Oceanic sources and sinks for atmospheric CO_2

The Ocean Inversion Contribution

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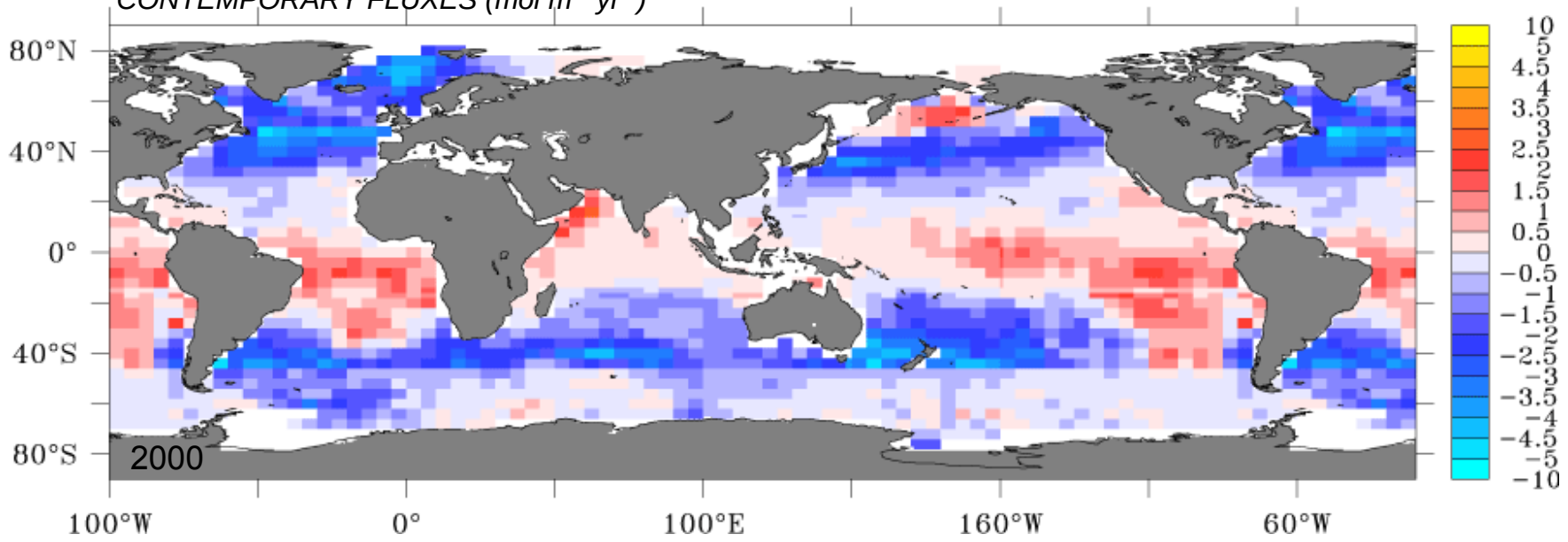
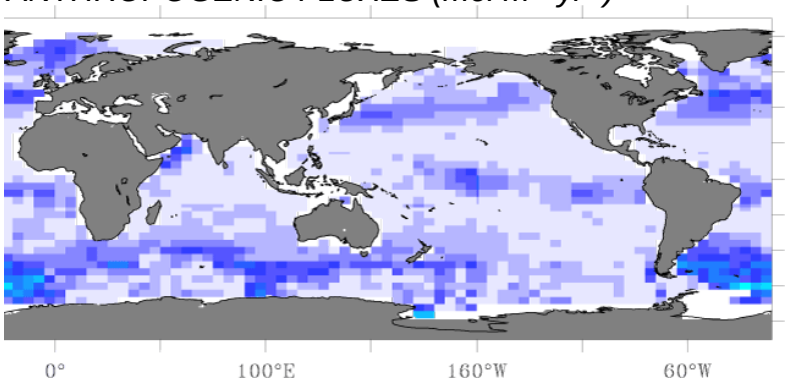
Air-sea CO_2 fluxes from the ocean inversion (2000)

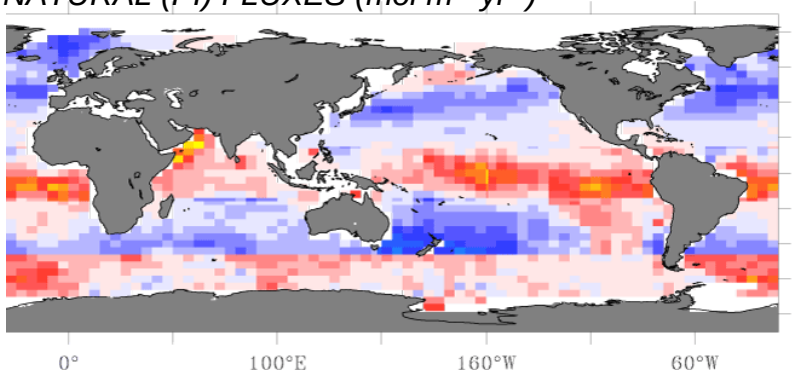
CONTEMPORARY FLUXES (mol m^{-2} yr^{-1})



ANTHROPOGENIC FLUXES (mol m^{-2} yr^{-1})

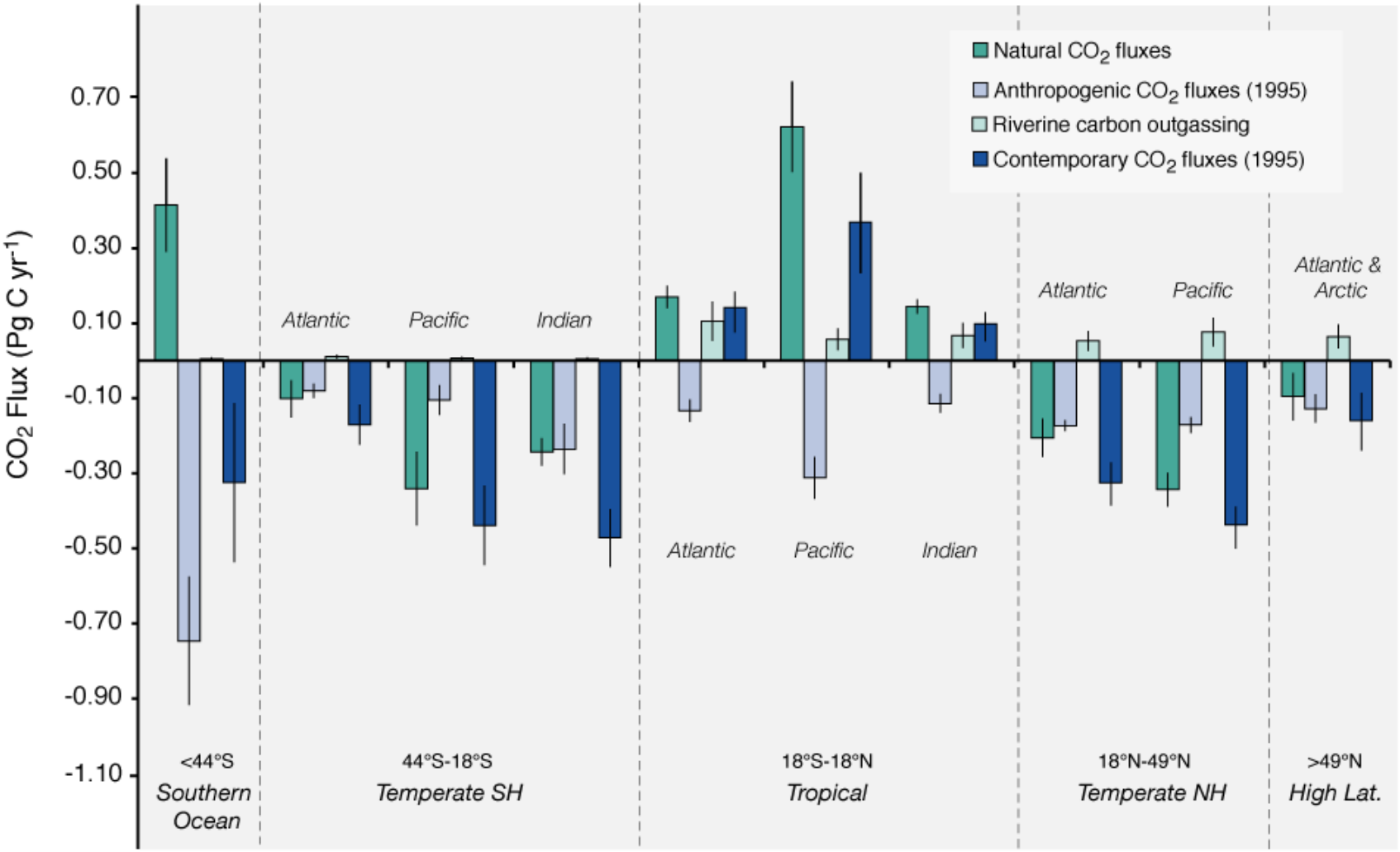


NATURAL (PI) FLUXES (mol m^{-2} yr^{-1})



Gruber et al. (2009)

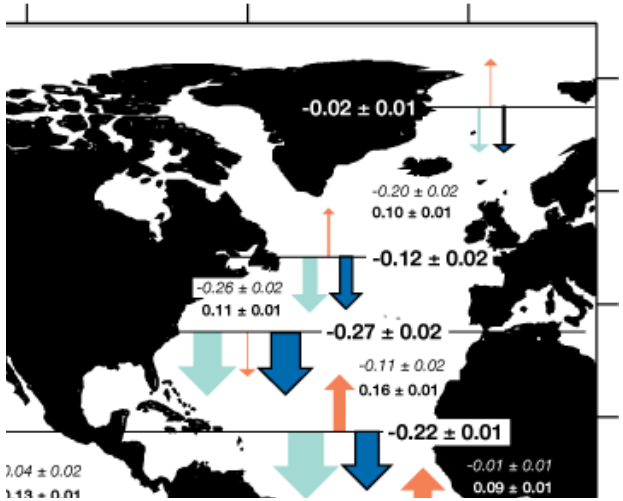
Air-sea CO_2 fluxes from the ocean inversion



Global uptake of anthropogenic CO_2: 2.2 Pg C yr^{-1}

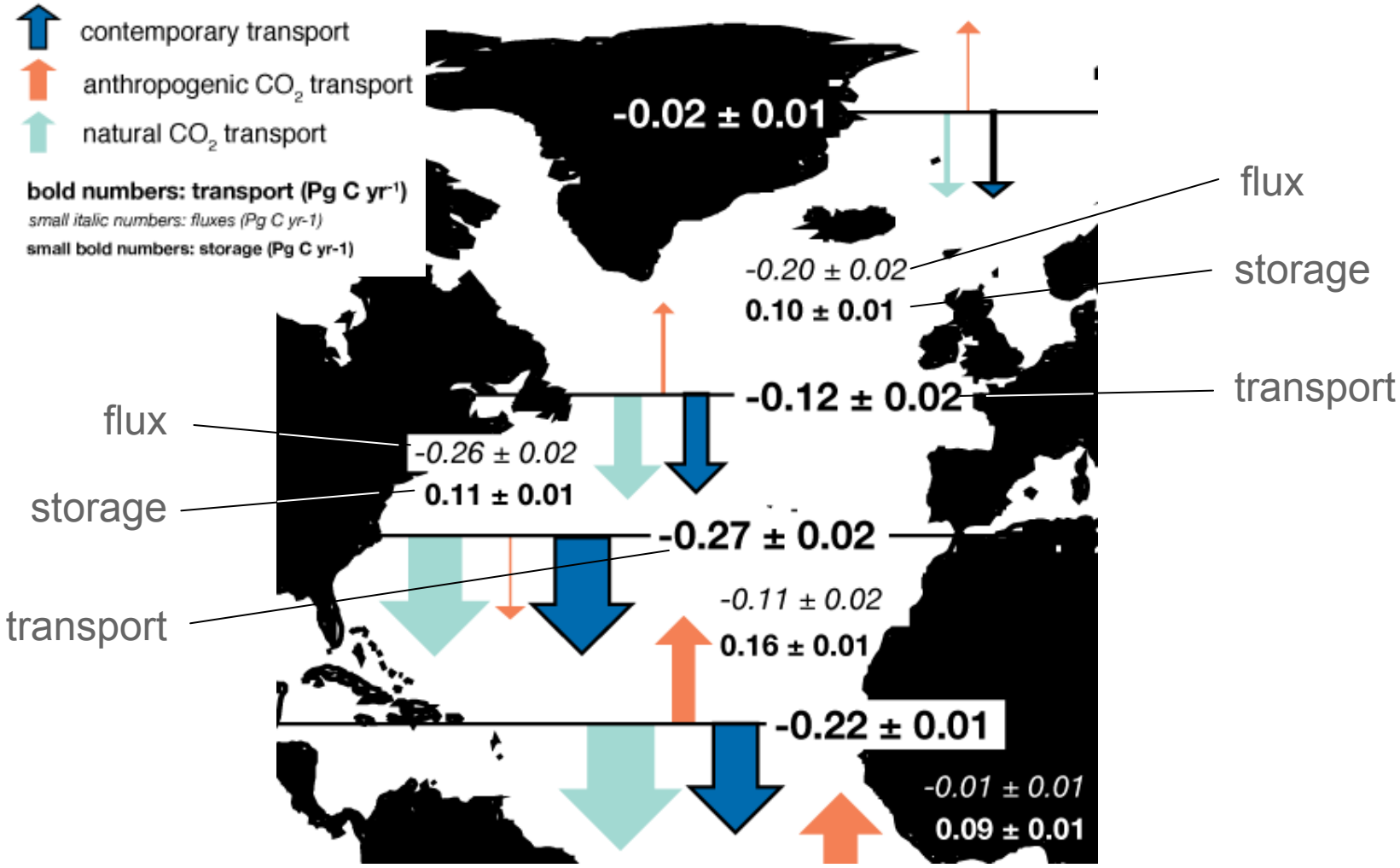
Gruber et al. (2009)

The importance of lateral transport



Gruber et al. (2009)

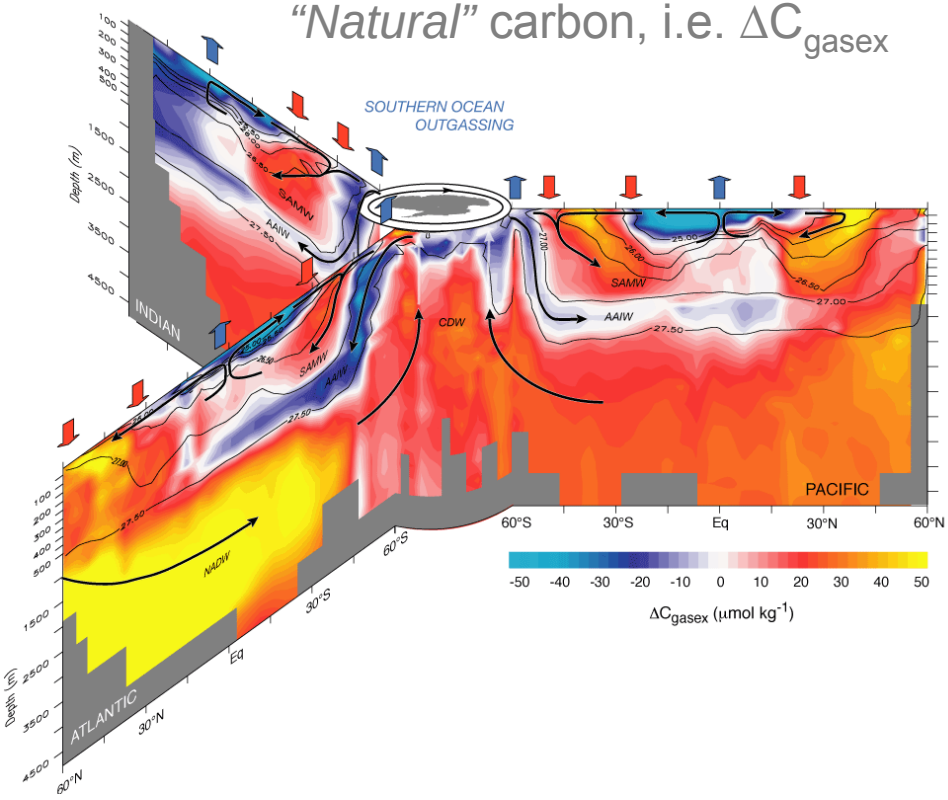
The importance of lateral transport



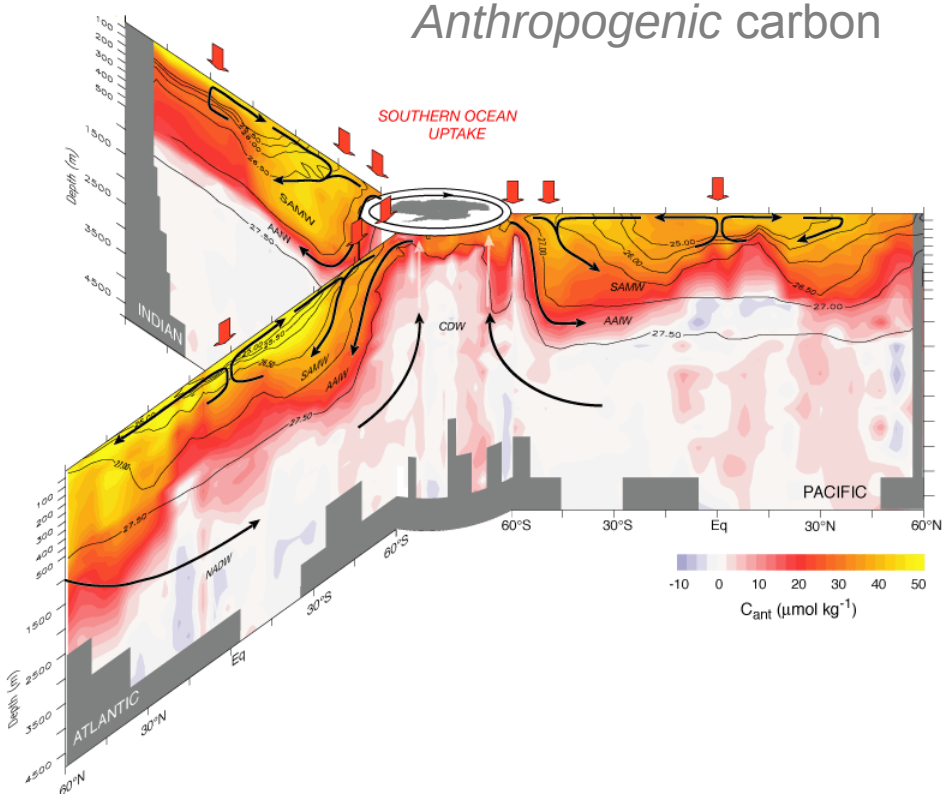
Gruber et al. (2009)

How were these air-sea fluxes estimated?

"Natural" carbon, i.e. ΔC_{gasex}



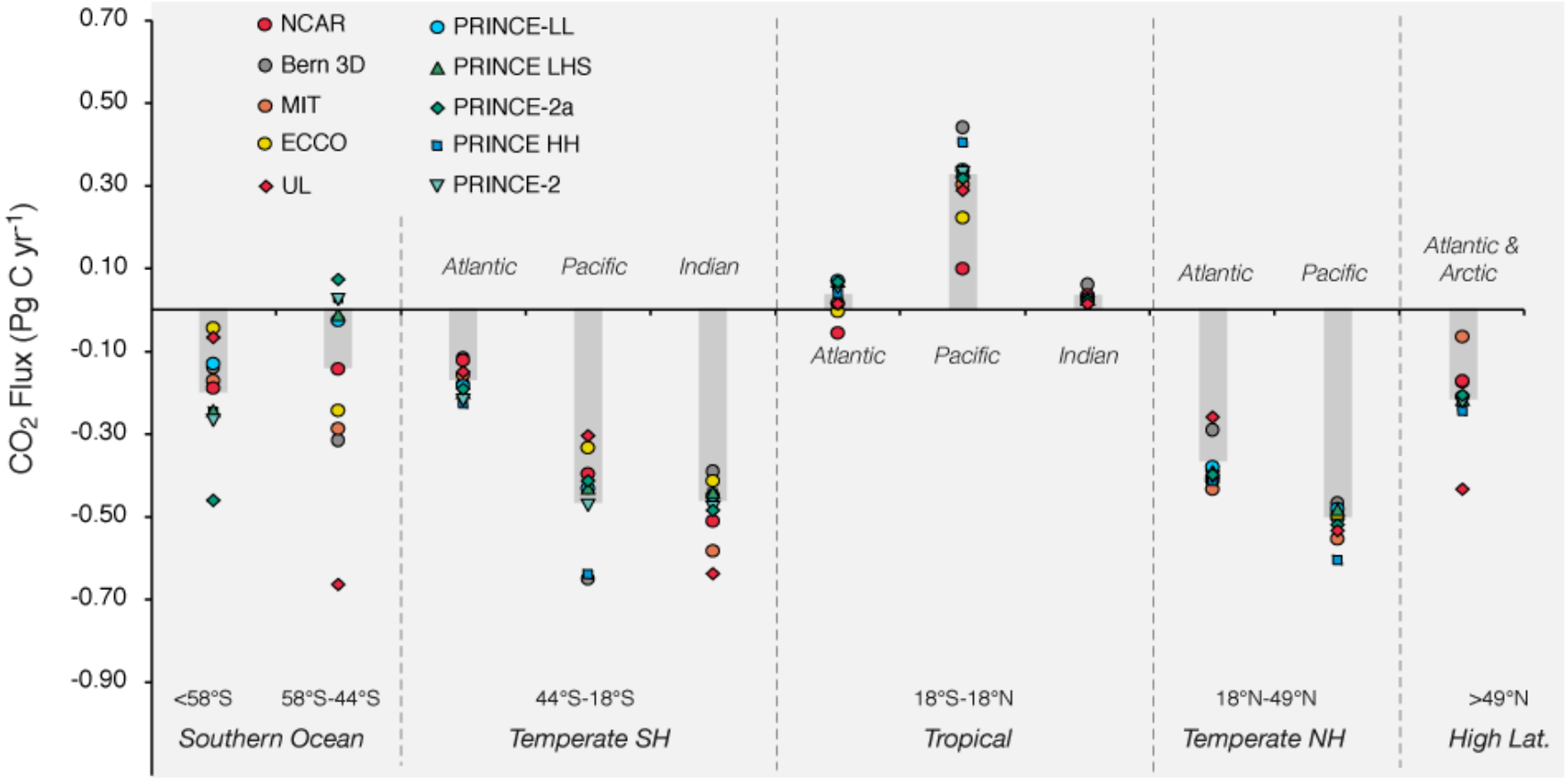
Anthropogenic carbon



Using classical Green's function inverse methods, one can infer the surface sources and sinks of anthropogenic and natural CO_2 from their ocean interior distribution.

Gruber et al. (2009)

Uncertainty estimate provided by range of model results



Estimates come with formal uncertainty estimates, mostly stemming from the spread of ocean models

Gruber et al. (2009)

Air-sea fluxes (and transports) from ocean inversion

STRENGTHS	*LIMITS*
Independent data-based estimate (independent of pCO_2 data and gas-exchange coefficient)	Only annual mean fluxes (no monthly estimates)
Formal uncertainty estimates (including co-variances and estimates for individual models)	Error stems from a combination of data and ocean transport uncertainties
Attribution to natural and anthropogenic fluxes (for 1995, 2000, 2005)	
Permits to estimate fluxes, storage, and lateral transport (for natural, anthropogenic, and contemporary carbon)	

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Access to the data

PATH

http://lgmacweb.env.uea.ac.uk/lequere/recc go to ETH folder

CONTENT

readme_eth.txt

fluxes_covariances_OIP_1995-2000-2005.mat

gridded_results_OIP_1995-2000-2005.nc

PIFLX	preindustrial CO2 flux (OIP)	1:360	1:180	1:10	...
ANTFLX	anthropogenic CO2 flux (OIP)	1:360	1:180	1:10	1:3
CONFLX	contemporary CO2 flux (OIP)	1:360	1:180	1:10	1:3
PIFLXM	model mean PI flux (OIP)	1:360	1:180	...	...
ANTFLXM	model mean ANT flux (OIP)	1:360	1:180	1:3	...
CONFLXM	model mean CON flux (OIP)	1:360	1:180	1:3	...
PIFLXWM	weighted model mean PI flux (OI	1:360	1:180	...	...
ANTFLXWM	weighted model mean ANT flux (O	1:360	1:180	1:3	...
CONFLXWM	weighted model mean CON flux (O	1:360	1:180	1:3	...
PIFLXM_UNMAPPED	model mean PI flux,unmapped	1:360	1:180	...	...
ANTFLXM_UNMAPPED	model mean ANT flux,unmapped	1:360	1:180	1:3	...
CONFLXM_UNMAPPED	model mean CON flux,unmapped	1:360	1:180	1:3	...
PIFLXWM_UNMAPPED	weighted model mean PI flux,unm	1:360	1:180	...	...
ANTFLXWM_UNMAPPED	weighted model mean ANT flux,un	1:360	1:180	1:3	...
CONFLXWM_UNMAPPED	weighted model mean CON flux,un	1:360	1:180	1:3	...

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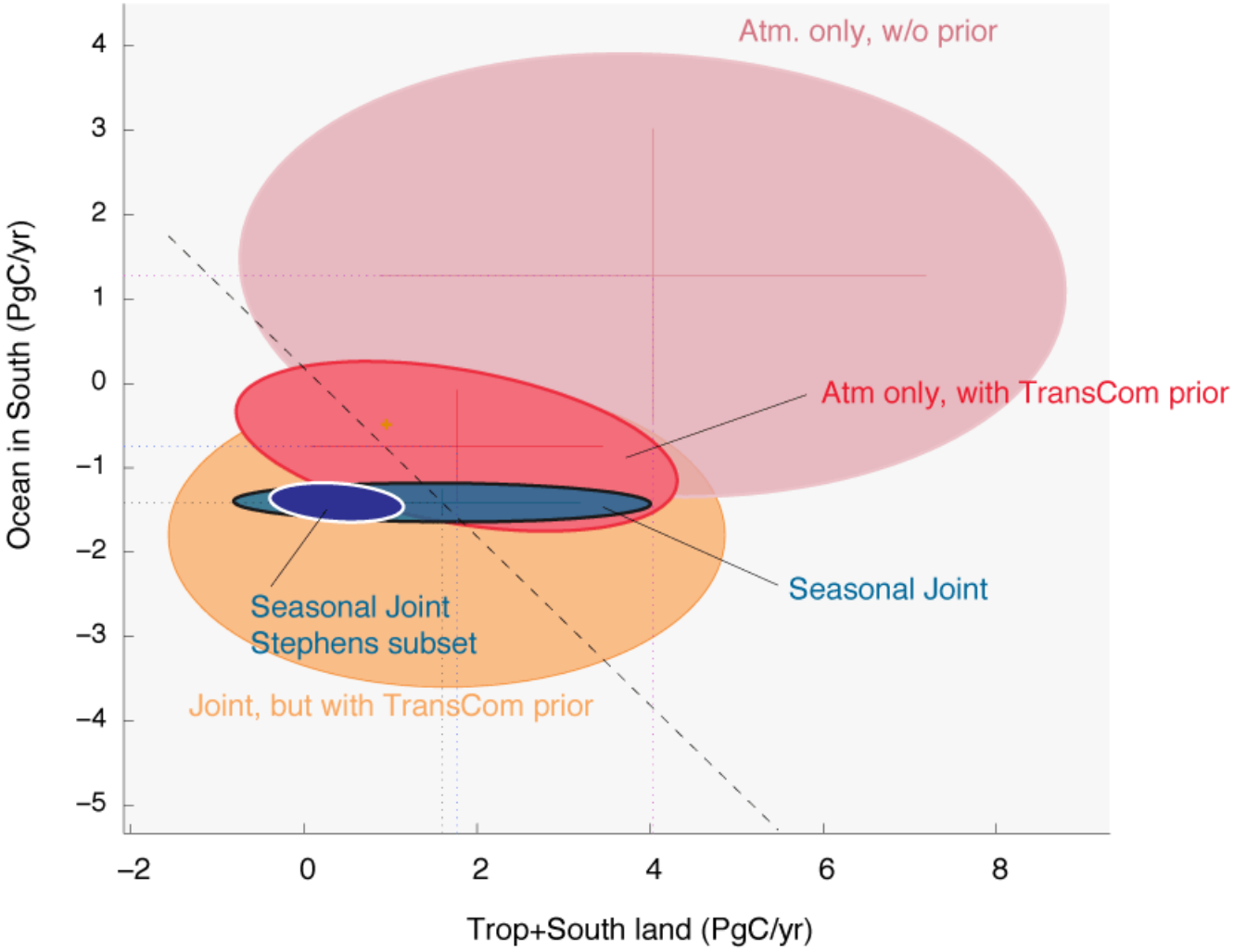
ADD-ON: Joint-atmosphere-ocean inversion

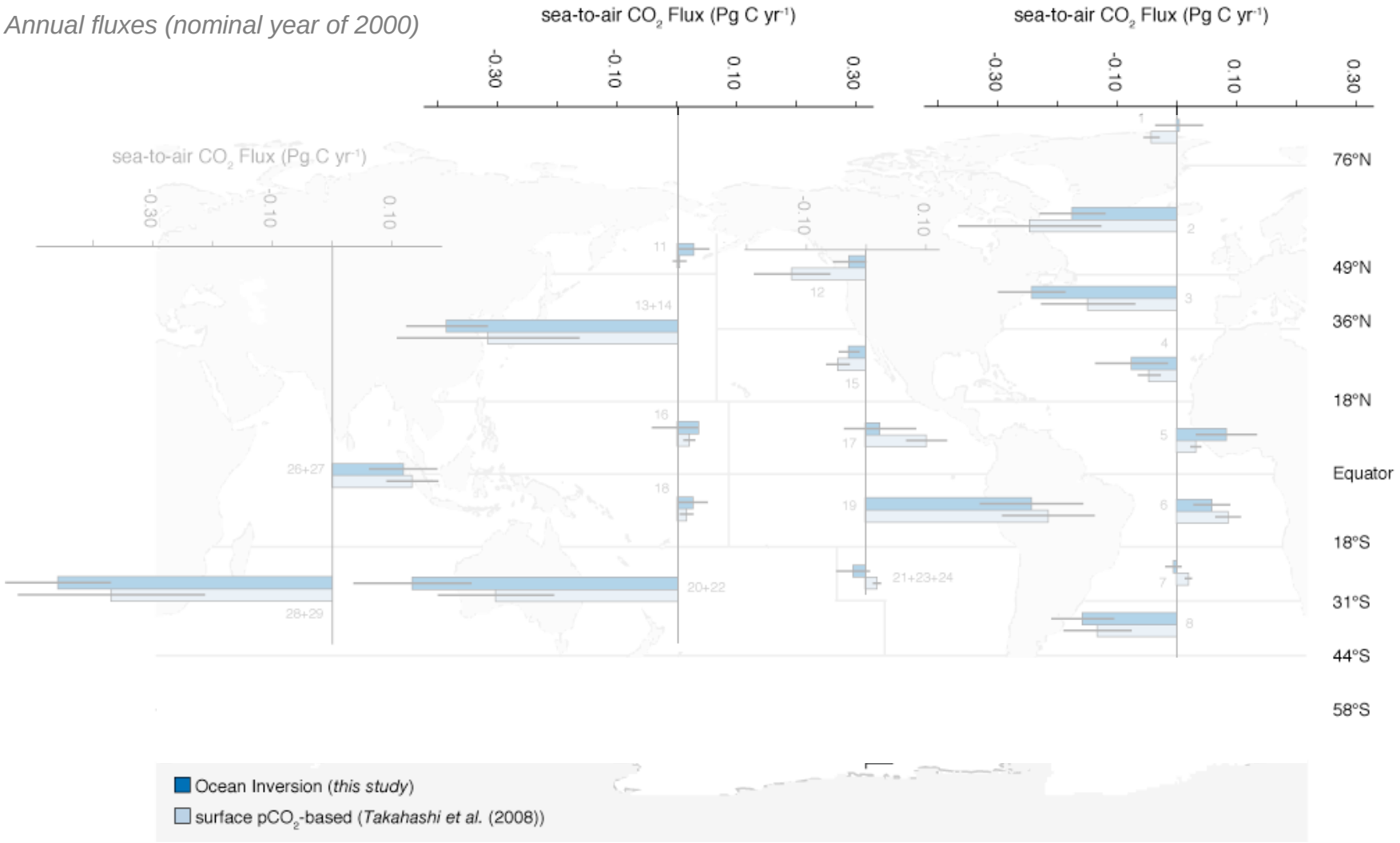


Substantial shift in mean flux for tropical and southern land regions


The End.

Convergence of air-sea CO_2 flux estimates

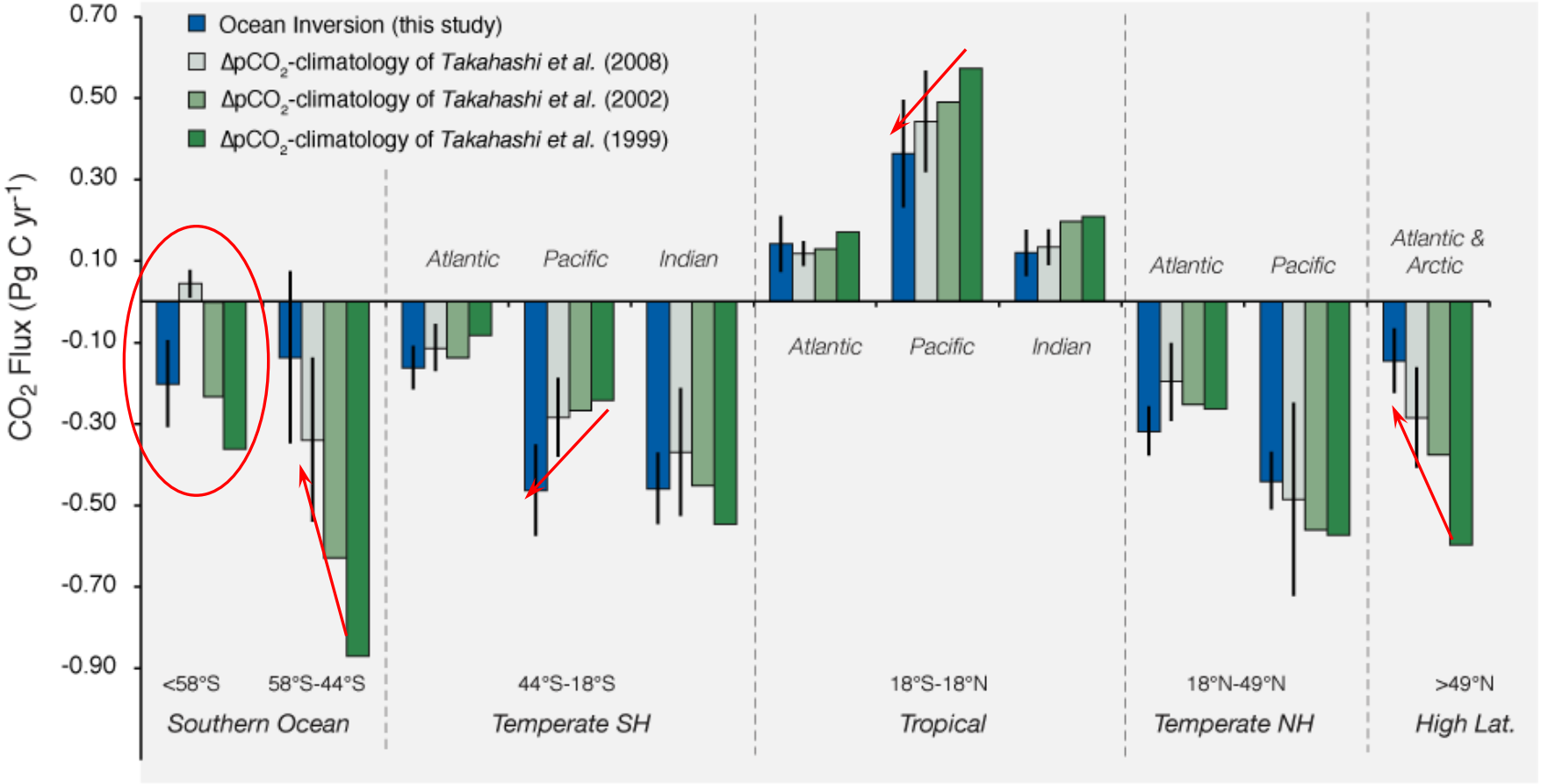
Annual fluxes (nominal year of 2000)



A remarkable agreement is found, with the exception of the regions south of 44°S.

Gruber et al. (2009)

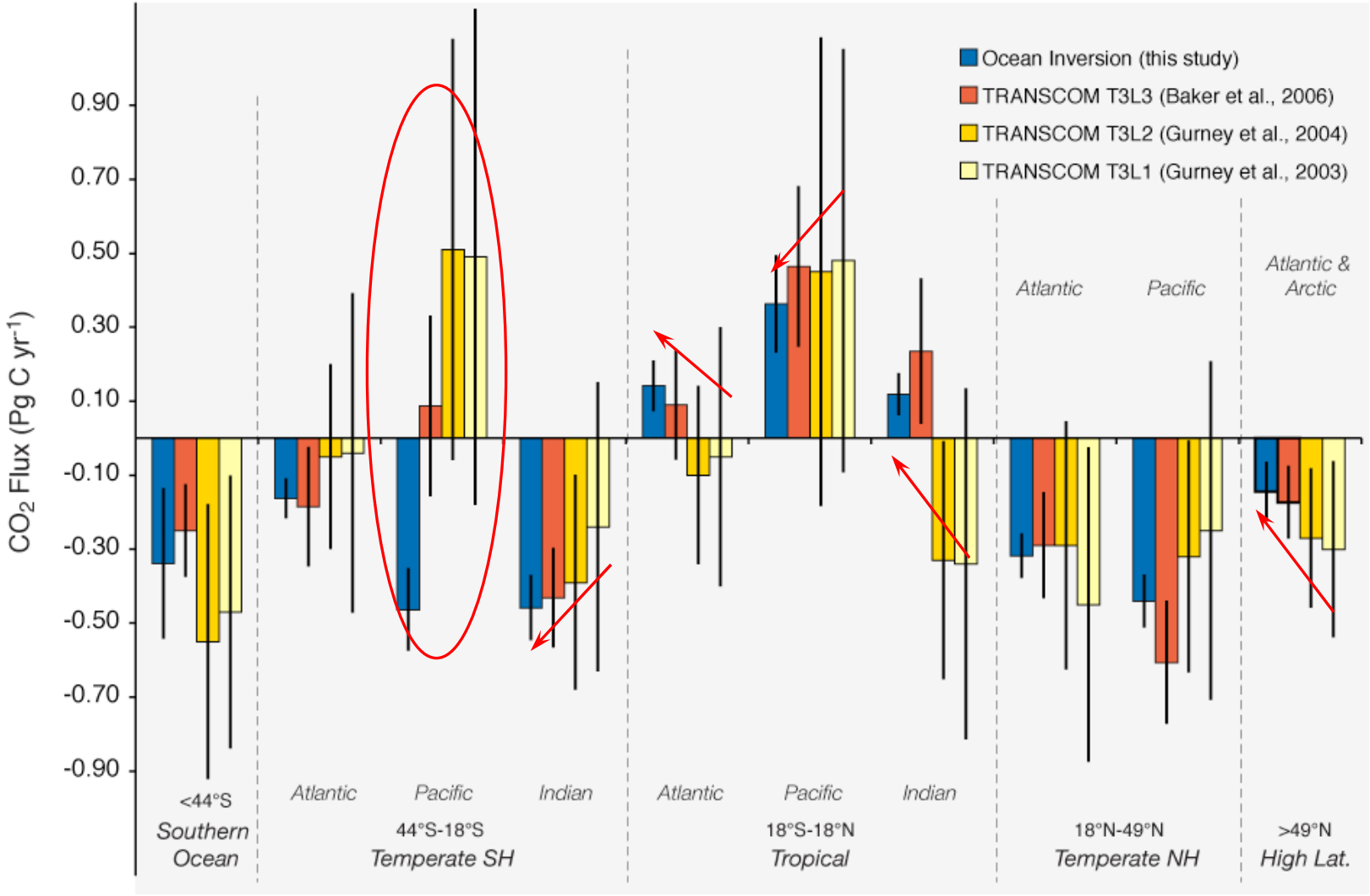
Comparison of ocean inverse estimates with Takahashi climatologies



With the exception of the Southern Ocean, each subsequent edition of the Takahashi et al. climatology became more consistent with the results of the ocean inversion.

Gruber et al. (2009)

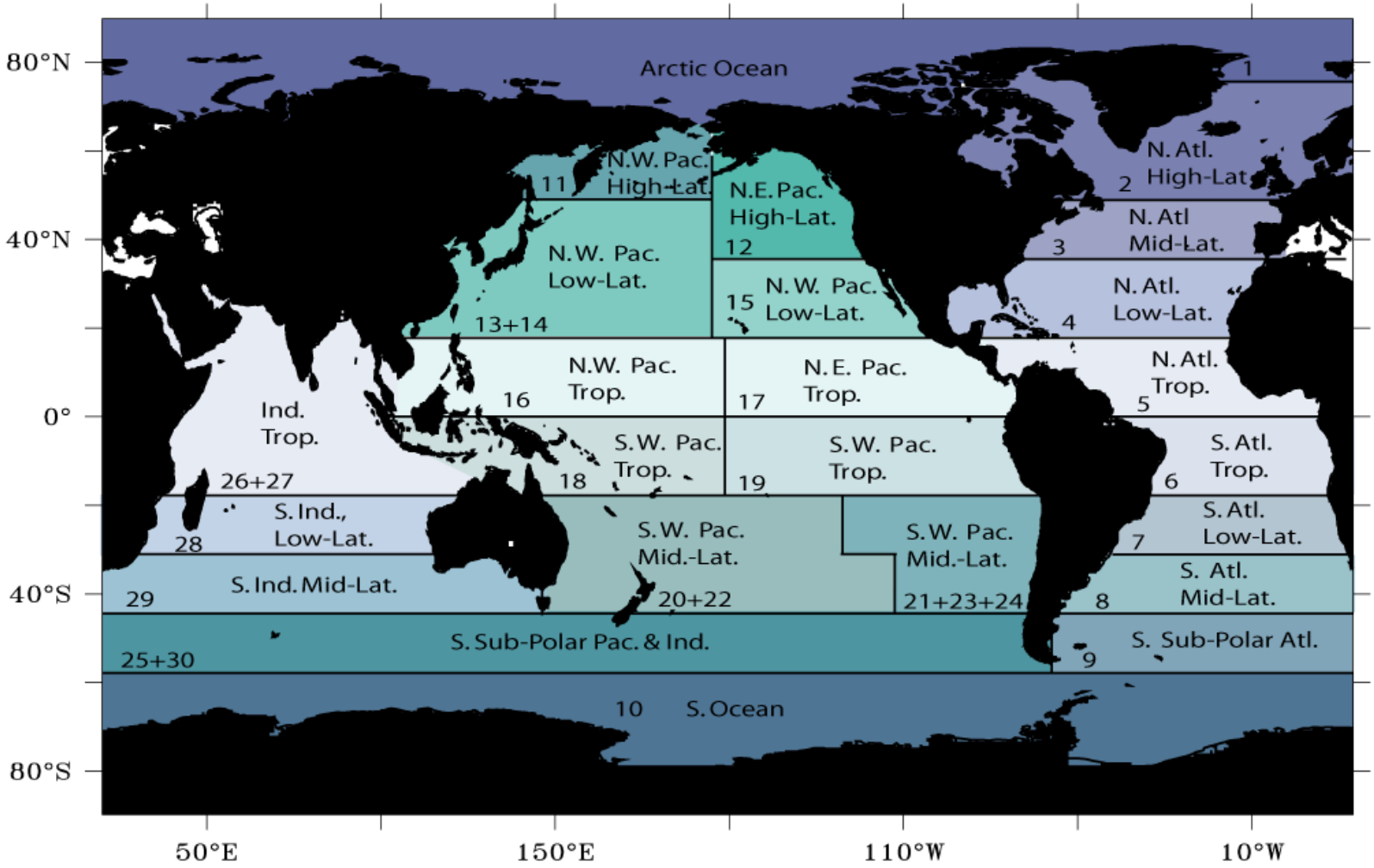
Comparison of ocean inverse estimates with TransCOM



Moving from L1 to L3, TransCOMs estimates became more consistent with those from the ocean inversion

Gruber et al. (2009)

Ocean Inversion Method



The ocean is divided into 30 regions

Mikaloff Fletcher et al. (2006, 2007)

Inversion of ocean interior observations using a Green's function approach

footprints *fluxes* *obs*

$$A\phi = c$$

Premultiply both sides by inverse of A

$$\hat{\phi} = A^{-1}c$$

estimated fluxes

- *Basis functions* are model simulated footprints of unit emissions from a number of fixed regions
- Estimate *linear combination* of basis functions that fits observations in a least squares sense.

→ Inversion is analogous to *linear regression*