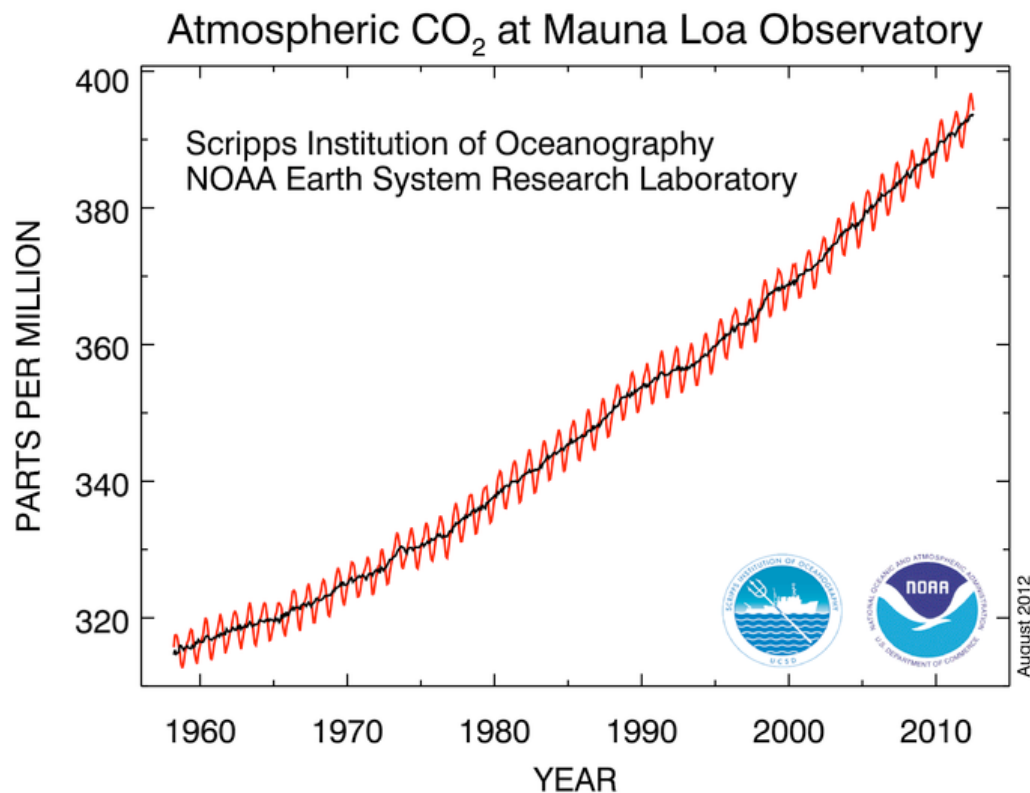


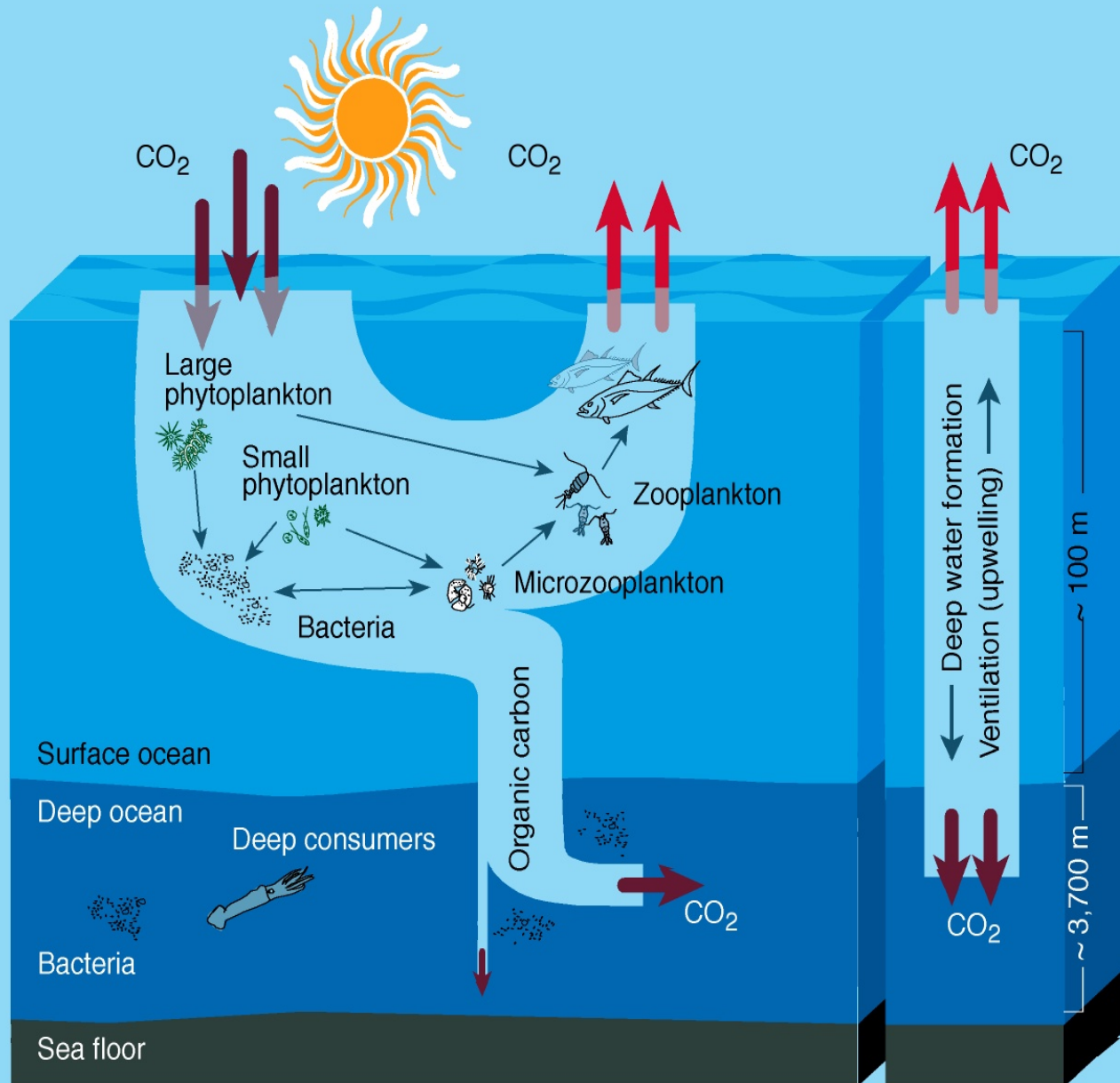
Impacts of climate forcing on CO₂ uptake in the North Atlantic

Scott Doney & Ivan Lima (WHOI)
Keith Lindsay & Matt Long (NCAR)
Keith Moore (UC Irvine)

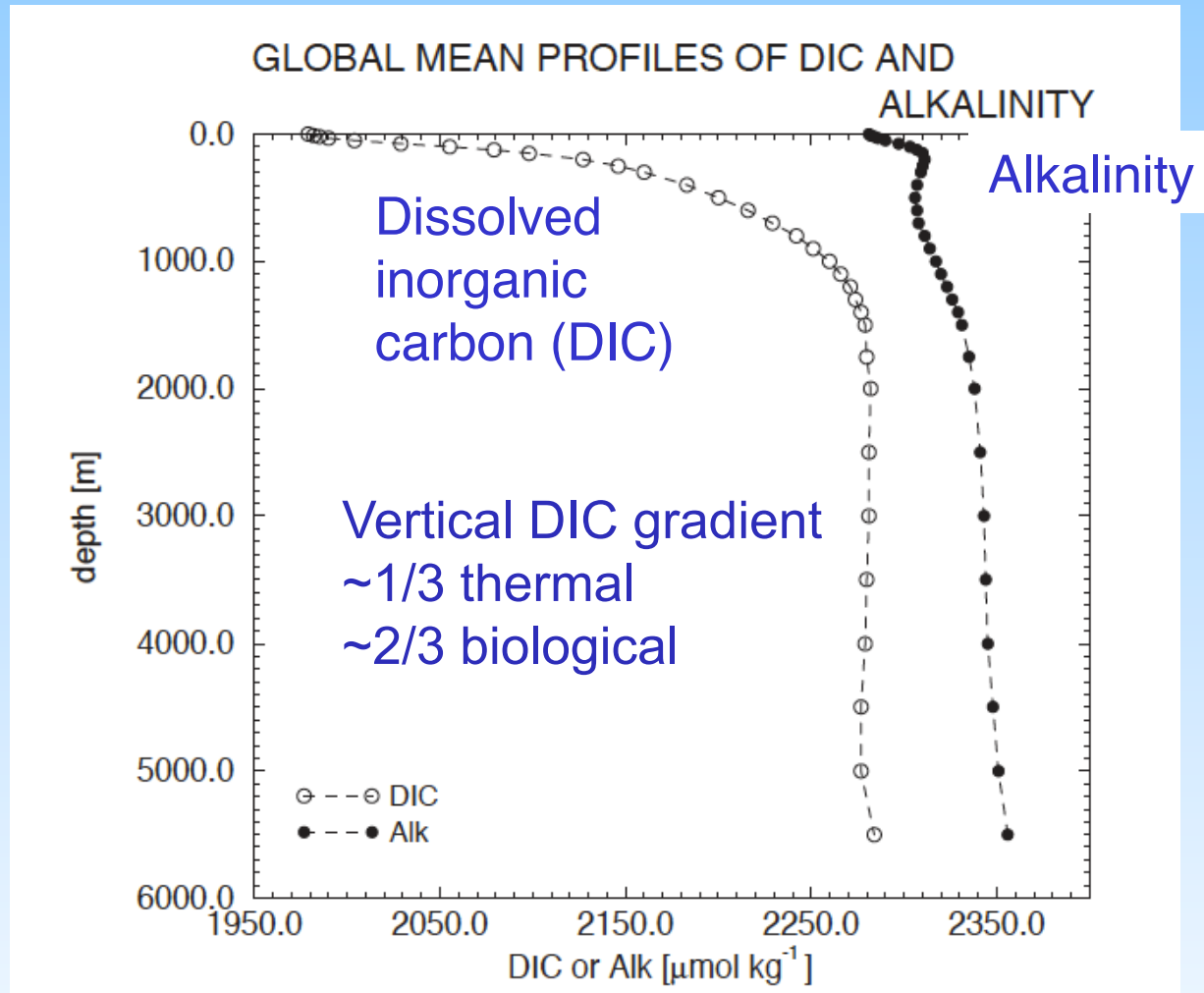


- North Atlantic carbon cycle primer
- CESM1-Carbon model
 - climate change impacts
 - natural variability

Solubility & Biological Carbon Pumps



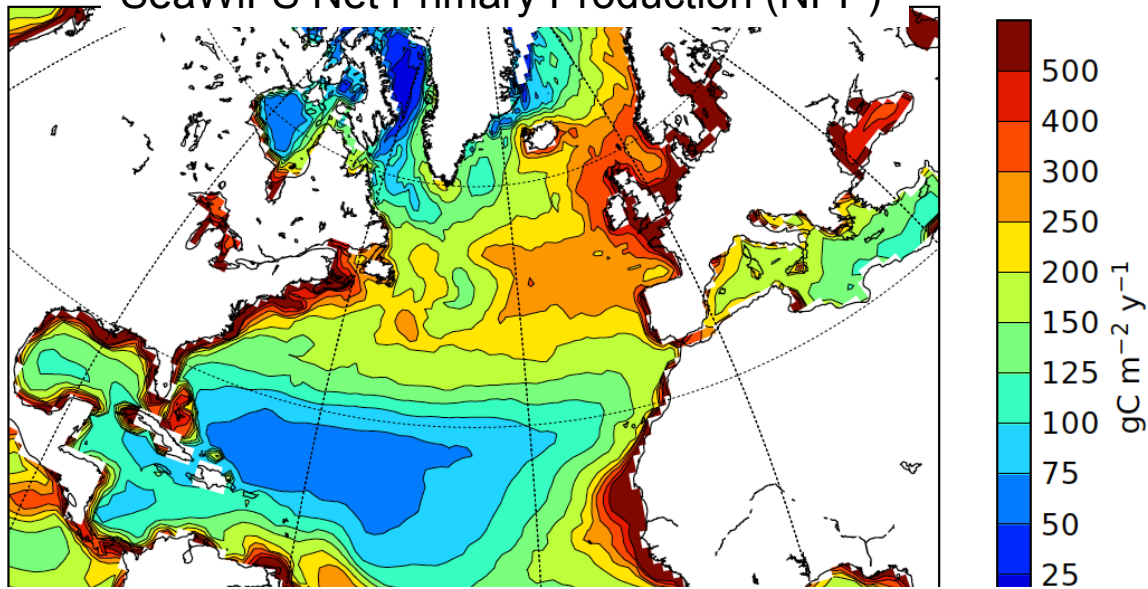
Ocean Inorganic Carbon Distribution



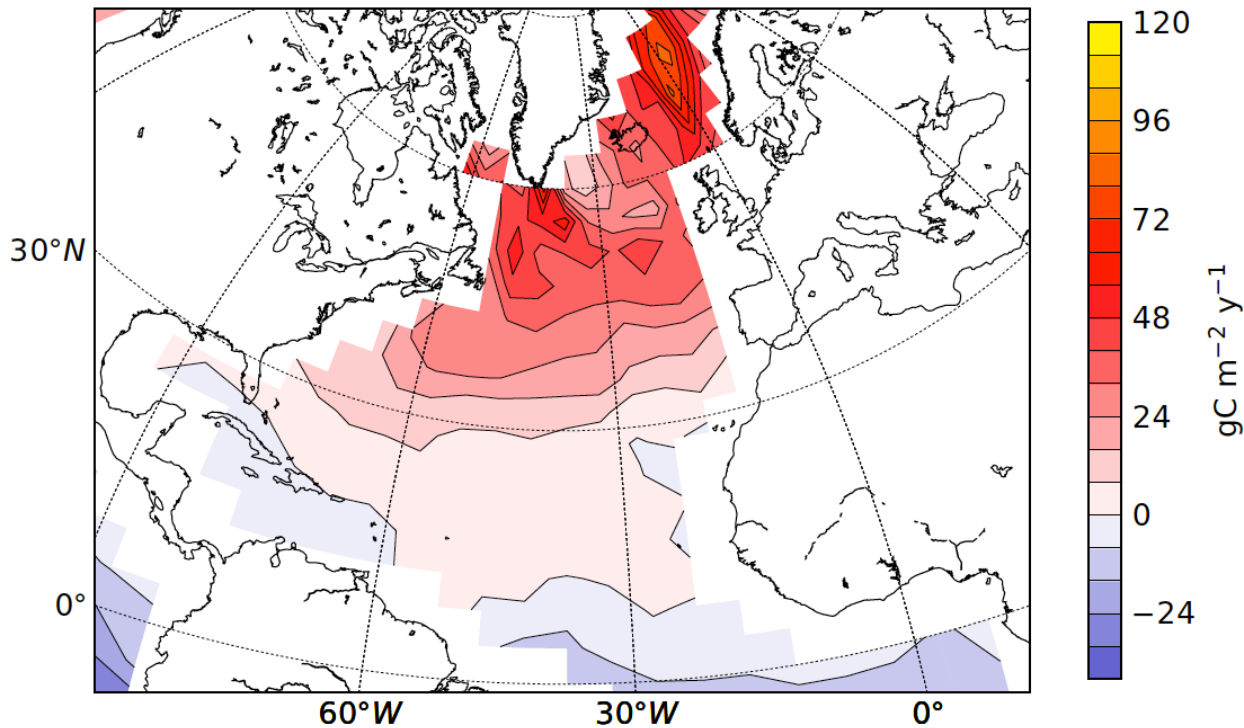
DIC = Total of all dissolved inorganic carbon species
Alkalinity = Measure of acid buffering capacity

Subpolar Atlantic Productivity & CO₂ Uptake

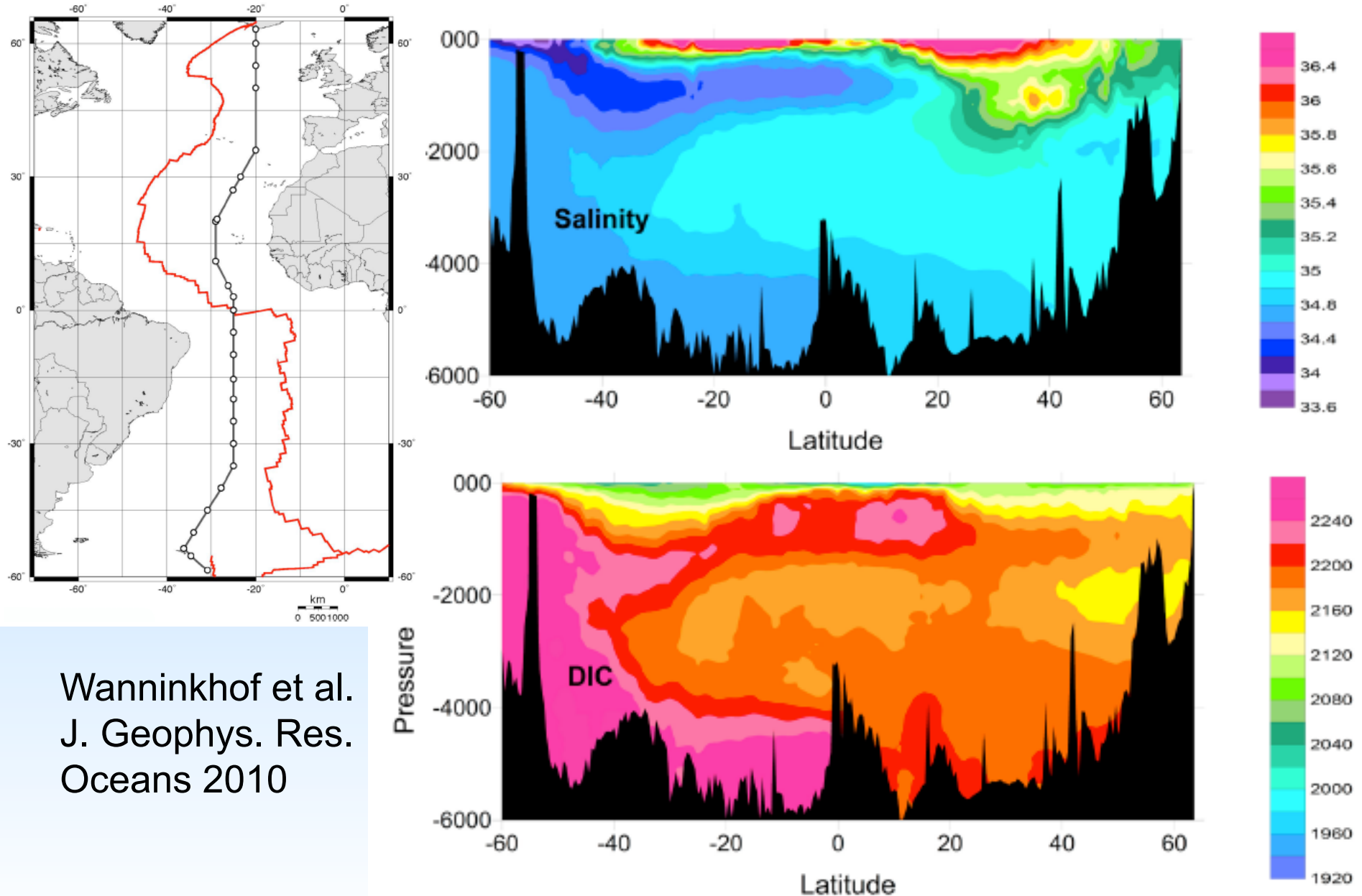
SeaWiFS Net Primary Production (NPP)



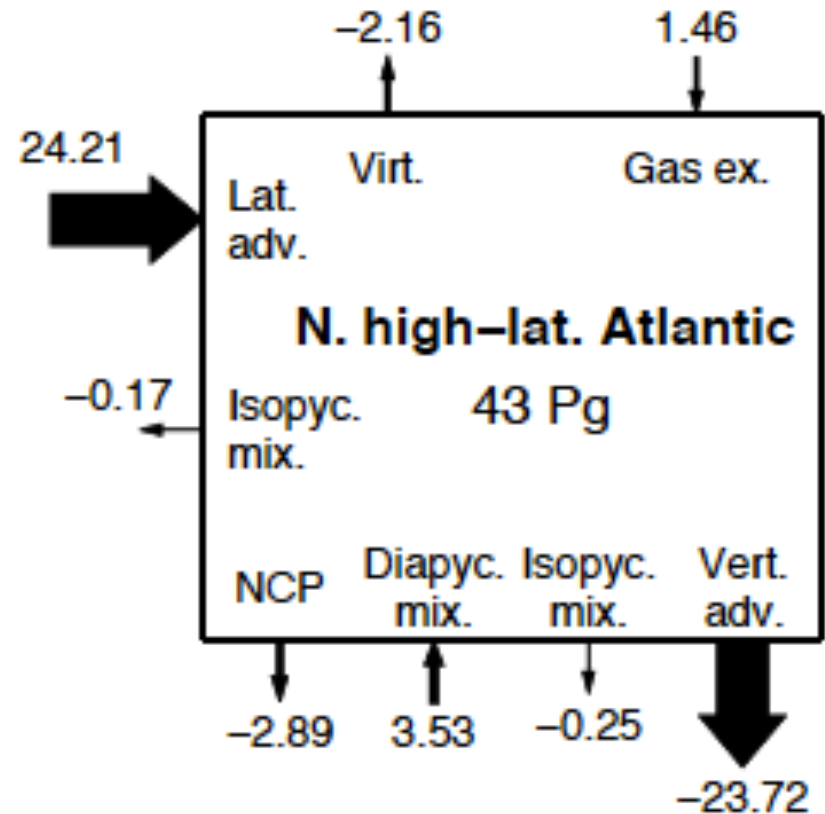
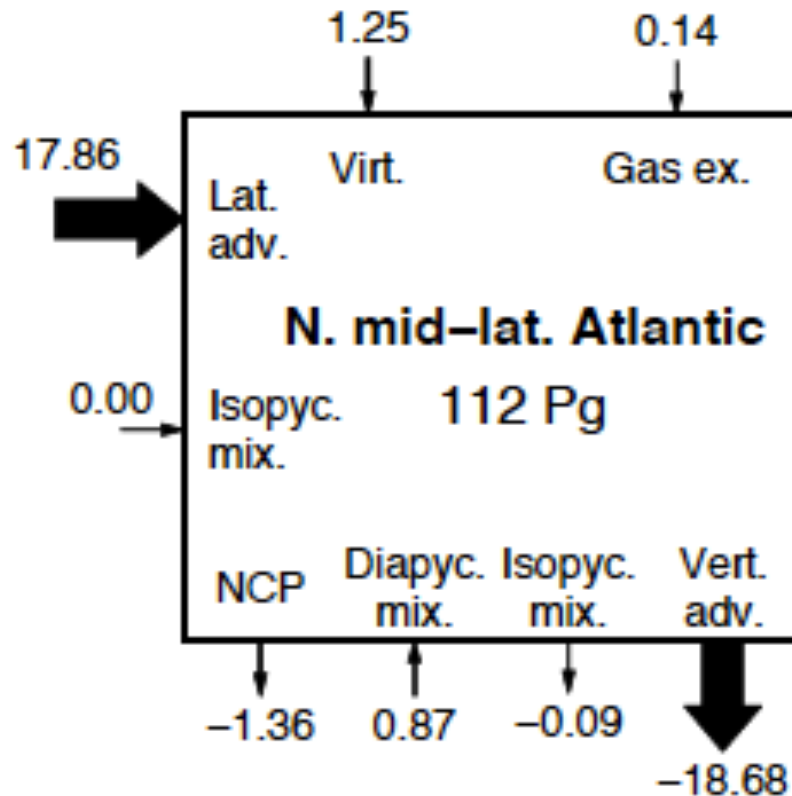
Takahashi (2002) air-sea CO₂ flux



North Atlantic Water Masses



Upper Ocean Carbon Budgets



Long et al., in prep.

Fate of Anthropogenic CO₂ Emissions (2000-2009)

1.1±0.7 Pg C y⁻¹



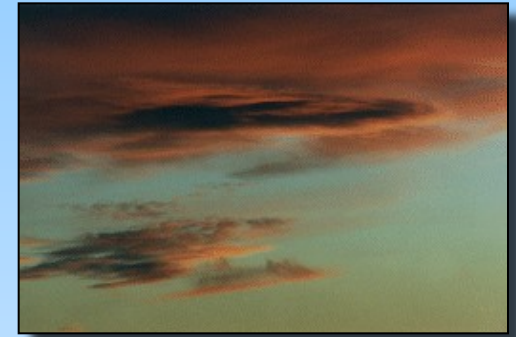
+

7.7±0.5 Pg C y⁻¹



4.1±0.1
Pg C y⁻¹

Atmosphere
47%



2.4 Pg C y⁻¹

Land
27%

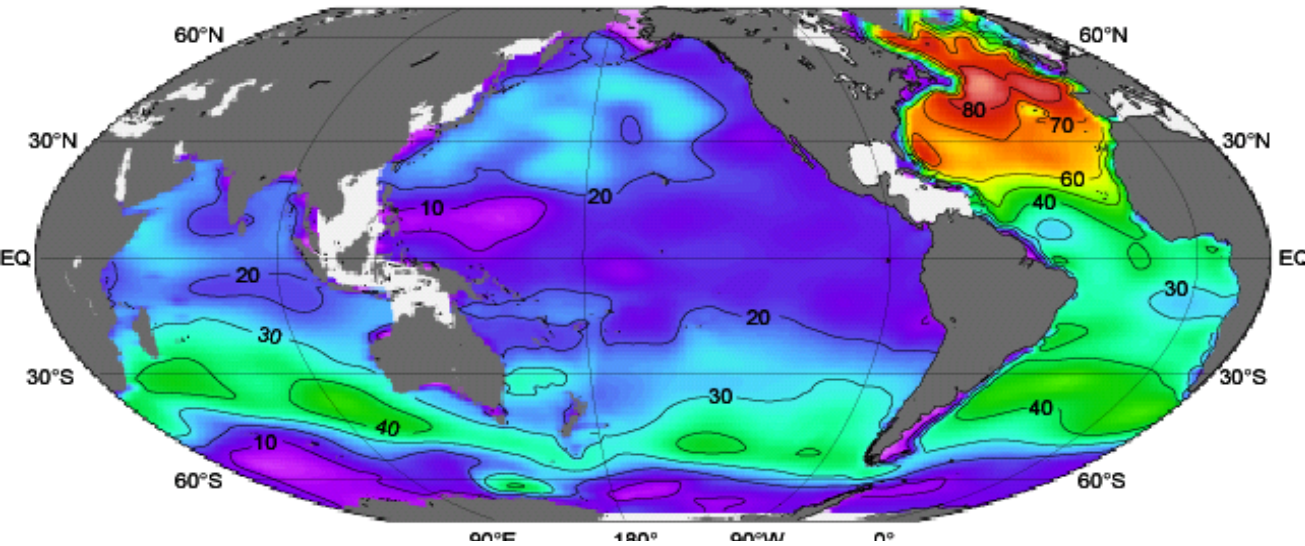


2.3±0.4
Pg C y⁻¹

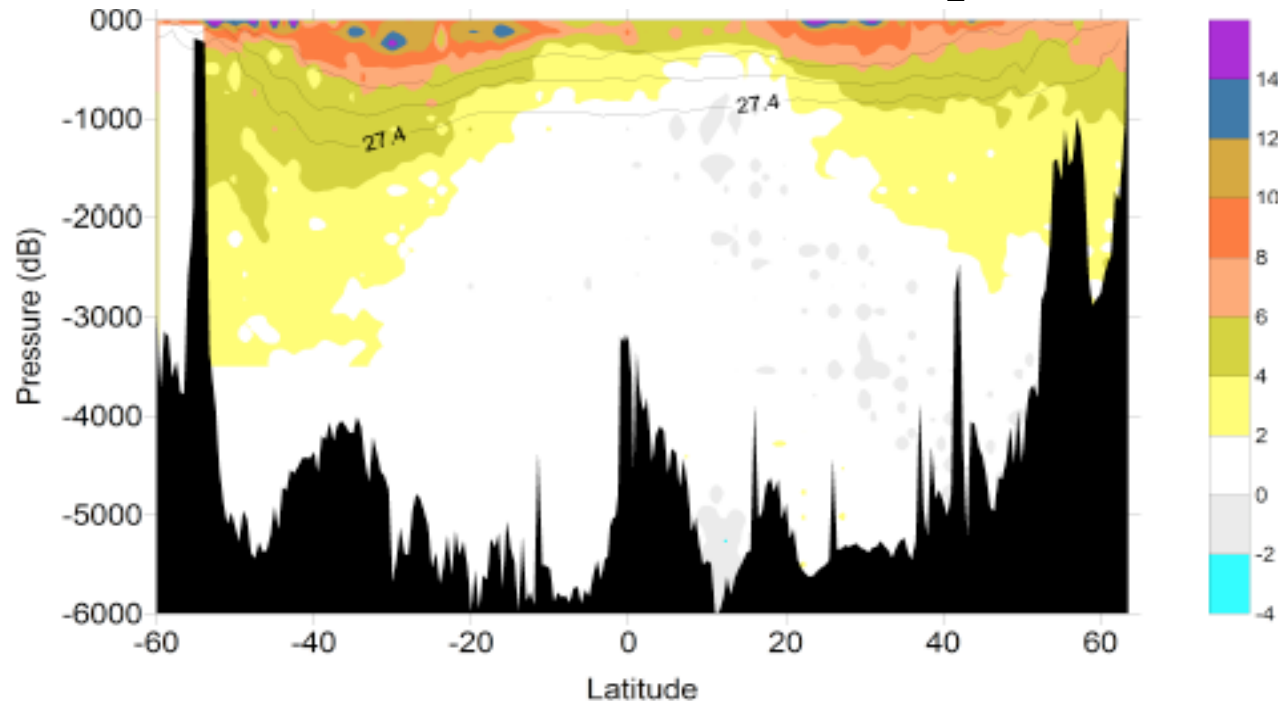
Oceans
26%



Anthropogenic CO₂ Column Inventories (mol m⁻²)



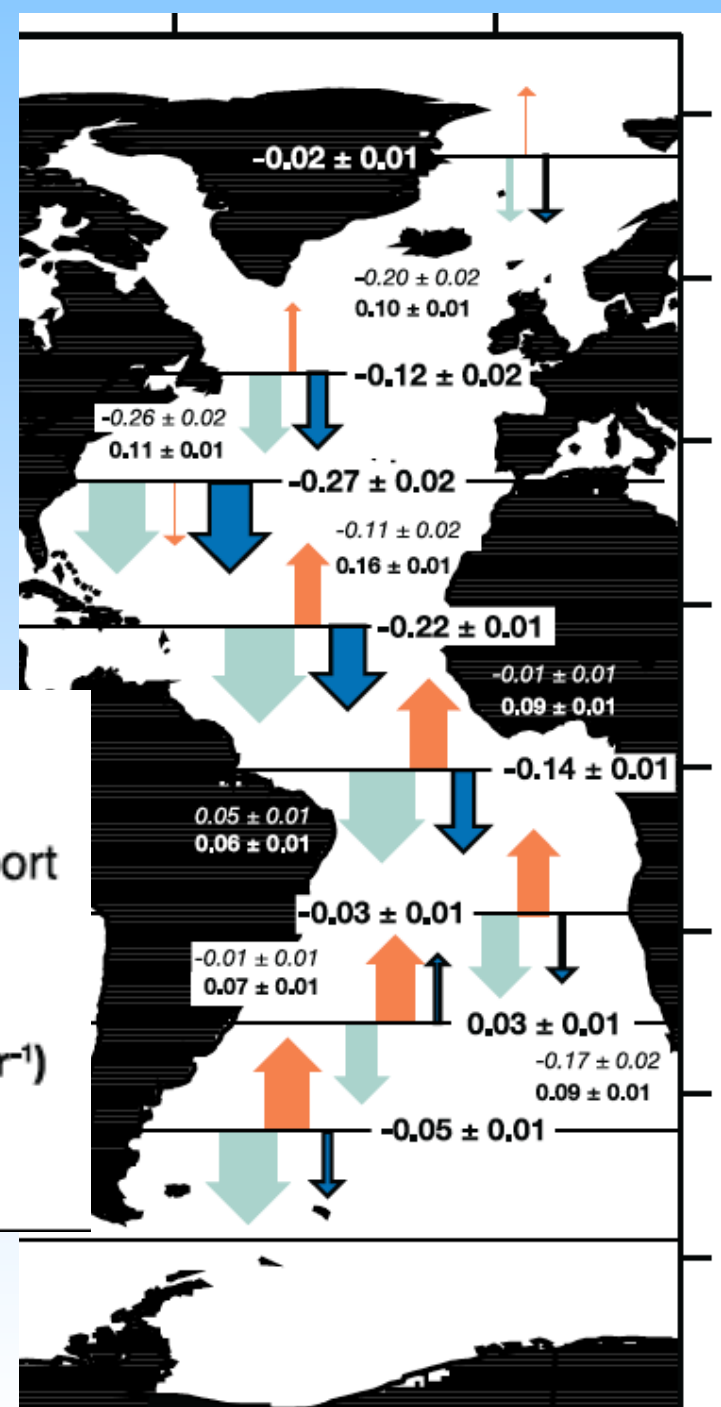
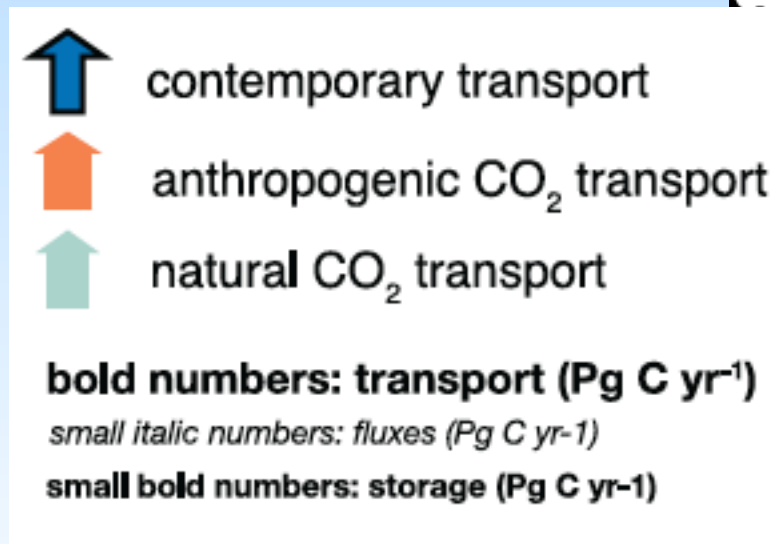
Decadal Change in Anthropogenic CO₂ (umol kg⁻¹)



Anthropogenic Carbon Uptake

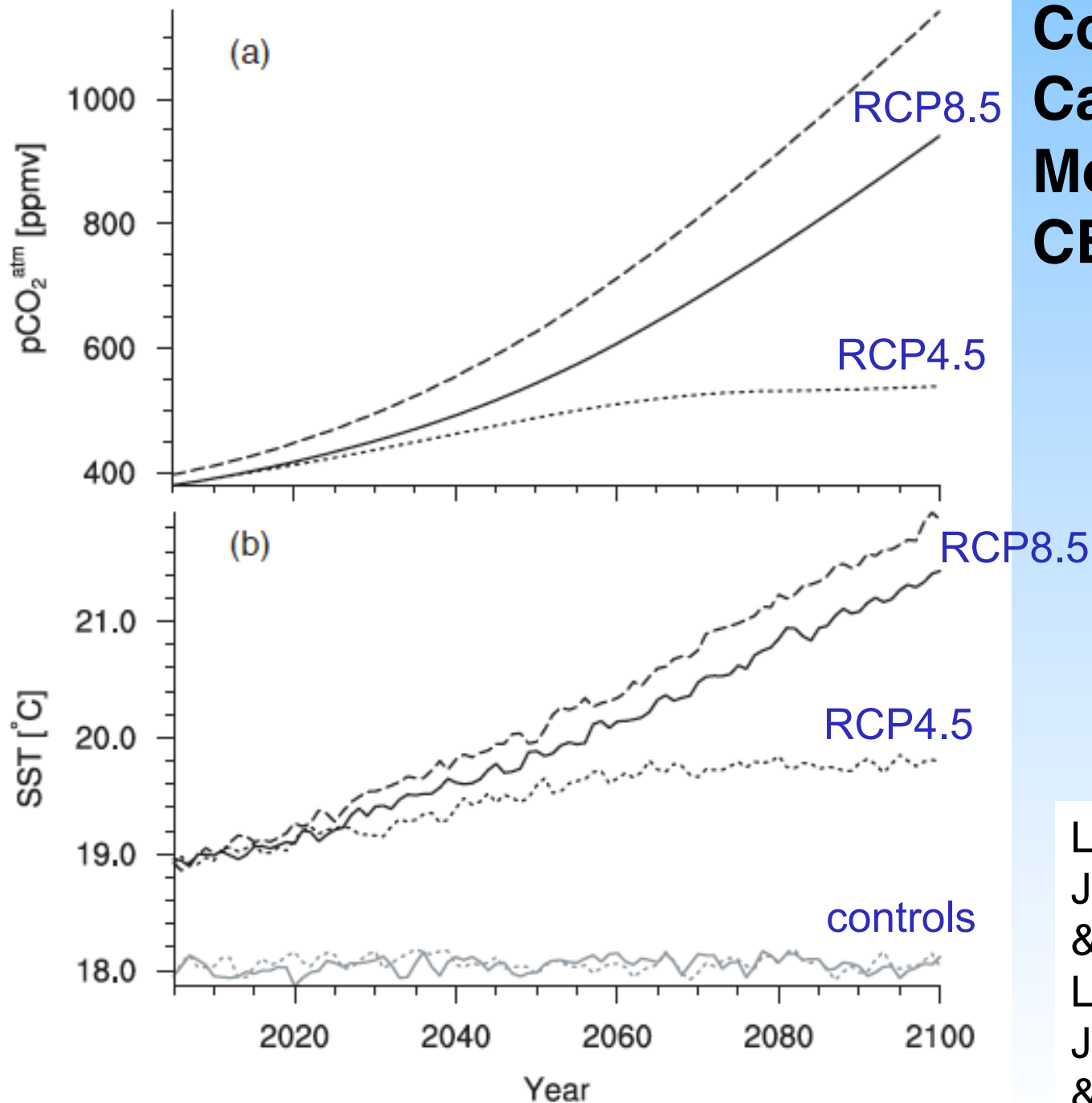
Sabine et al.
Science 2010
Wanninkhof et al.
J. Geophys. Res.
Oceans 2010

Opposing Meridional Transport of Natural & Anthropogenic Carbon



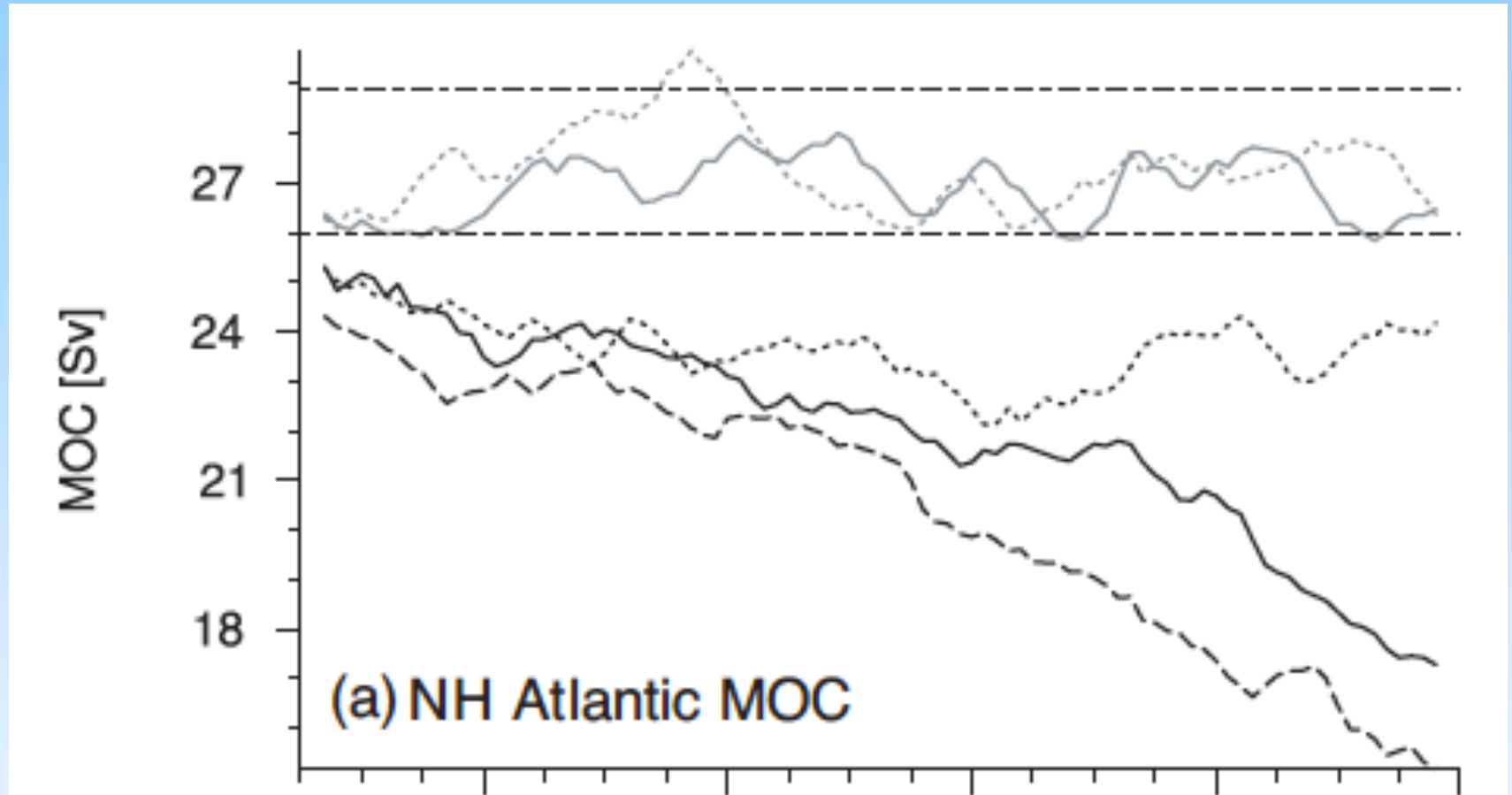
Gruber et al.
 Global Biogeochemical Cycles
 2009

Coupled Carbon-Climate Model CESM1-Carbon



Lindsay et al.
J. Climate submitted
& in prep.
Long et al.
J. Climate submitted
& in prep.

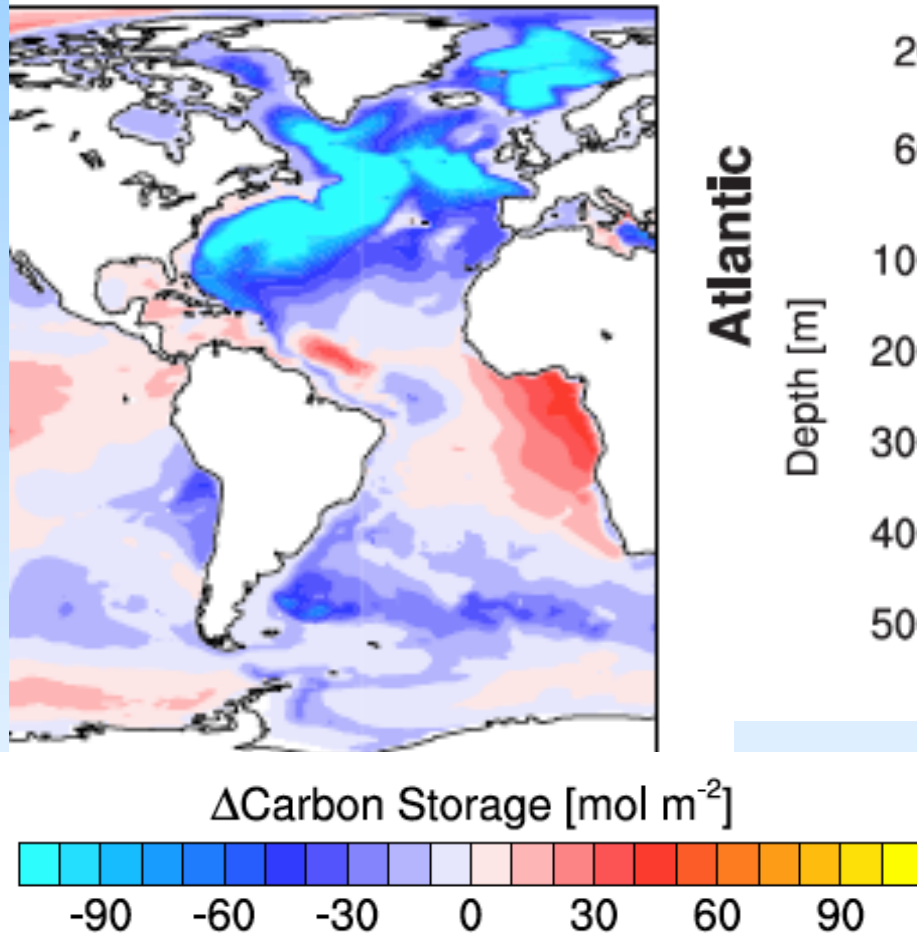
Climate Impact on Atlantic Overturning



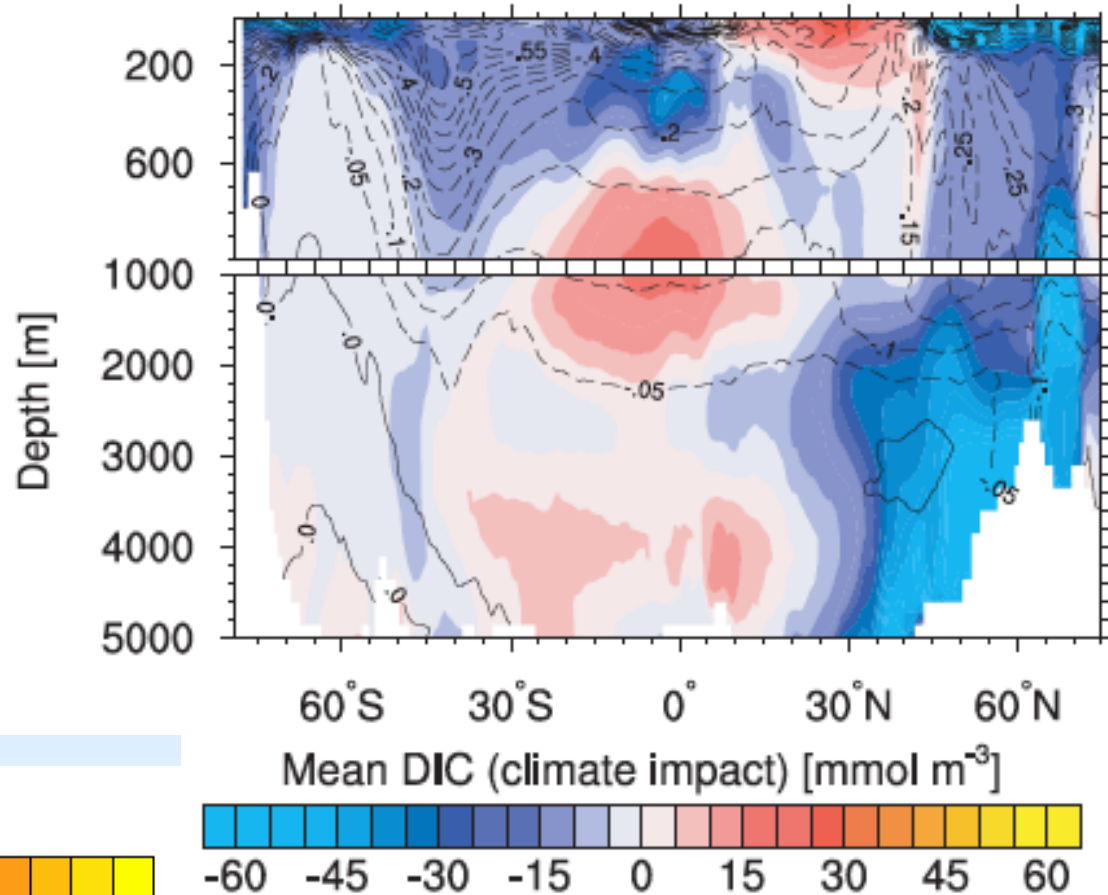
Long et al. in prep.

Climate Effects on Ocean Carbon

Δ Carbon Inventory

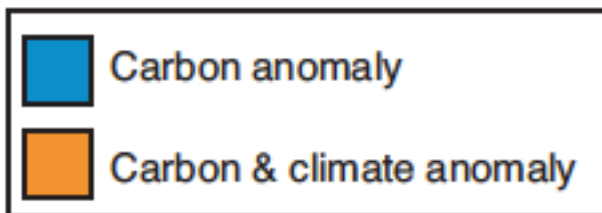
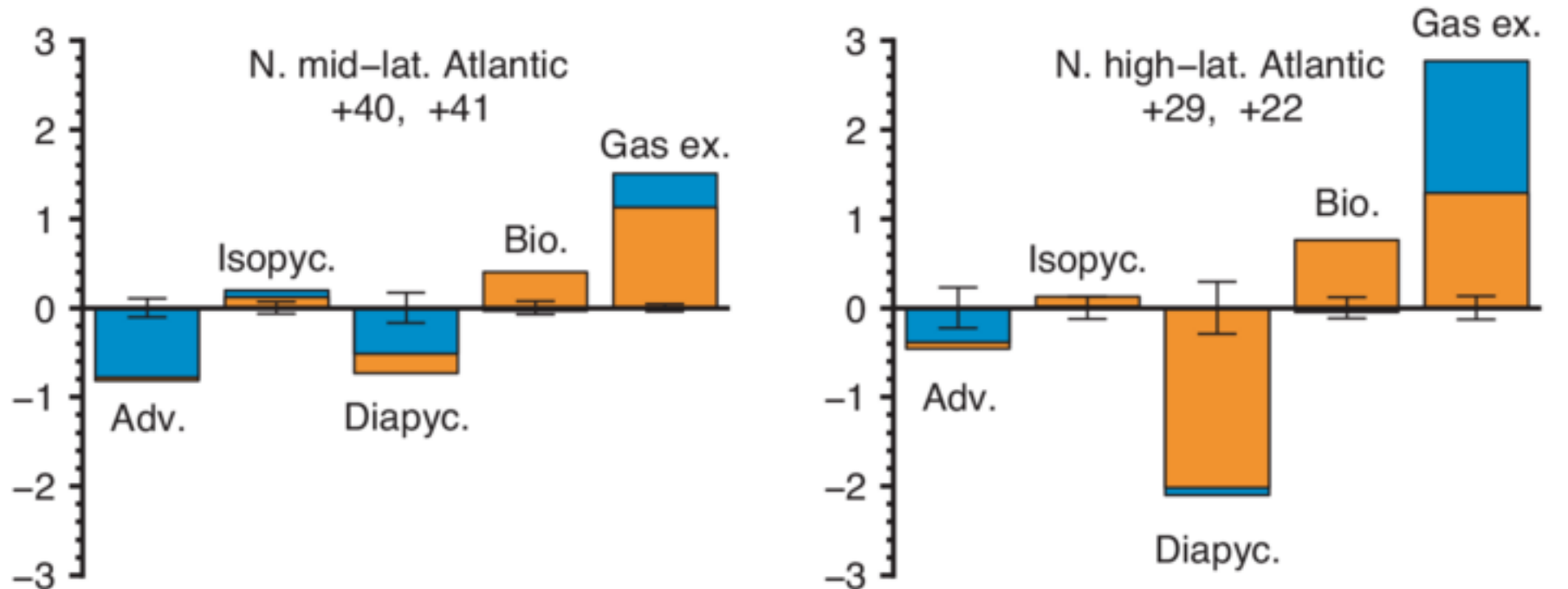


Δ Carbon Concentration



Fung et al. PNAS 2005
Long et al. in prep.

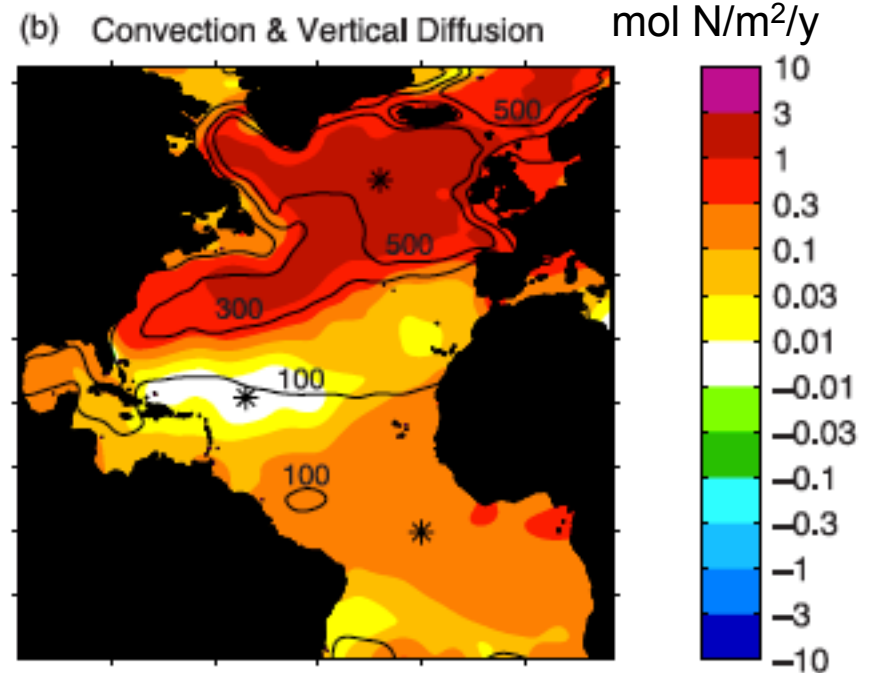
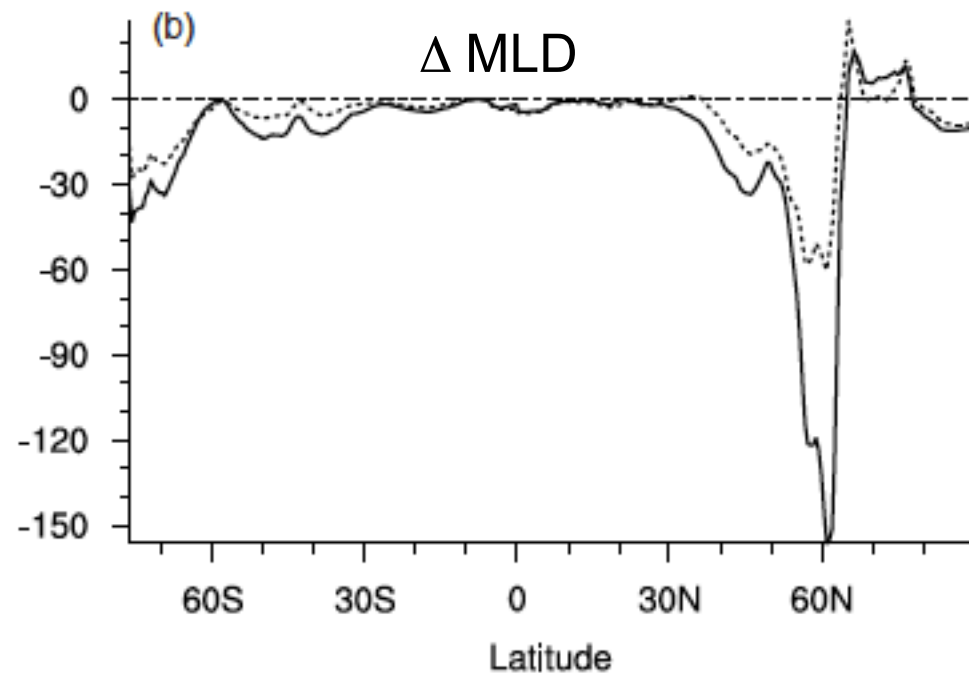
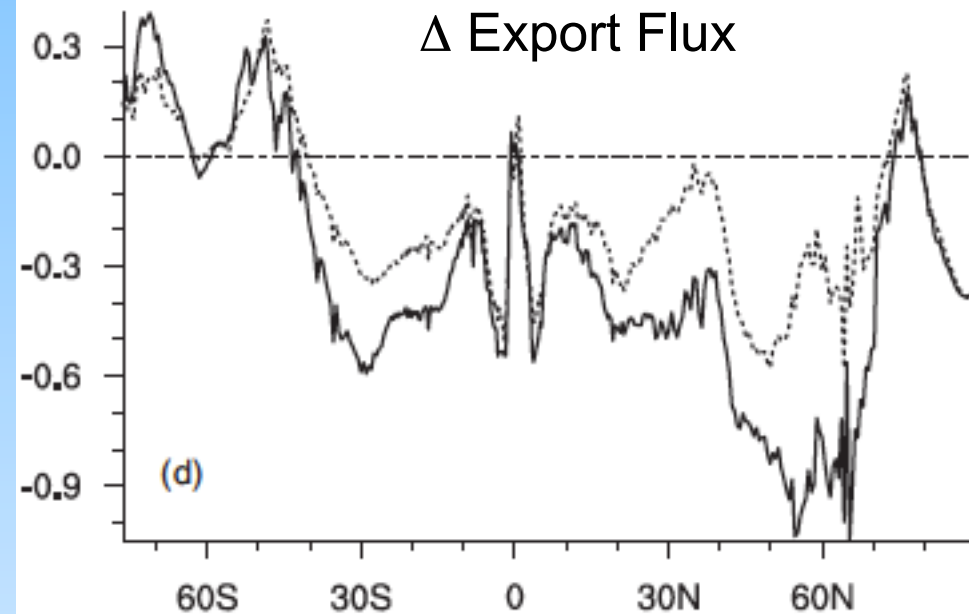
Upper Ocean Carbon Budget Anomalies from CO₂ & Climate



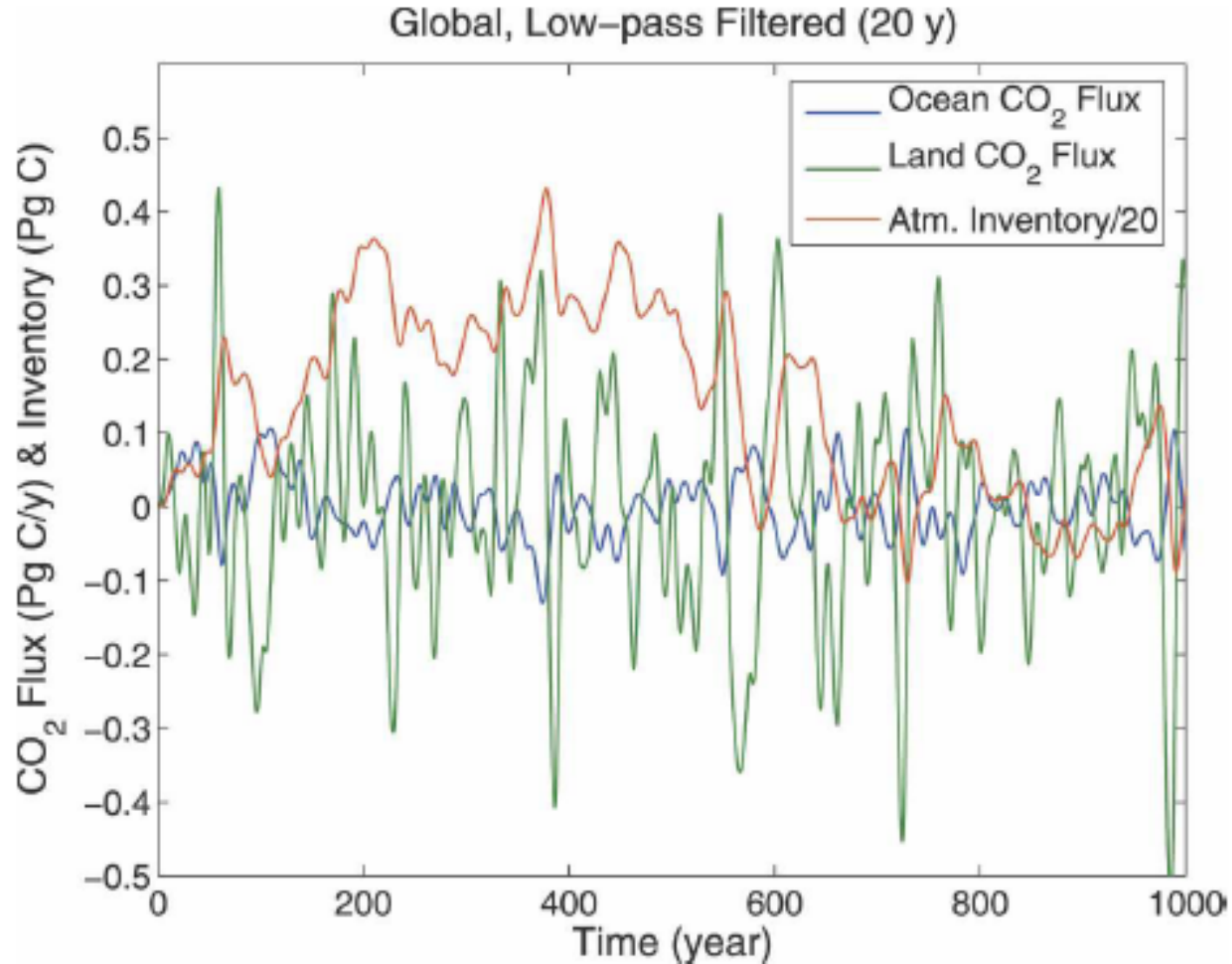
CESM1-Carbon RCP8.5
 0-200m budget
 2081-2100 vs. control
 Long et al., in prep.

Productivity, Mixing & Nutrient Supply

Nutrient Supply



Pre-industrial Low-Frequency Variability

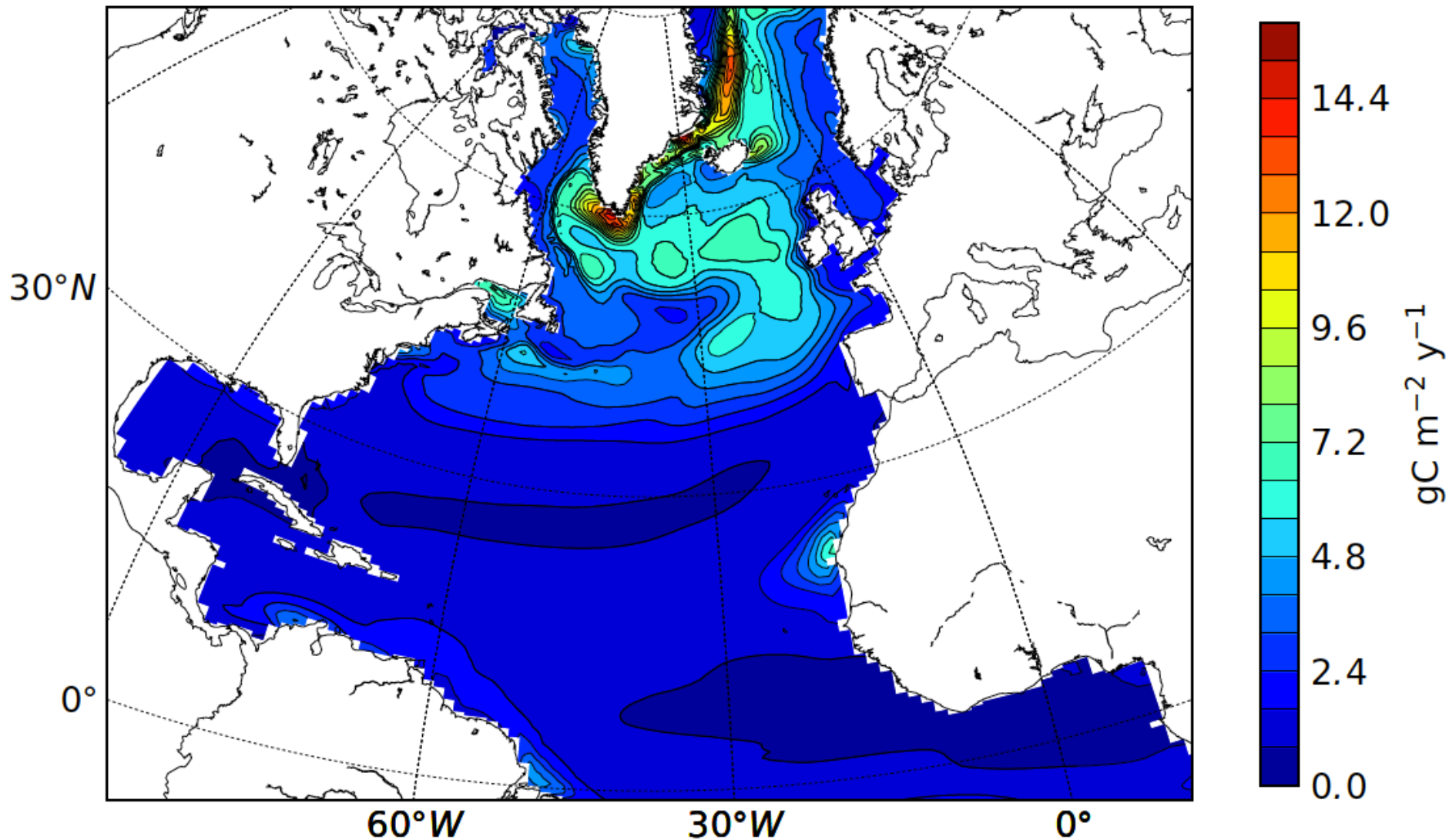


Doney et al. J. Climate 2006

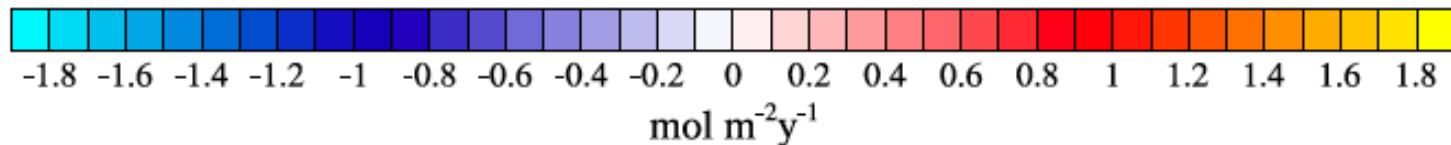
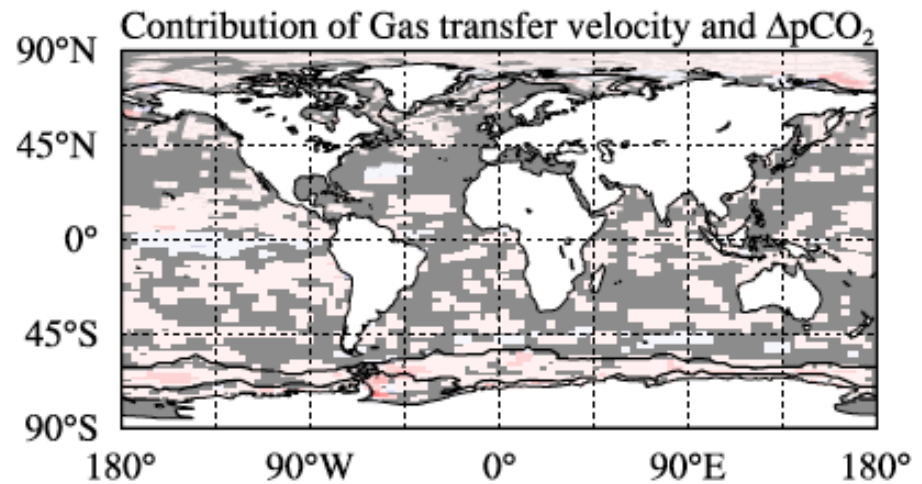
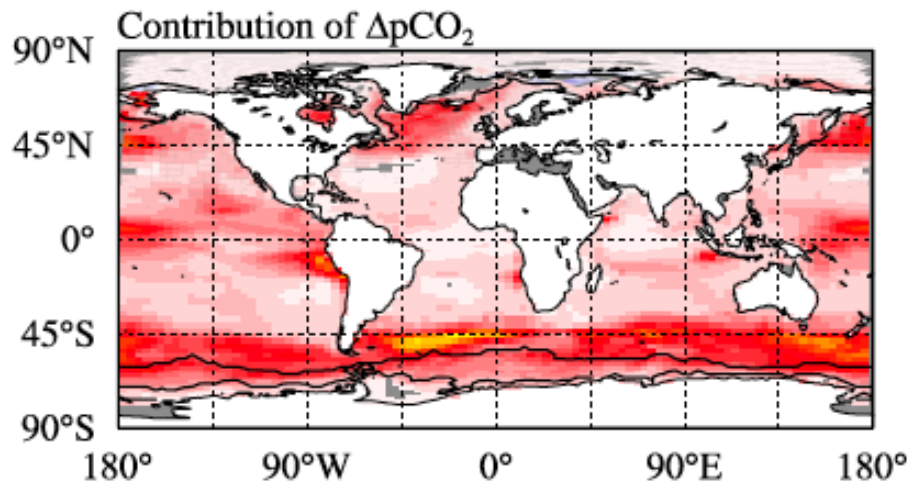
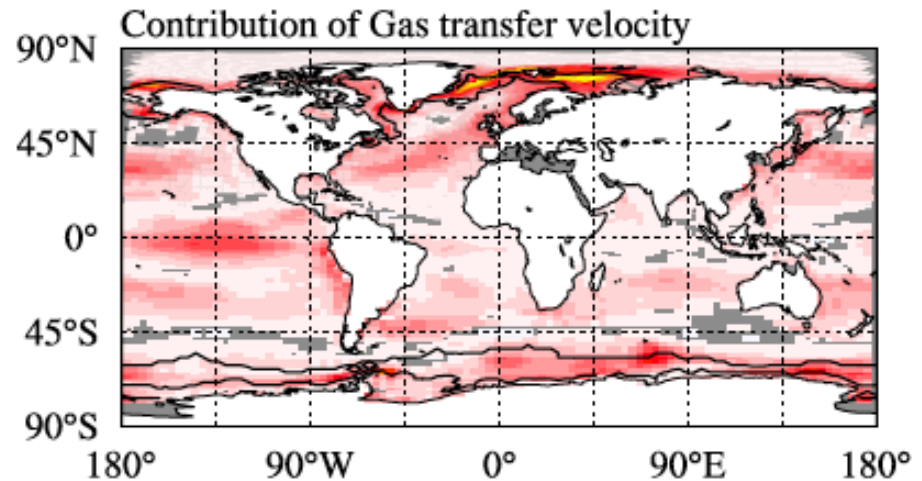
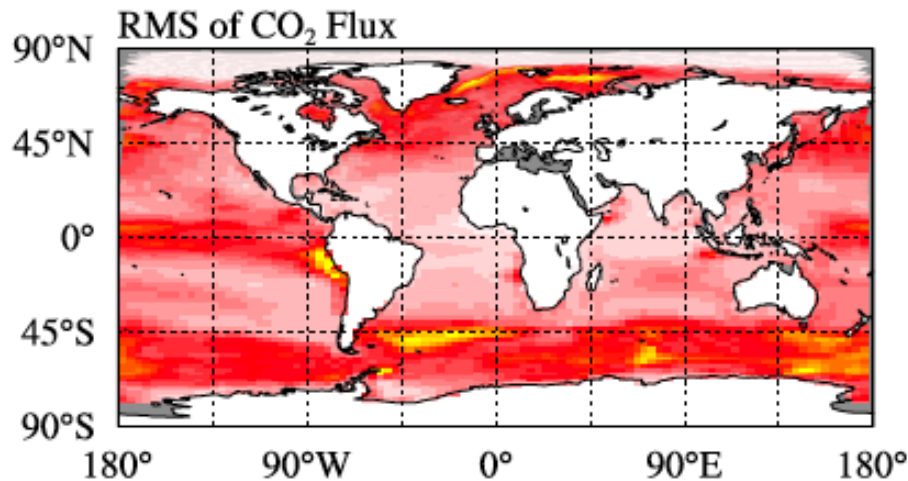
Lindsay et al. J. Climate submitted

Air-Sea CO₂ Flux Variability

Air-sea CO₂ flux std

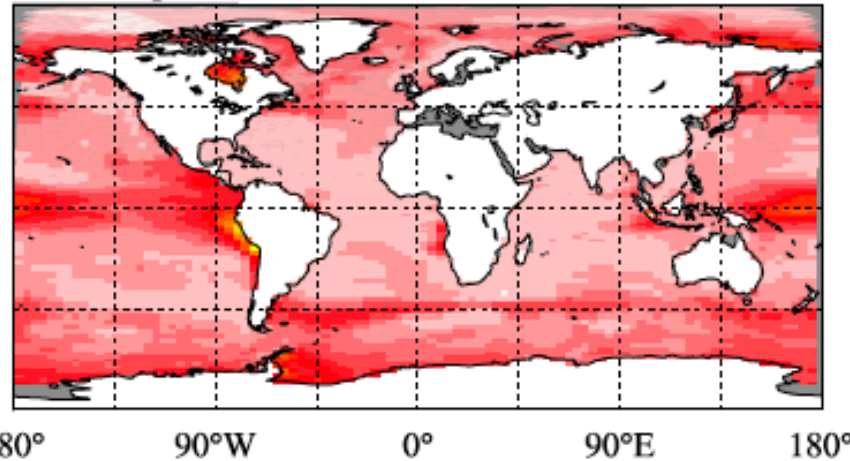


$$F'_{CO_2} = (k\alpha)' \overline{\Delta p CO_2} + \overline{(k\alpha)} \Delta p CO_2' + \left((k\alpha)' \Delta p CO_2' - \overline{(k\alpha)' \Delta p CO_2'} \right)$$

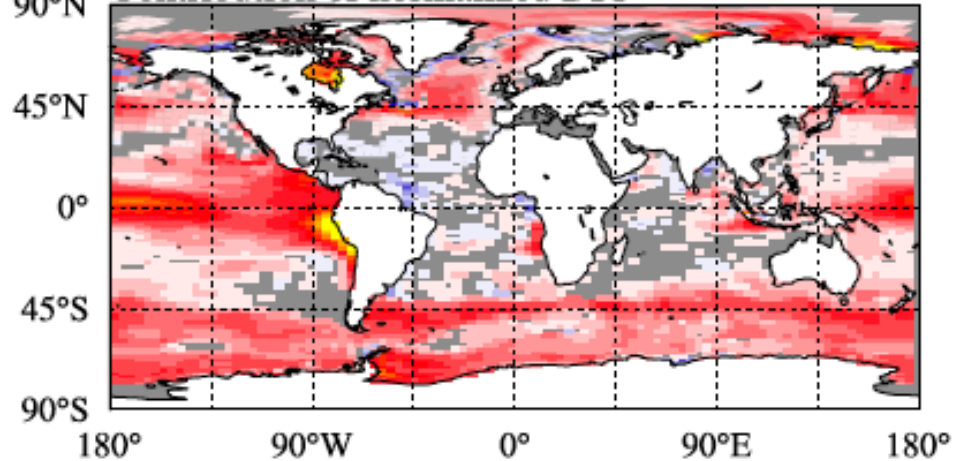


$$pCO_2' = \frac{\partial pCO_2}{\partial T} T' + \frac{\partial pCO_2}{\partial DIC} nDIC' + \frac{\partial pCO_2}{\partial Alk} nAlk' + \frac{\partial pCO_2}{\partial S_{(DIC, ALK, s)}} S'$$

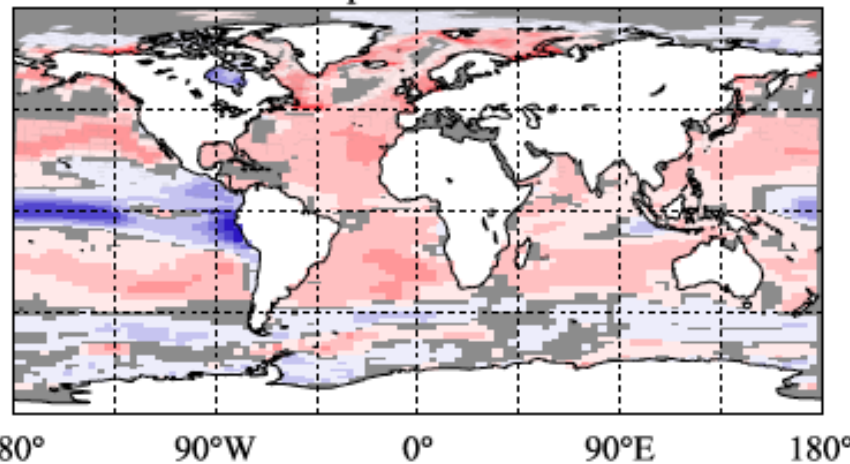
RMS of pCO_2



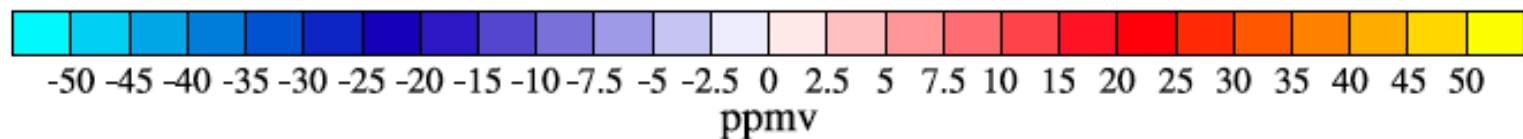
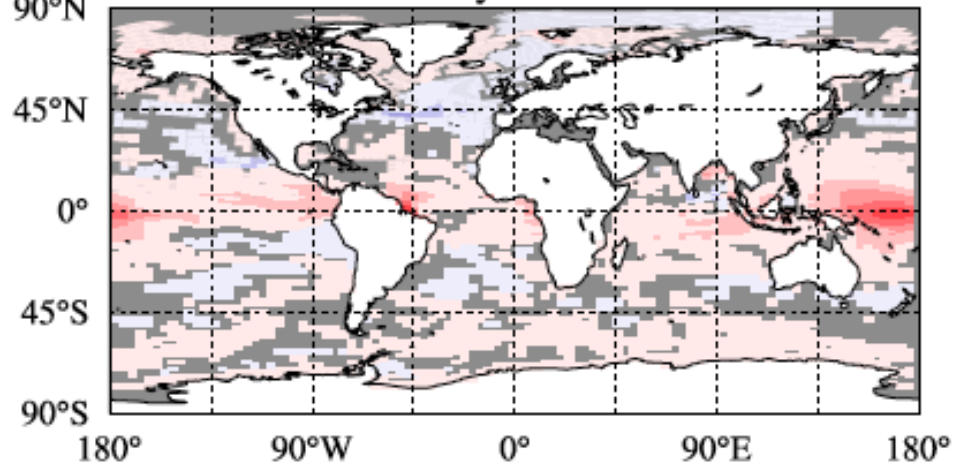
Contribution of normalized DIC



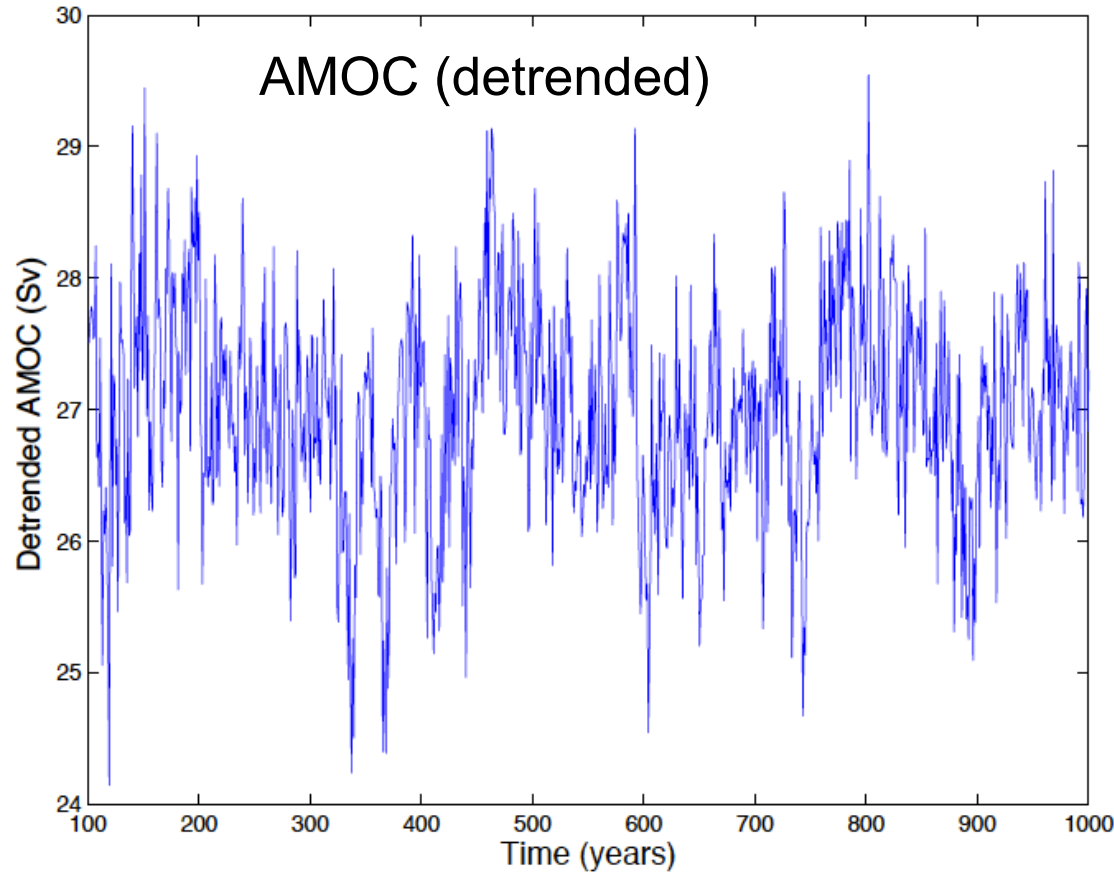
Contribution of Temperature



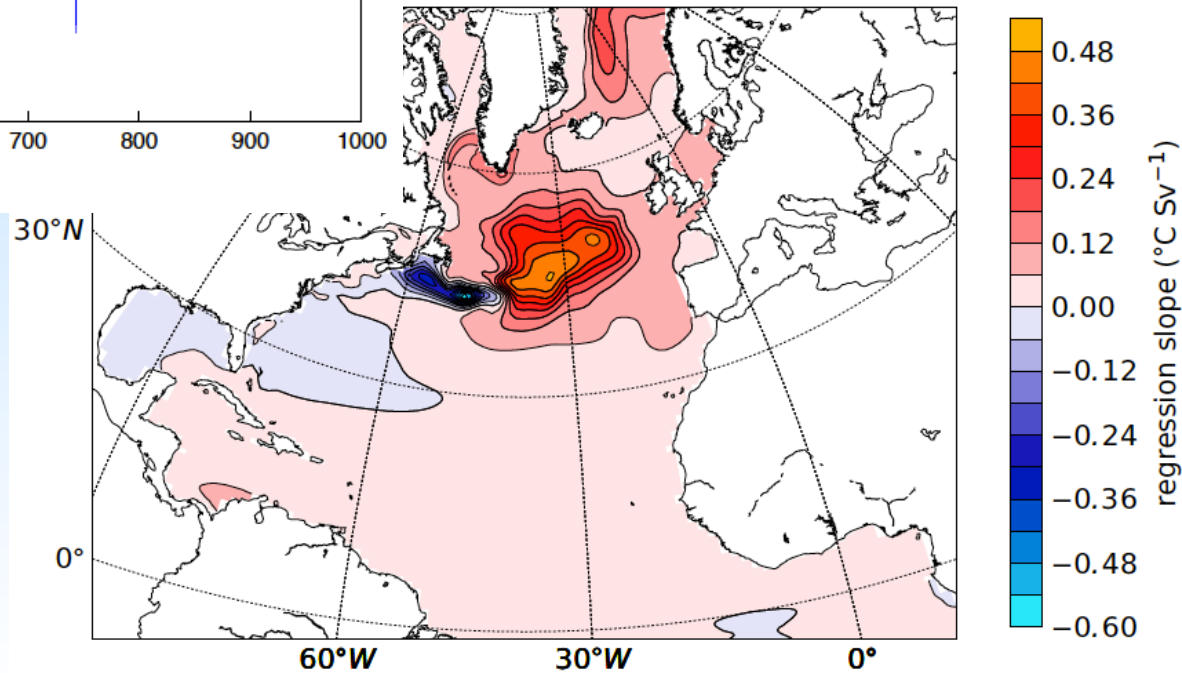
Contribution of Salinity



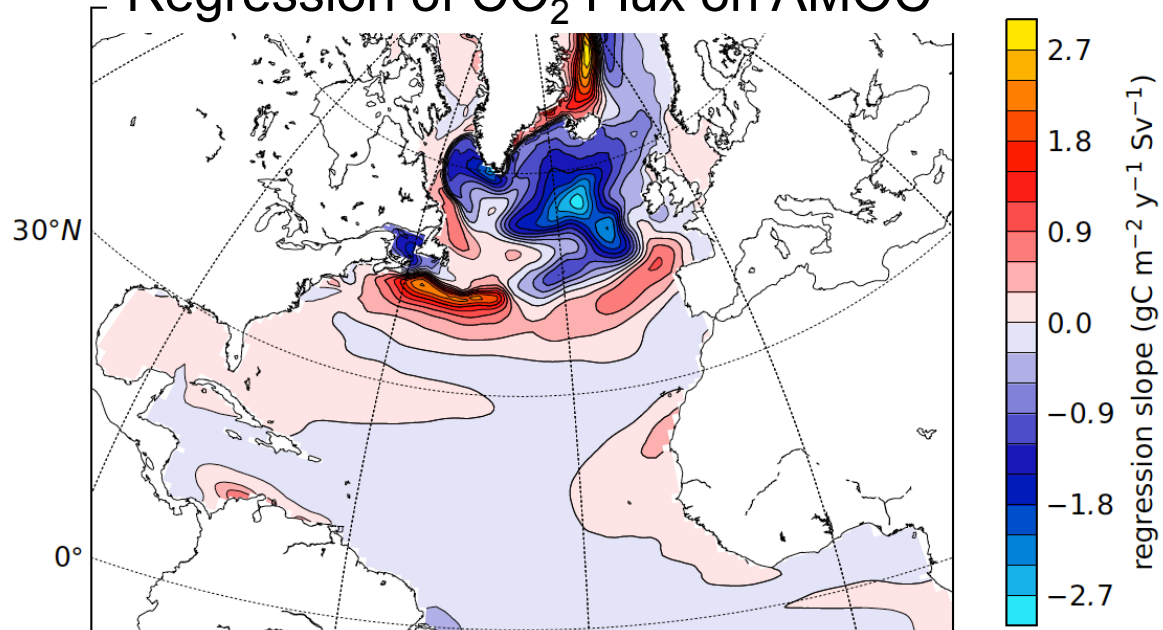
Natural Variability in Control Simulation



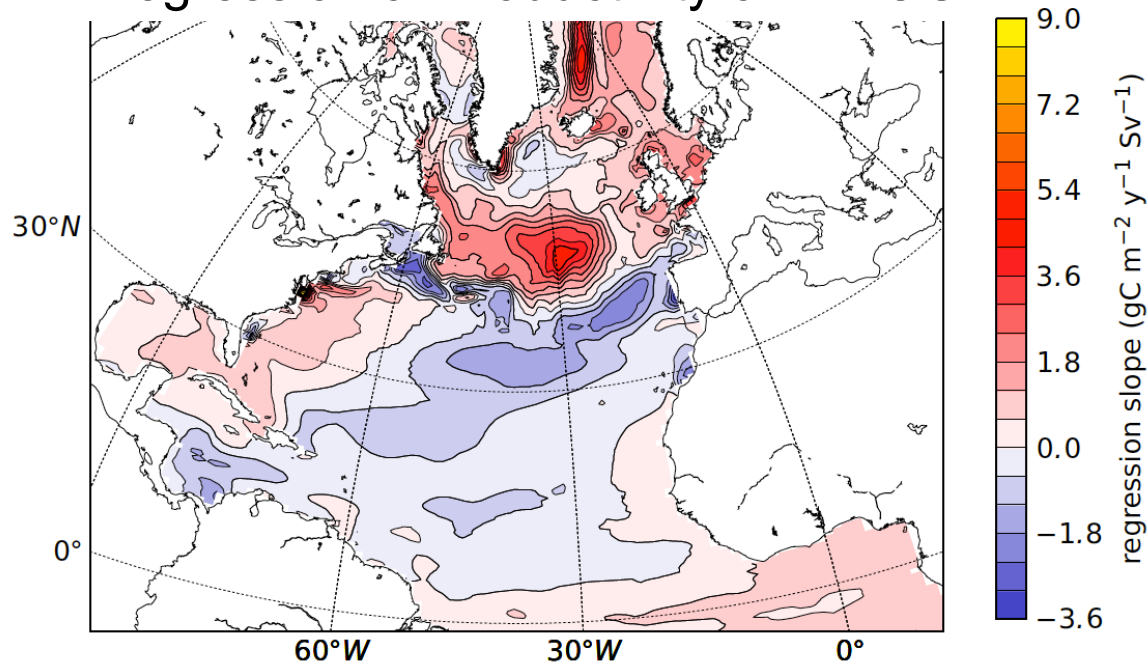
Regression of SST on AMOC



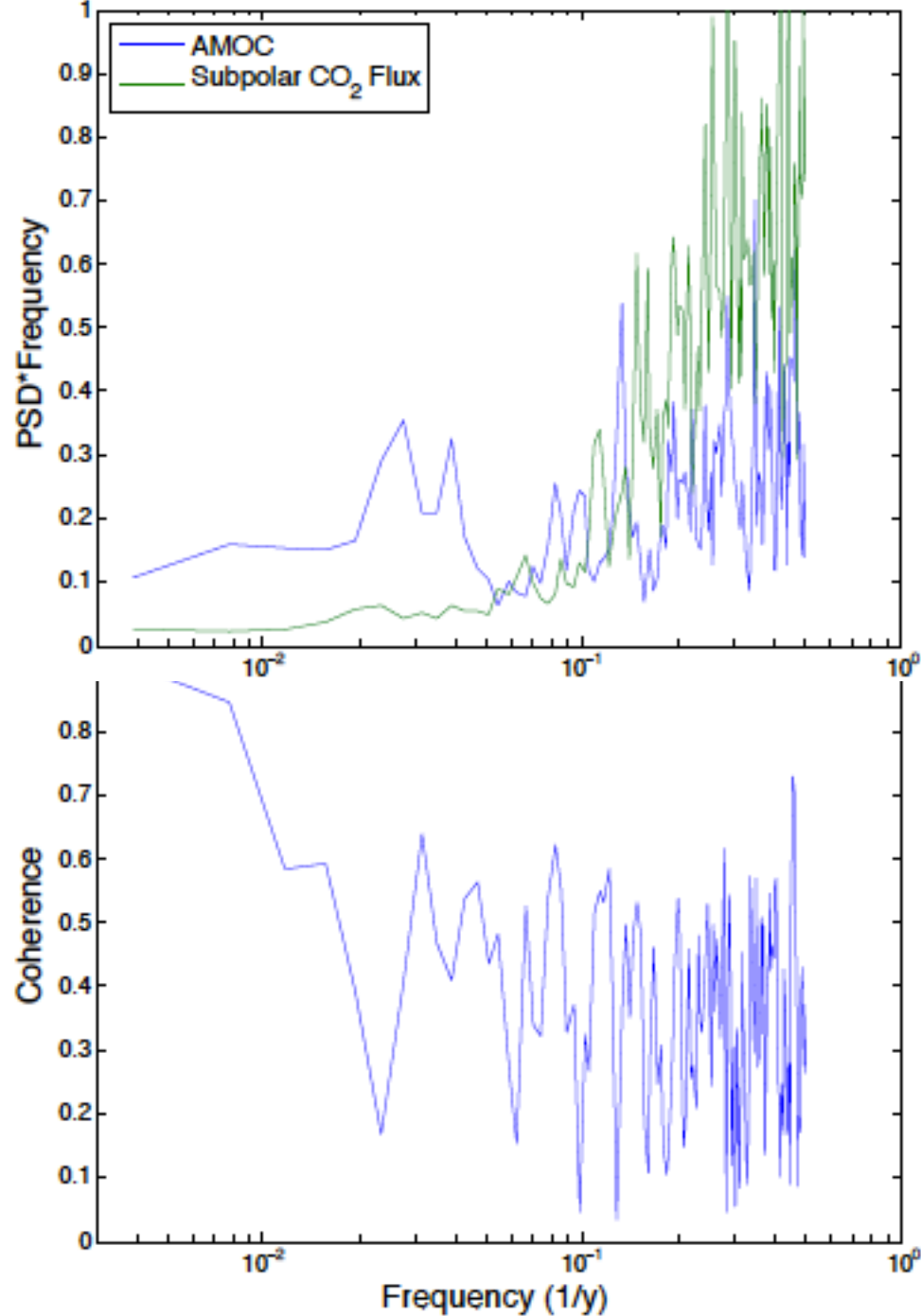
Regression of CO₂ Flux on AMOC



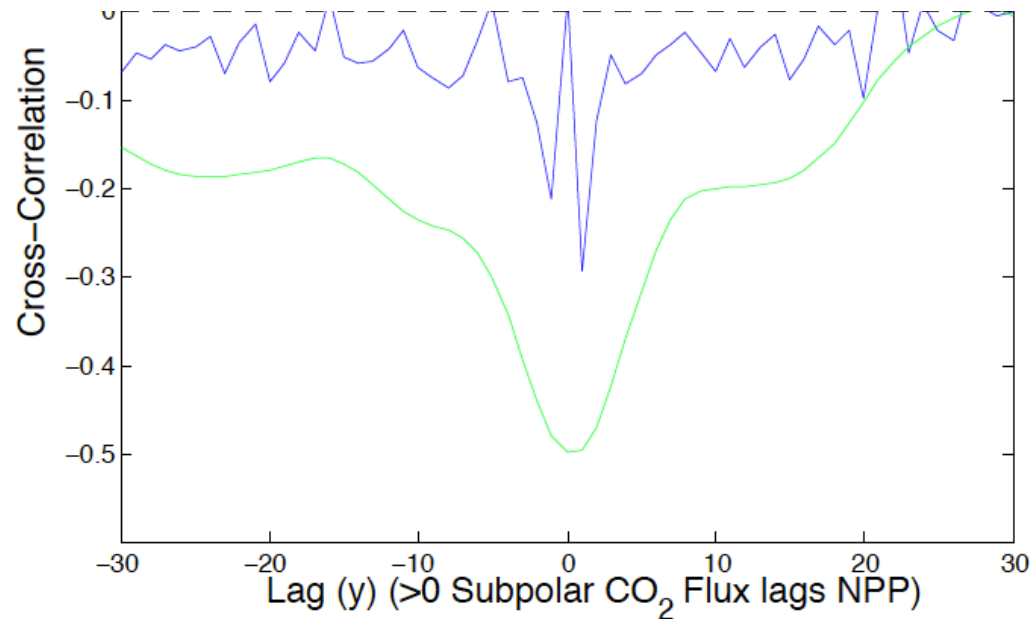
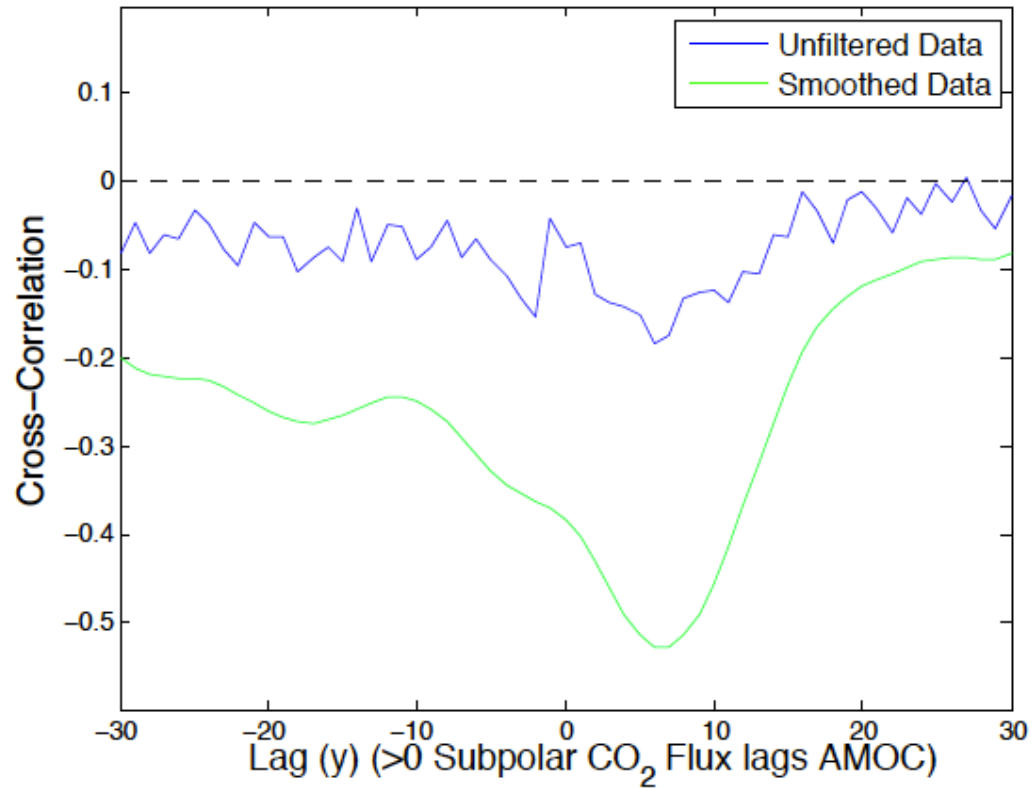
Regression of Productivity on AMOC



Spectral Analysis AMOC vs. Subpolar CO₂ Flux

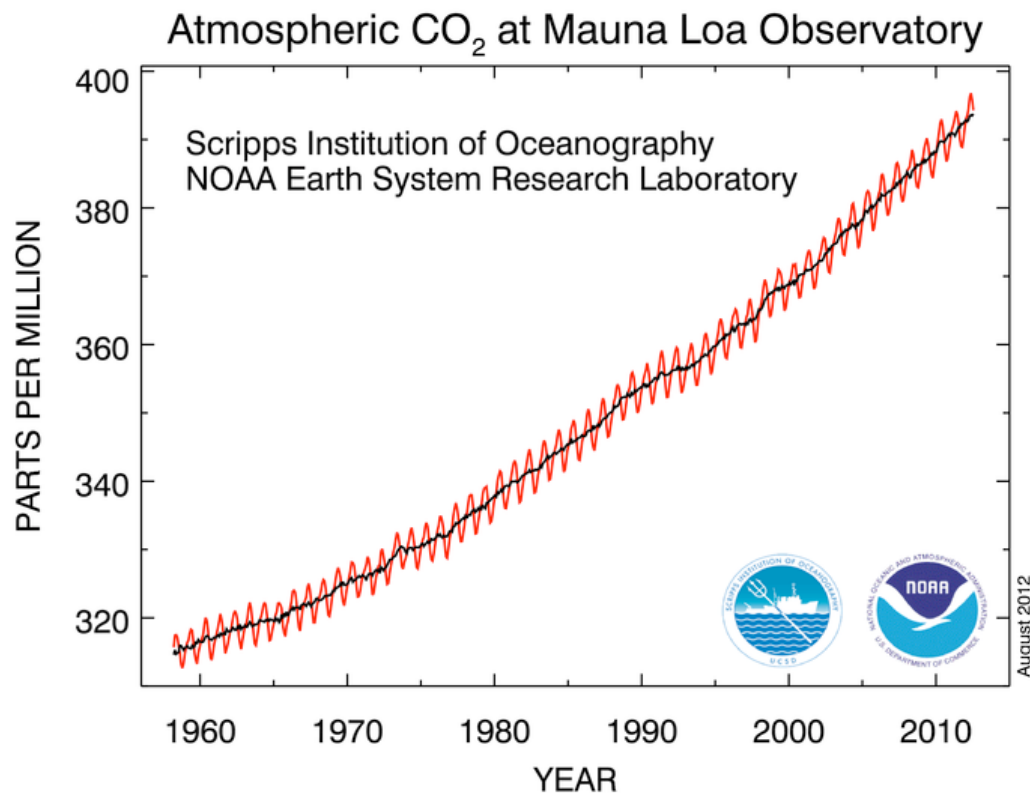


Lagged Correlations



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