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für Meteorologie



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Observing variability in ocean CO₂ fluxes (based on surface ocean CO₂ observations)

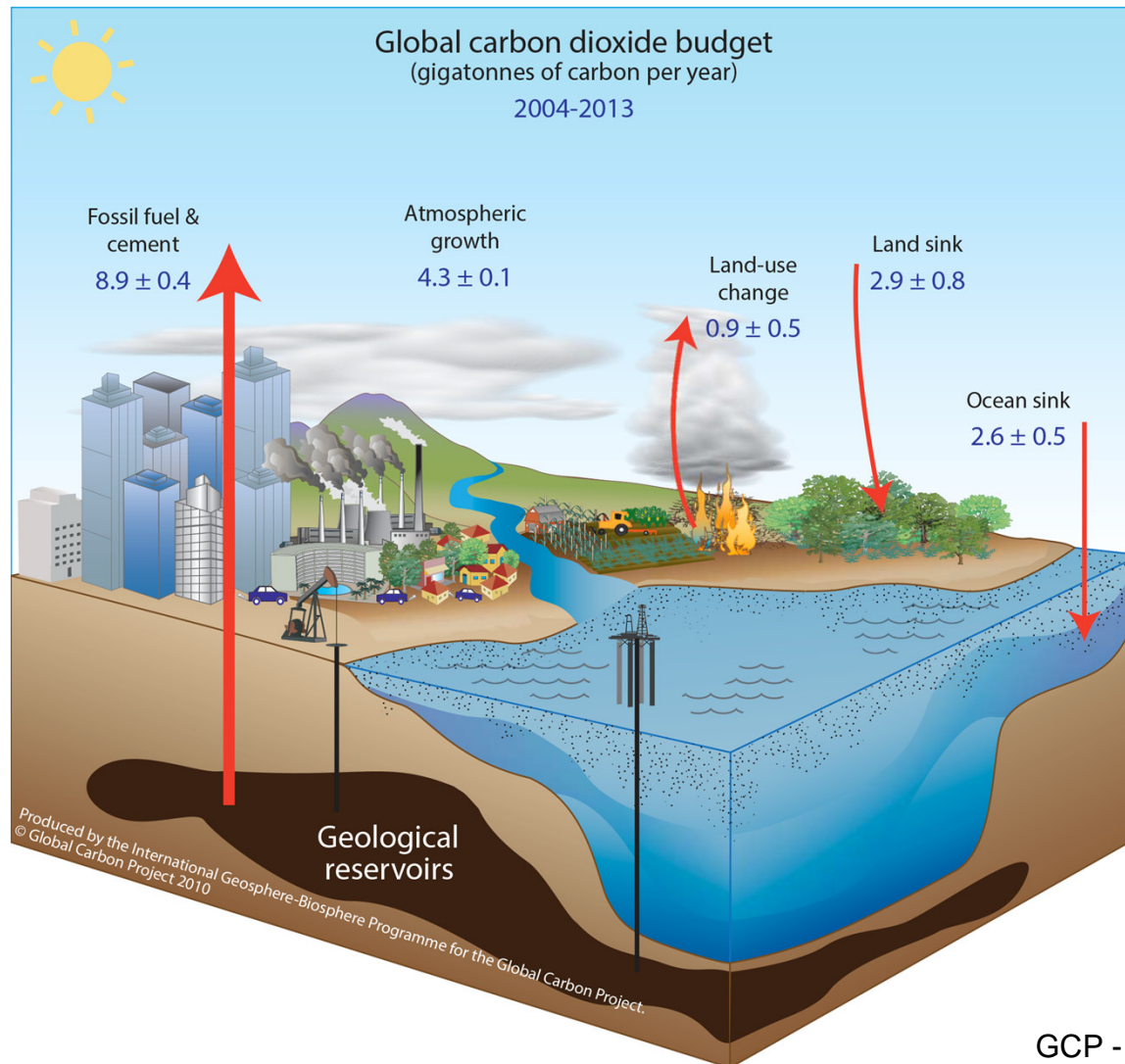
Peter Landschützer

Max Planck Institute for Meteorology
Hamburg, Germany

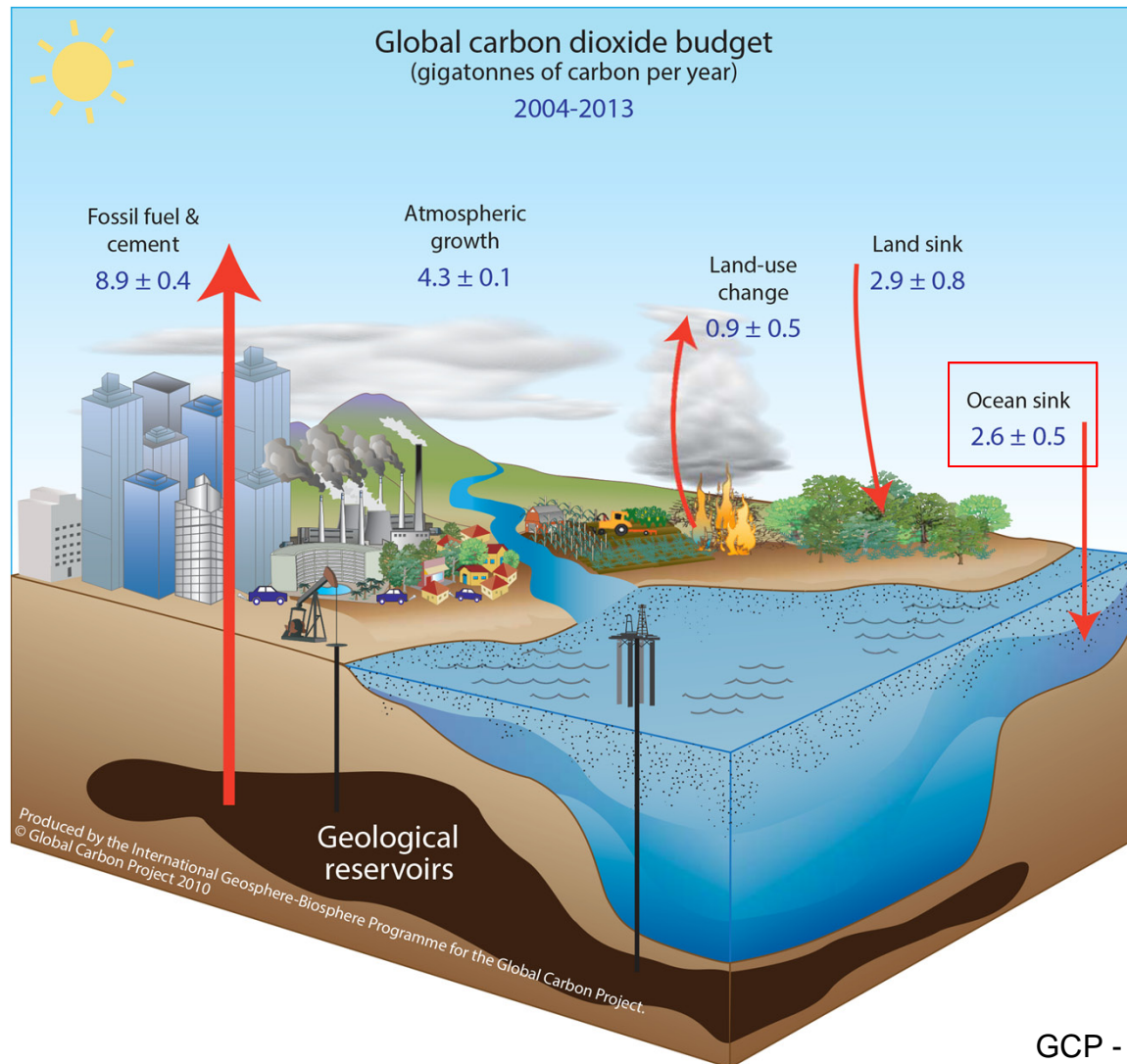
Special thanks to Niki Gruber and Dorothee C.E. Bakker
and many more



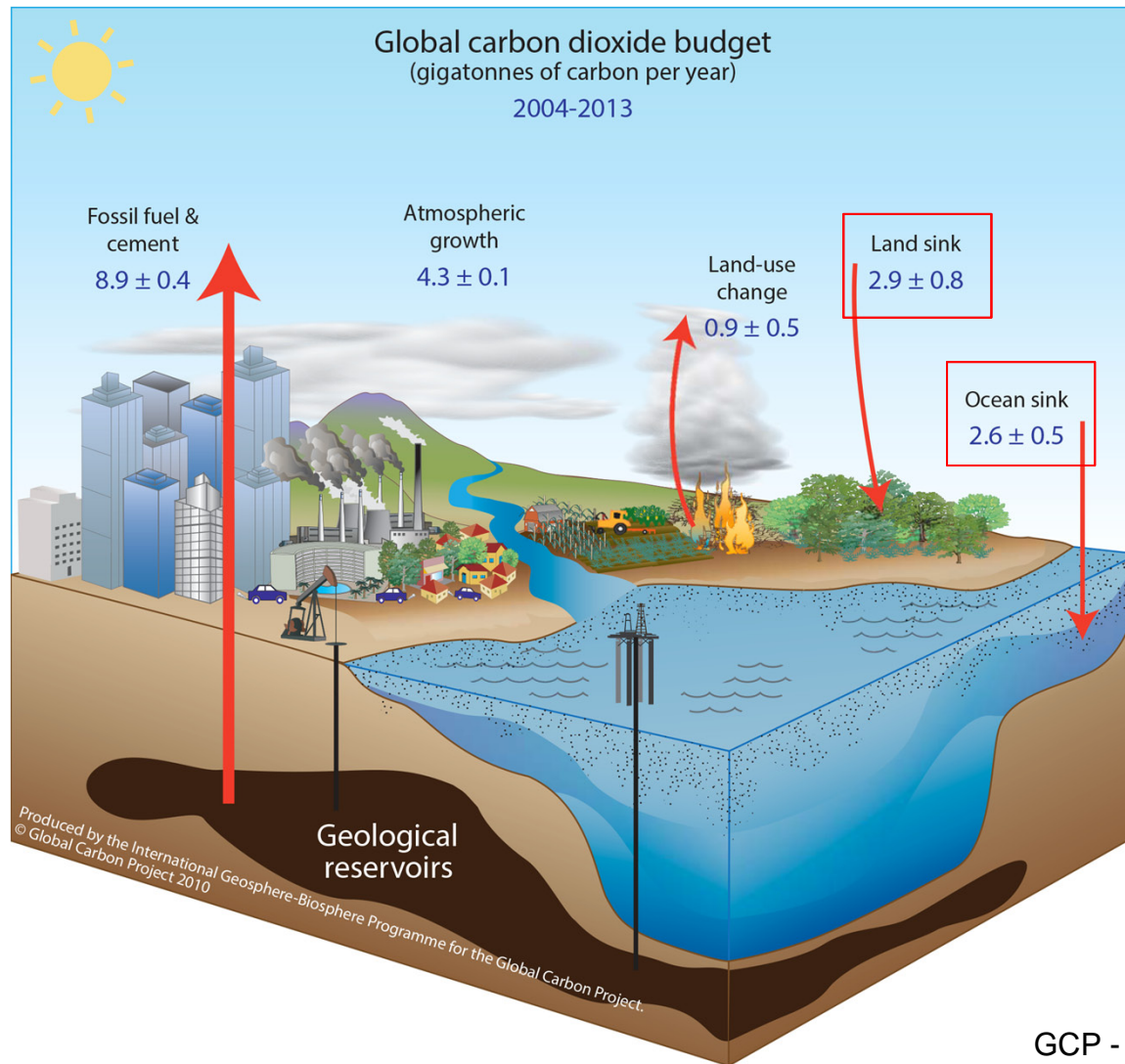
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GCP - Le Quéré et al 2015, ESSD

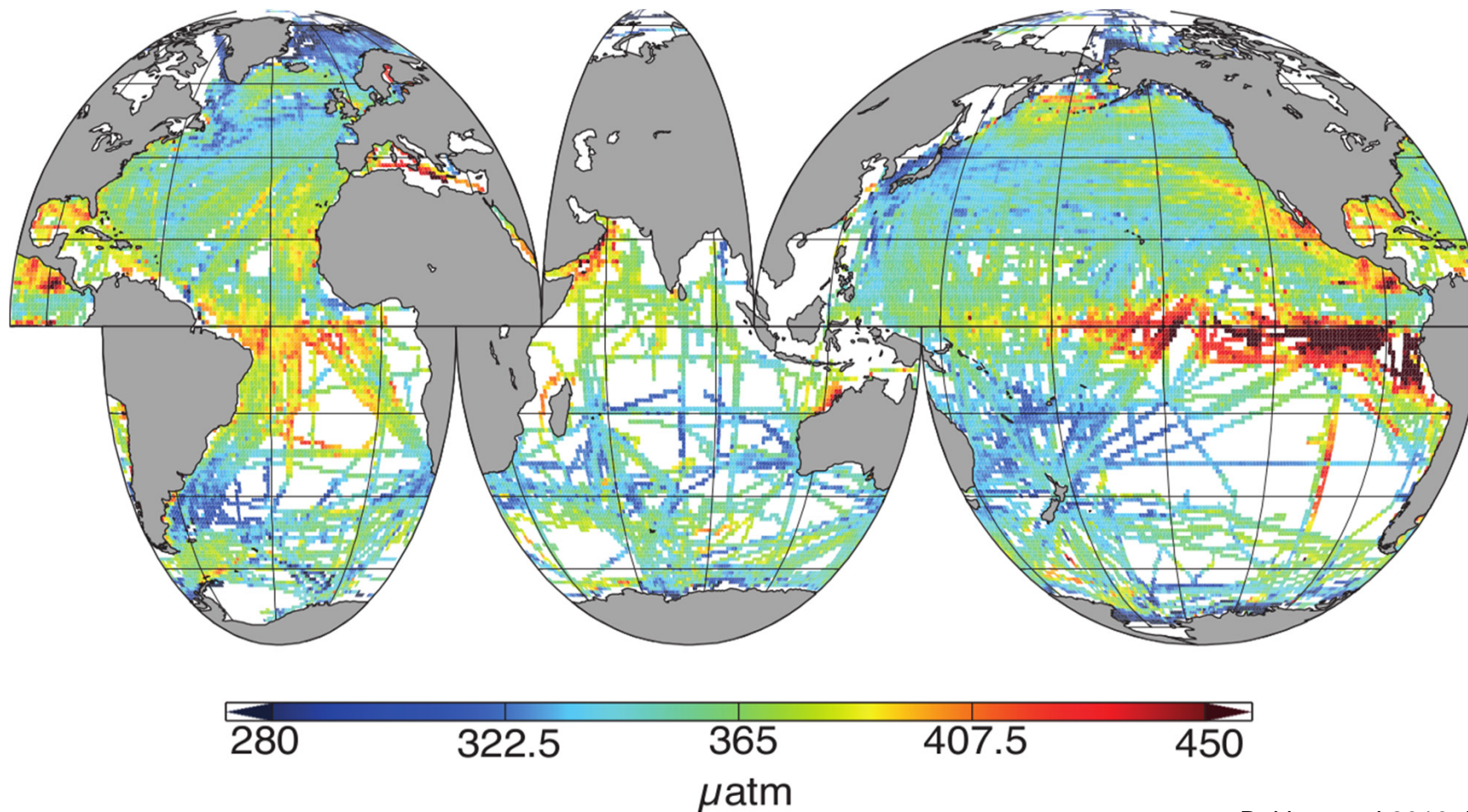


GCP - Le Quéré et al 2015, ESSD



GCP - Le Quéré et al 2015, ESSD

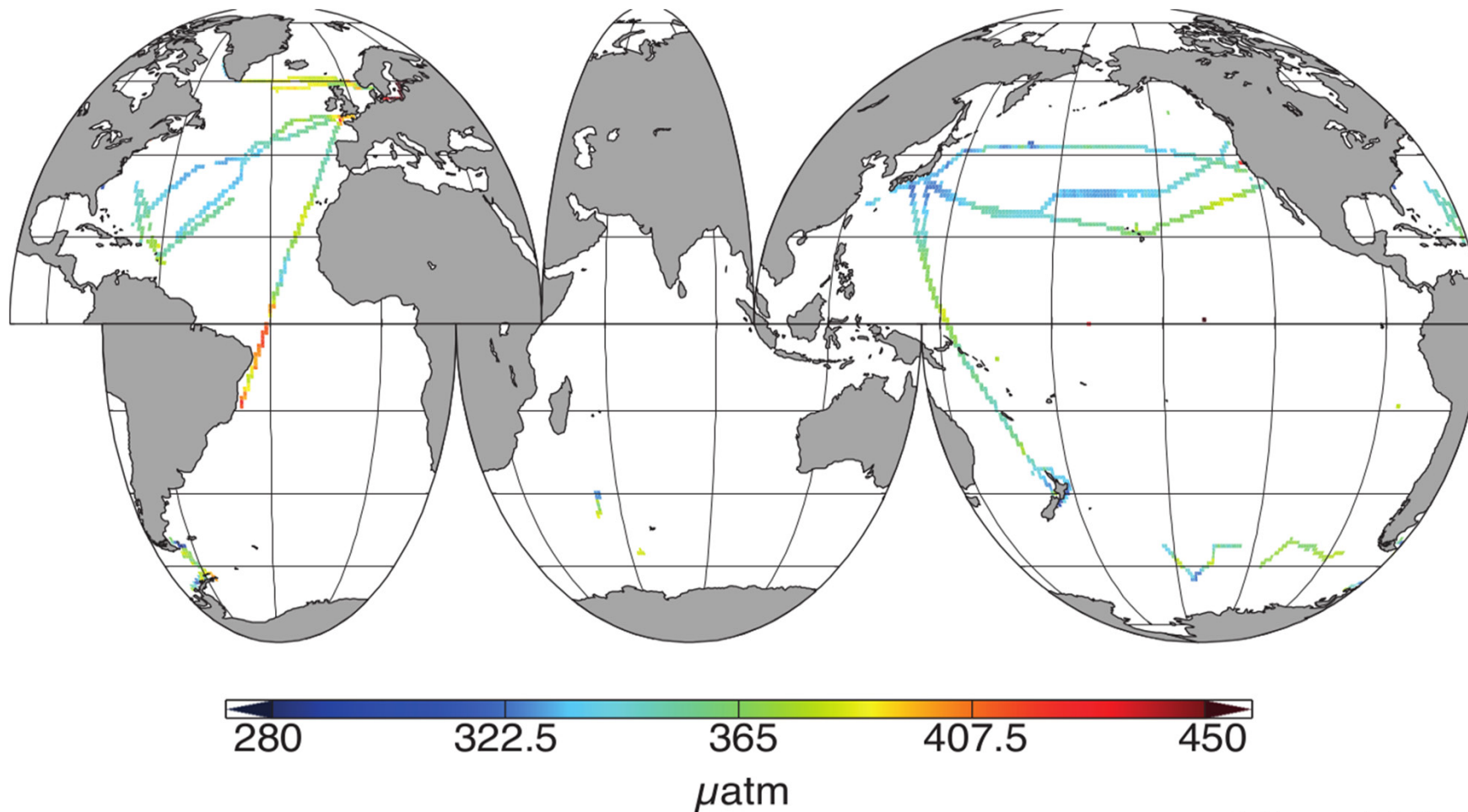
The SOCAT database (1982-2014)



Bakker et al 2016, ESSDD

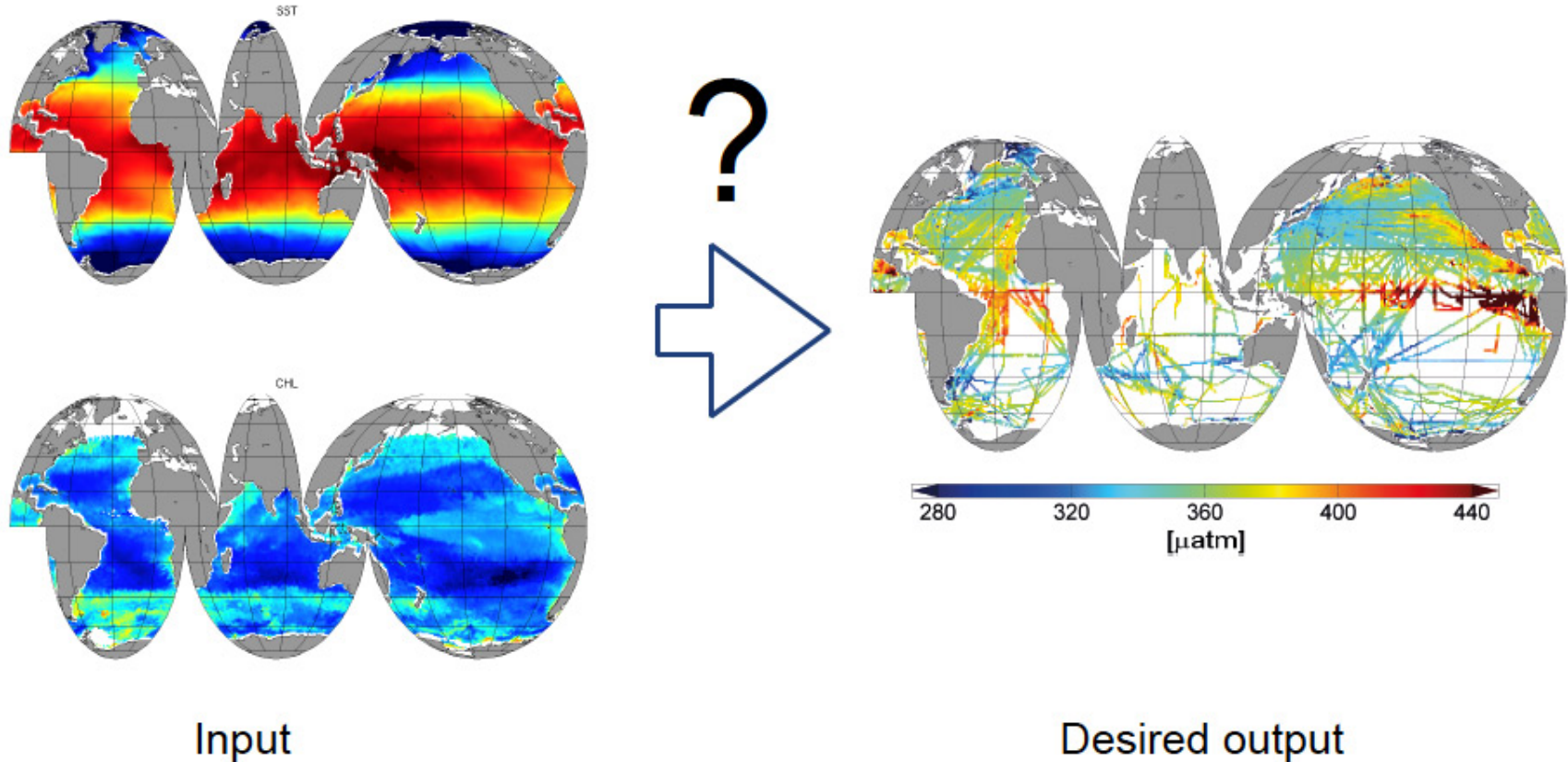
The SOCAT database

(Jan 2010)



Bakker et al 2016, ESSDD

pCO₂ in seawater



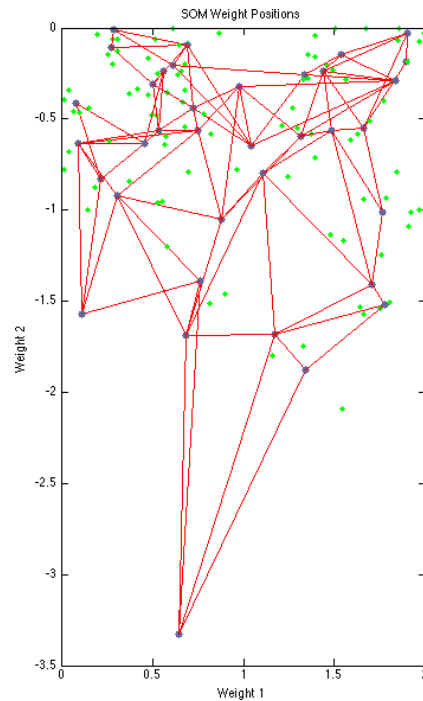
$p\text{CO}_2 = f(\text{SST}, \text{SSS}, \text{CHL-a}, \text{MLD}, \text{ACO}_2, \dots)$; but what form?

Neural network step I: Self organizing map

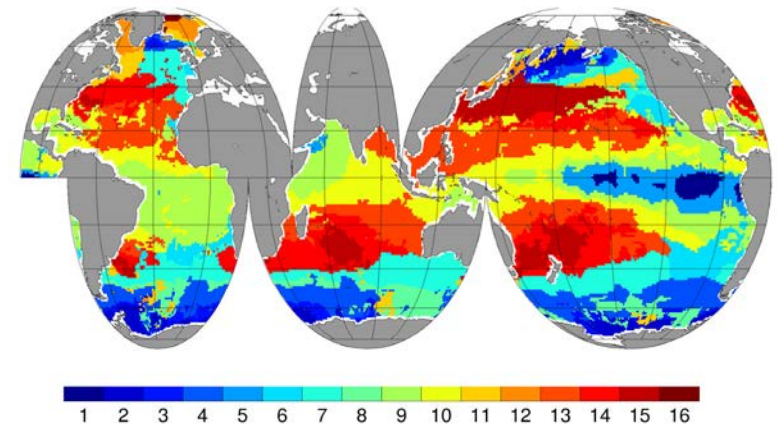
Input

pCO_{2,clim}
SST
SSS
MLD

Network



Output



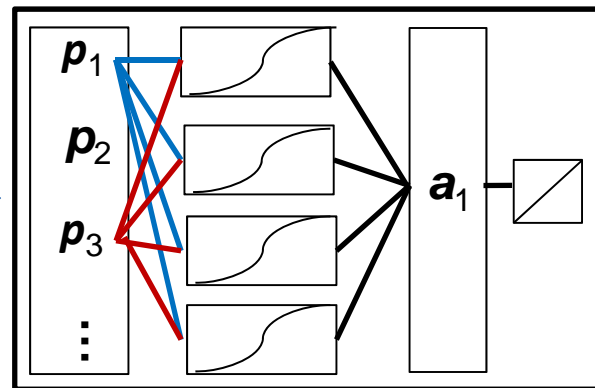
Landschützer et al 2013, BG; 2014, GBC

Neural network step II: Feed-forward network

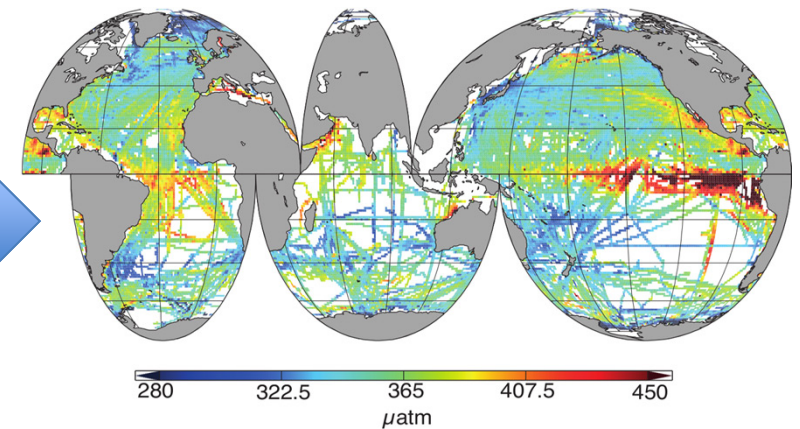
Input

SST
SSS
MLD
CHL
ACO₂

Network

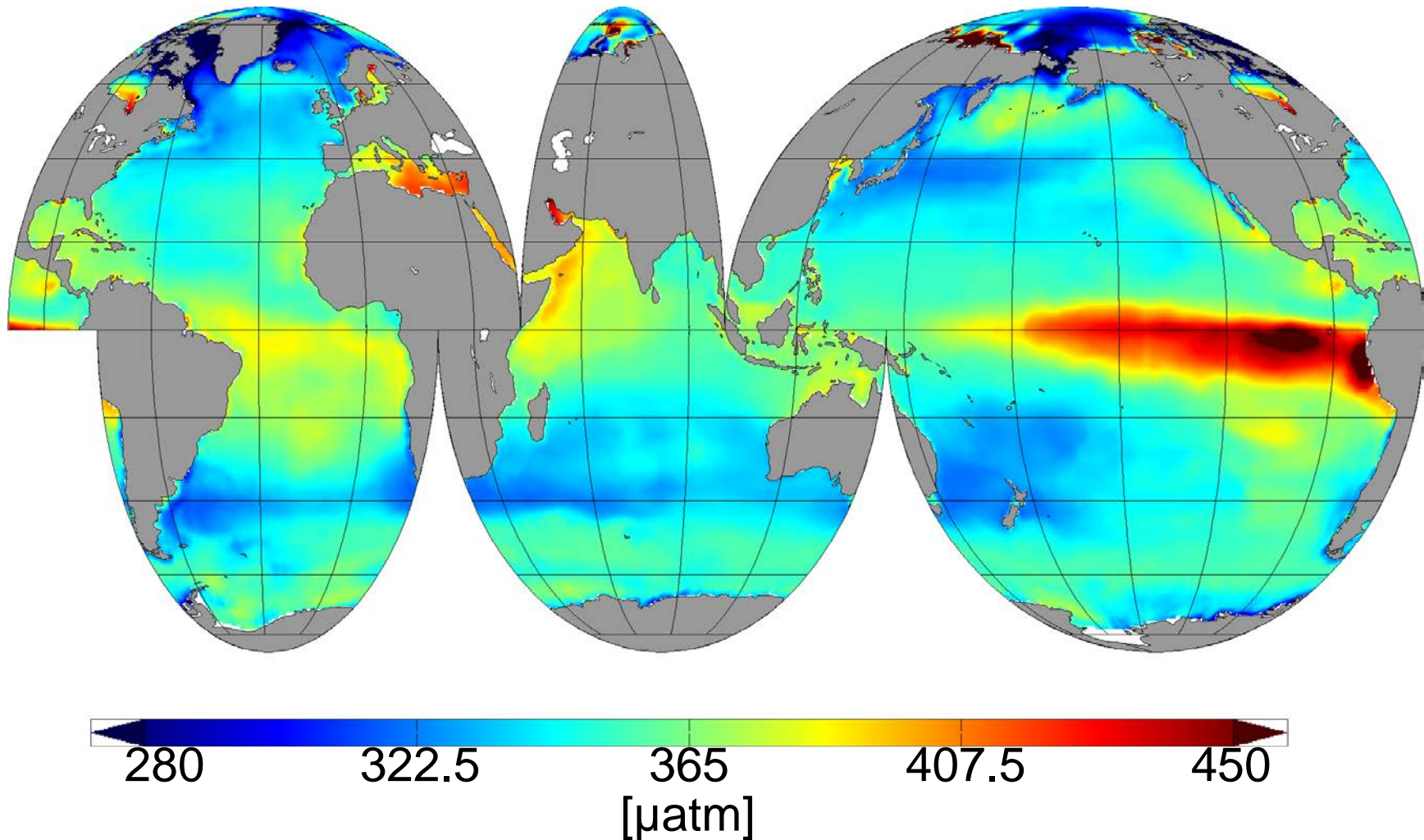


Output

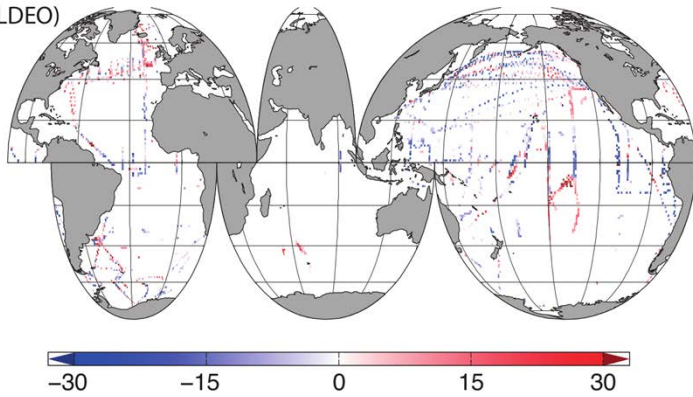


Landschützer et al 2013, BG; 2014, GBC

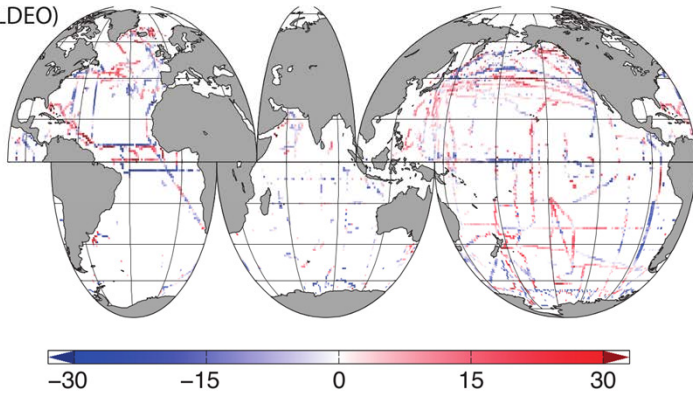
Interpolated pCO₂ (1982-2014)



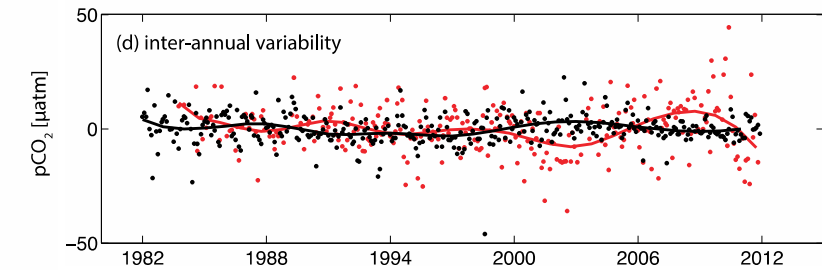
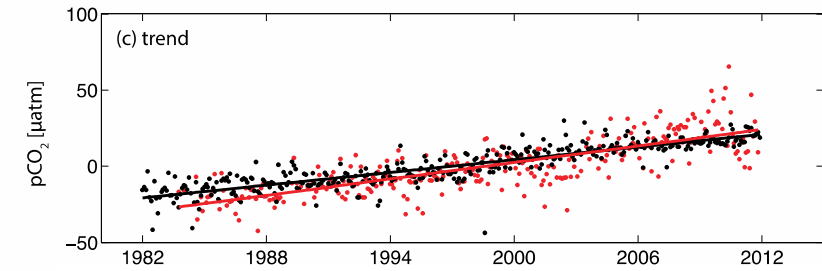
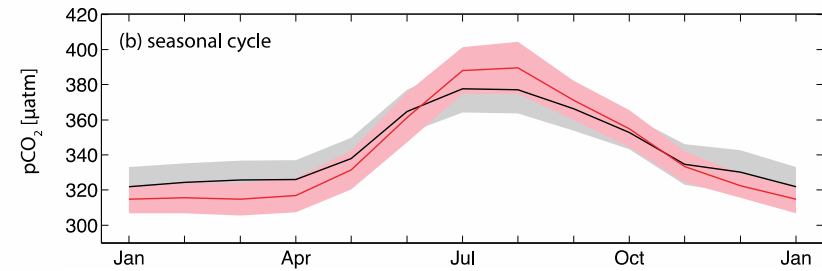
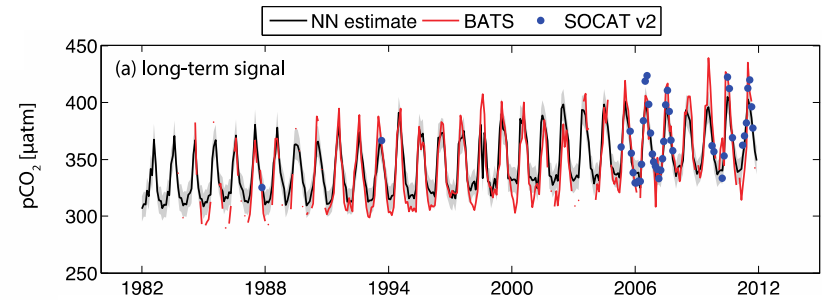
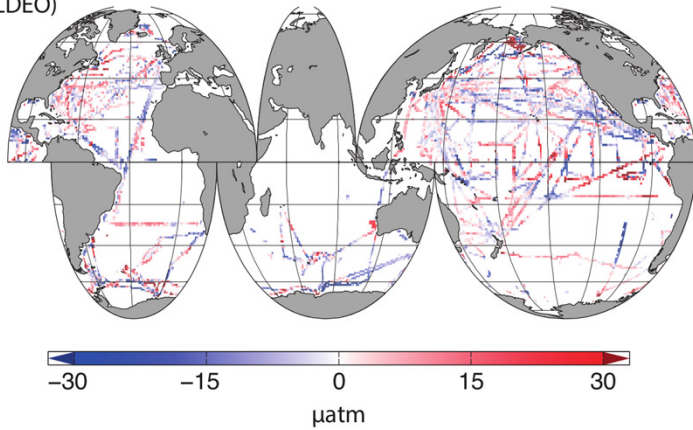
(a) bias (NN-LDEO)
1982-1991



(b) bias (NN-LDEO)
1992-2001



(c) bias (NN-LDEO)
2002-2011

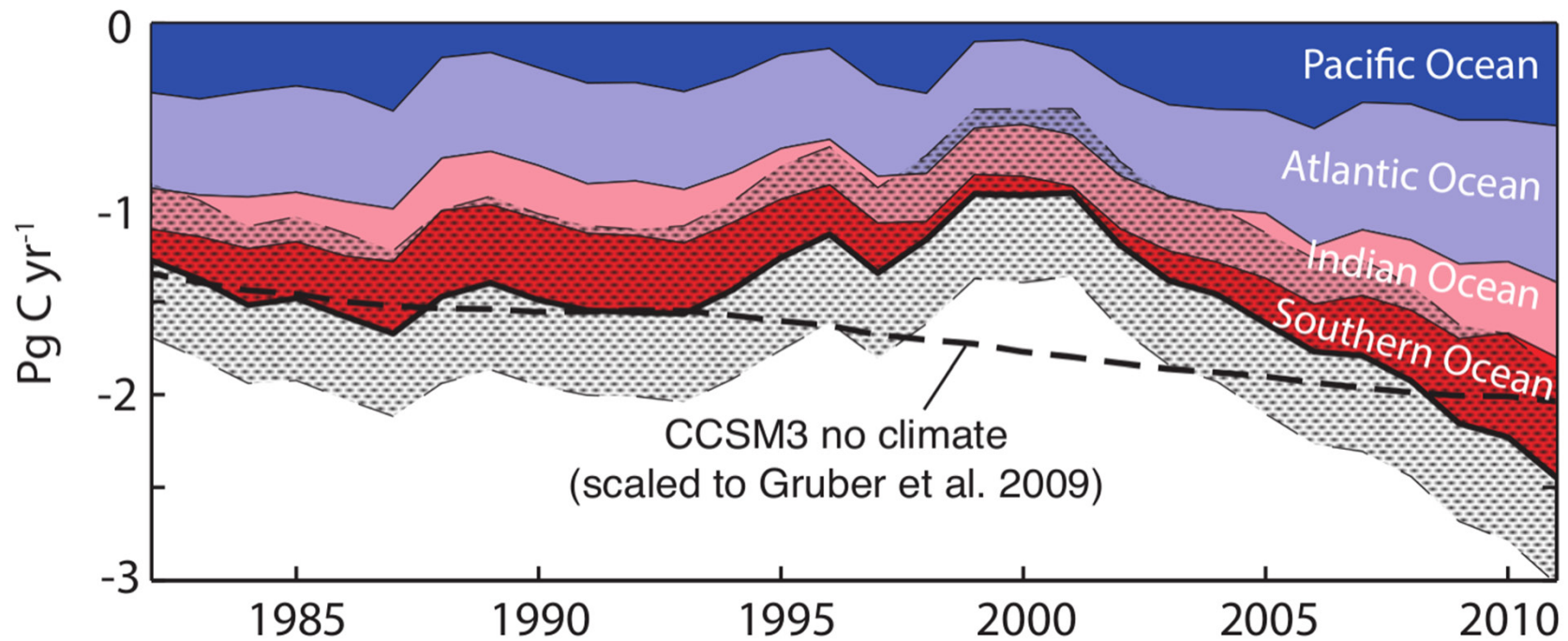


Landschützer et al in review, GBC



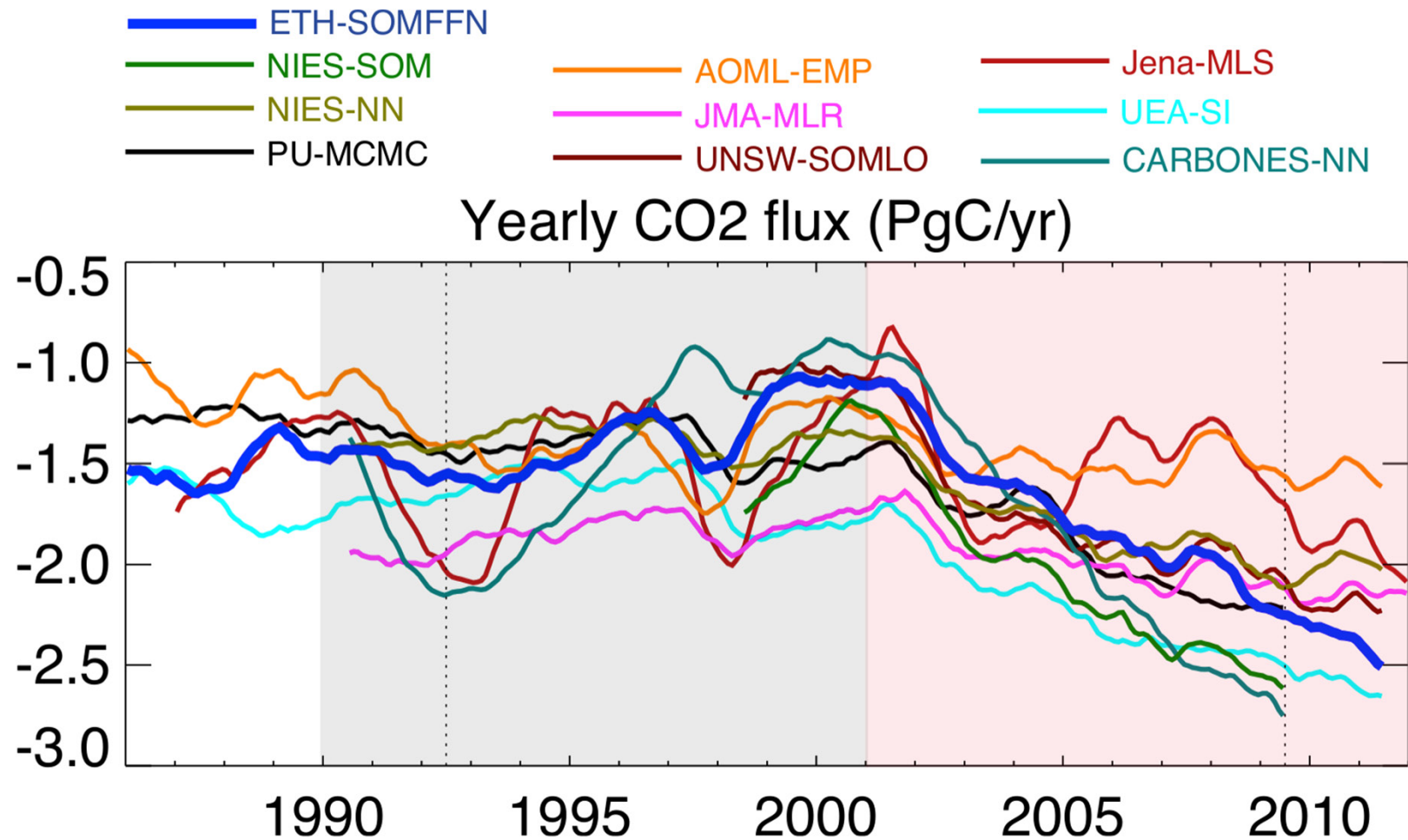
mol C/m²/yr

Air-sea CO₂ flux



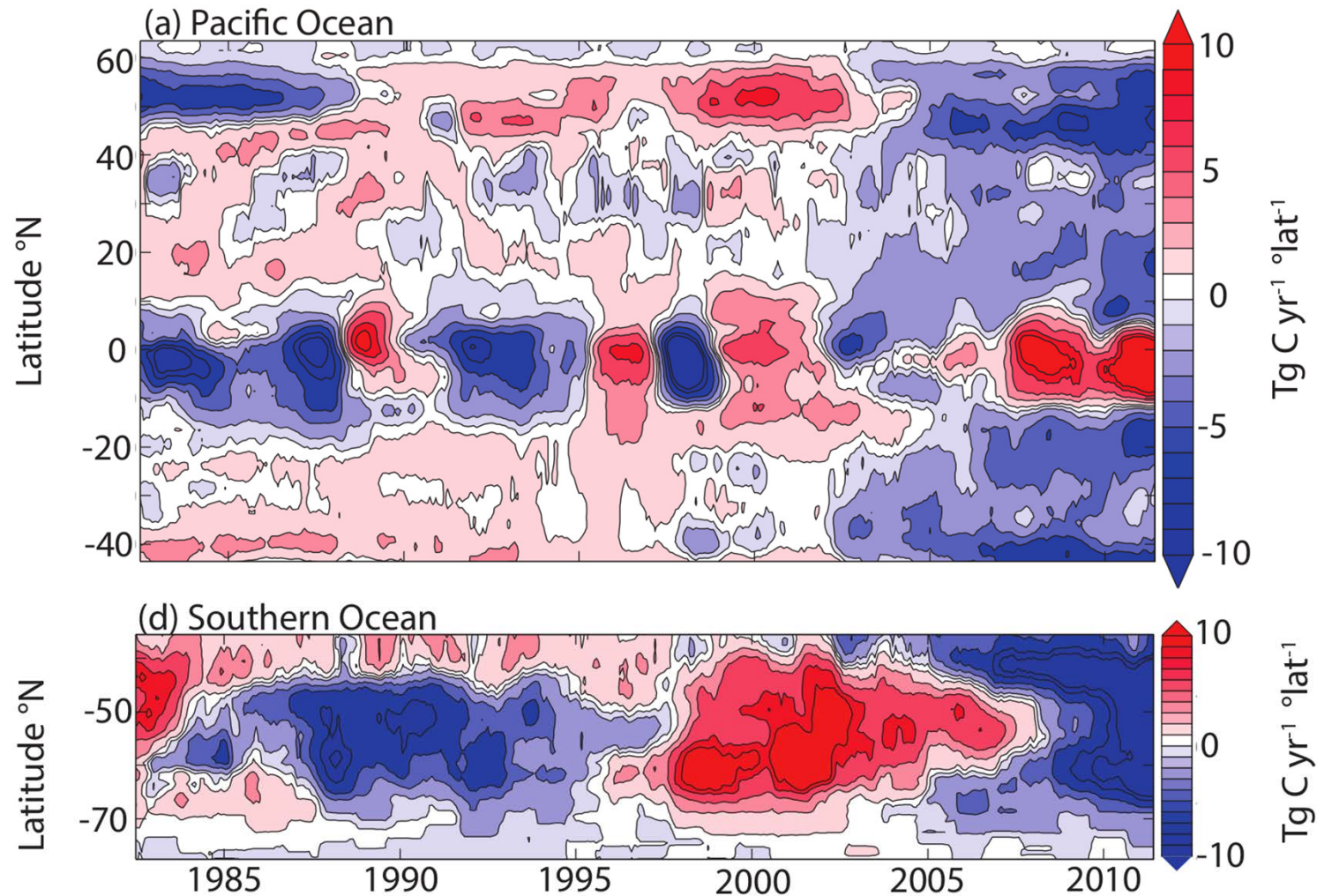
Landschützer et al in review, GBC

The Surface Ocean CO₂ Mapping intercomparison project



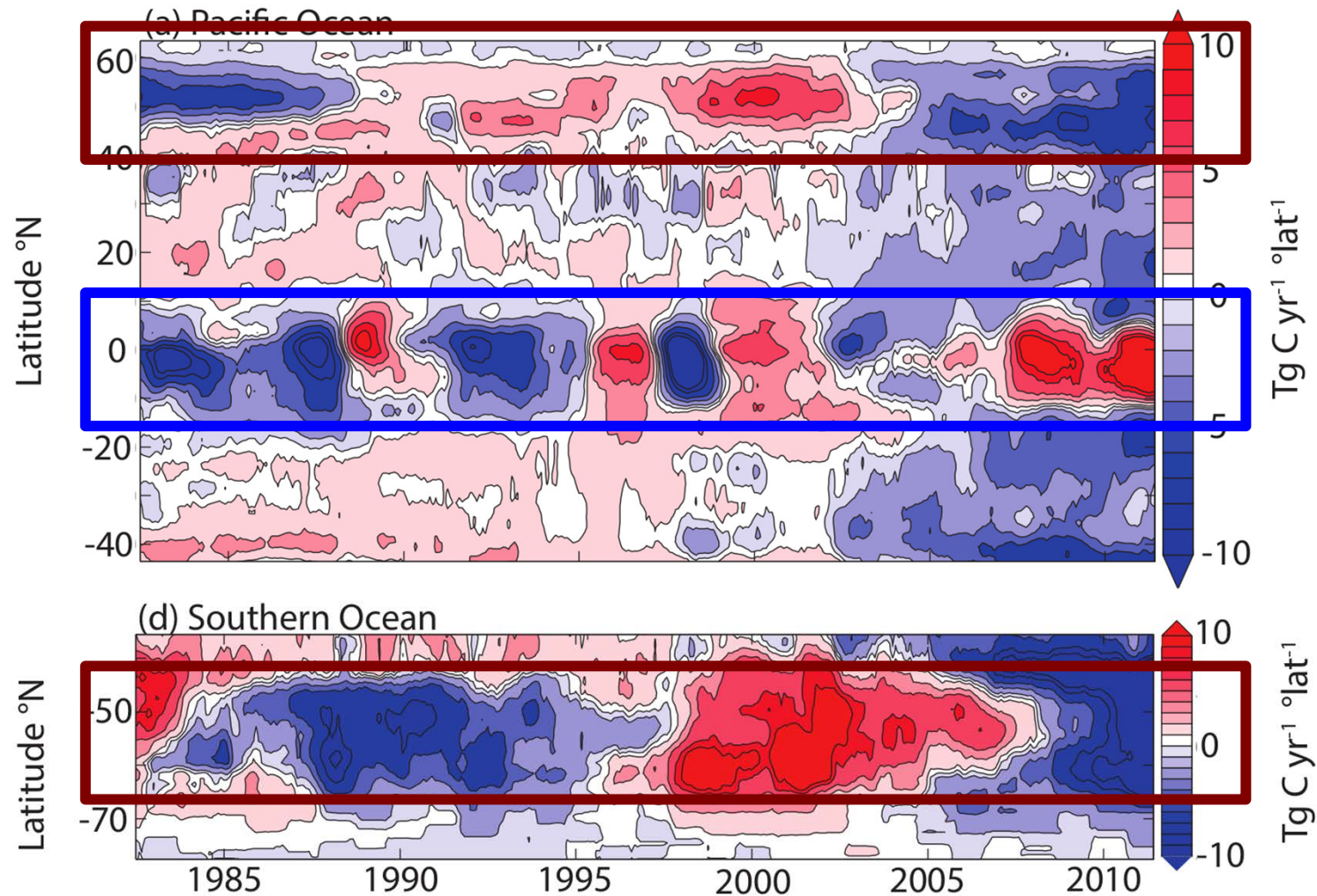
Modified from Rödenbeck et al 2015, BG

Air-sea flux anomaly



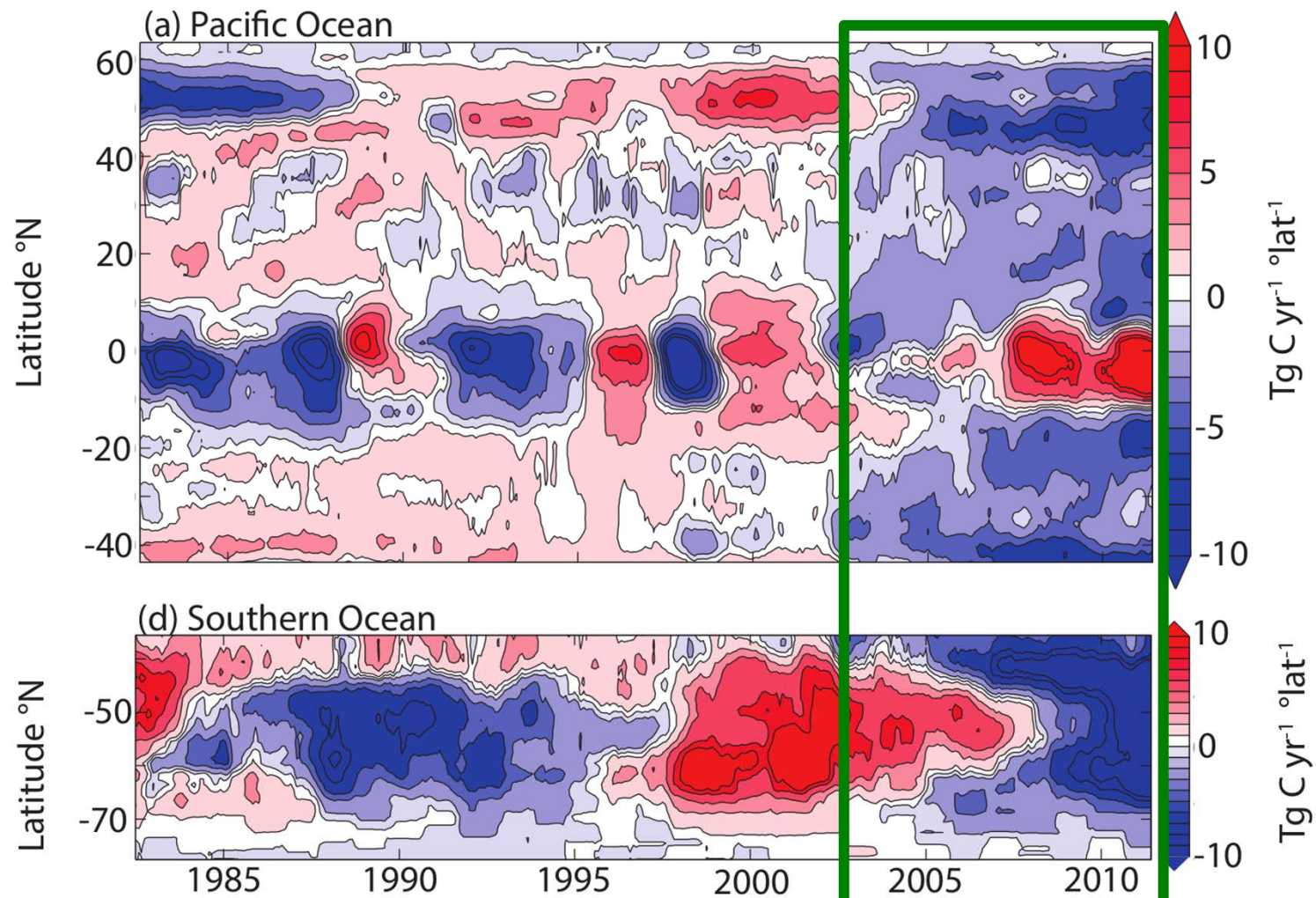
Landschützer et al in review, GBC

Air-sea flux anomaly



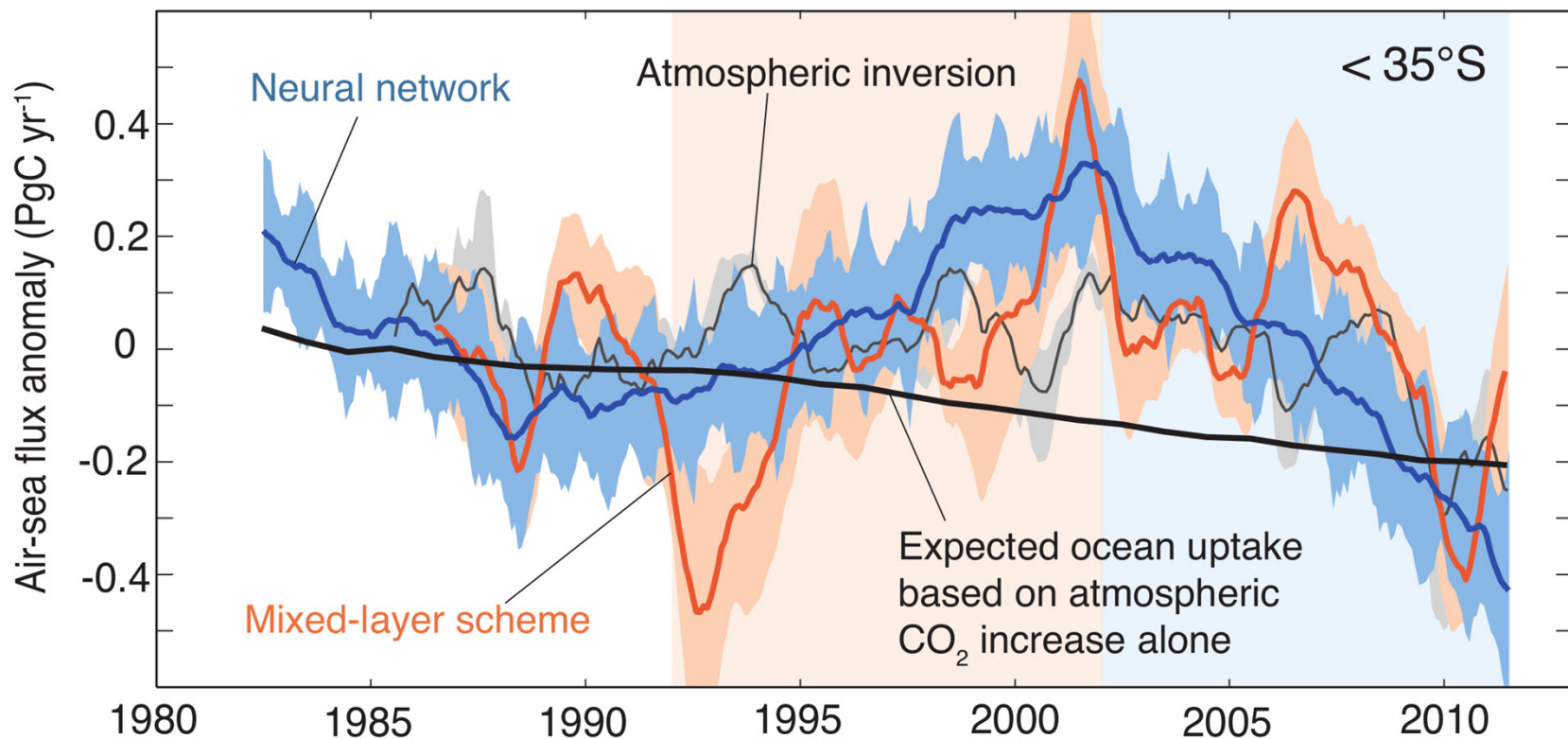
Landschützer et al in review, GBC

Air-sea flux anomaly



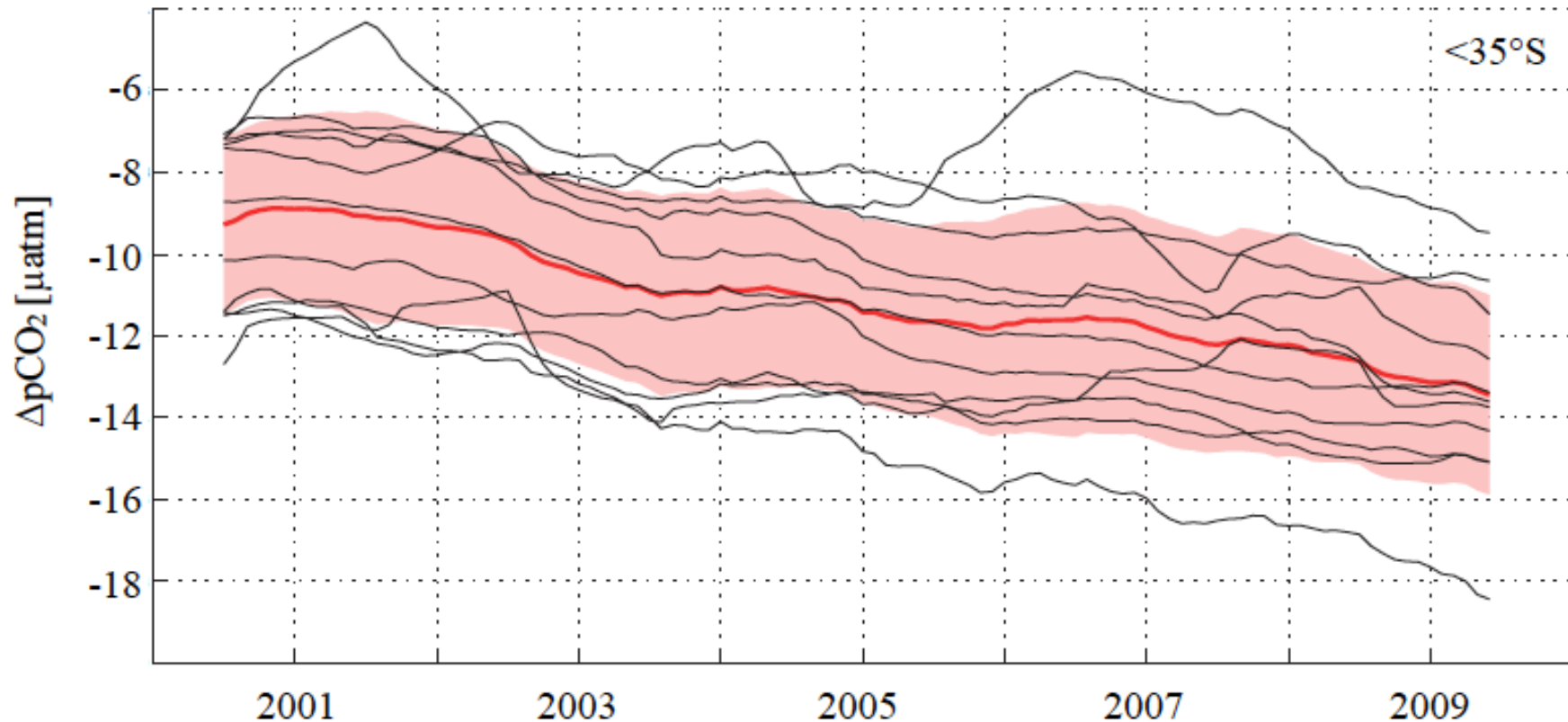
Landschützer et al in review, GBC

The reinvigoration of the Southern Ocean carbon sink



Landschützer et al 2015, SCIENCE

The Surface Ocean CO₂ Mapping intercomparison project

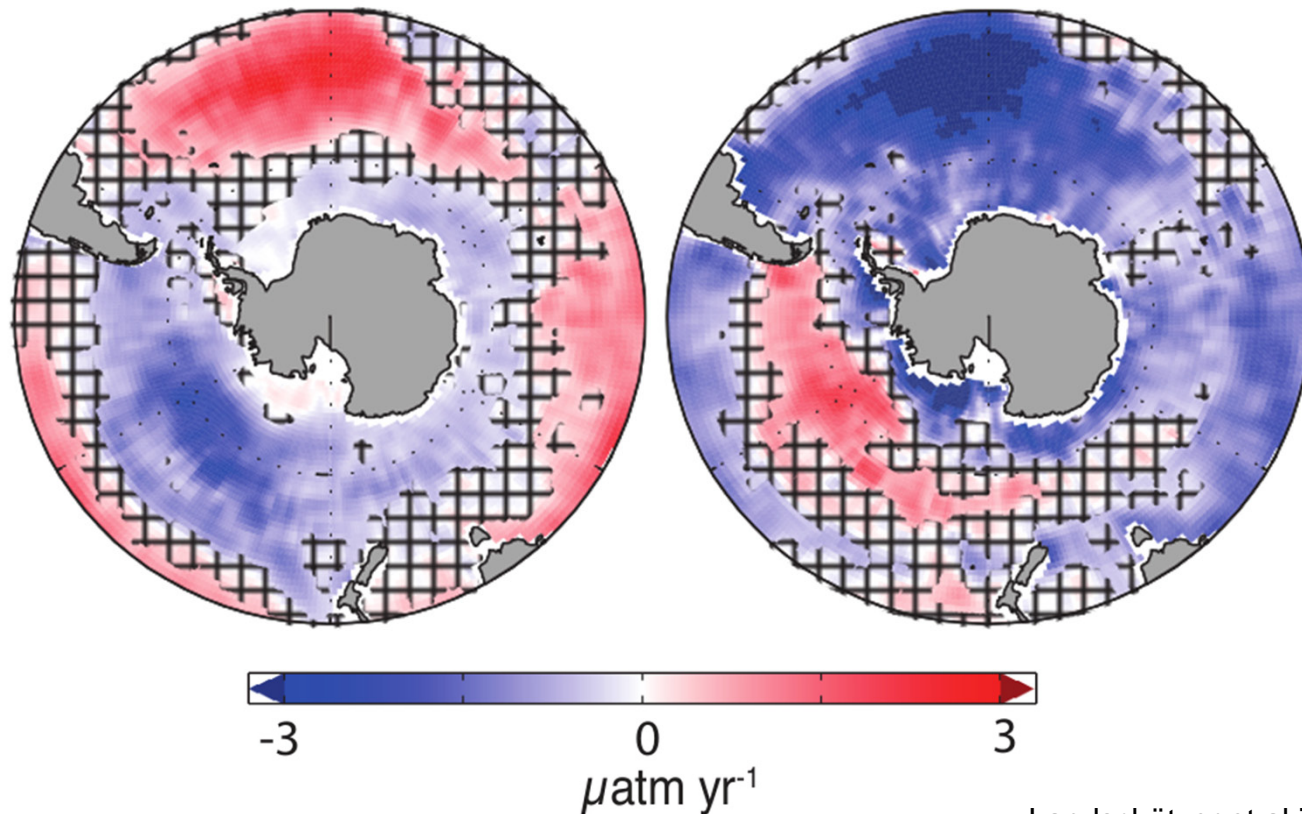


Surface ocean pCO₂ increases at a rate of about 0.4 $\mu\text{atm}/\text{yr}$
slower than atmospheric pCO₂ on average

The reinvigoration of the Southern Ocean carbon sink

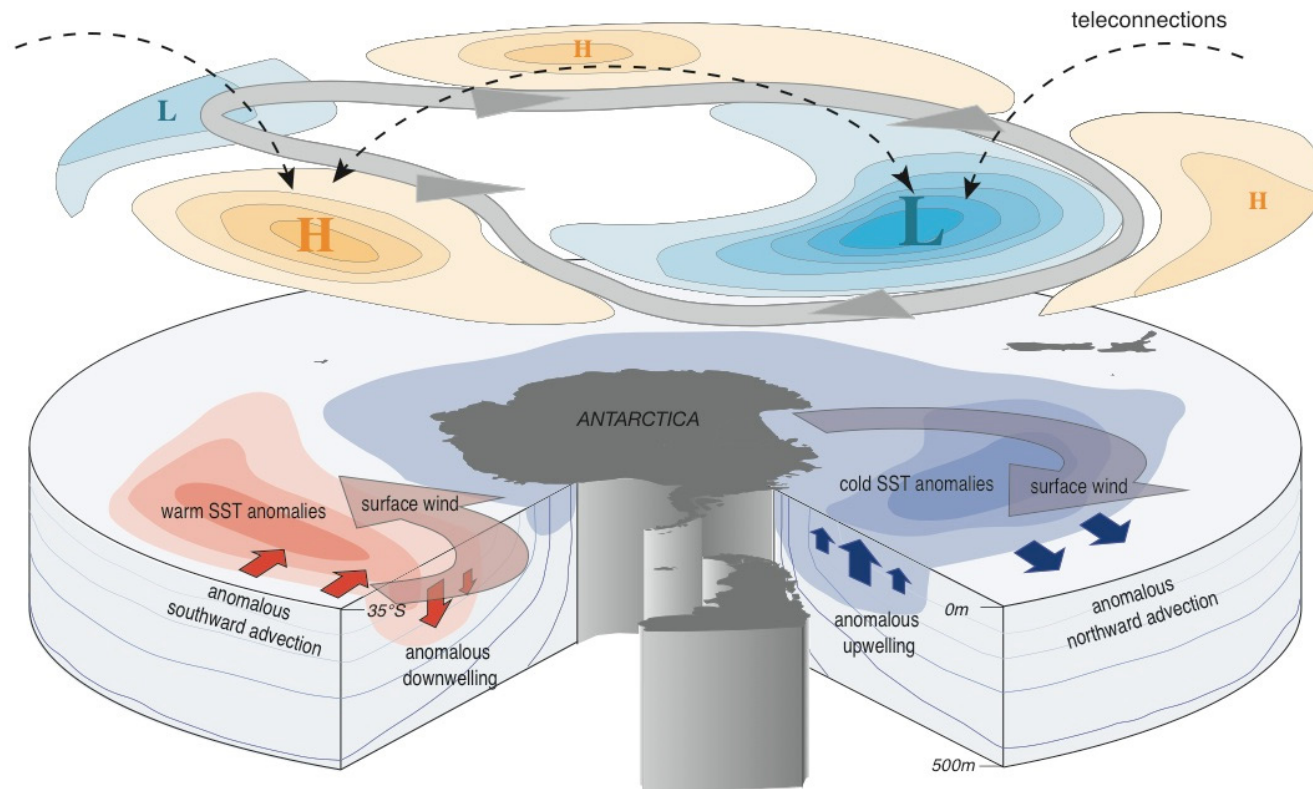
Thermal pCO₂ trend

Non-thermal pCO₂ trend



Landschützer et al in 2015, SCIENCE

The reinvigoration of the Southern Ocean carbon sink



ATLANTIC SECTOR

- Thermal trend \oplus
- DIC/Alk-driven trend \ominus

- Overall pCO₂-trend \ominus**

PACIFIC SECTOR

- Thermal trend \ominus
- DIC/Alk-driven trend \oplus

- Overall pCO₂-trend \ominus**

Summary

- Surface ocean $p\text{CO}_2$ observations suggest strong decadal carbon sink variations
- Decadal variability stems from high latitudes and inter-annual variability from low latitudes
- Global ocean (particularly Southern Ocean) CO_2 sink strengthened in the most recent decade

