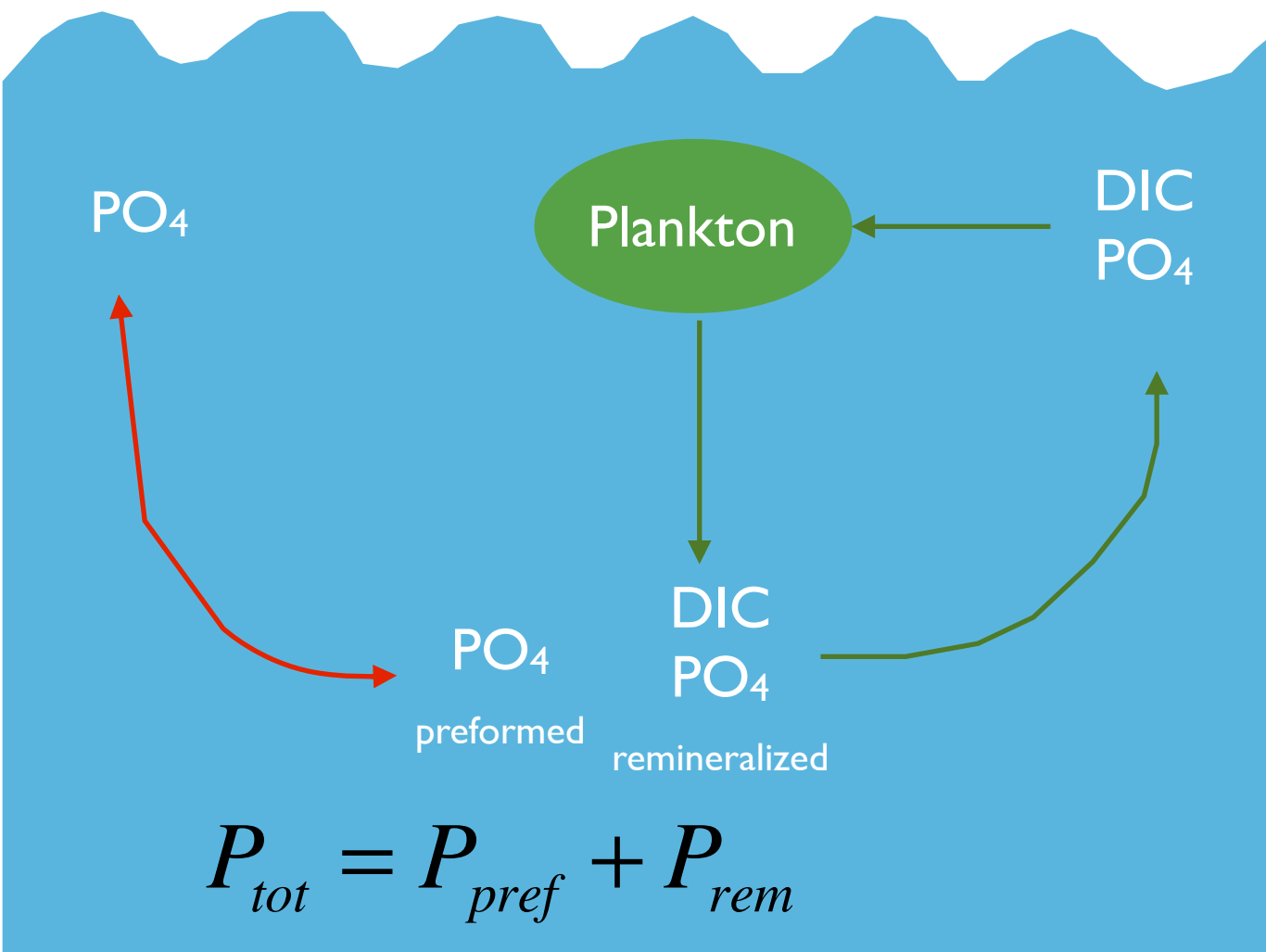
Conclusions

- Hosing experiments explore effects of AMOC changes
- Large AMOC reductions
 1. decrease productivity
 2. decrease efficiency of biological pump
 3. increase atmospheric CO₂
- Deep ocean carbon isotope data consistent with large AMOC reduction during early deglacial (Heinrich Stadial 1)

Thanks



Efficiency of the Biological Pump and Preformed Nutrient Inventory



Ito & Follows 2005 J. Mar. Res

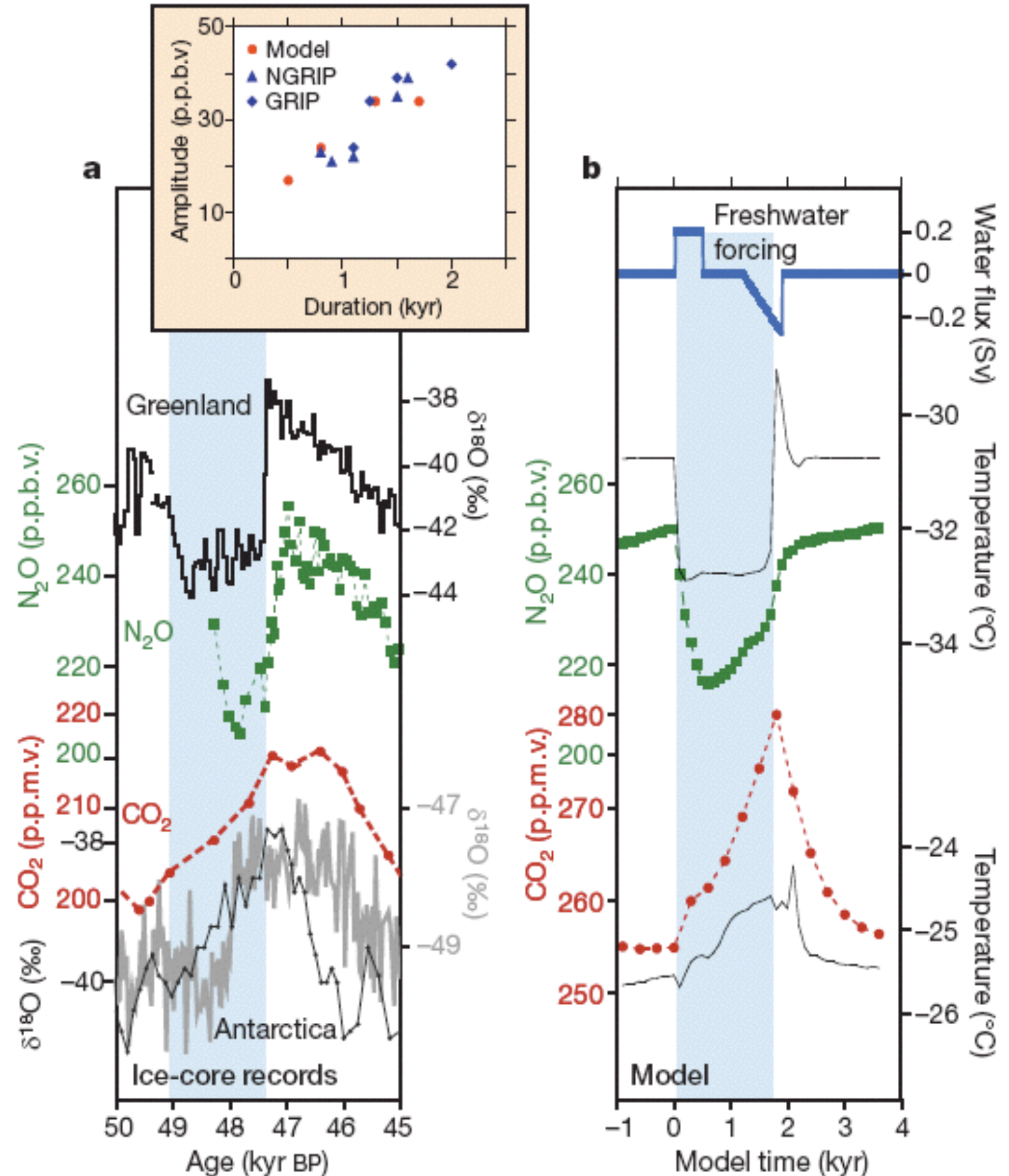
$$\Delta p_{CO_2} = 312 \times \Delta P_{pref} / P_{tot}$$

$$P_{remi} = AOU \times R_{P:O_2}$$

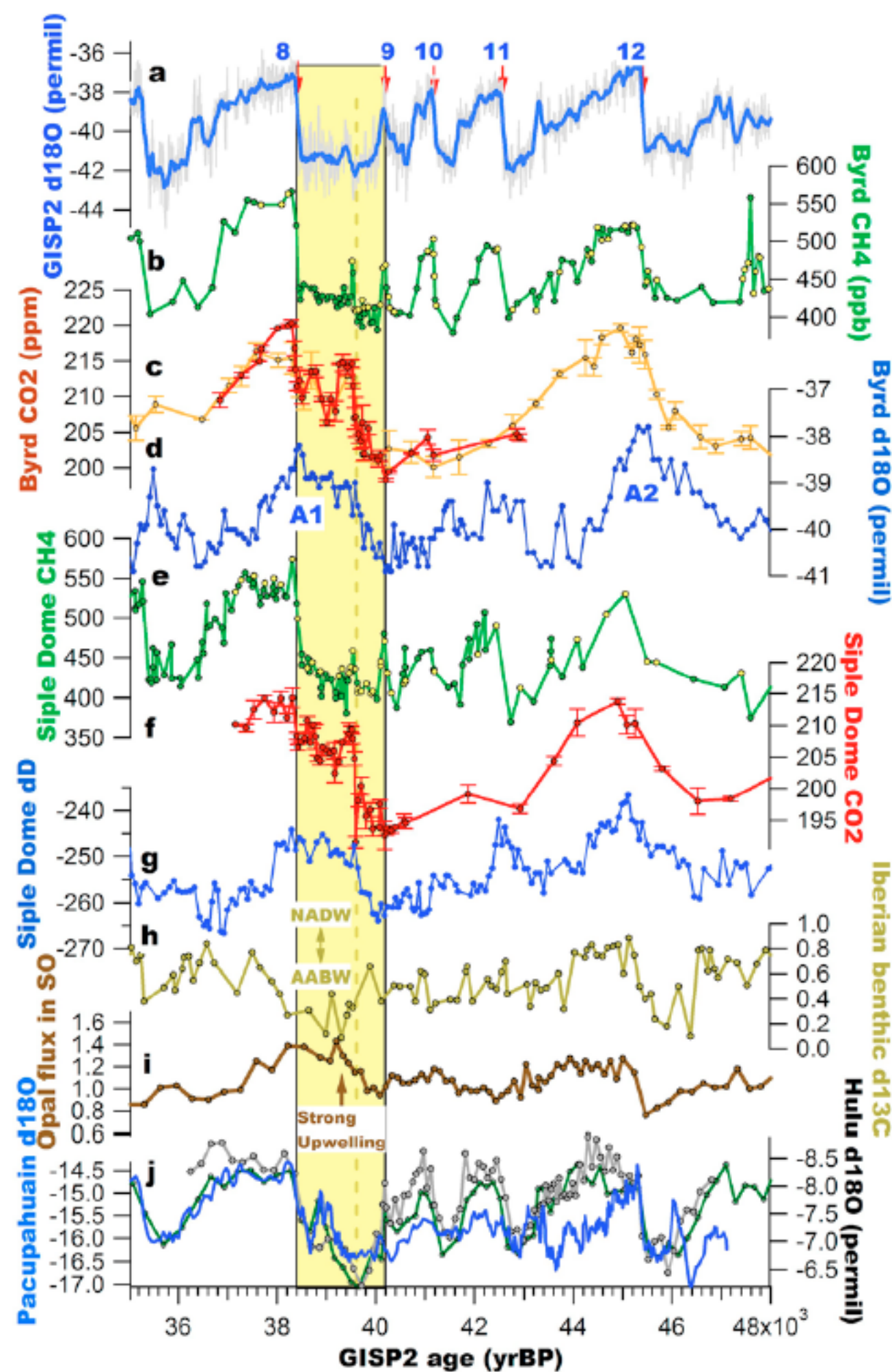
$$AOU = O_2 - O_2^{sat}(T)$$

Comparison with Ice Core Record

- Model reproduces N_2O amplitude and timescale
- Model reproduces CO_2 amplitude and timescale
- CO_2 decreases too rapidly after Greenland warming



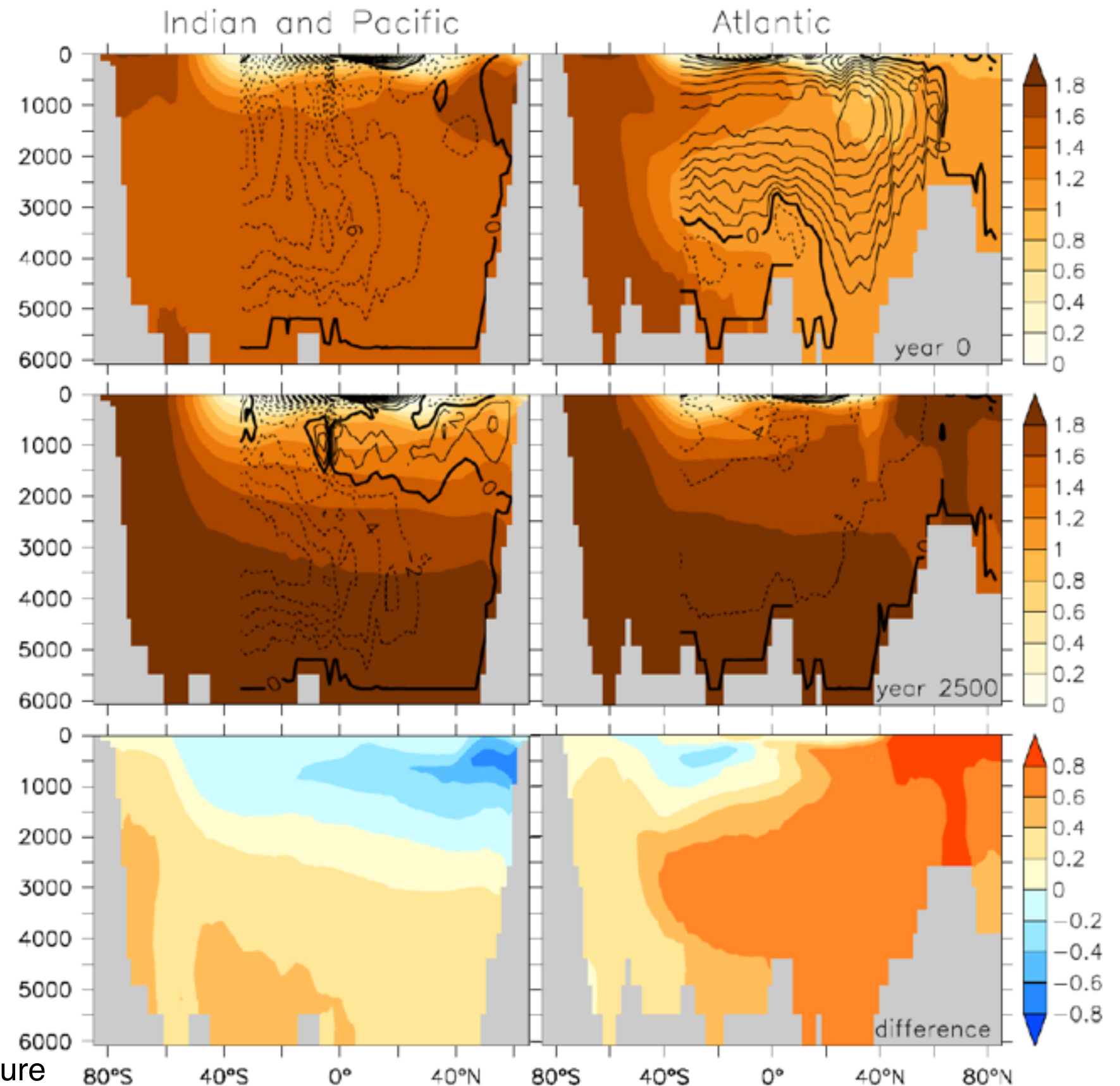
BUT: what causes the rapid CO₂ variations recently discovered in high resolution measurements ?



Ahn et al. (2012) GRL

Preformed Nutrients (Phosphate)

NADW injects low preformed nutrients into deep ocean.
Increases respired carbon content.



AMOC shutdown:
Deep ocean loses respired
carbon, gains preformed
nutrients.

Brazil Basin (35°W, 27°S)

