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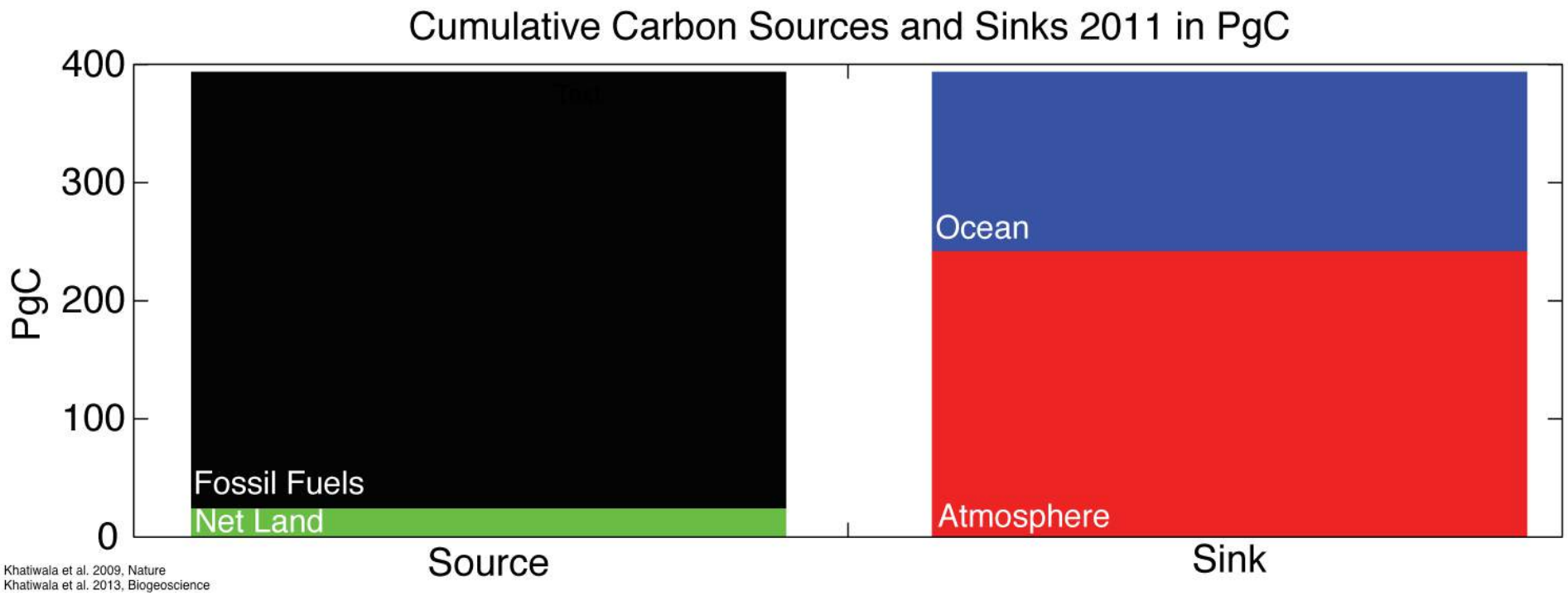
Biogeochemistry questions to motivate ASTE-BGC

Galen McKinley

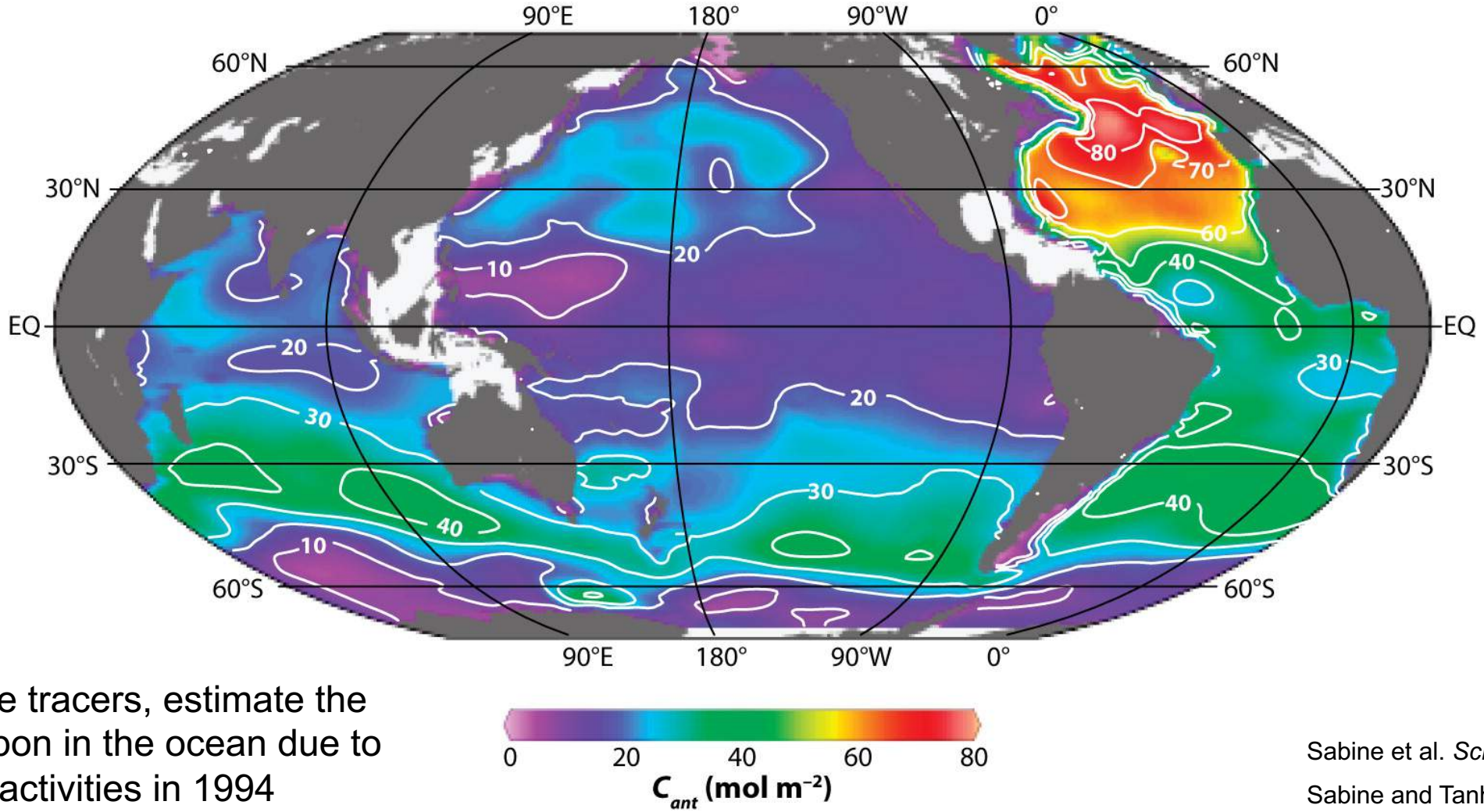
29-31 August 2018

ECCO Annual Meeting

Our carbon goes to either the ocean or the atmosphere



Total ocean anthropogenic carbon accumulation to 1994

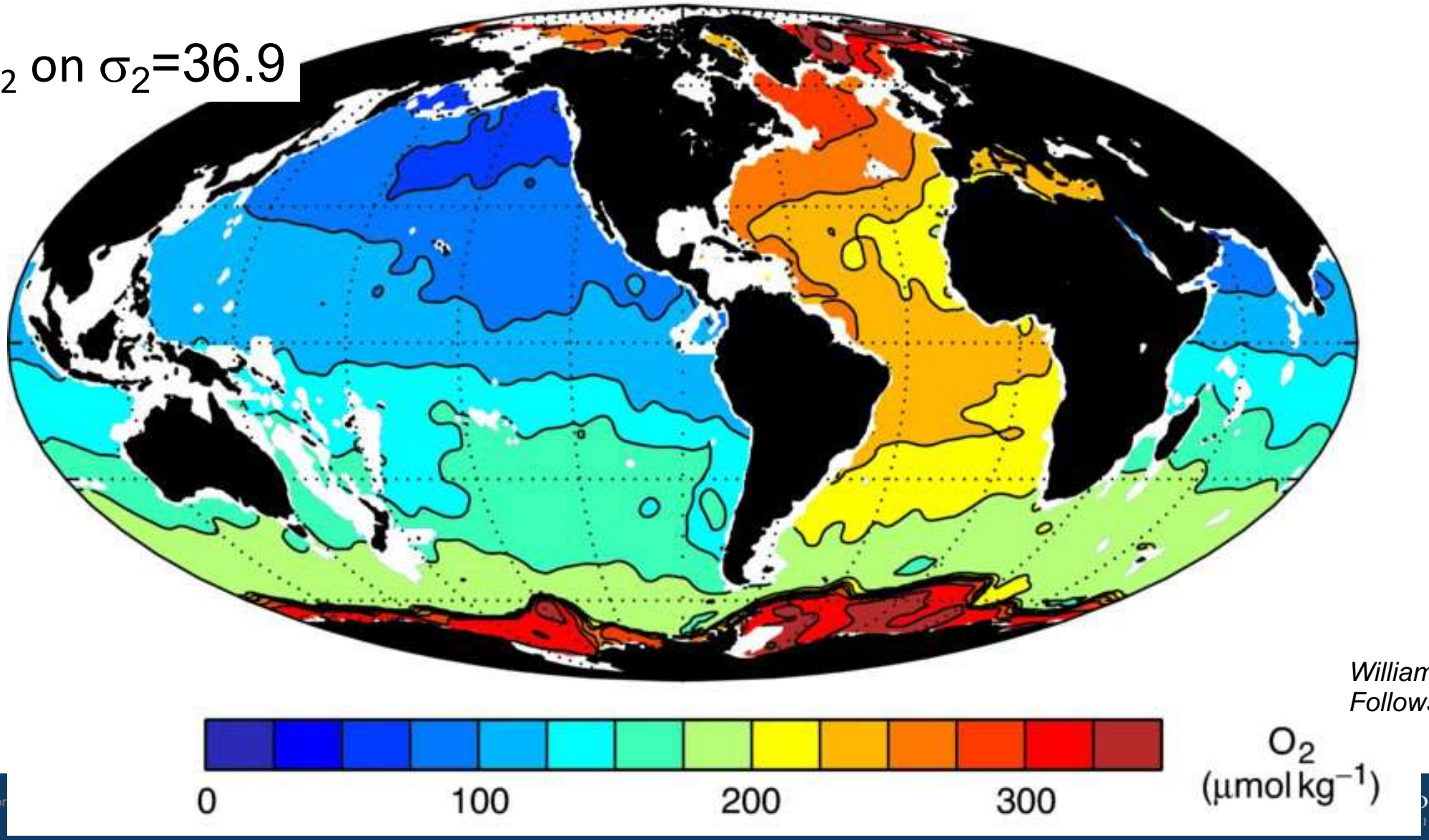


Using multiple tracers, estimate the additional carbon in the ocean due to human activities in 1994

Sabine et al. *Science* 2004

Sabine and Tanhua, *ARMS*, 2010

North Atlantic oxygenates the deep ocean



Williams and Follows 2011

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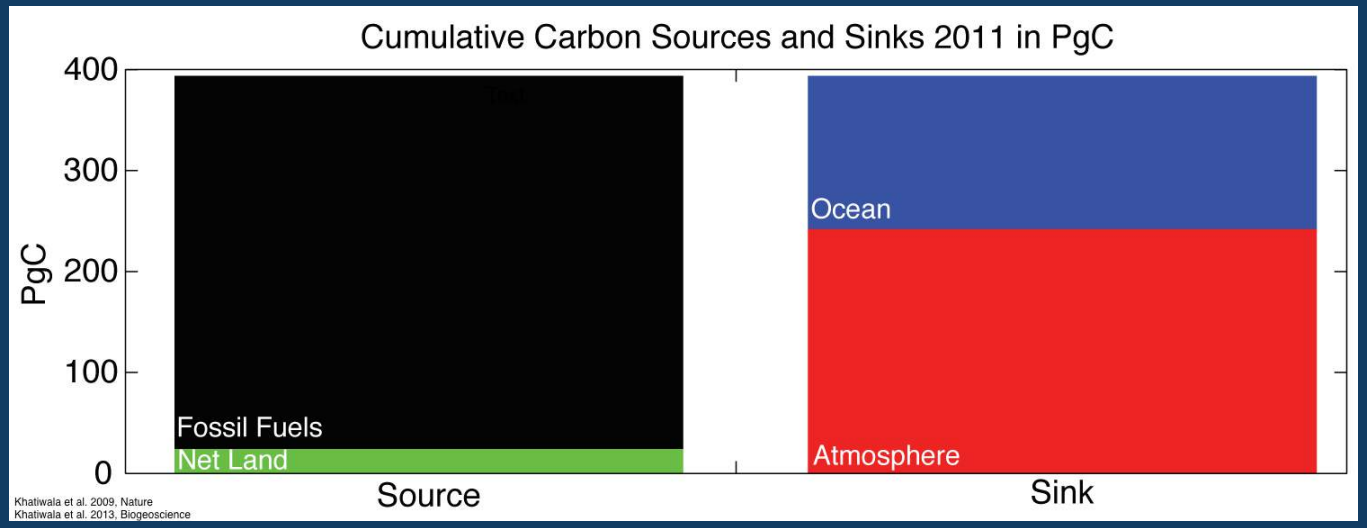
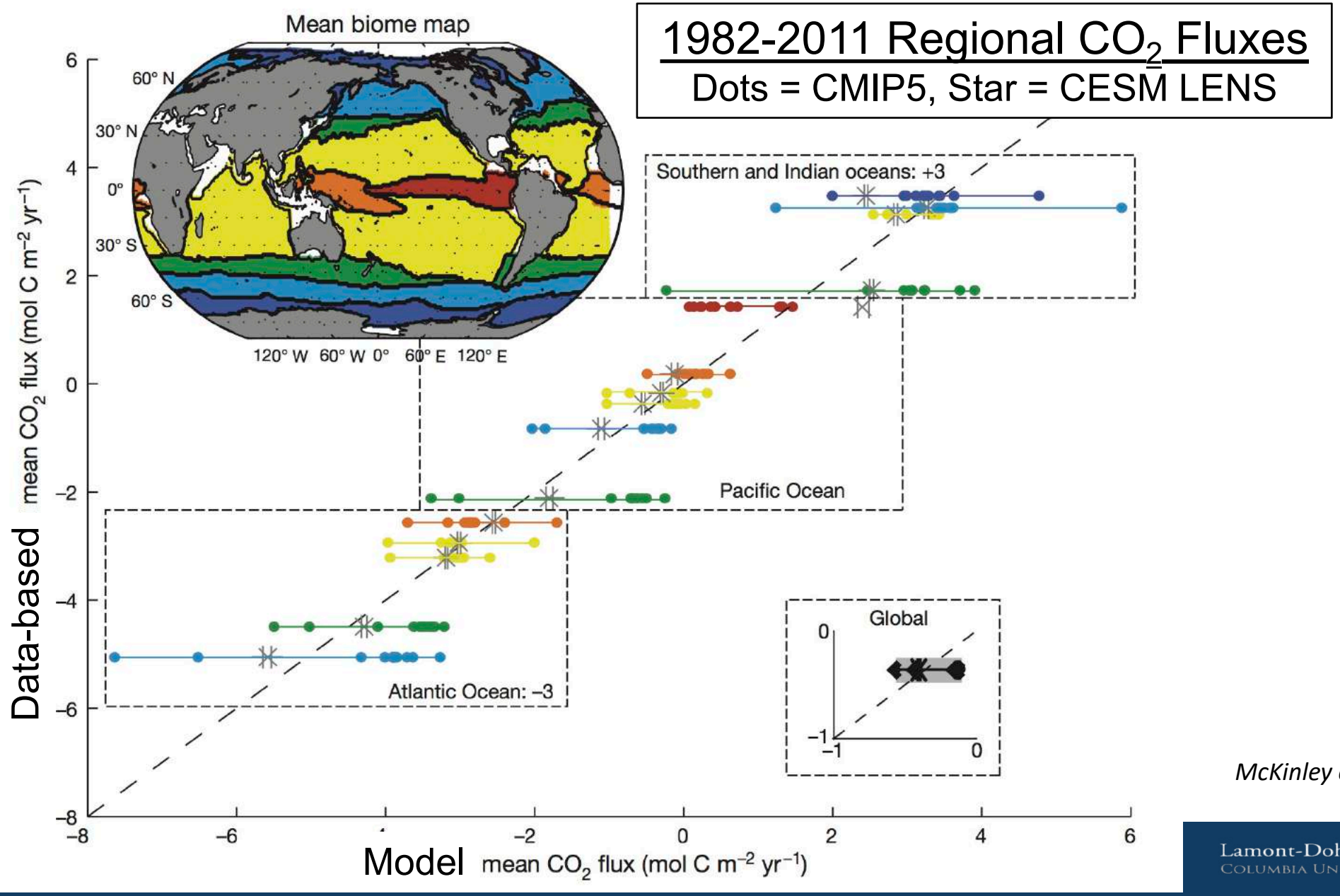
Global carbon fluxes and their variability

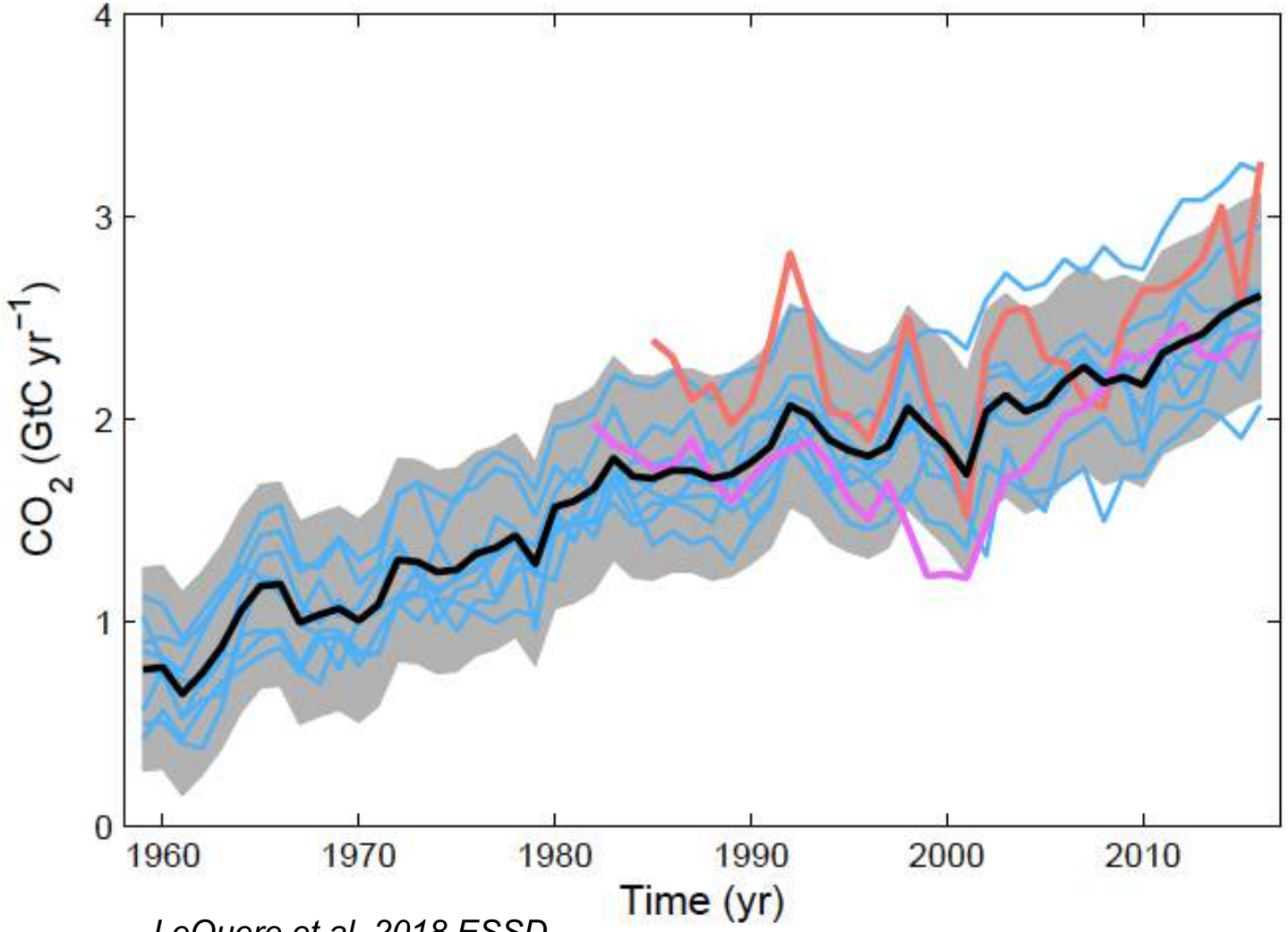


Models converge to a global mean CO_2 sink, but differ regionally



McKinley et al. 2016 Nature

Ocean Carbon Sink from Global Carbon Budget 2017



LeQuere et al. 2018 ESSD

HINDCAST MODELS

Blue = 8 Hindcast models

Black = Hindcast model median (used in budget)

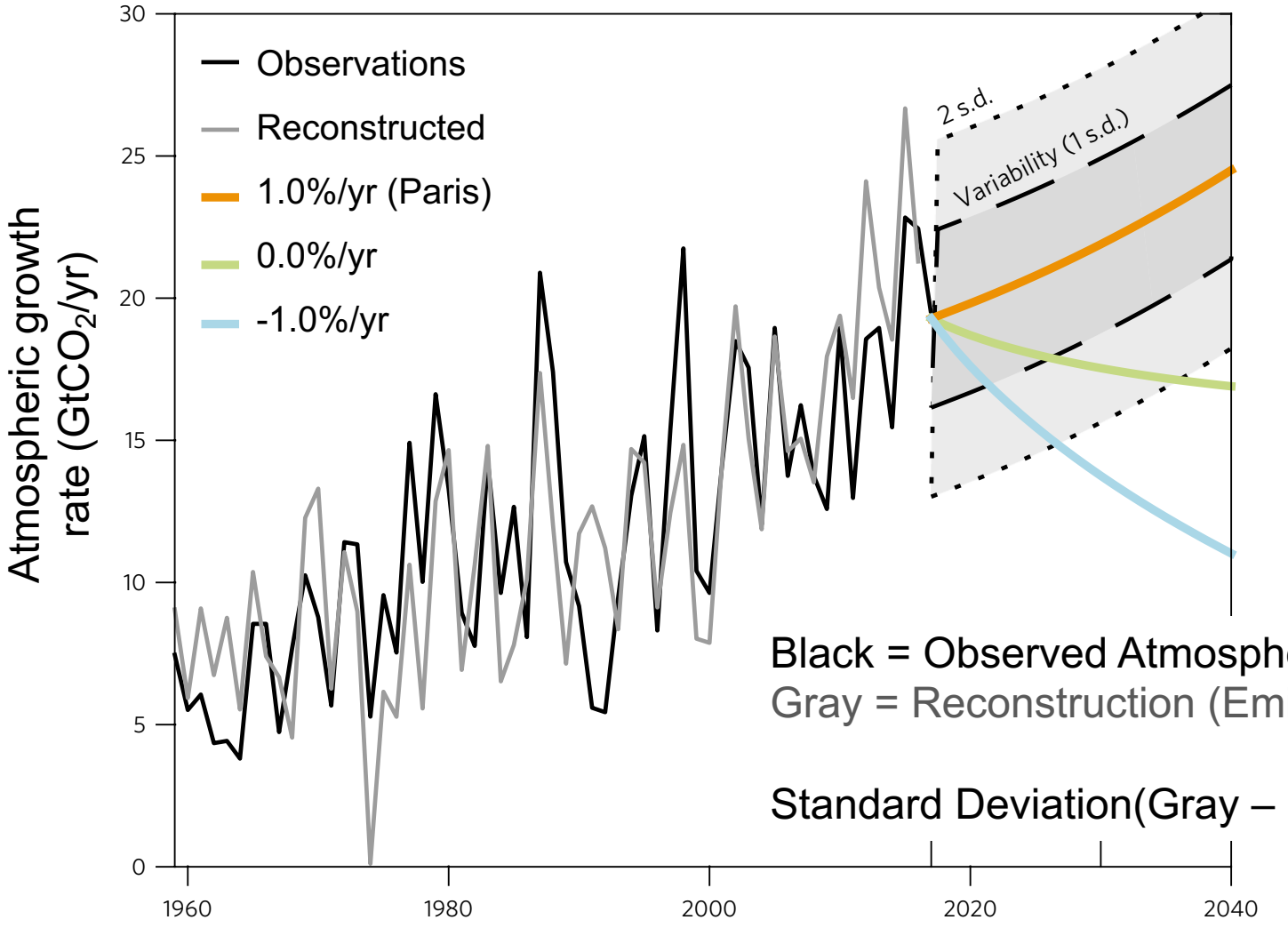
DATA PRODUCTS

Orange = Rodenbeck et al. 2013,2015

Pink = Landschutzer et al 2014, 15, 16

Models all less variable than data-based estimates. Which correct?

When can emission cuts be distinguished given sink variability?



Black = Observed Atmospheric Growth Rate

Gray = Reconstruction (Emission–Land–Ocean)

Standard Deviation(Gray – Black) = 3 $GtCO_2$/yr

Peters et al. 2017 Nature Climate Change

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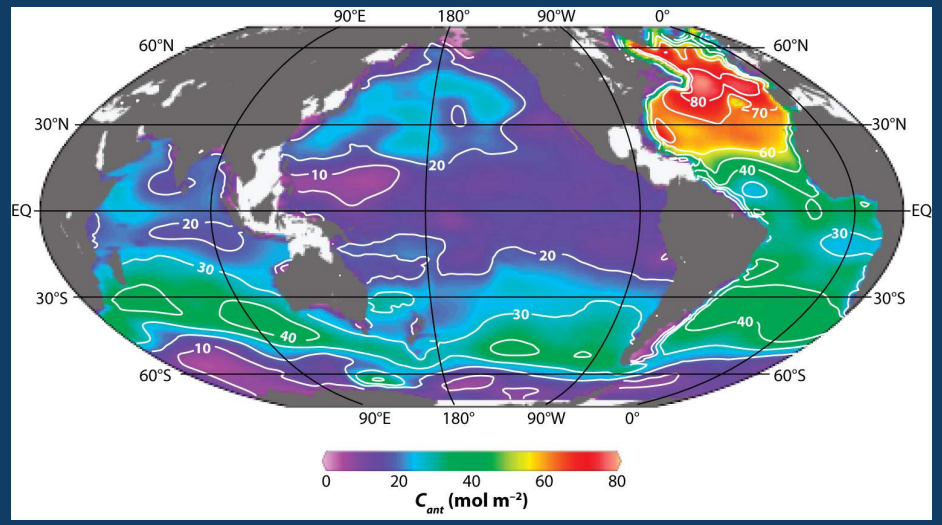
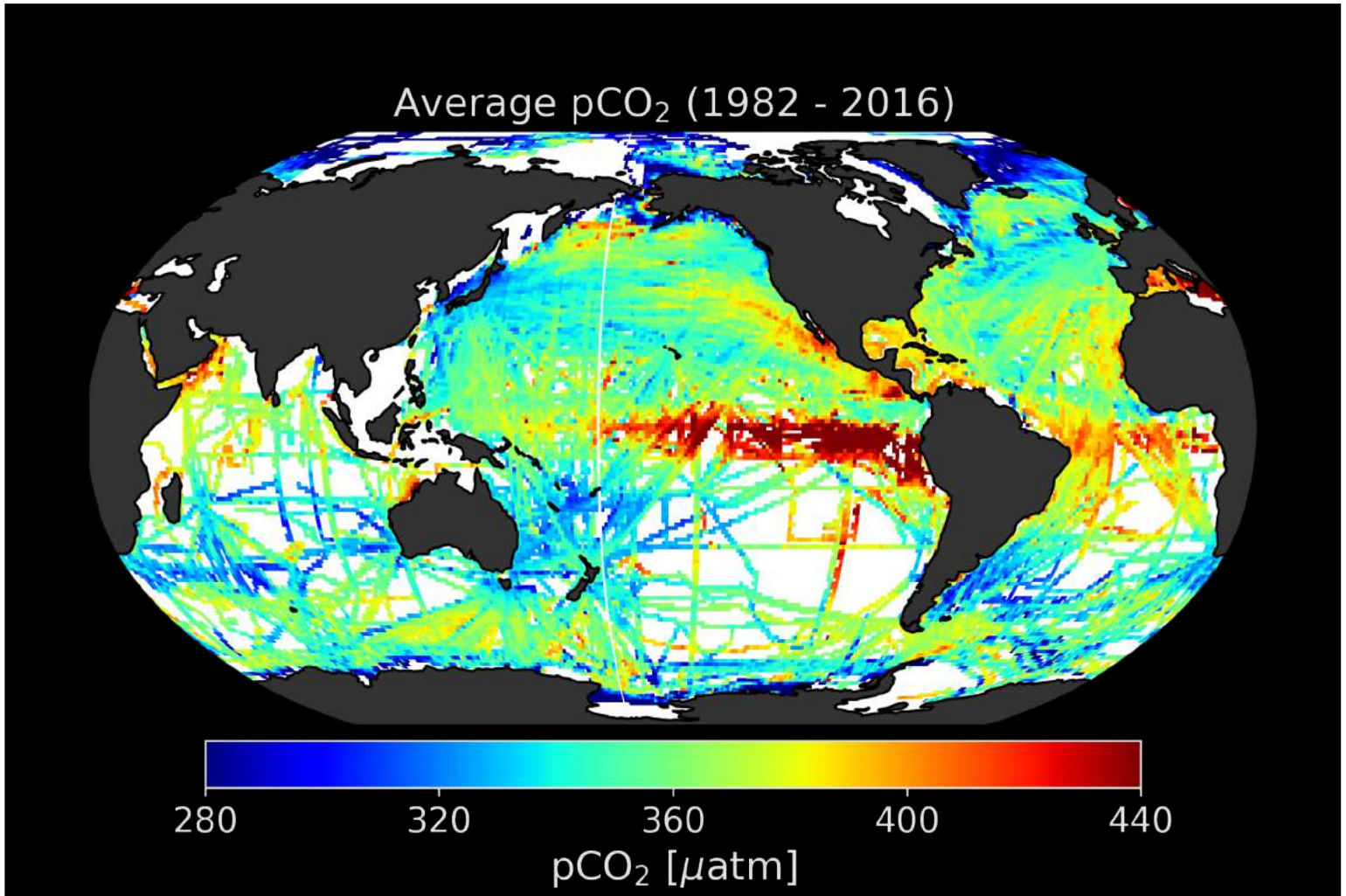
North Atlantic carbon flux trends



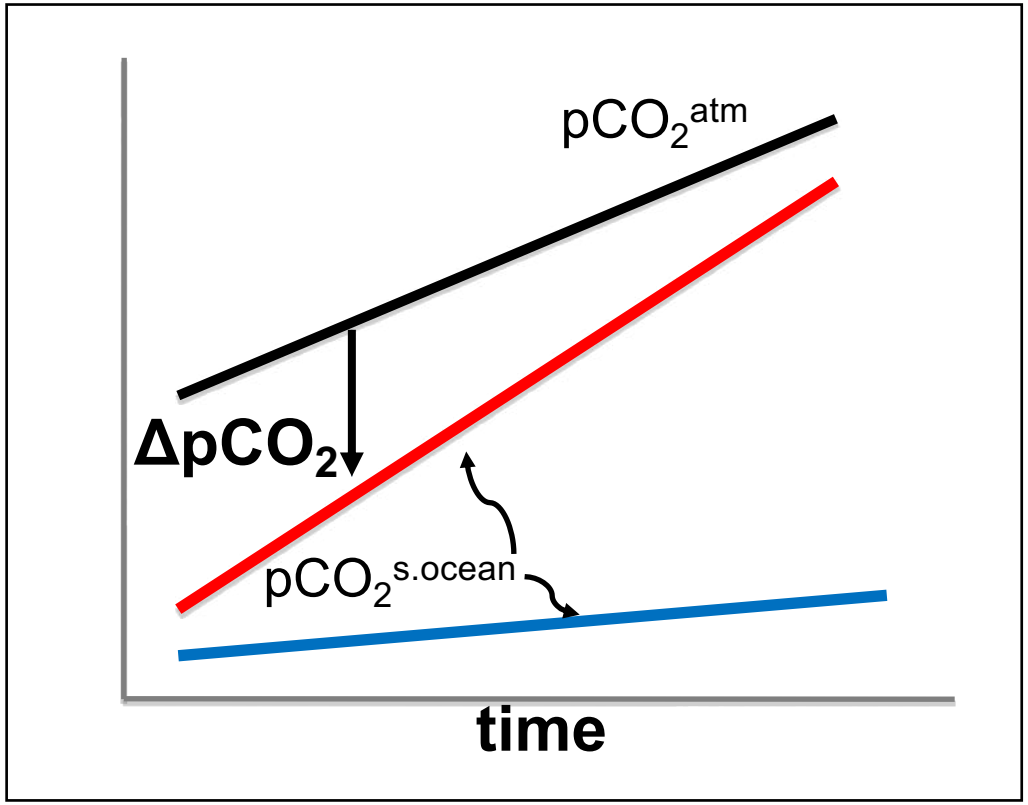
Surface pCO_2 data, as CO_2 flux proportional to ΔpCO_2



SOCATv5 (20+ Million, but still only 1% coverage)

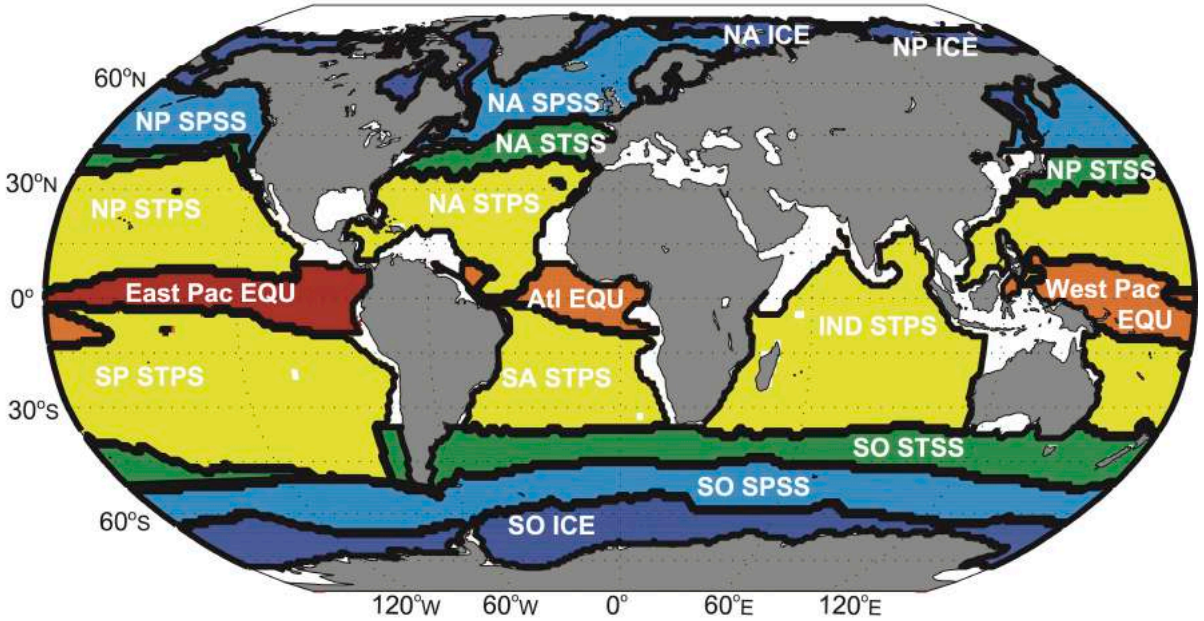
Bakker et al. 2016 ESSD
Sabine et al. 2013 ESSD

Non-zero ΔpCO_2 trend indicates CO_2 flux change



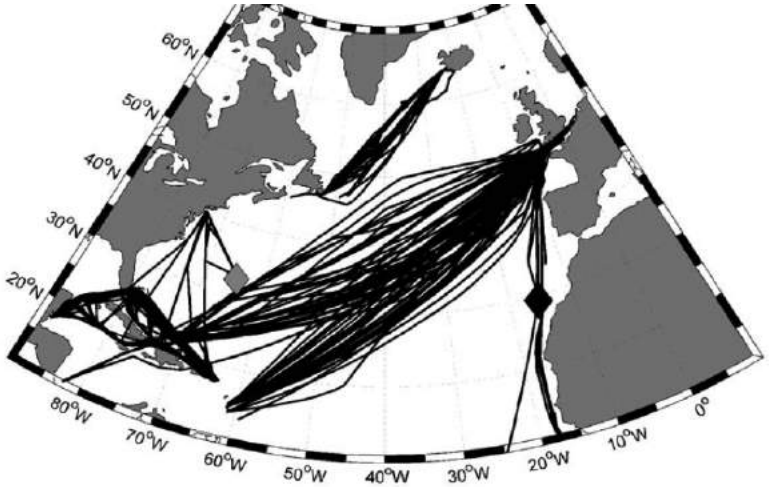
$d\Delta pCO_2/dt > 0$
DECLINING SINK

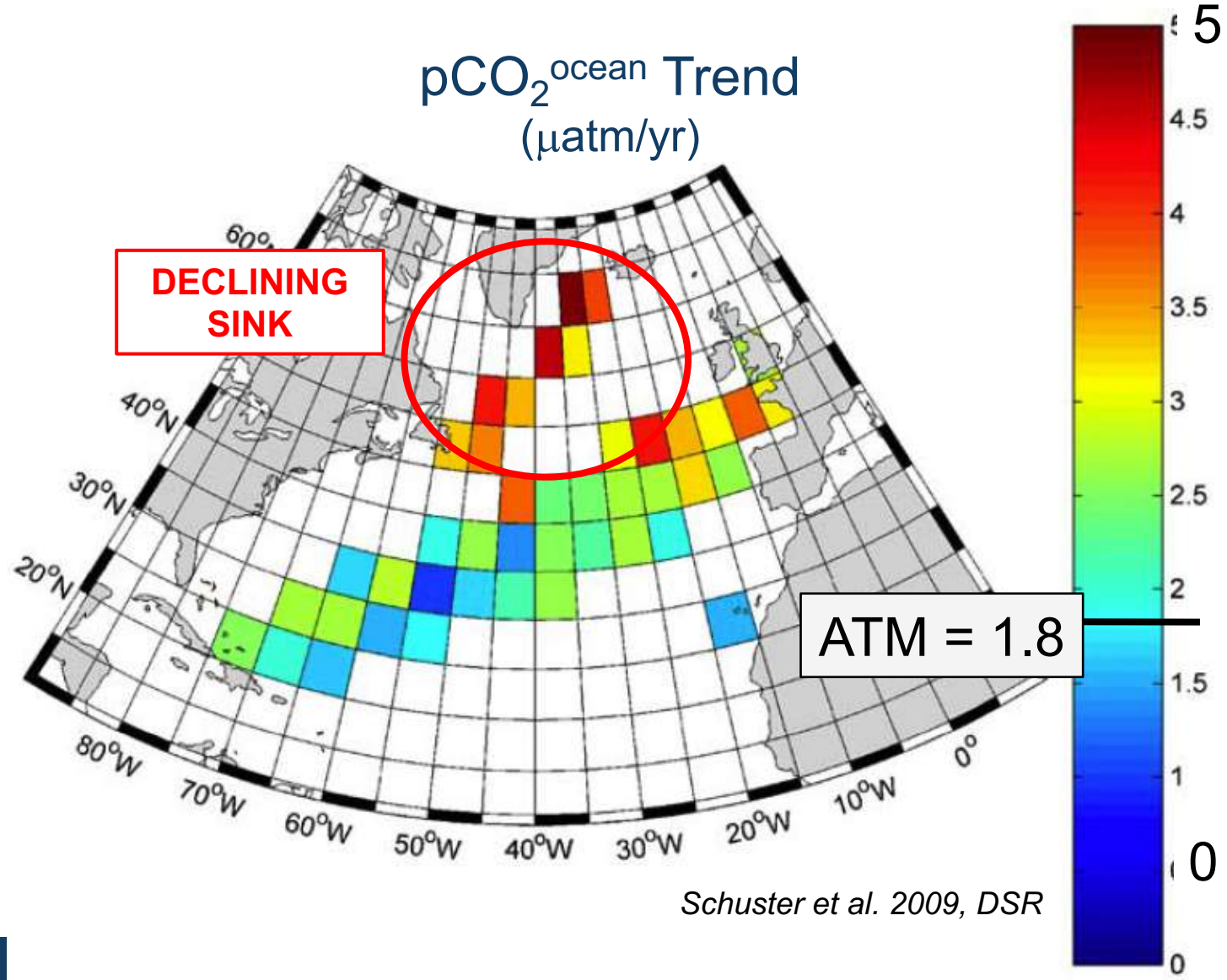
$d\Delta pCO_2/dt < 0$
GROWING SINK



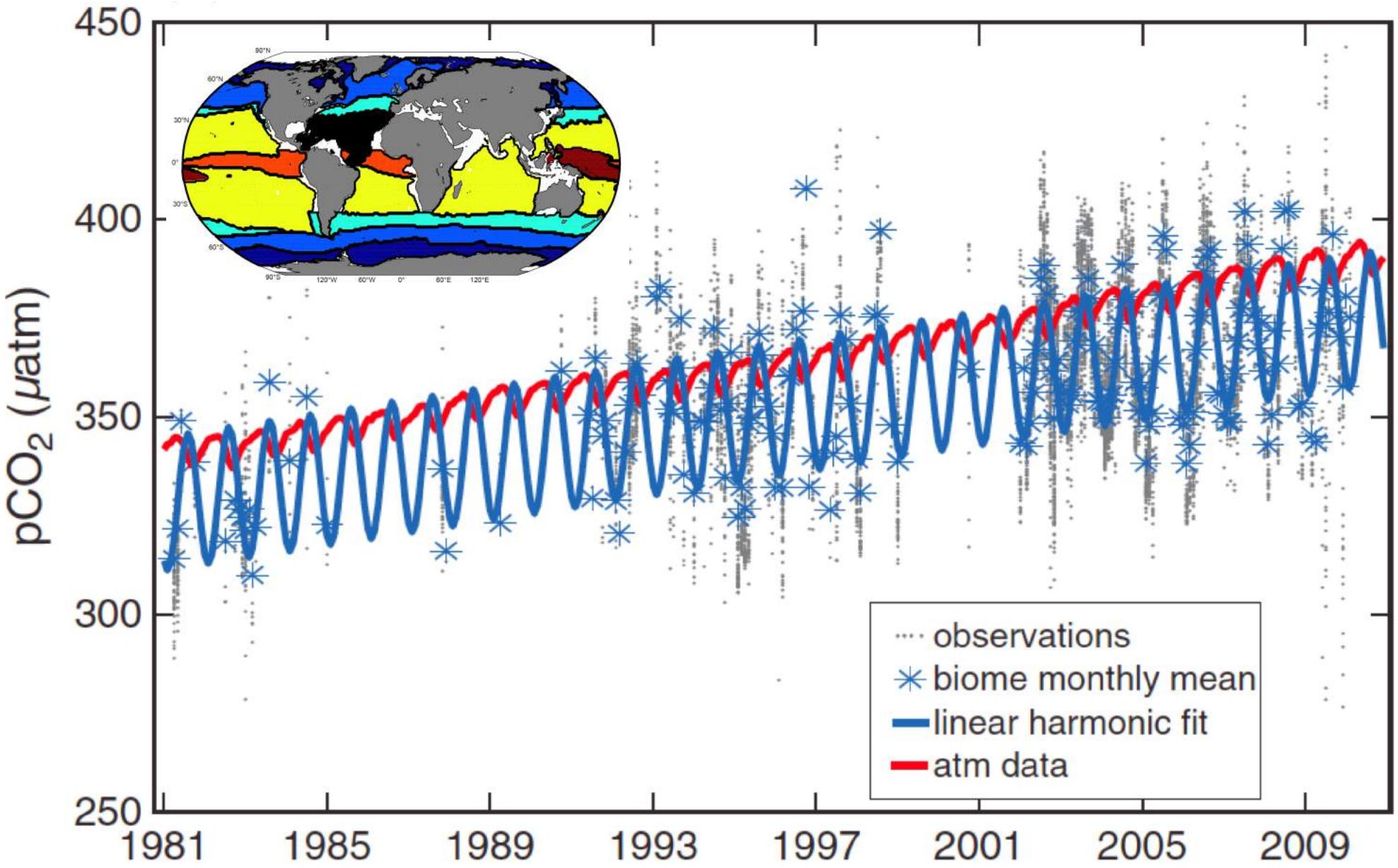
McKinley et al. (2011) Nat. Geosci.
Fay and McKinley (2013) GBC
Fay and McKinley (2014), ESSD
Fay et al. (2014) GRL
Lovenduski et al. (2015) GBC

North Atlantic pCO_2 data 1990-2006 trend



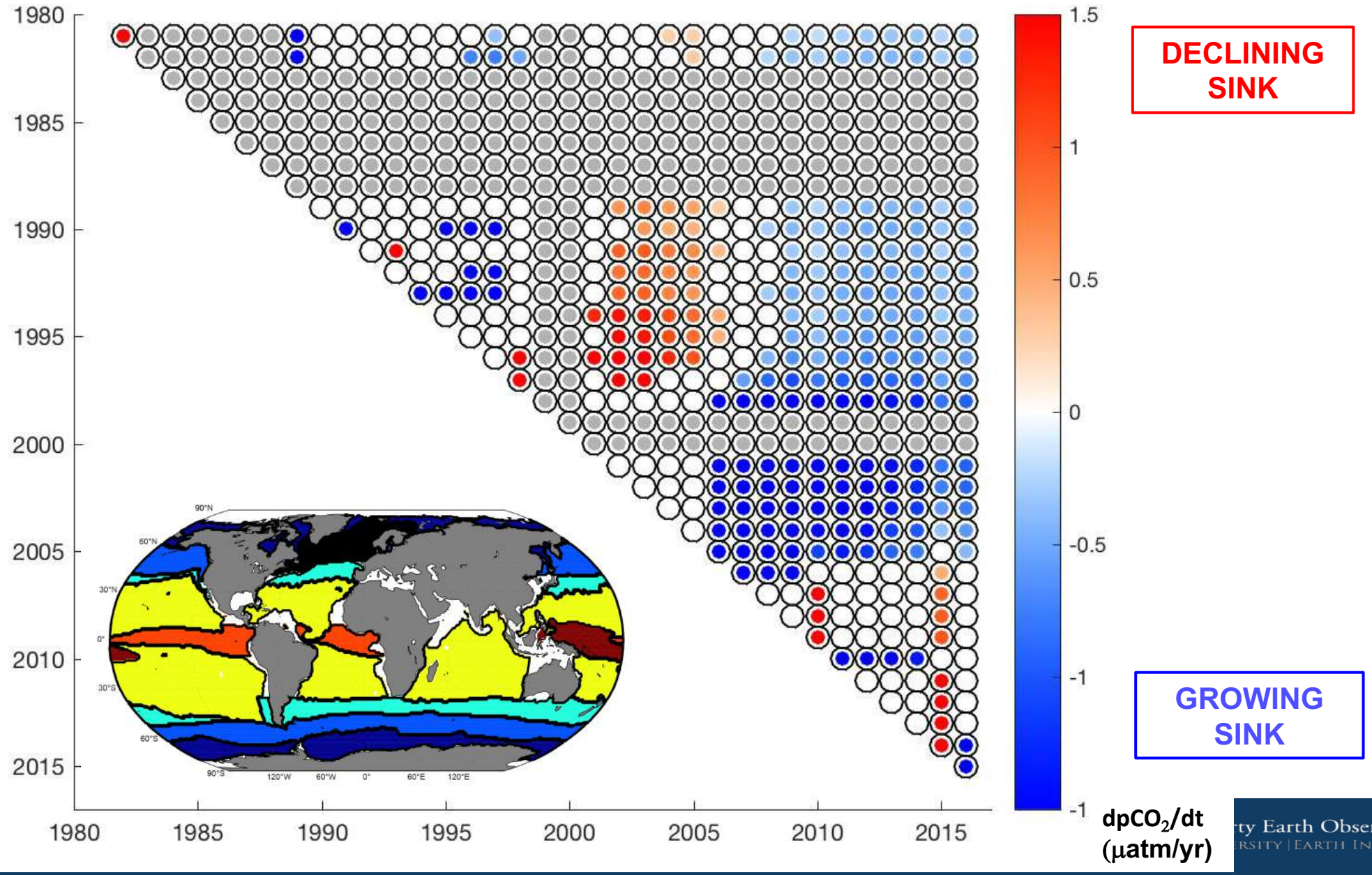


Schuster et al. 2009, DSR



Fay and McKinley, 2013 GBC

N. Atlantic Subpolar, Observed ΔpCO_2 trends



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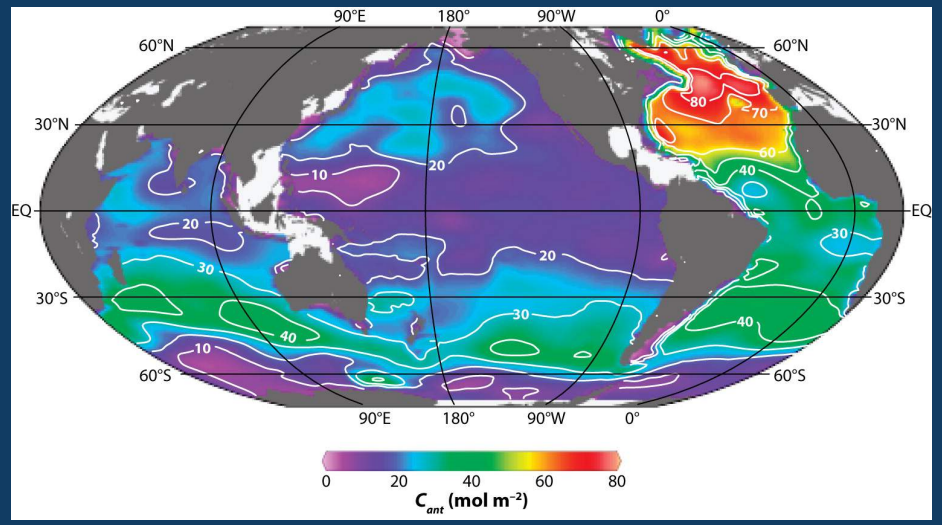
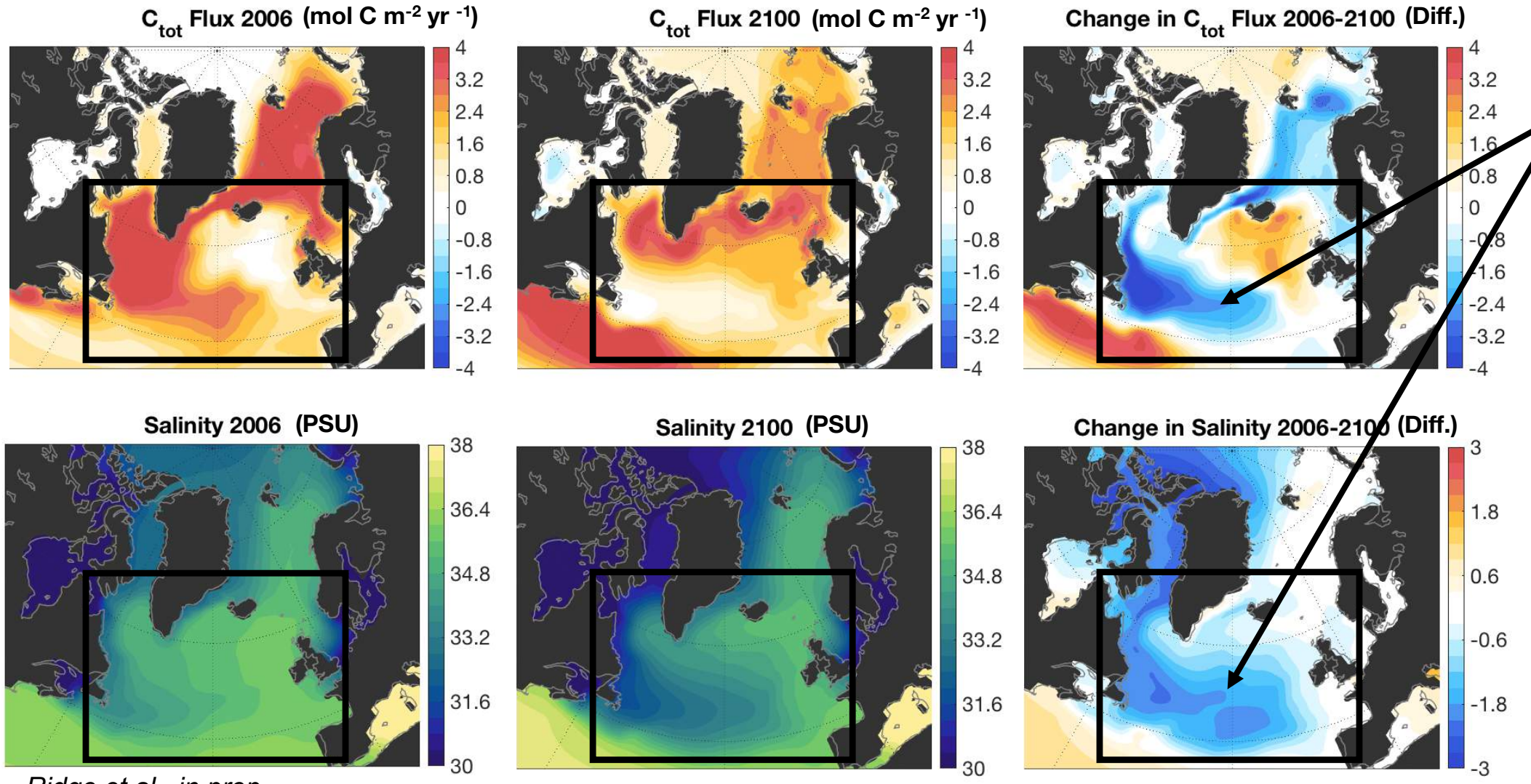
North Atlantic sink under influence of Arctic melt



CO_2 sink declines as surface freshens through 2100 (CESM LENS)



Freshening coherent with flux shutdown

Same coherent SSS and CO_2 flux changes in CMIP5 models

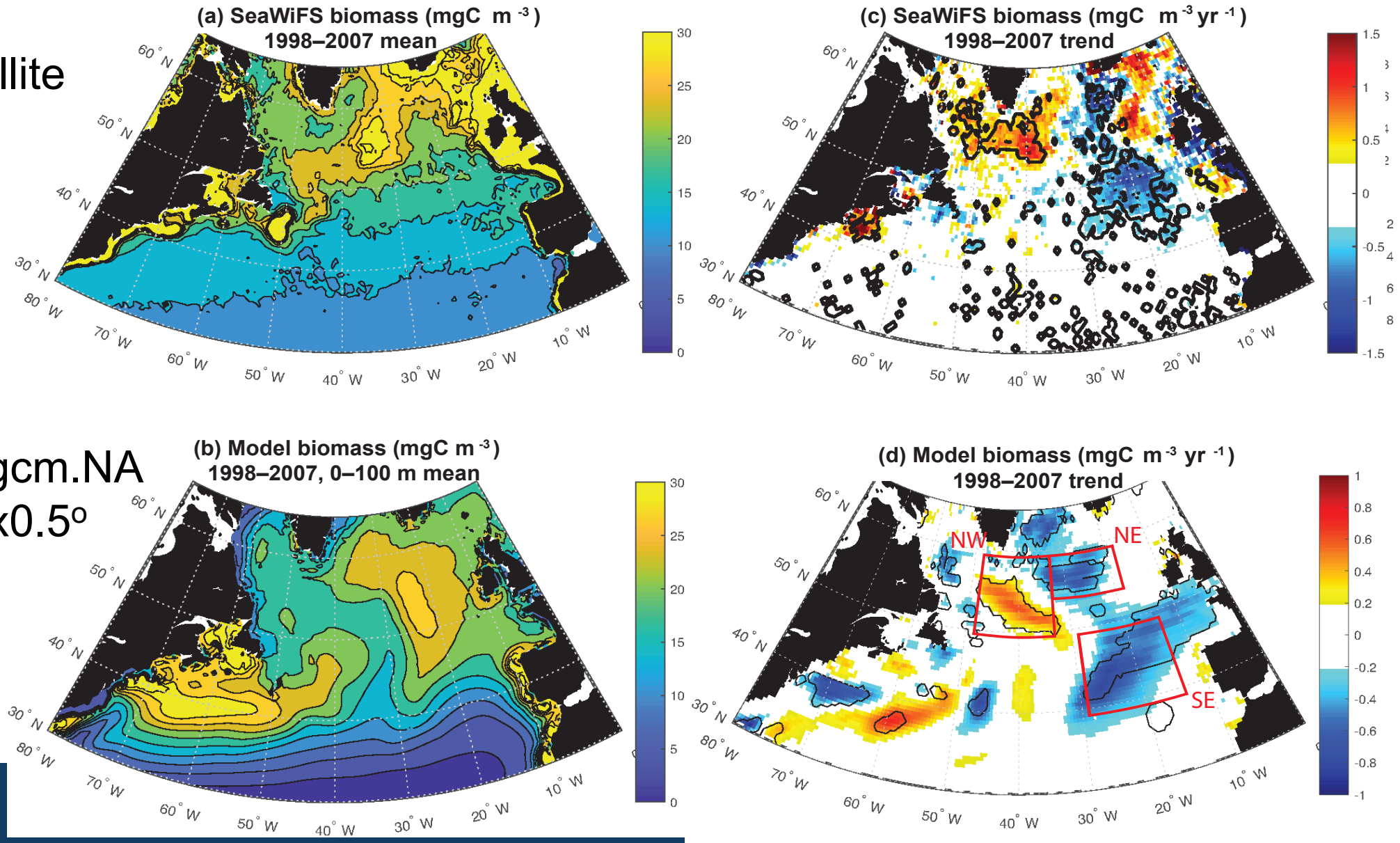
Ridge et al., in prep

North Atlantic biological trends

Mean Biomass (left); Biomass trends 1998-2007 (right)

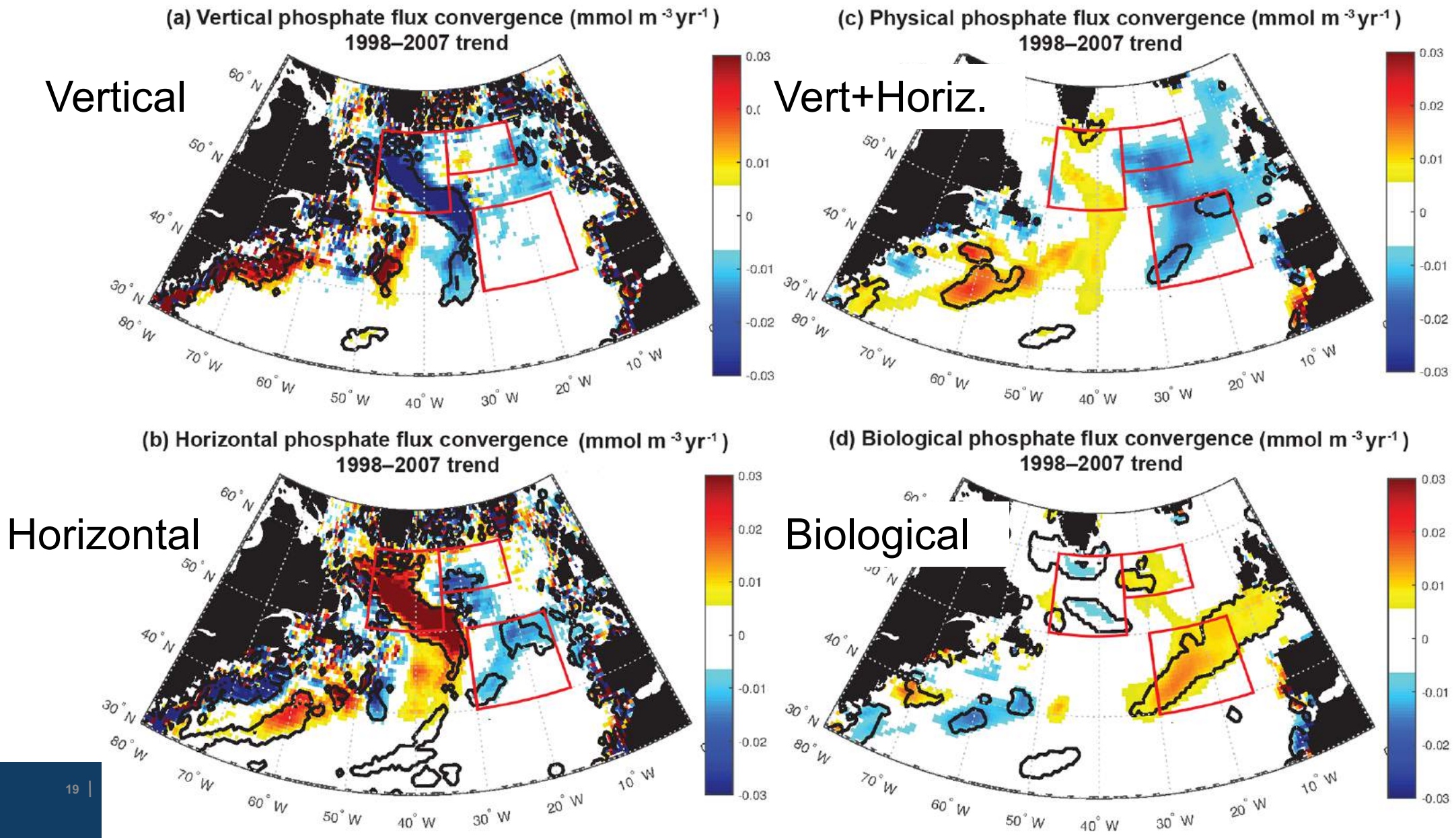
Satellite

MITgcm.NA
0.5°x0.5°



McKinley et al. 2018 Biogeosciences

Nutrient flux convergence trends drive eastern subpolar biomass

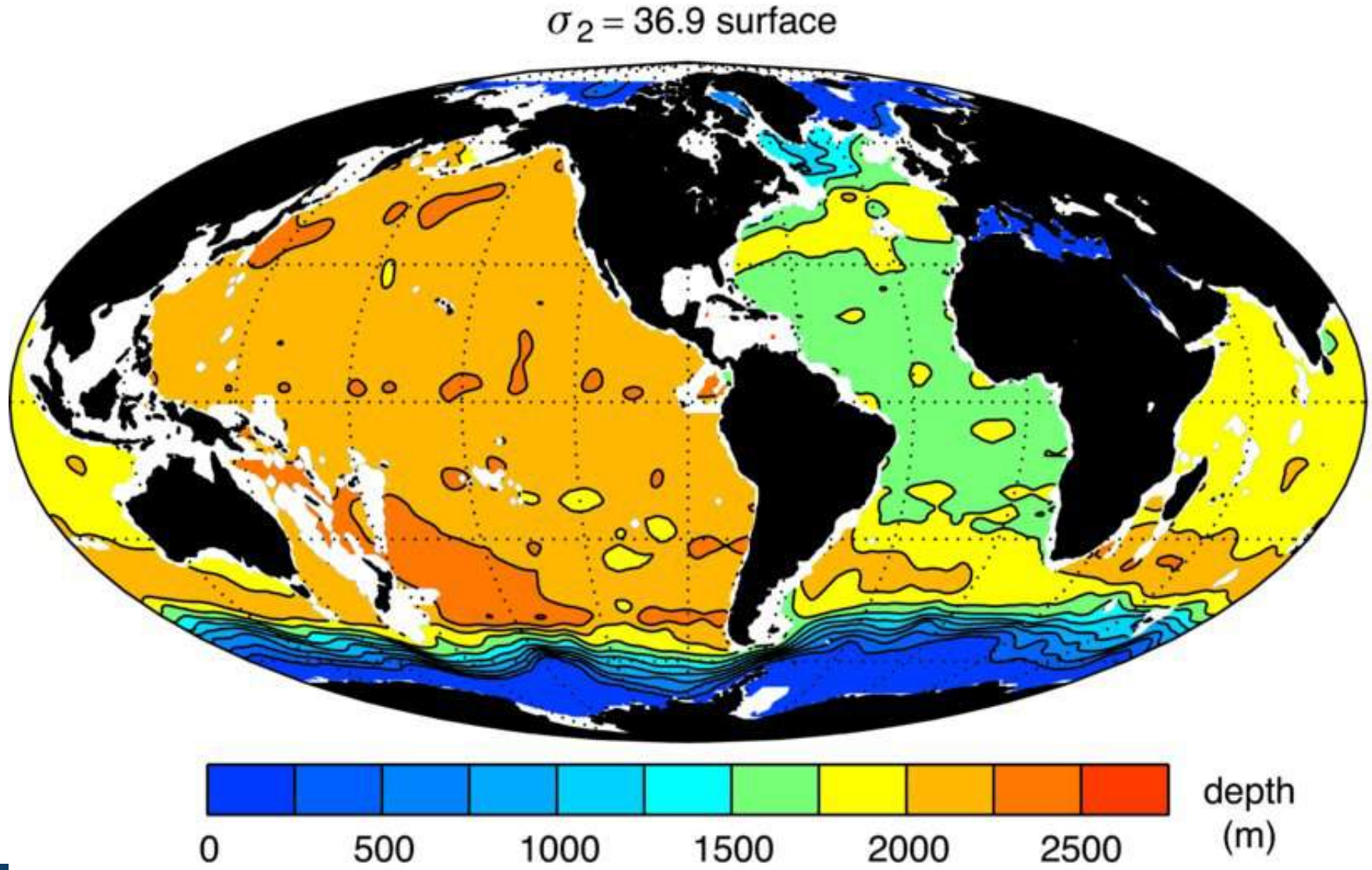


McKinley et al. 2018 Biogeosciences

ASTE-BGC Motivation

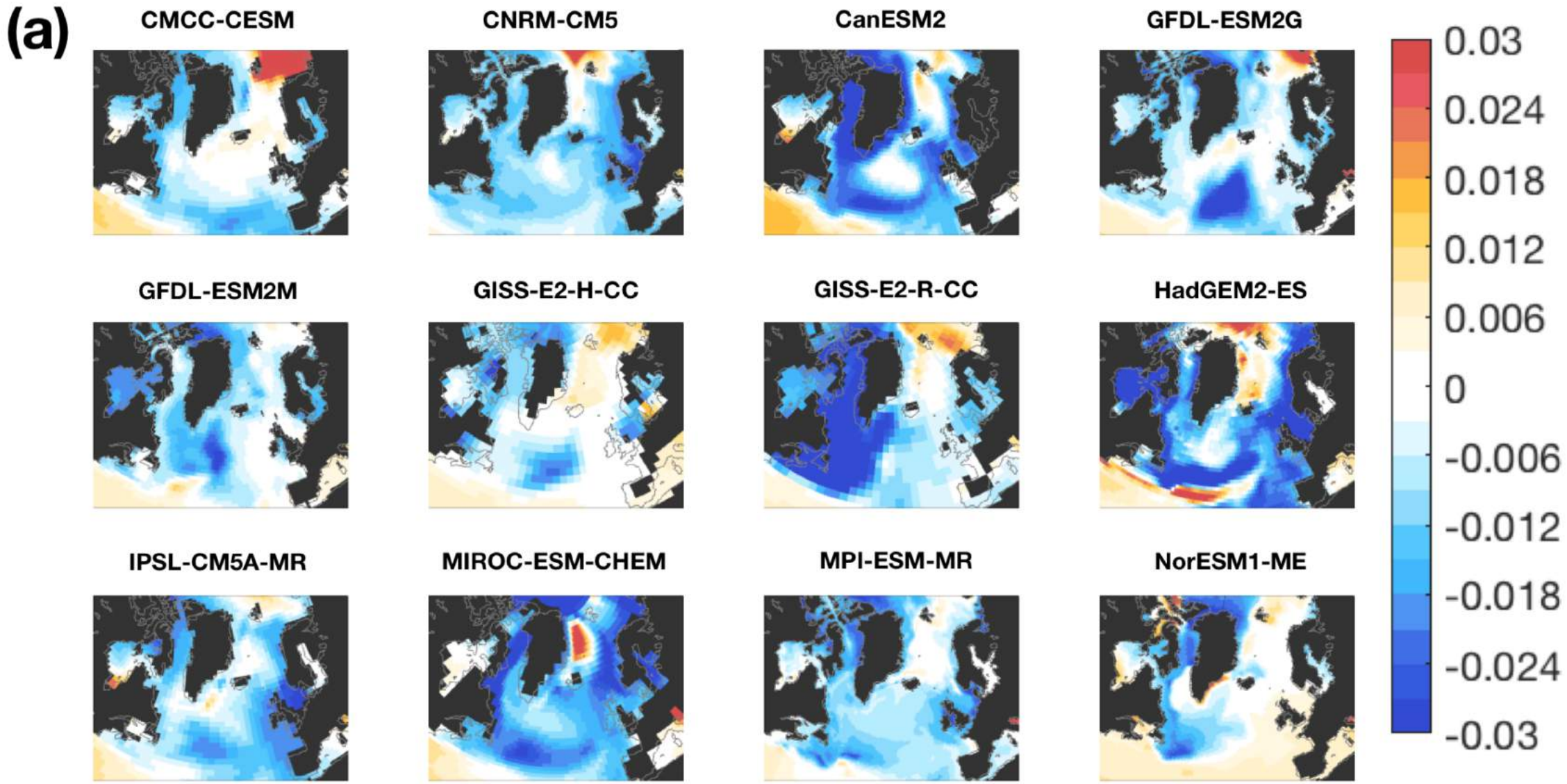
- Assess mechanisms of carbon and biogeochemical variability in the North Atlantic
- Understand impacts of Arctic change
- ….

Depth of σ_2=36.9



Williams and Follows 2011

Salinity trend (PSU yr $^{-1}$) 2006-2100



Air-sea CO_2 flux trends (mol C yr^{-1} yr^{-1}) 2006-2100

(b)