

Detection of a weakening Southern Ocean carbon sink

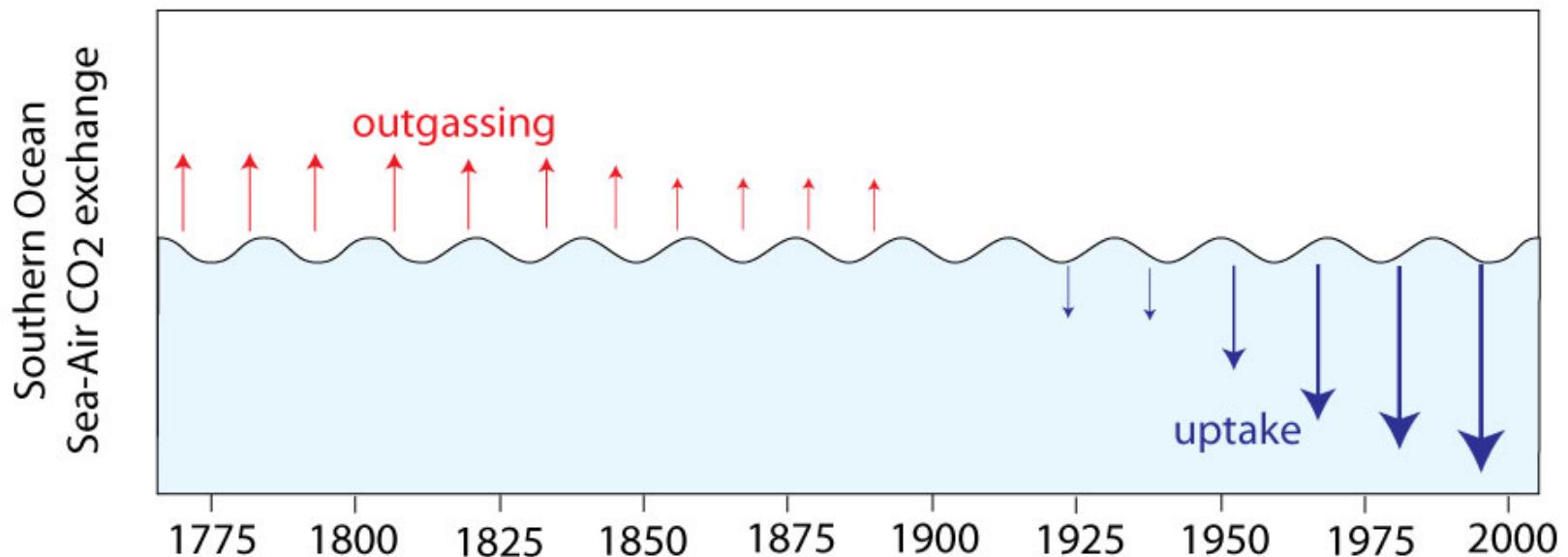
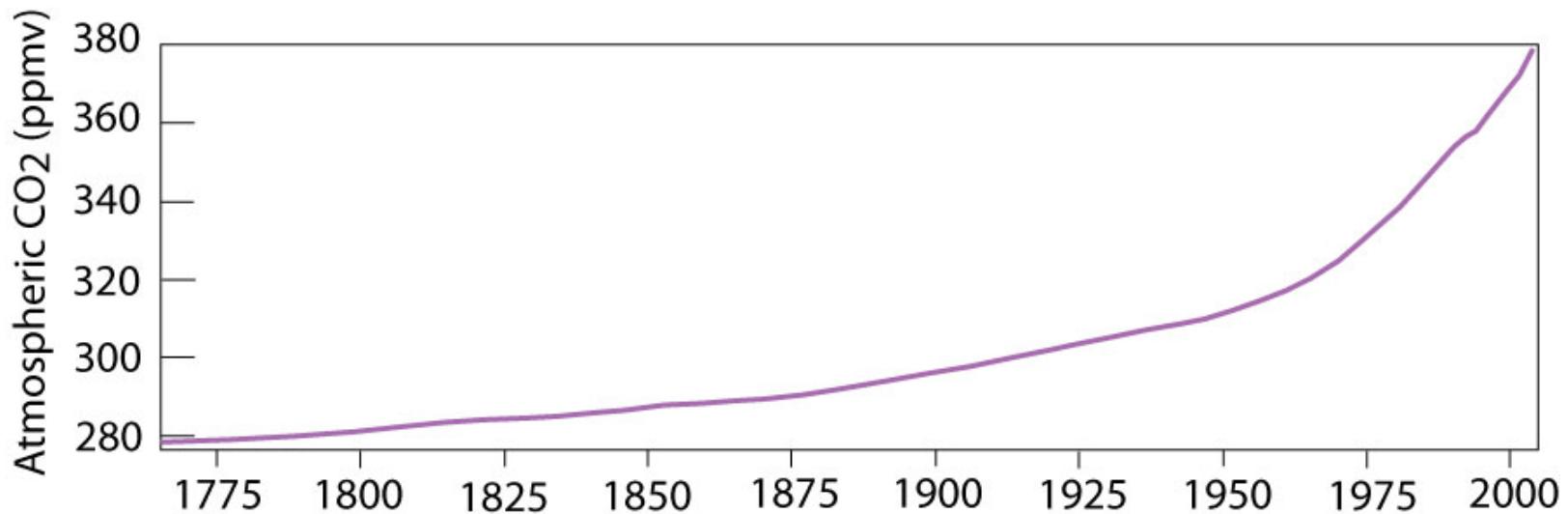
Nikki Lovenduski

University of Colorado Boulder

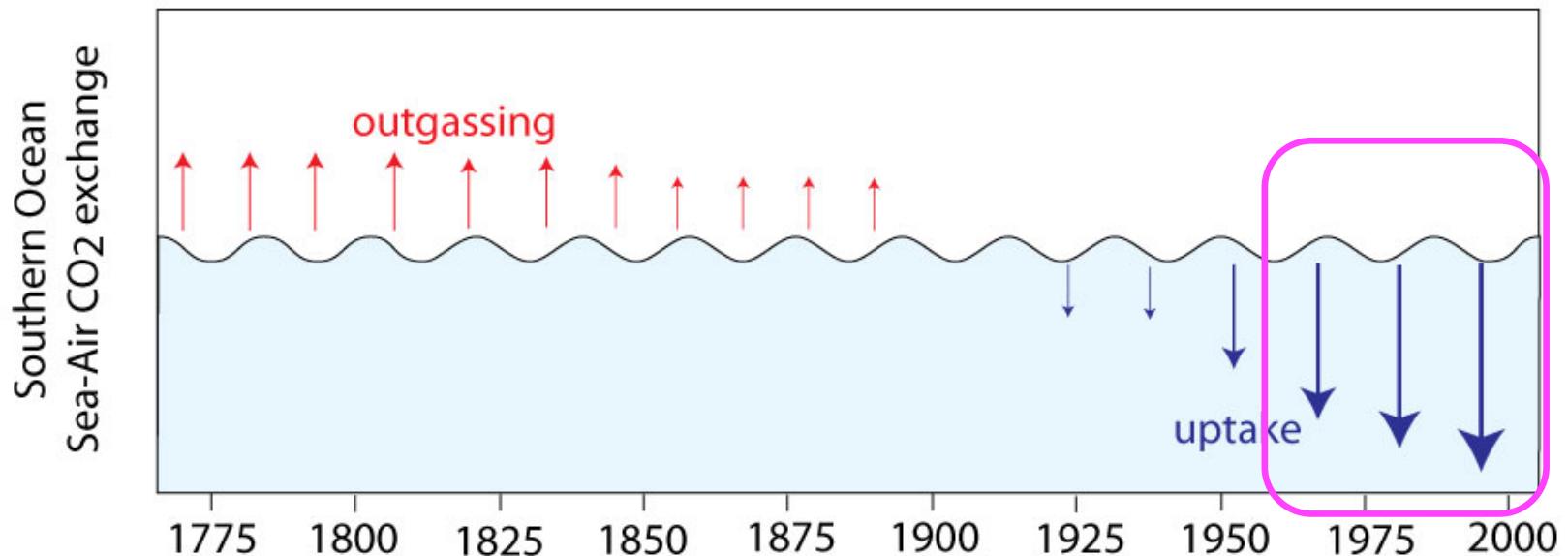
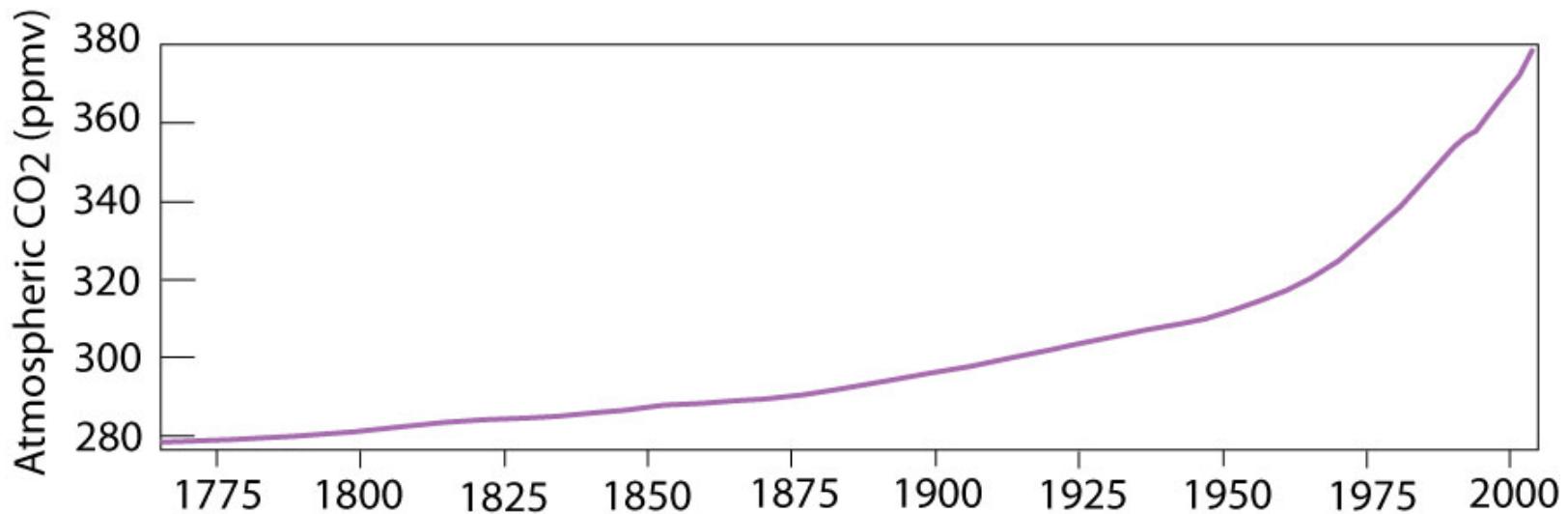
Thanks to

*Galen McKinley and Amanda Fay
University of Wisconsin - Madison*

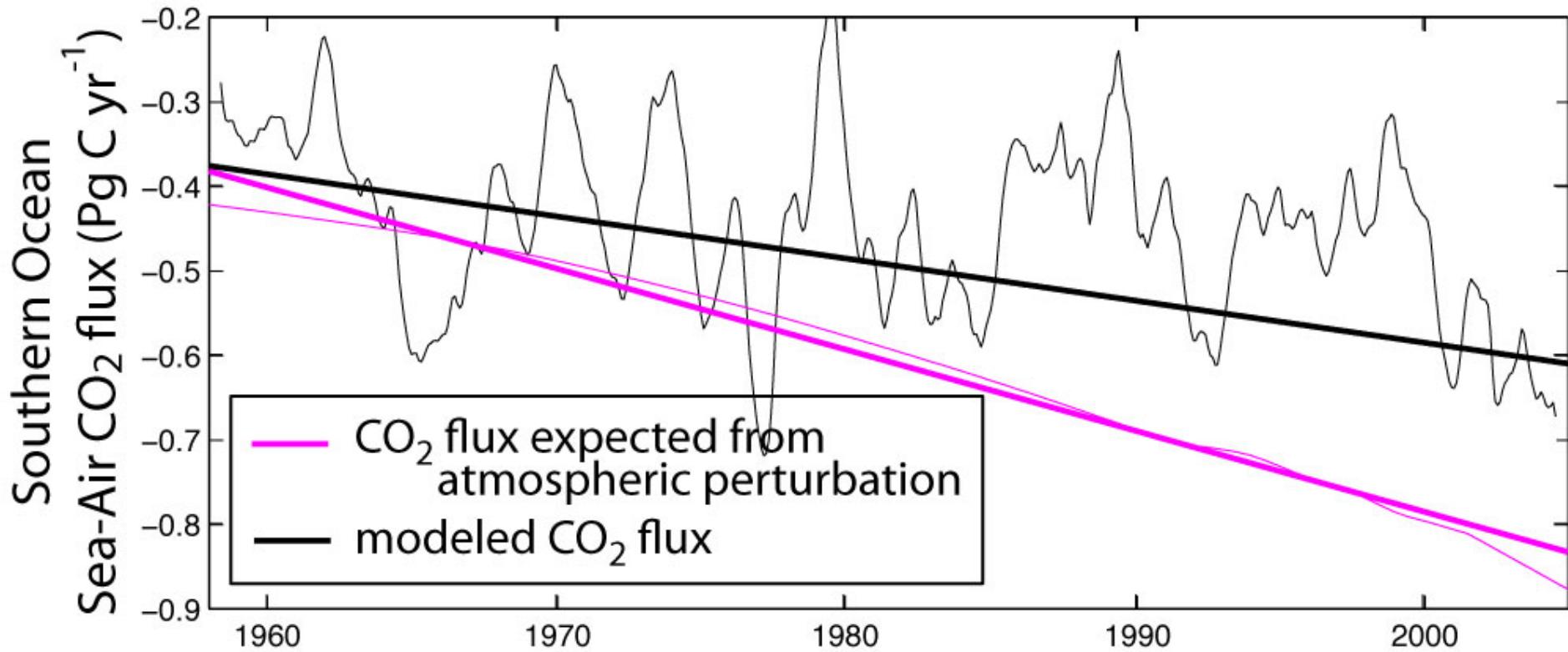
Evolution of Southern Ocean CO₂ exchange



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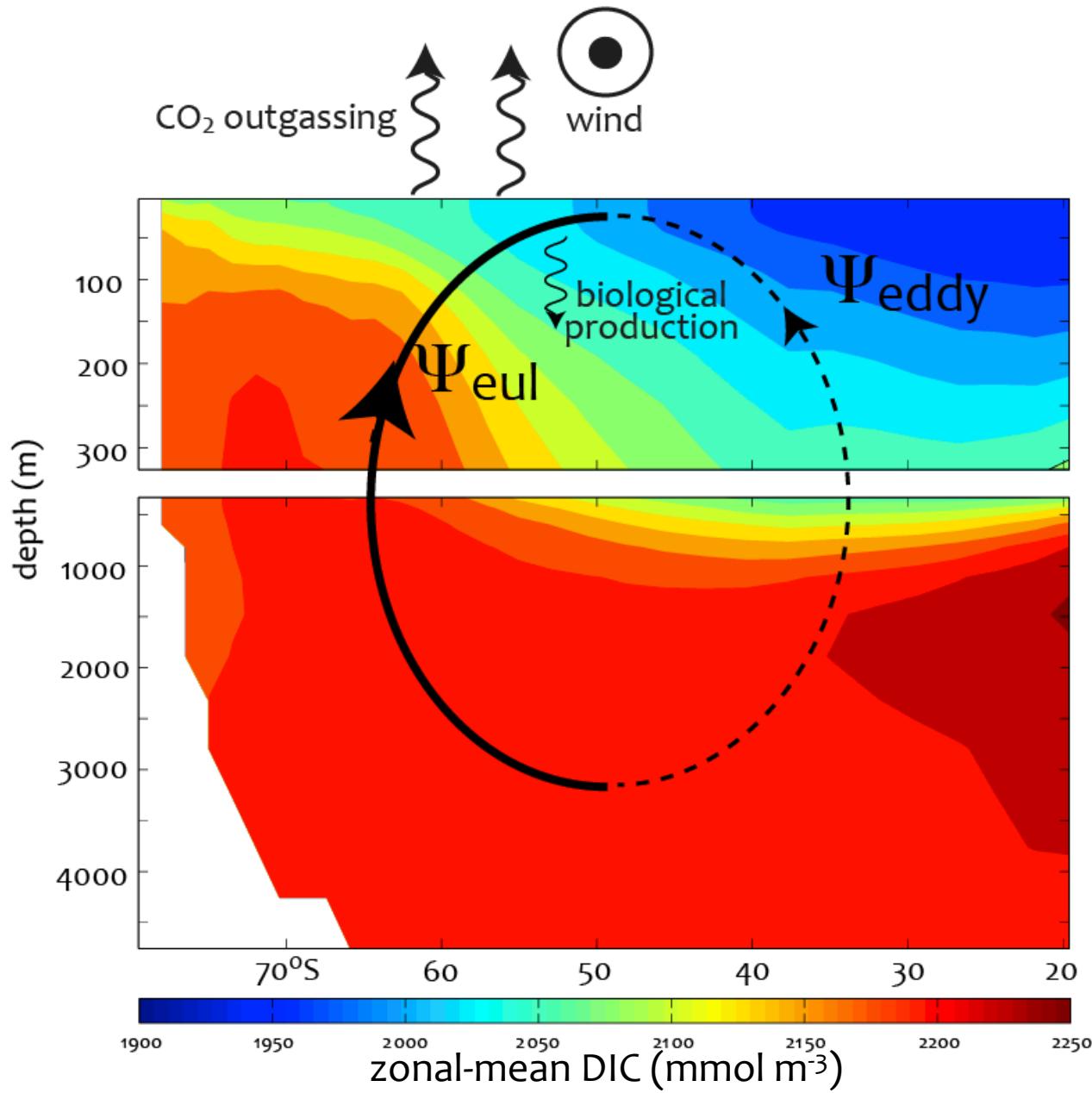


Saturation of the CO₂ sink

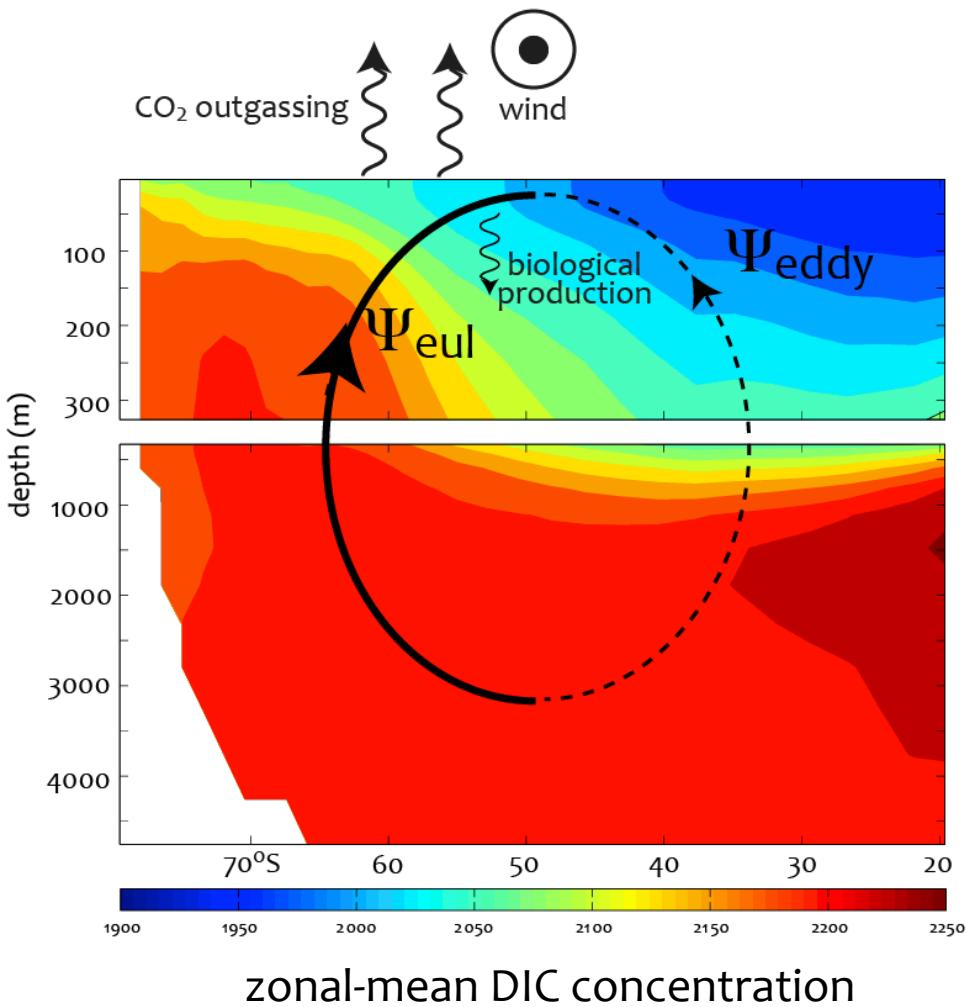


adapted from Lovenduski et al. (2008)

Mechanism



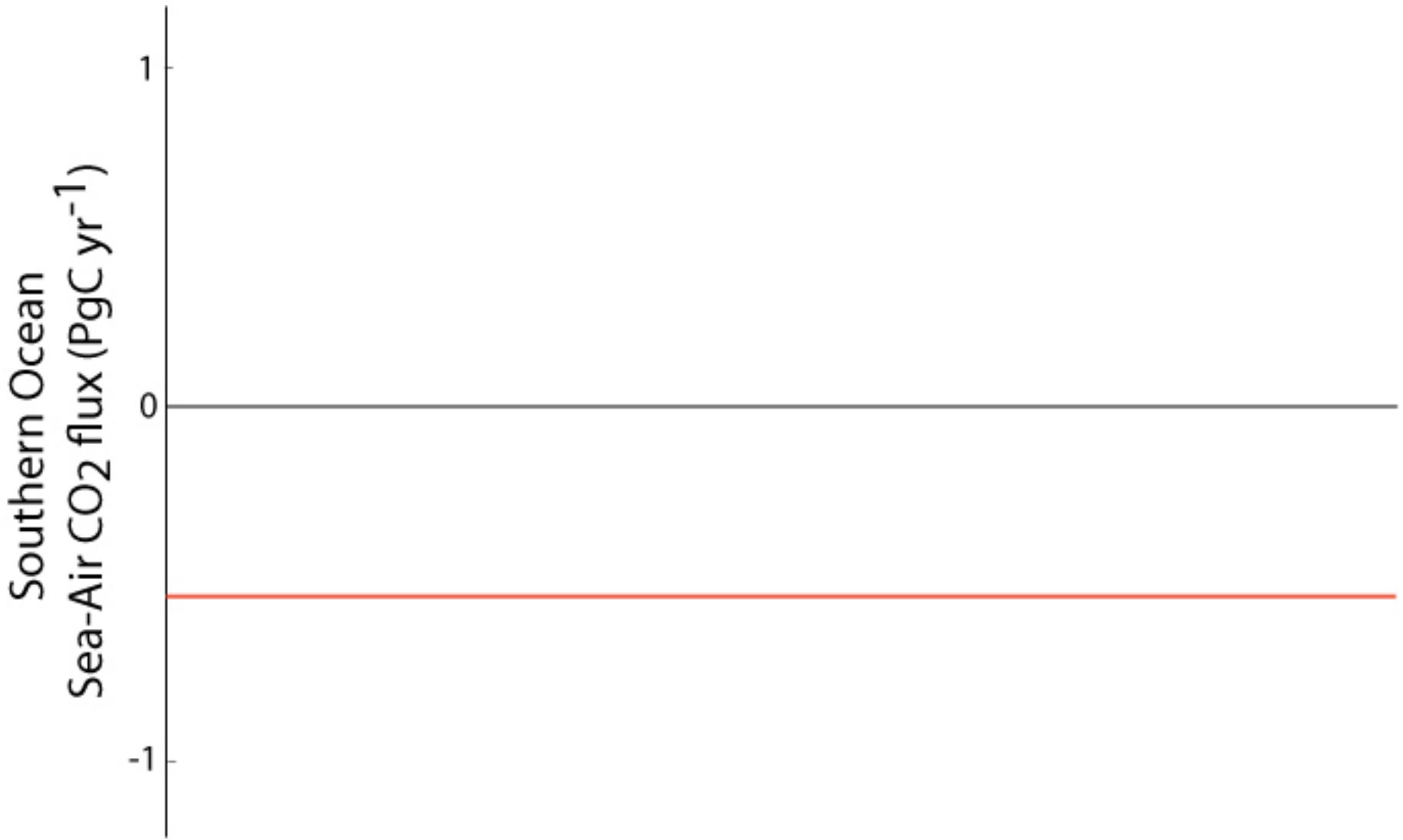
Corroborating model results



Model	Reference
Bern3D	Tschumi et al. 2008
CCSM/CESM	Lovenduski et al. 2007 Wang and Moore 2012 Lovenduski et al. 2013
CSIRO	Lenton et al. 2007
IPSL	LeQuéré et al. 2007 Lenton et al. 2009
LOVECLIM	Meniel et al. 2008
MITgcm	Lovenduski and Ito 2009 Hauck et al. 2013 Lauderdale et al. 2013
NASA GISS	Romanou et al. 2013
UVic	Zickfeld et al. 2007 Swart et al. 2014

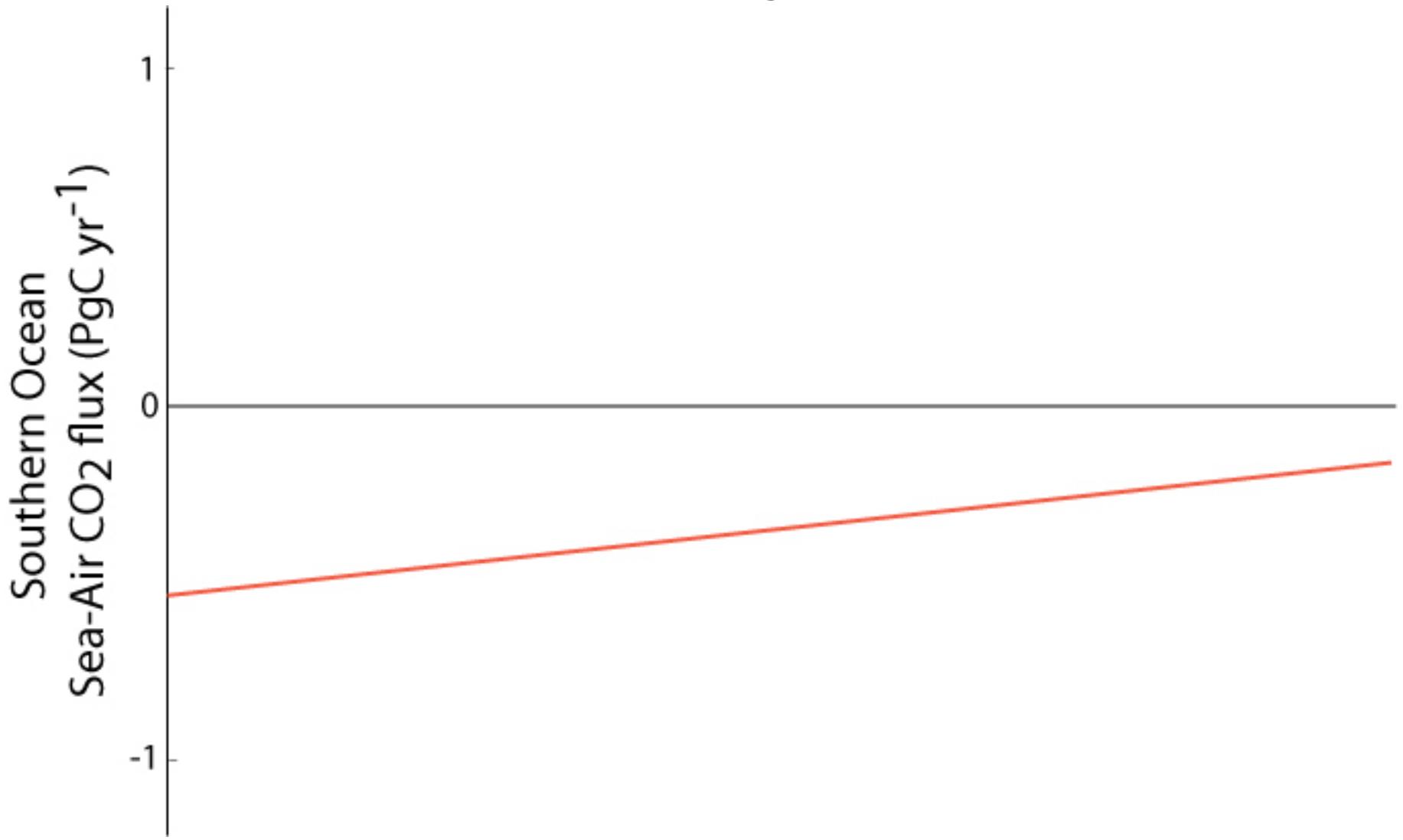
A note on language

steady sink



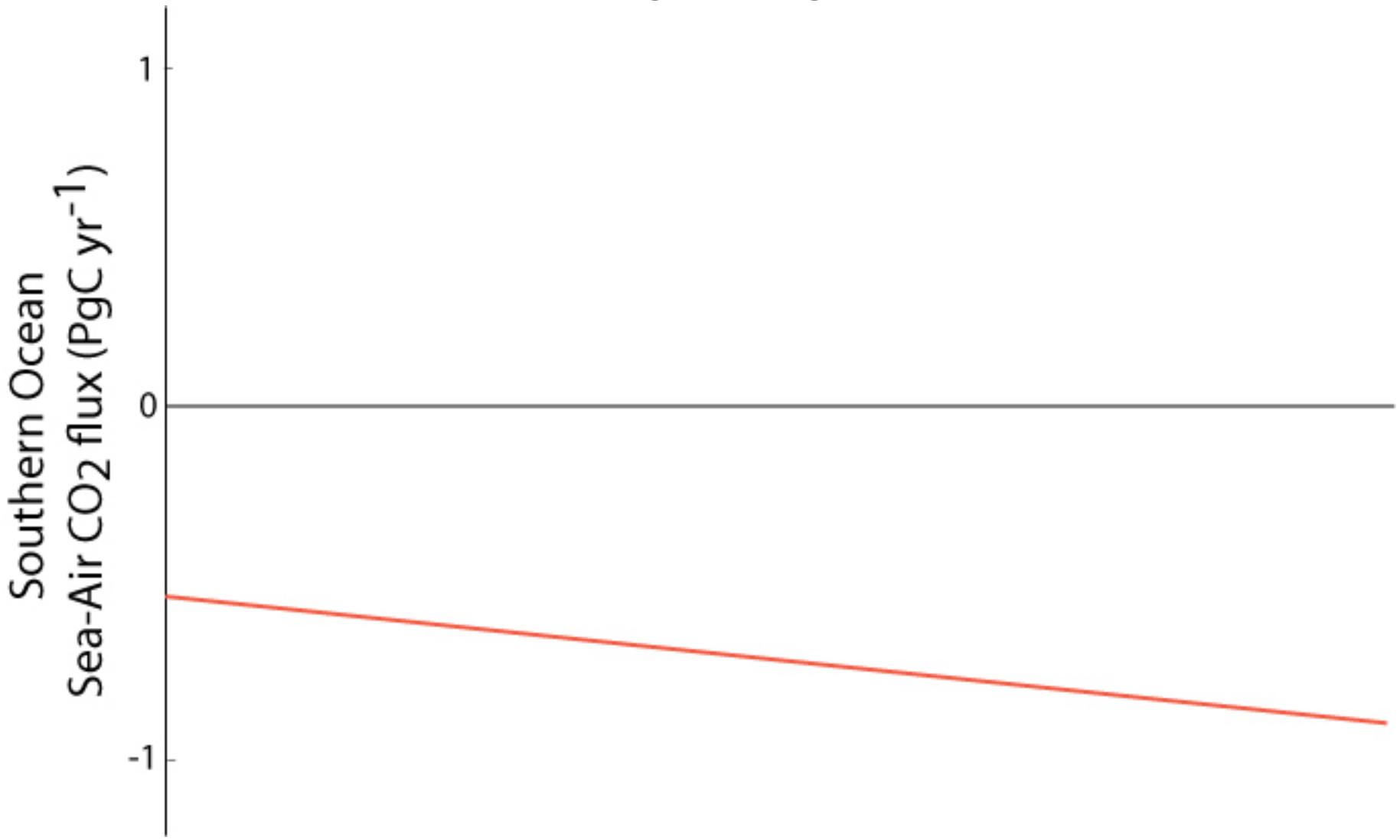
A note on language

weakening sink



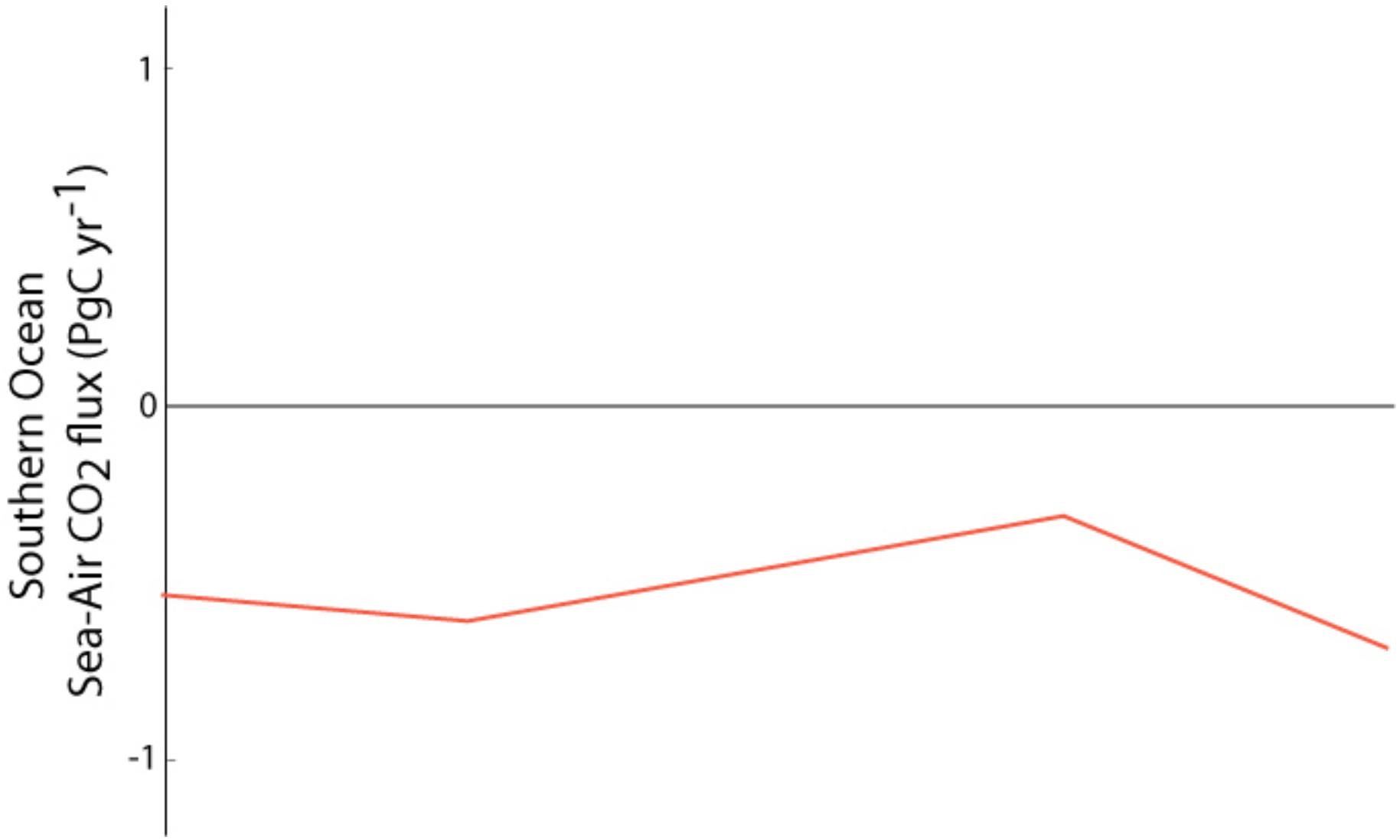
A note on language

strengthening sink



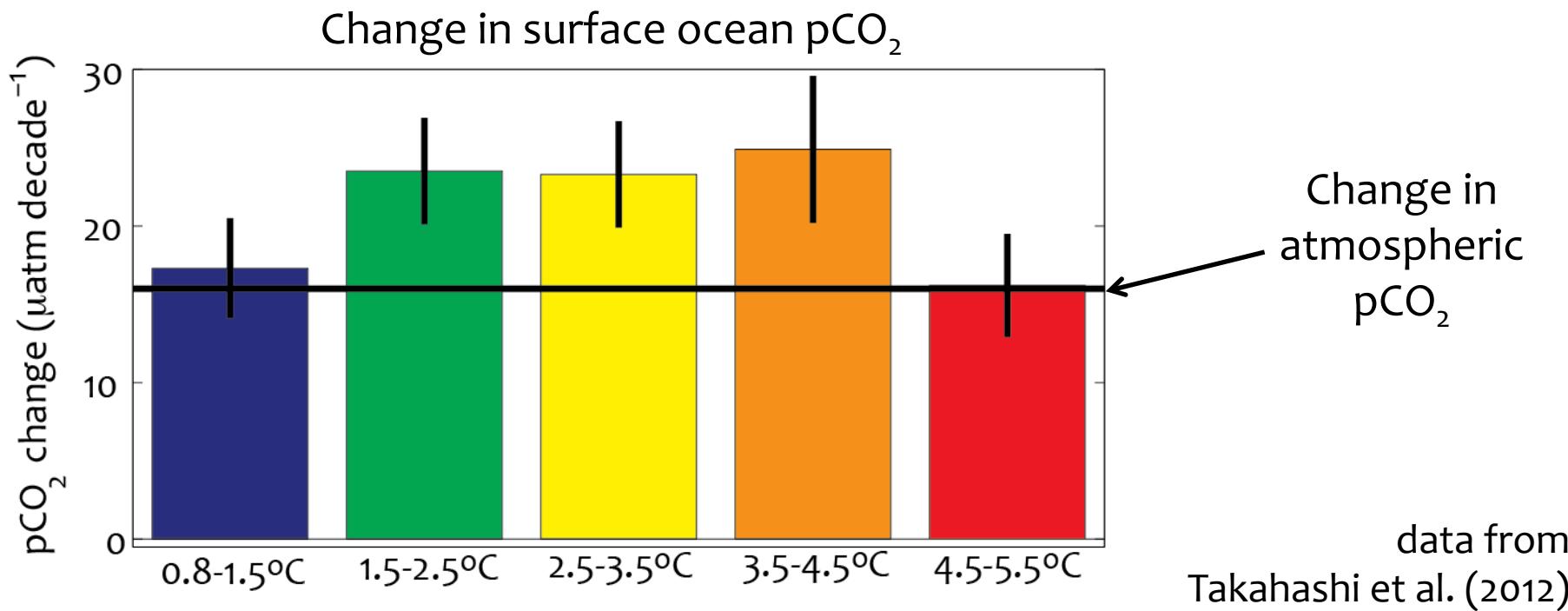
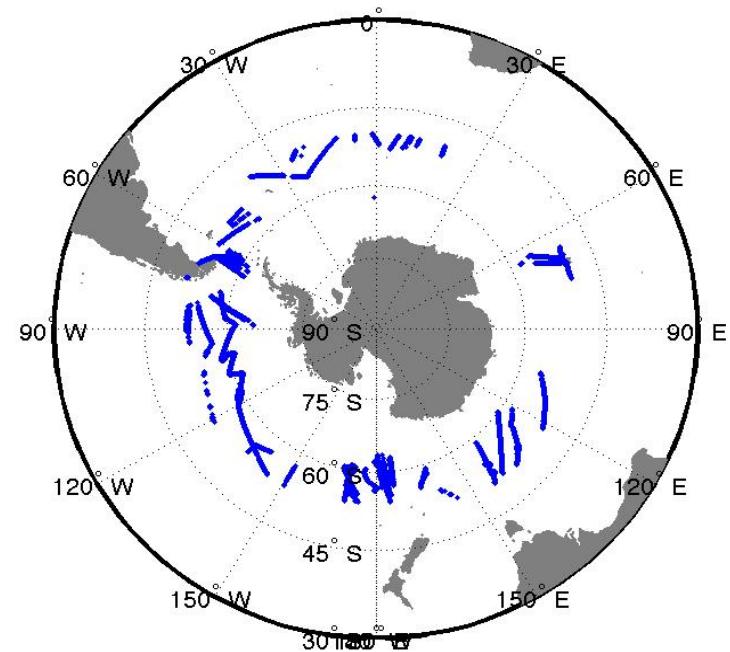
A note on language

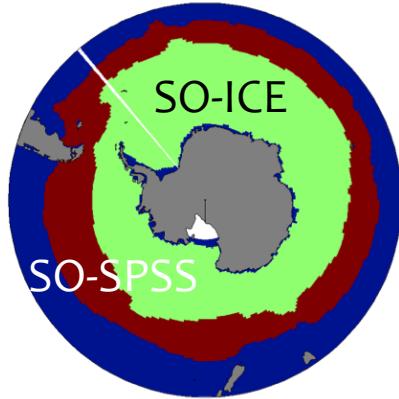
variable sink



Observed wintertime pCO₂ changes 1986-2010

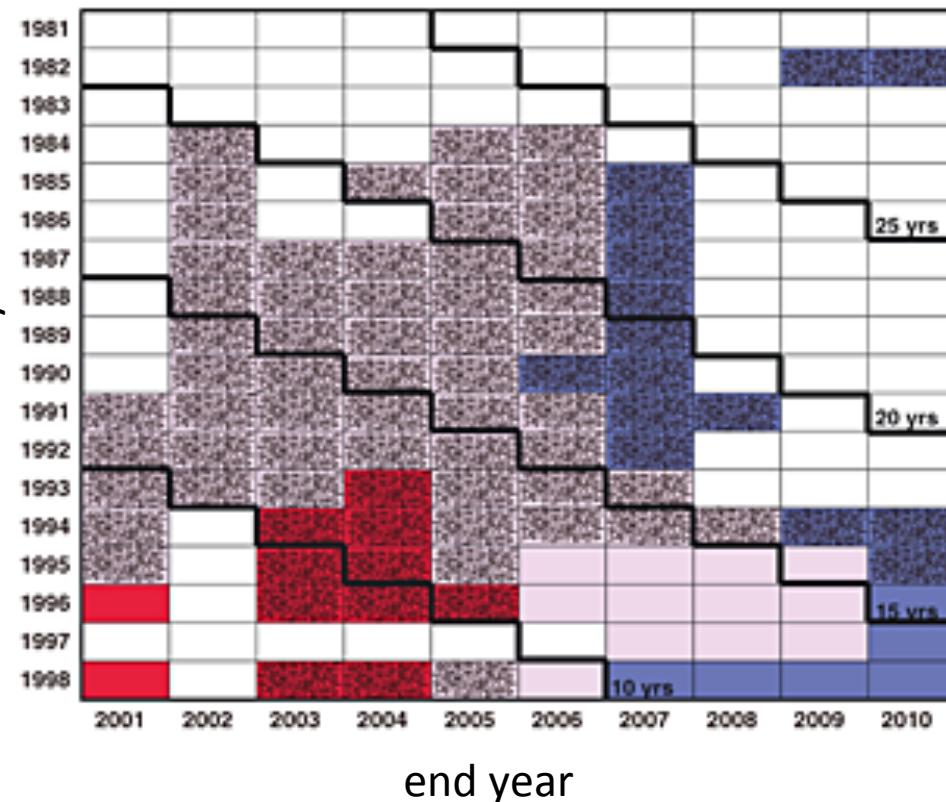
Wintertime data locations →



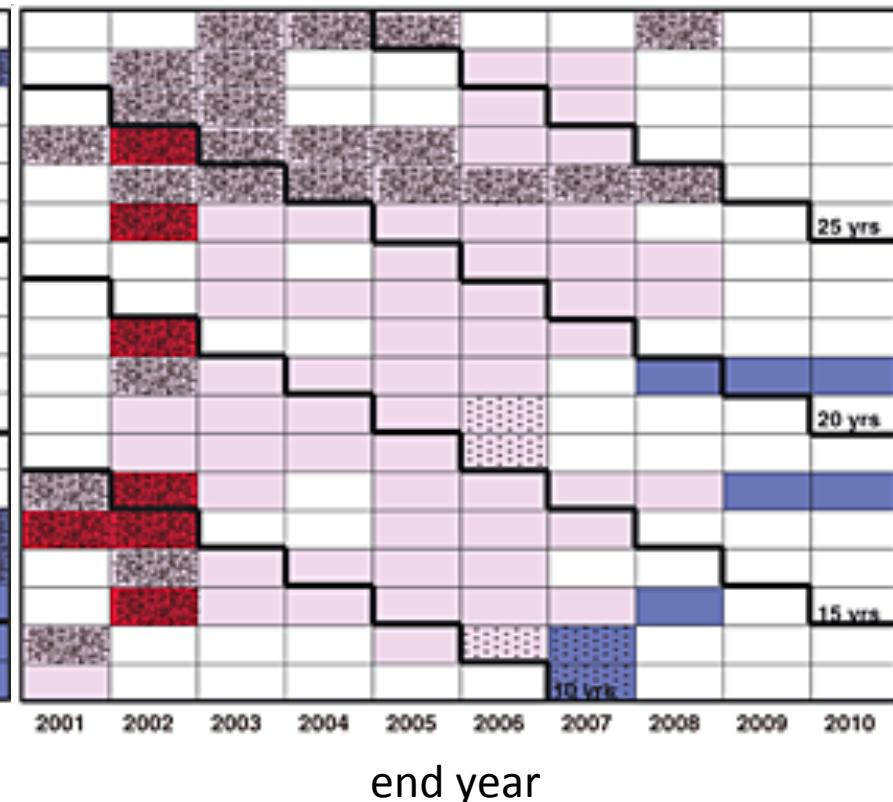


Trend in pCO_2^{oc} vs. pCO_2^{atm} trend

SO-ICE



SO-SPSS



$dpCO_2^{ocn}/dt < dpCO_2^{atm}/dt$	$dpCO_2^{ocn}/dt \sim dpCO_2^{atm}/dt$	$dpCO_2^{ocn}/dt > dpCO_2^{atm}/dt$
$\frac{dpCO_2 - T}{dt} > 0$		$\frac{dpCO_2 - T}{dt} < 0$

Fay and McKinley (2013)

Research questions

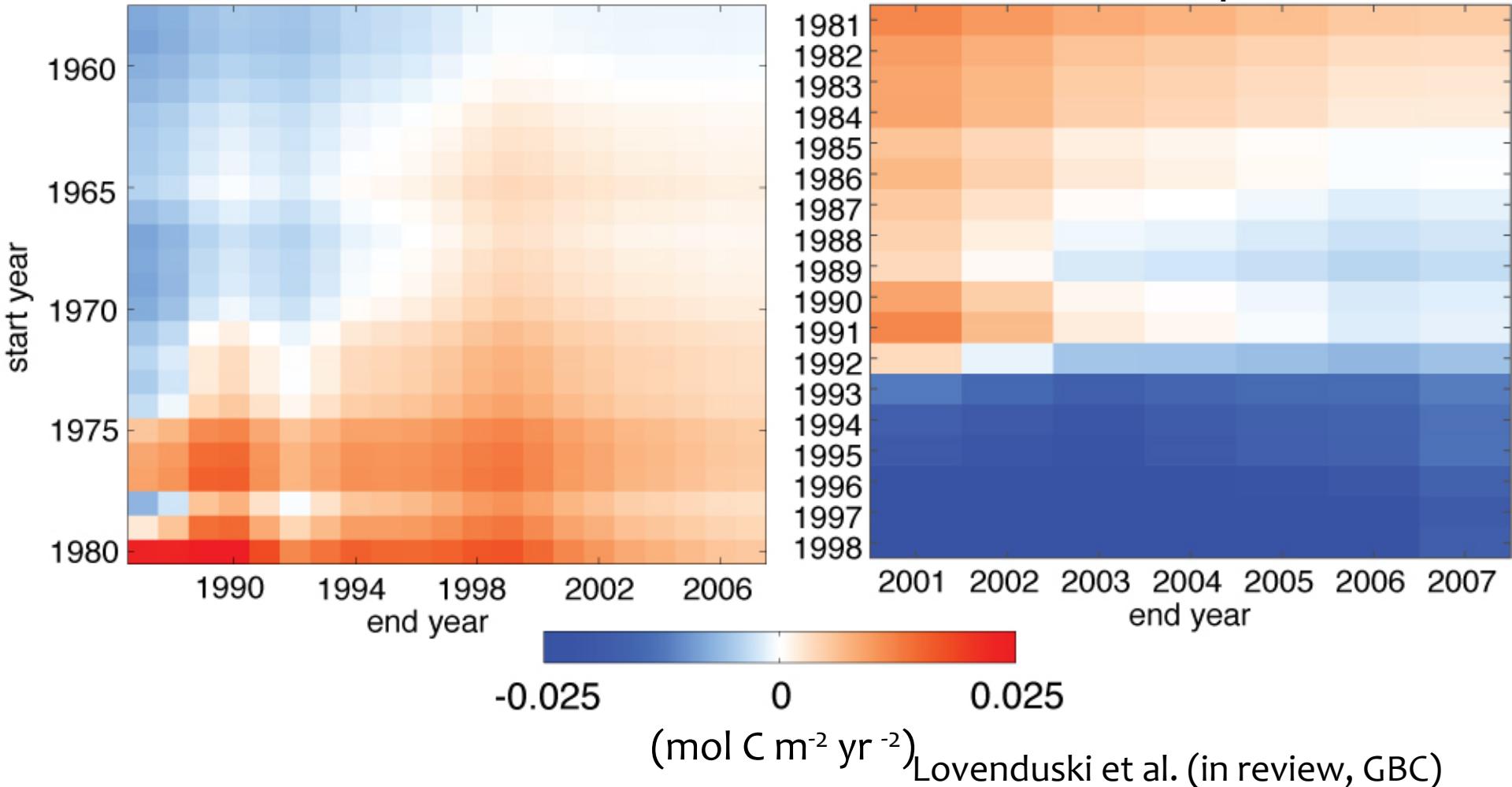
1. Are CO₂ flux trends affected by the choice of start/end year or season?
2. Does the observational sampling introduce biases into the ΔpCO₂ trends?
3. Do we have enough observational data to detect a weakening CO₂ sink?

Does the start/end year matter?

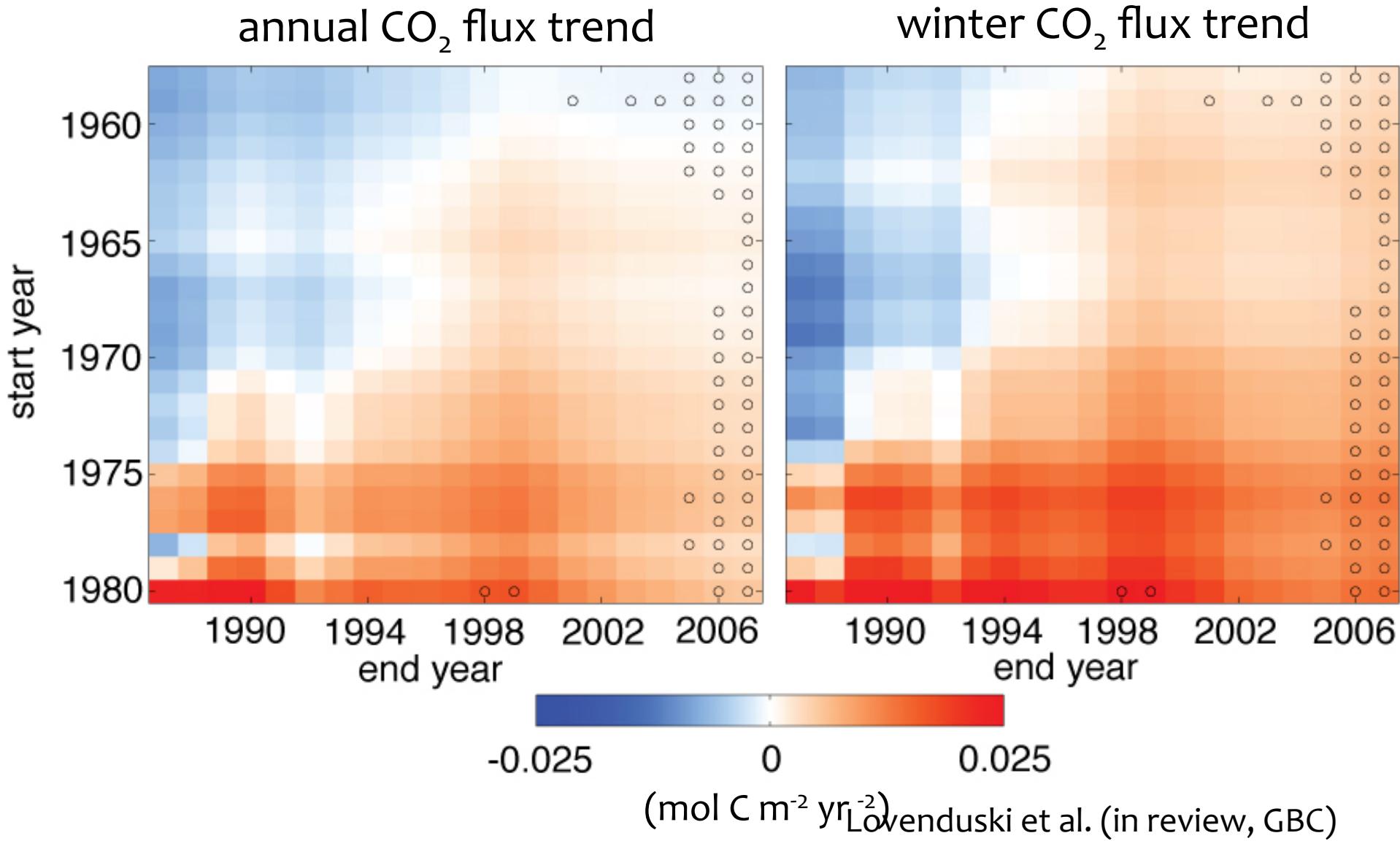
CO₂ flux trend, SO-SPSS

simulated period

observed period

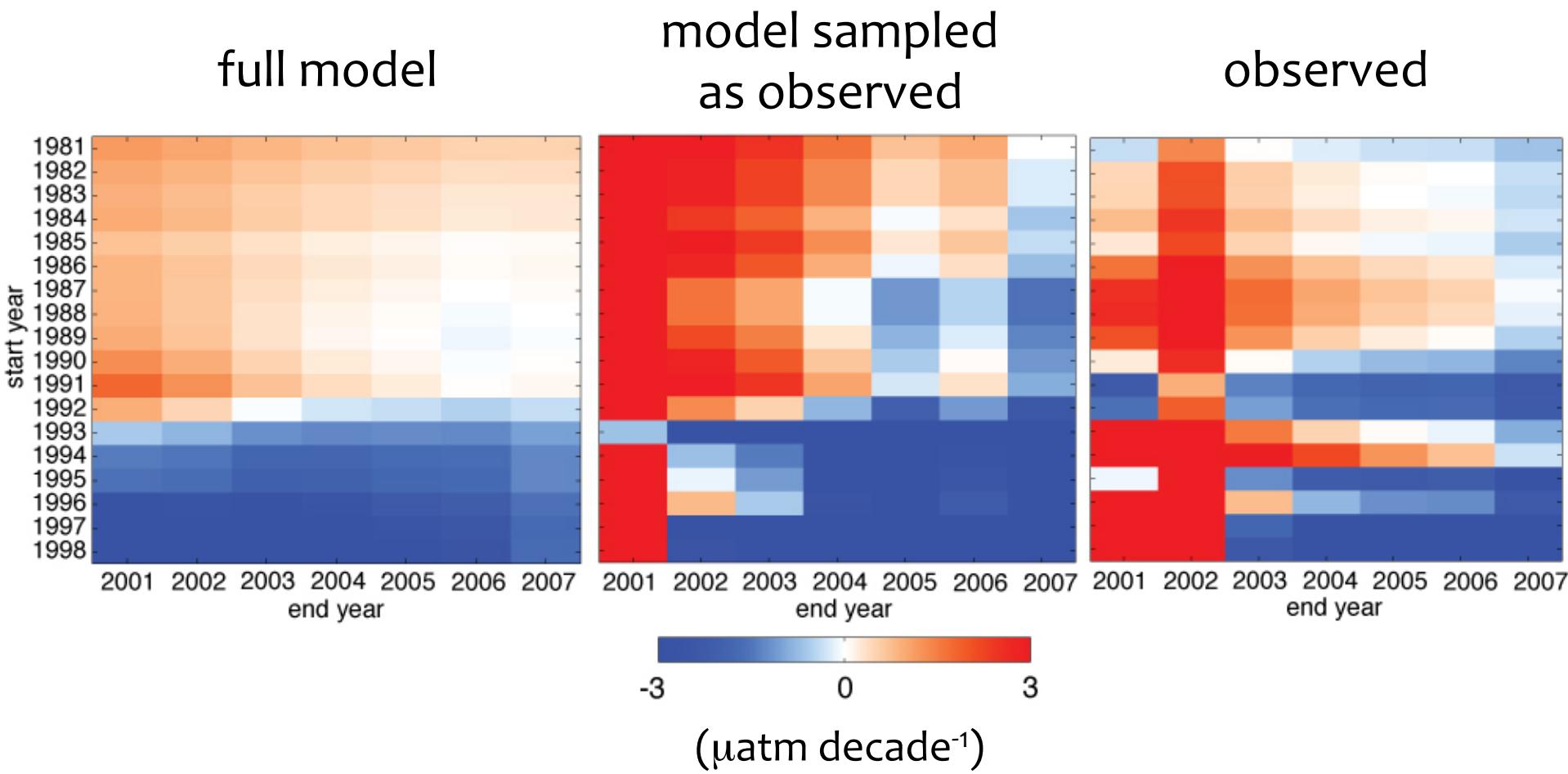


Is the CO₂ flux trend larger in winter?



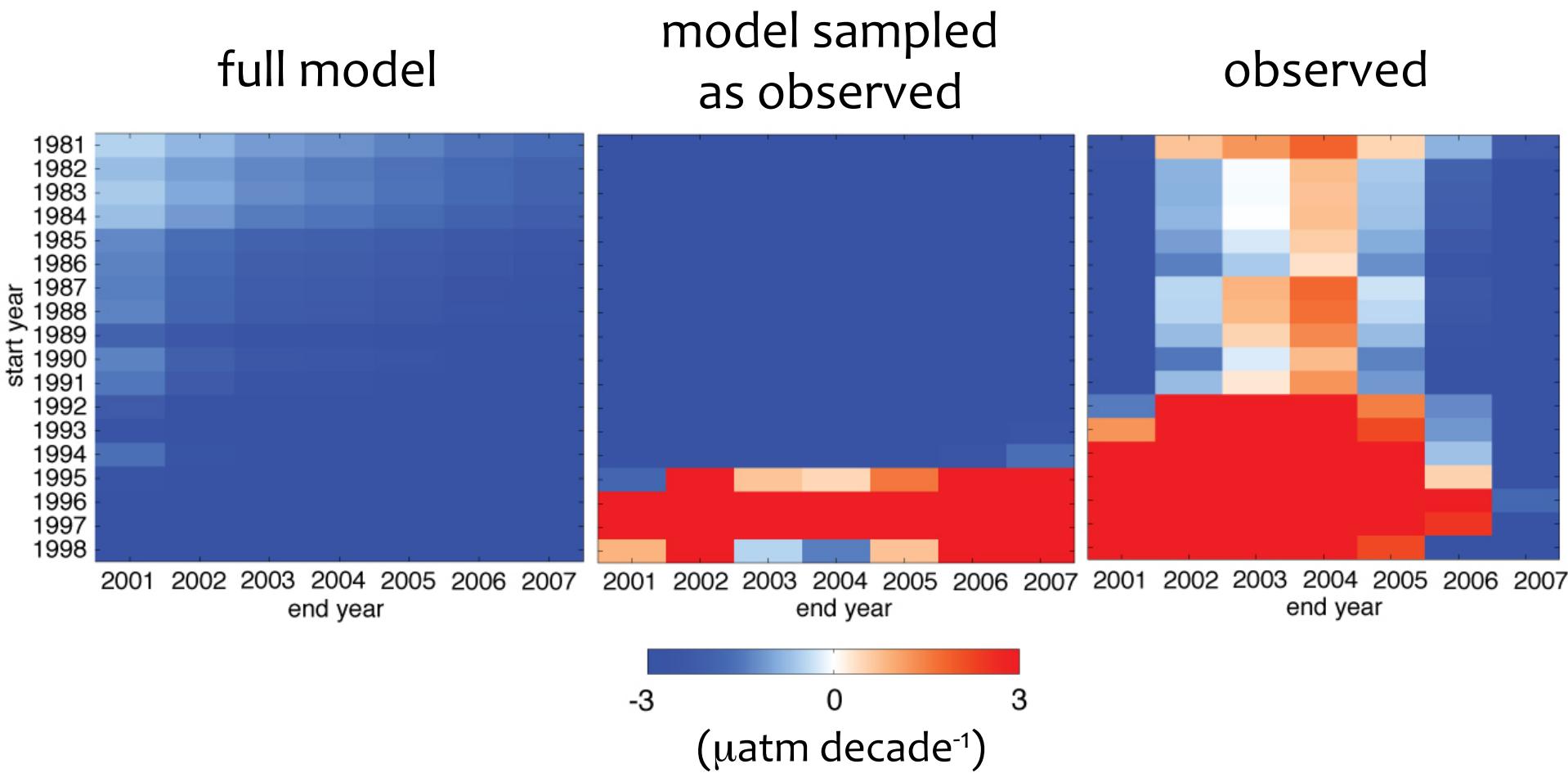
Do we have observational biases?

$\Delta p\text{CO}_2$ trend, SO-SPSS



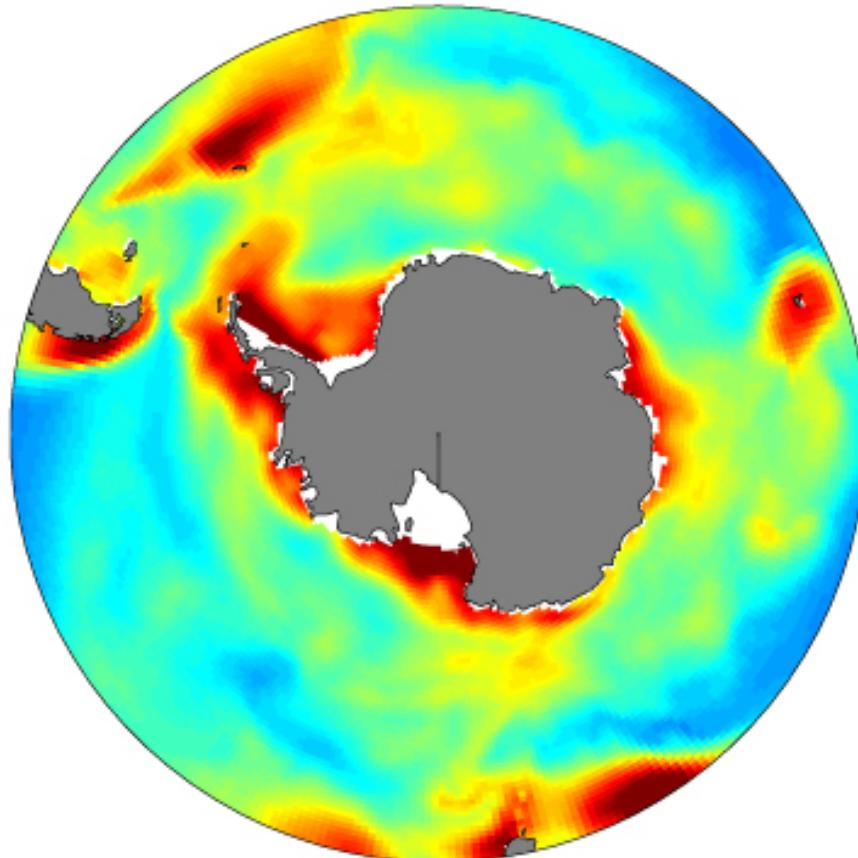
Do we have observational biases?

$\Delta p\text{CO}_2$ trend, SO-ICE

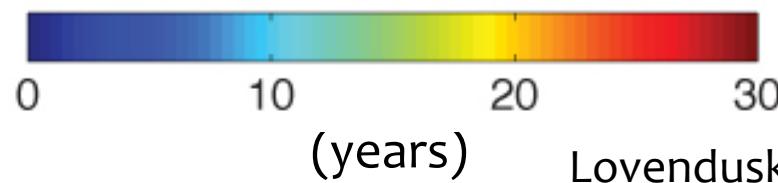
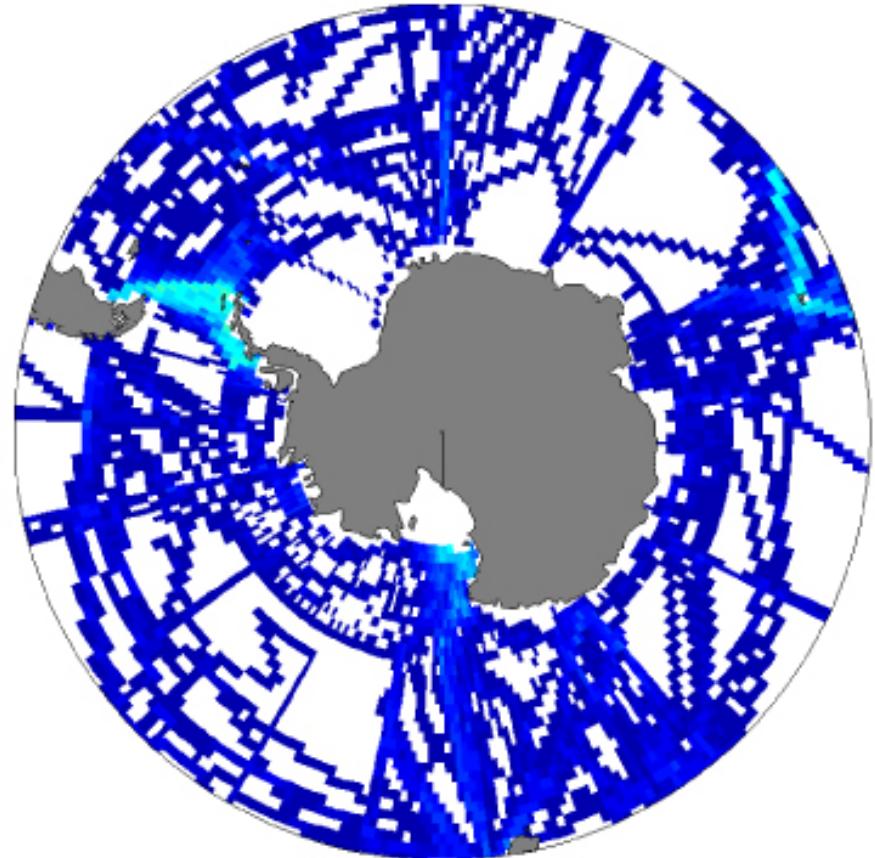


Do we have enough data?

Required length of time series



Years of data available



Lovenduski et al. (in review, GBC)

Conclusions

1. Are CO₂ flux trends affected by the choice of start/end year or season?
Start/end year: Yes.
Season: Not significantly.
2. Does the observational sampling introduce biases into the ΔpCO₂ trends?
In SO-SPSS: Only slightly.
In SO-ICE: Yes, but also model bias.
3. Do we have enough observational data to detect a weakening CO₂ sink?
No, but one promising route to detection is data from the Drake Passage time series.