

# The impact of the ozone hole on Southern Ocean carbon uptake

Nikki Lovenduski

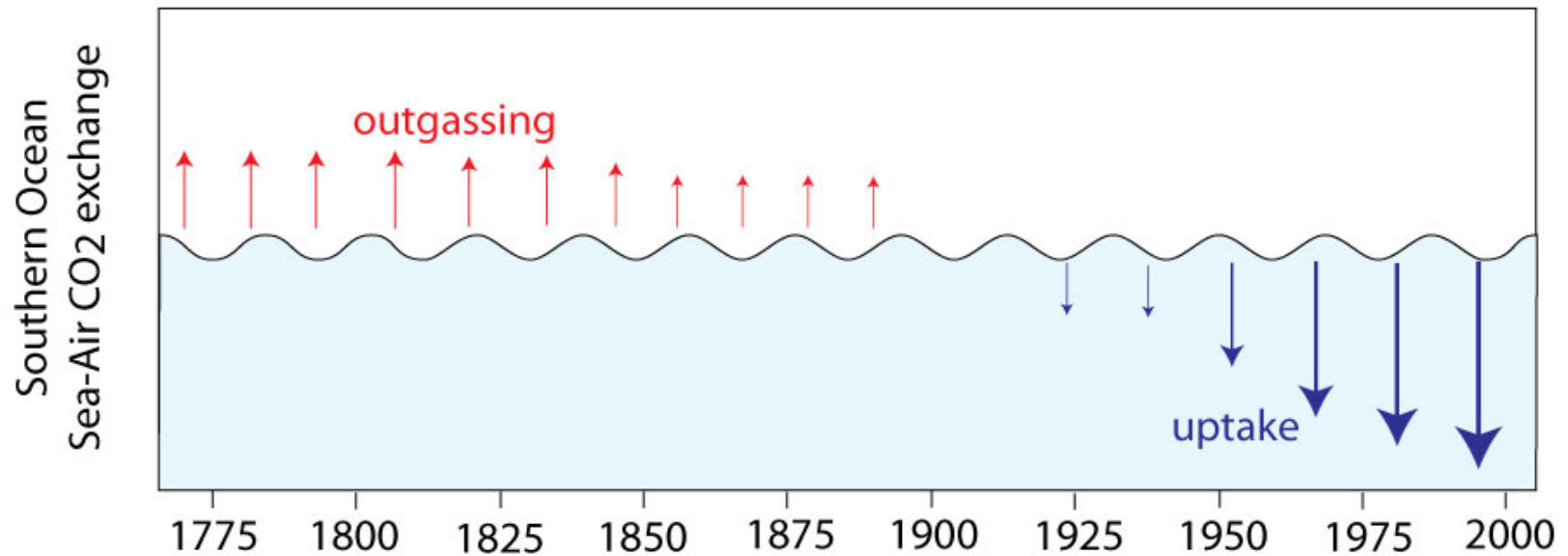
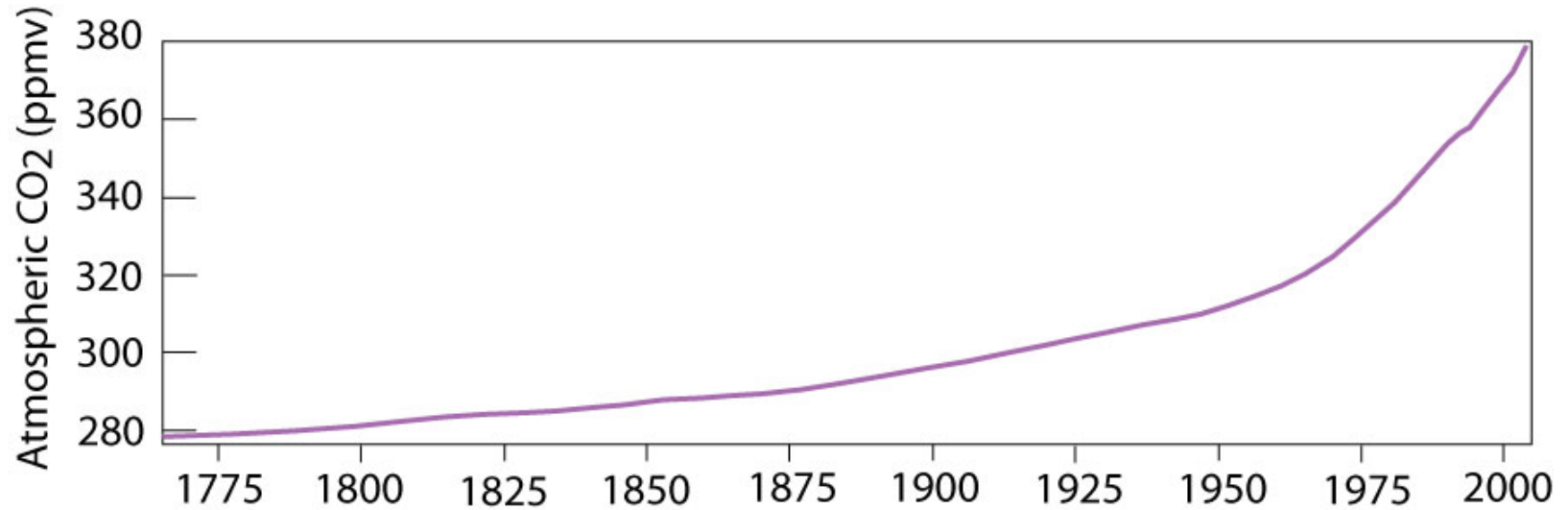
University of Colorado Boulder

*thanks to:*

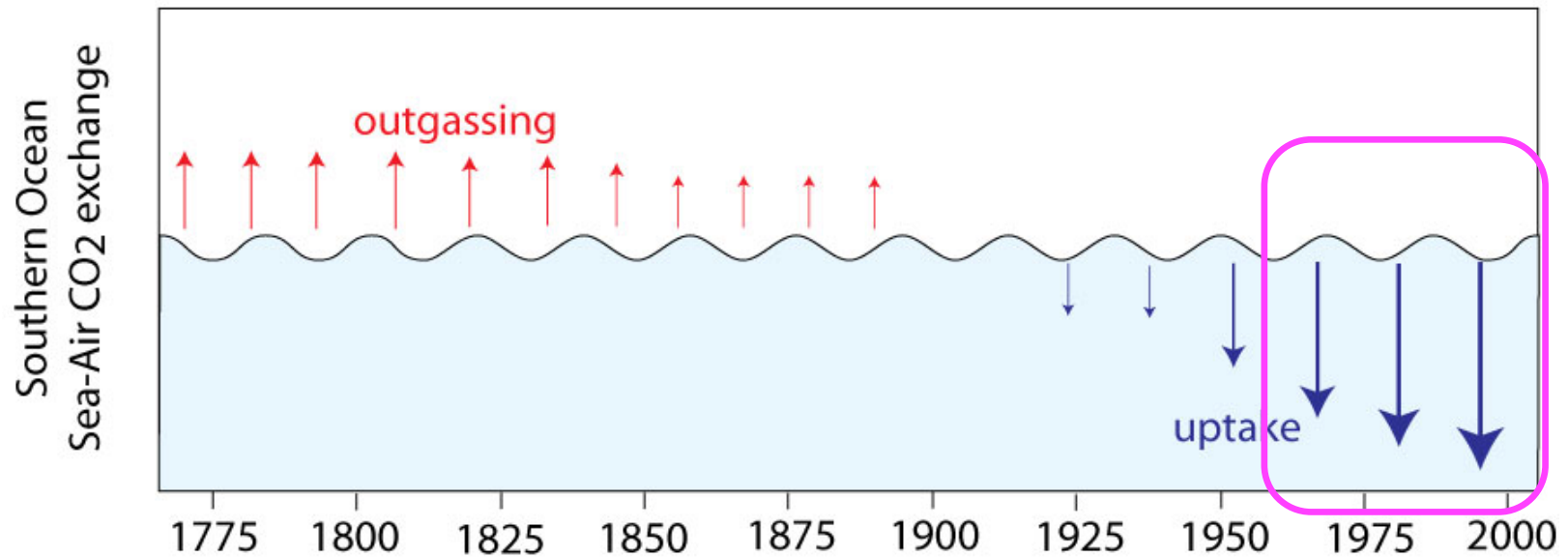
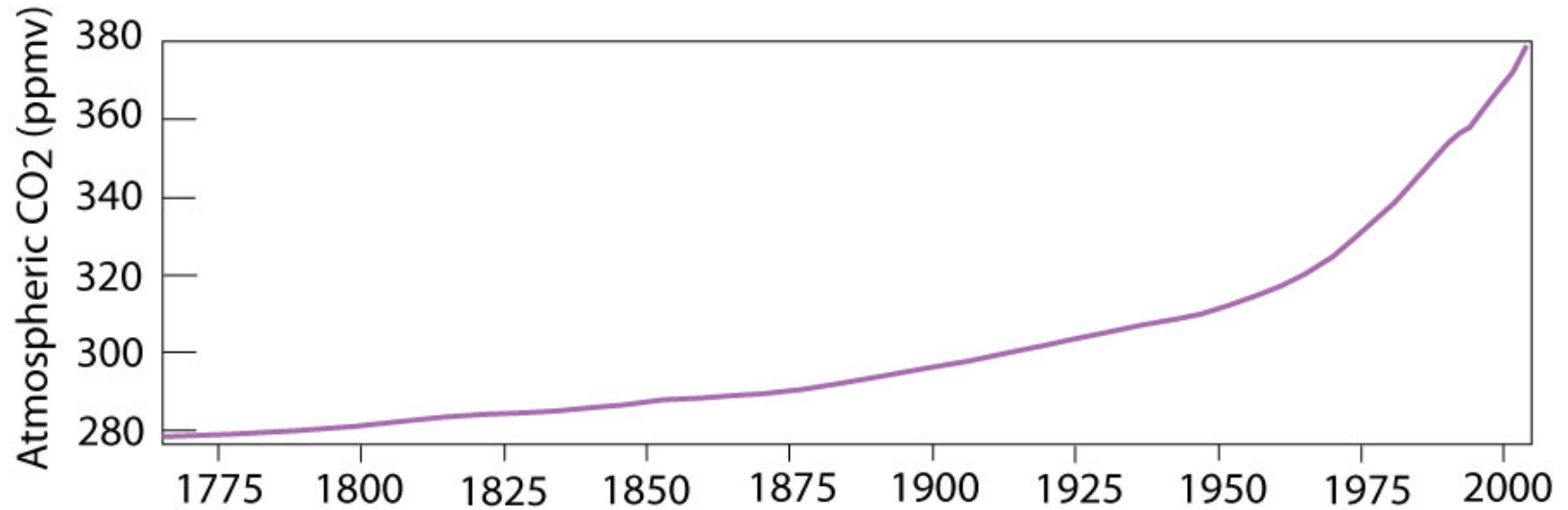
*Lorenzo Polvani and Ari Solomon*

*Columbia University*

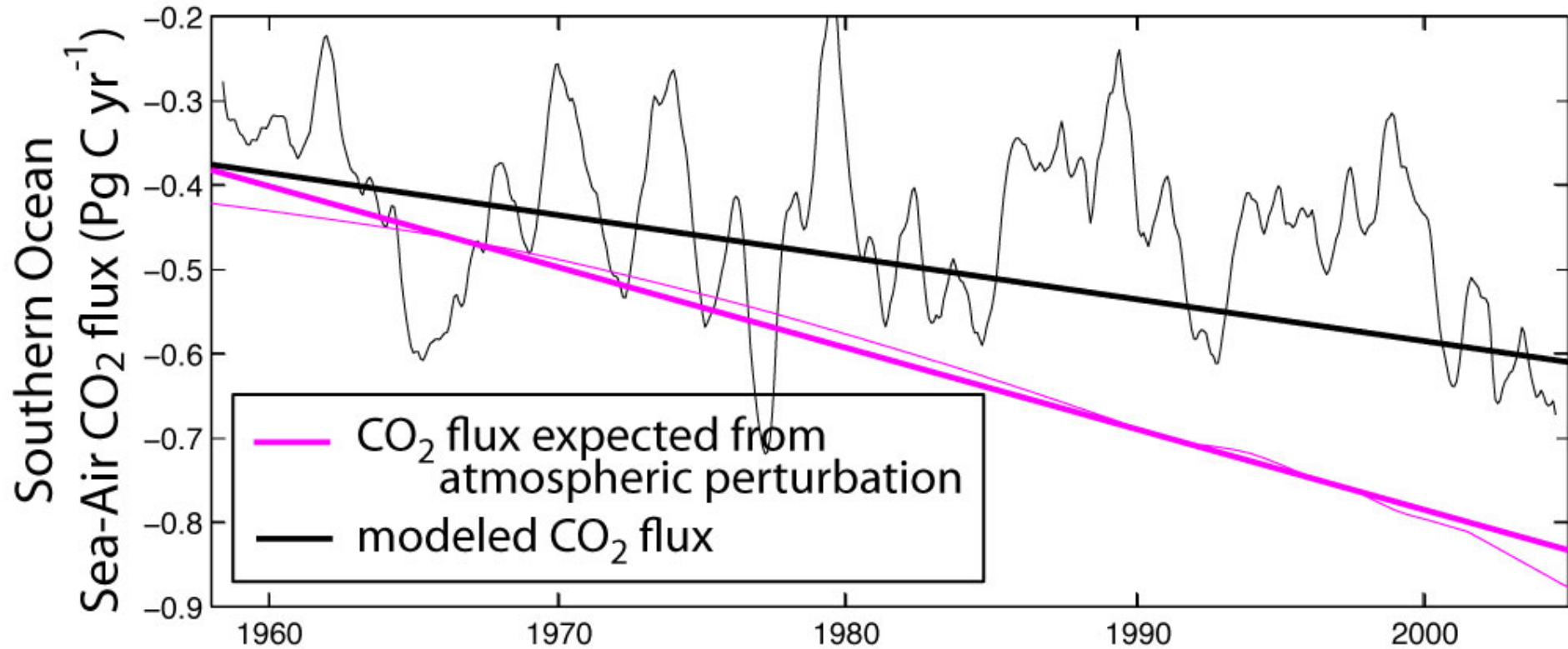
# Evolution of Southern Ocean CO<sub>2</sub> exchange



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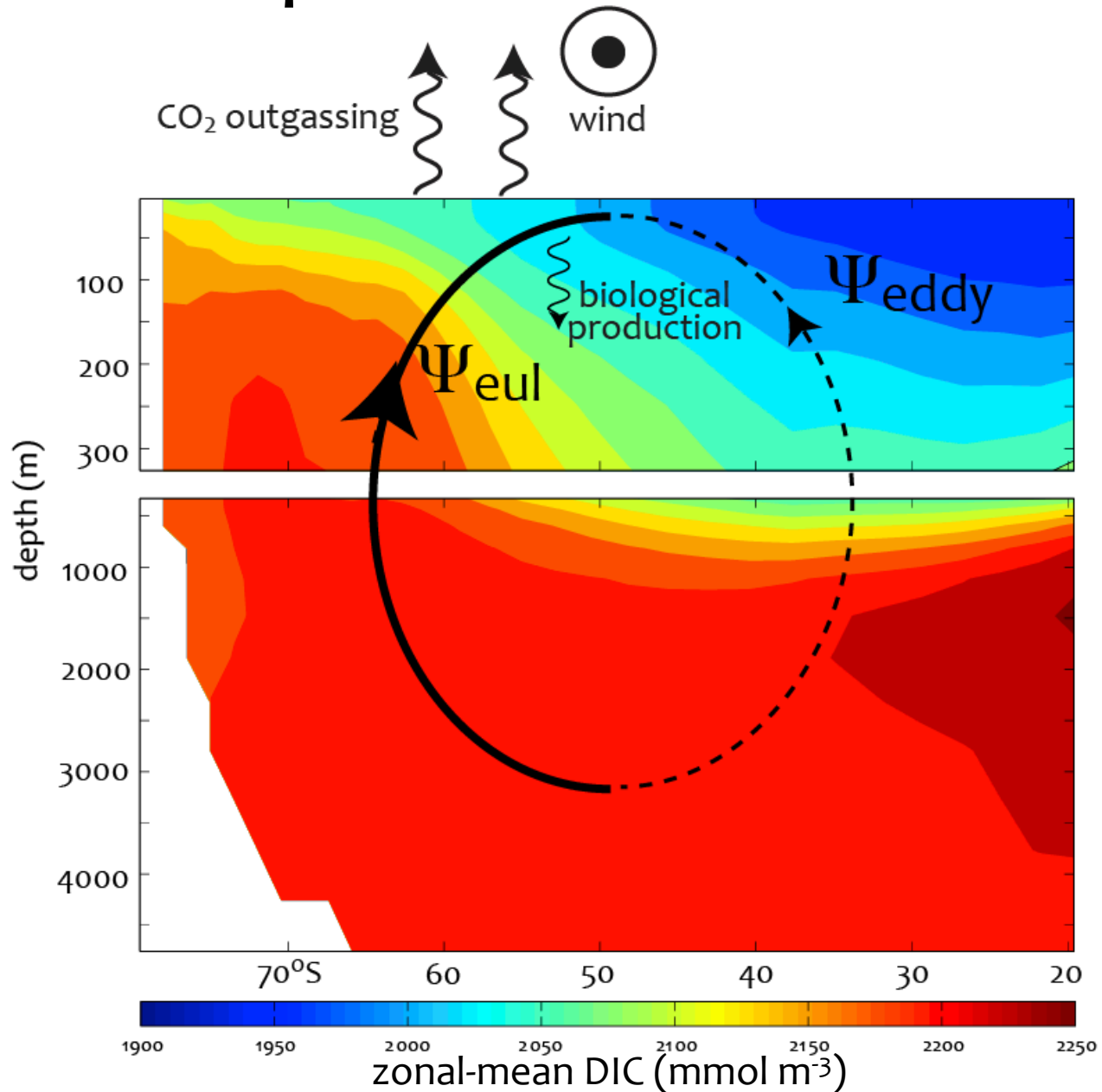


# Changes in Southern Ocean carbon uptake?



adapted from Lovenduski et al. (2008)

# Proposed mechanism



# Is the ozone hole the culprit?

GEOPHYSICAL RESEARCH LETTERS, VOL. 36, L12606, doi:10.1029/2009GL038227, 2009

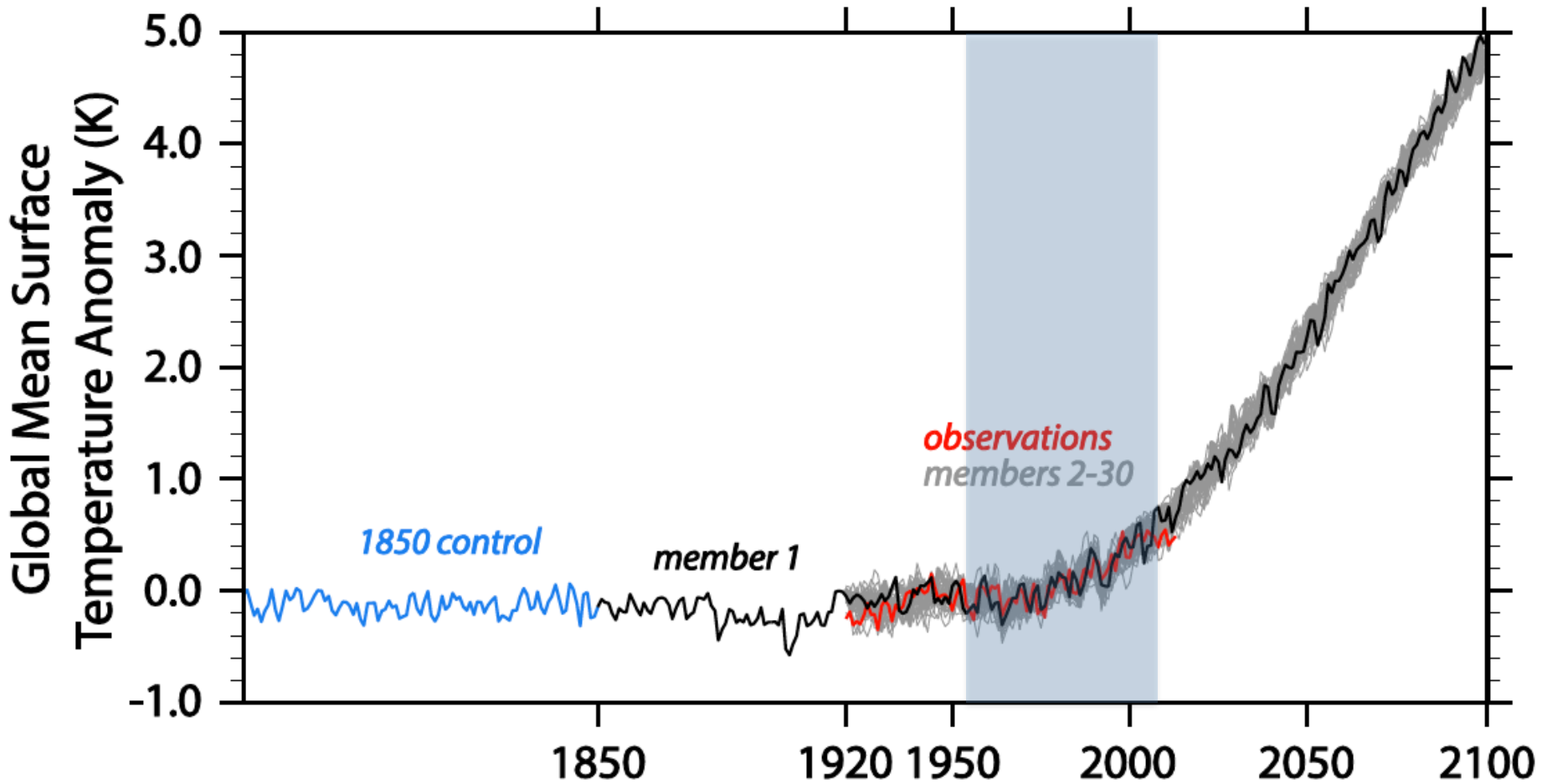
## **Stratospheric ozone depletion reduces ocean carbon uptake and enhances ocean acidification**

Andrew Lenton,<sup>1</sup> Francis Codron,<sup>2</sup> Laurent Bopp,<sup>3</sup> Nicolas Metzl,<sup>1</sup> Patricia Cadule,<sup>3</sup> Alessandro Tagliabue,<sup>3</sup> and Julien Le Sommer<sup>4</sup>

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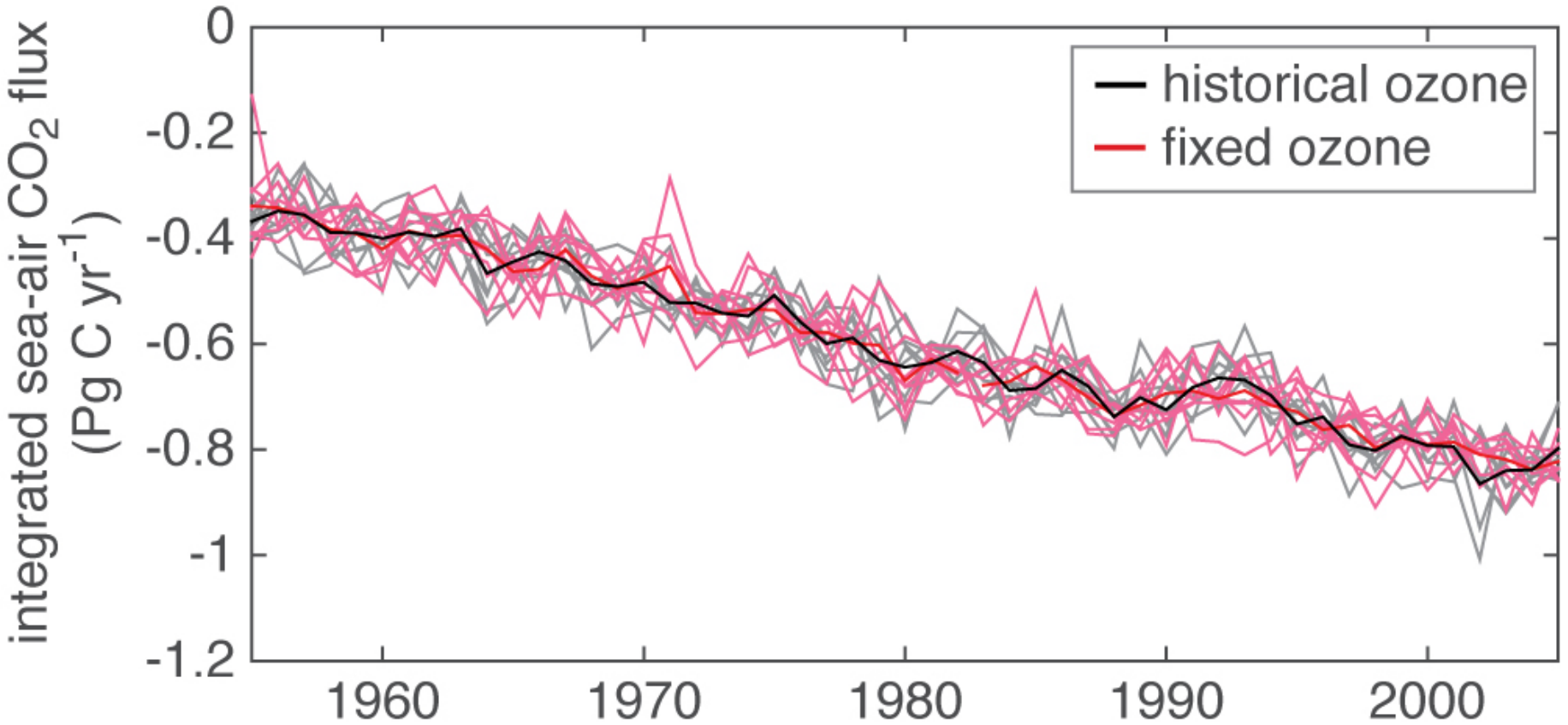
*“We show that by accounting for stratospheric ozone depletion in a coupled-climate-carbon model ... Southern Ocean carbon uptake is reduced by 2.47 Pg C (1987-2004).”*

# The CESM ensembles



# Does the ozone hole change carbon uptake?

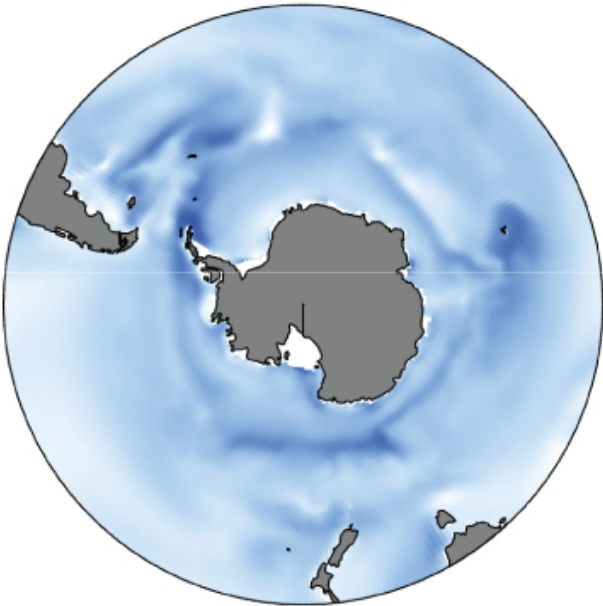
Southern Ocean (south of 35°S) integrated CO<sub>2</sub> flux



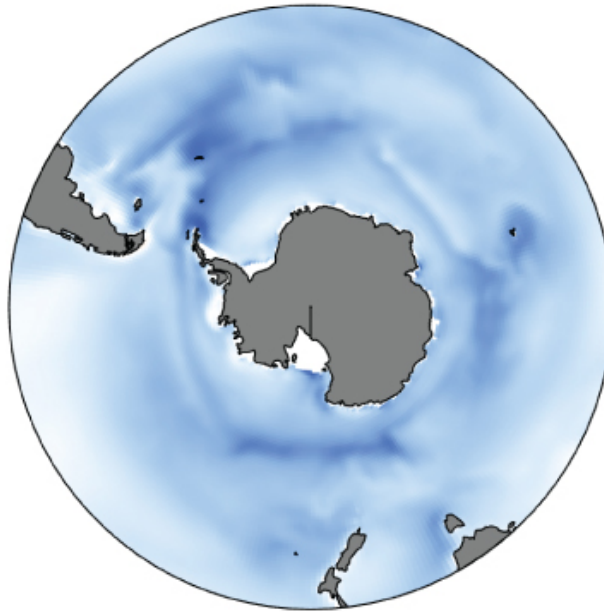


# Change in CO<sub>2</sub> flux [1996-2005] – [1955-1964]

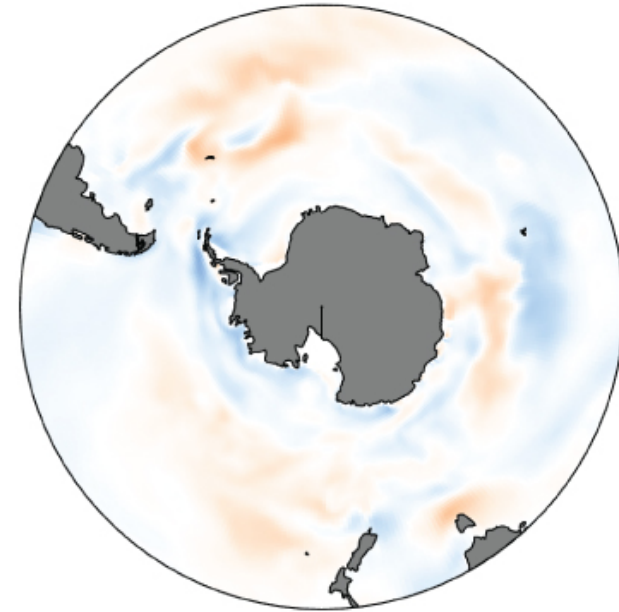
historical ozone



fixed ozone

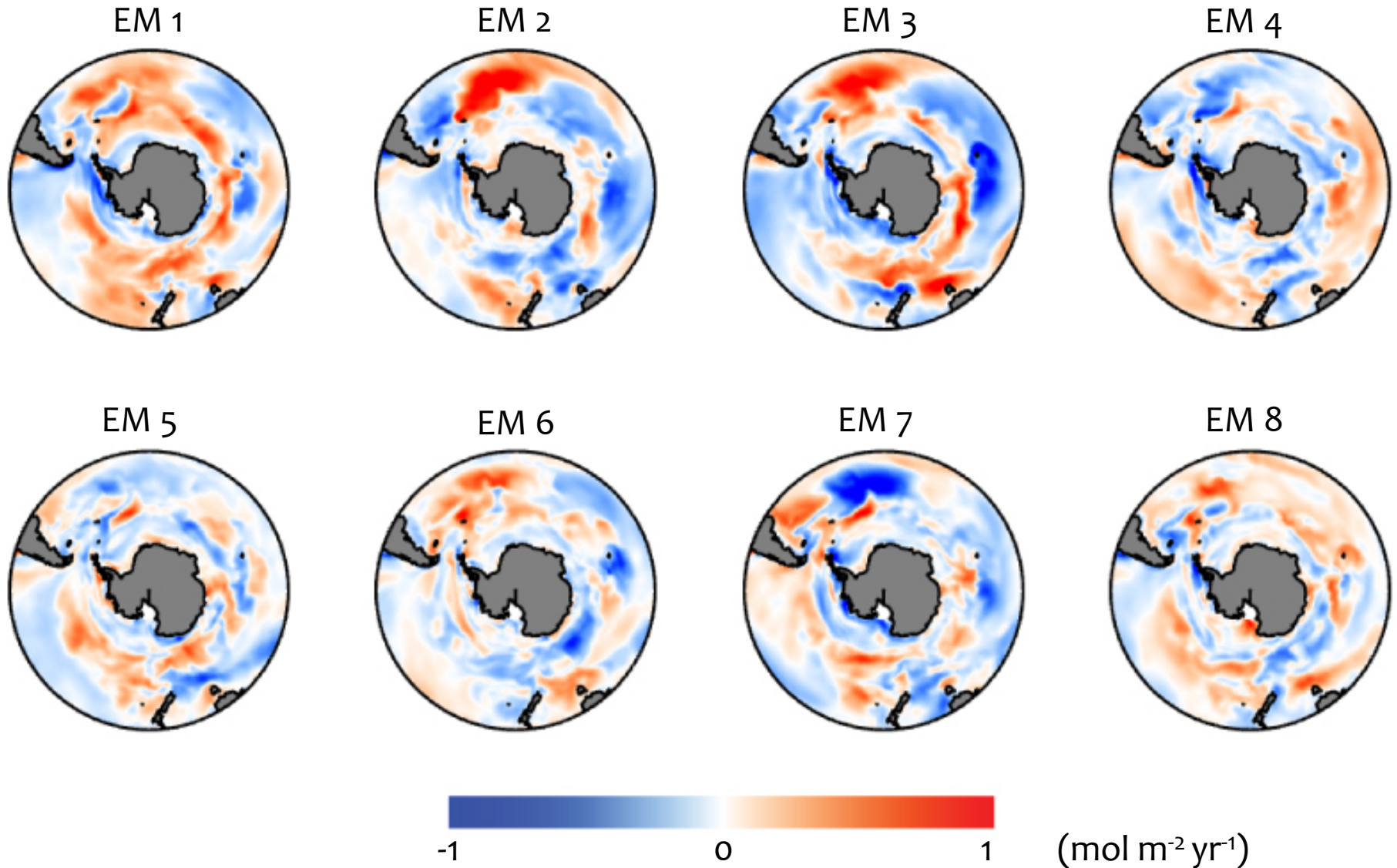


ozone hole



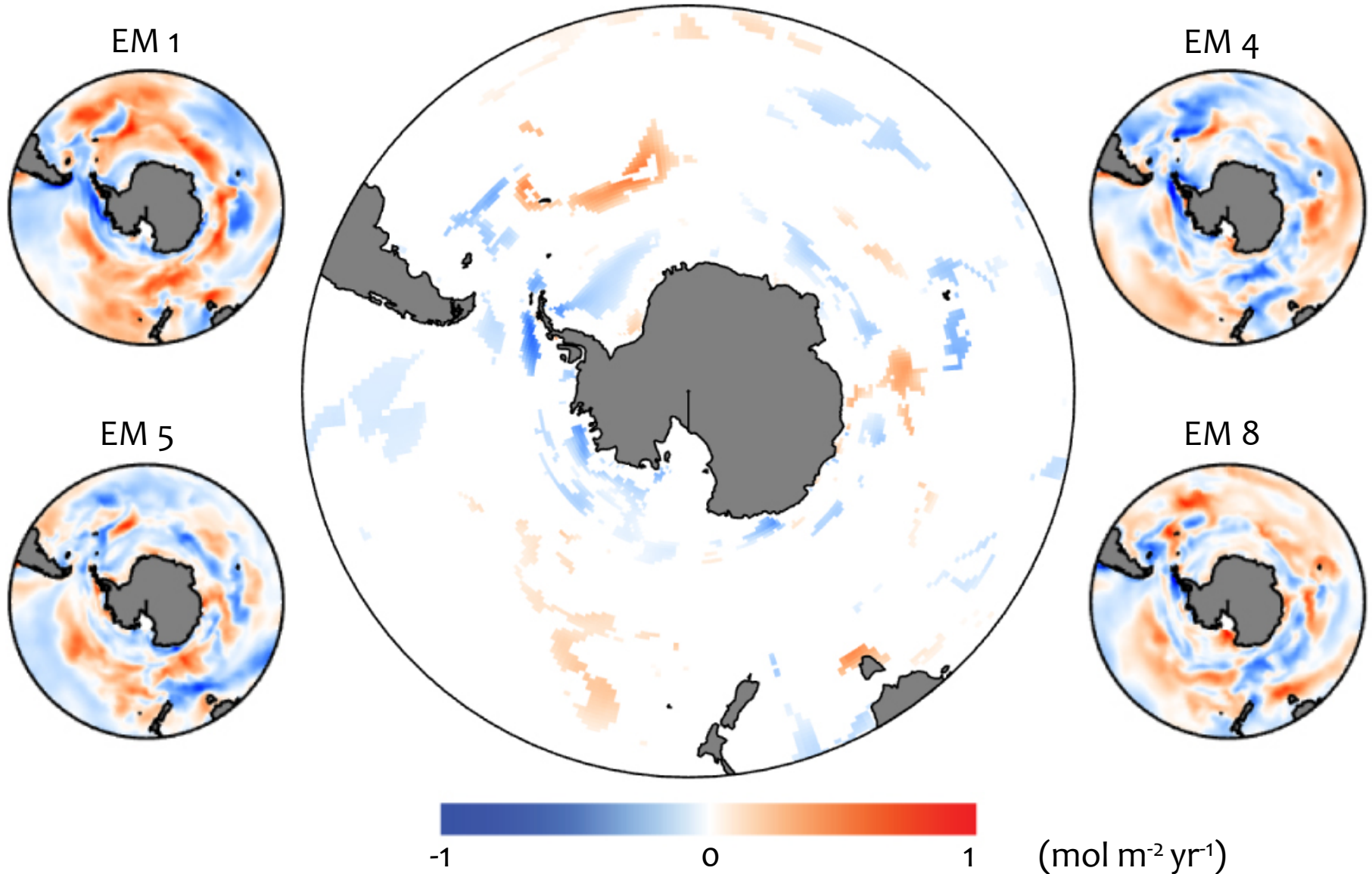
# Change in CO<sub>2</sub> flux due to ozone hole

[1996-2005] – [1955-1964]



# Change in CO<sub>2</sub> flux due to ozone hole

[1996-2005] – [1955-1964]

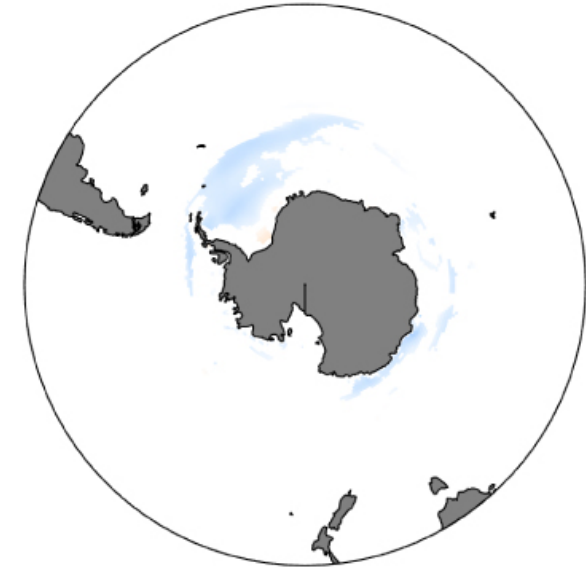
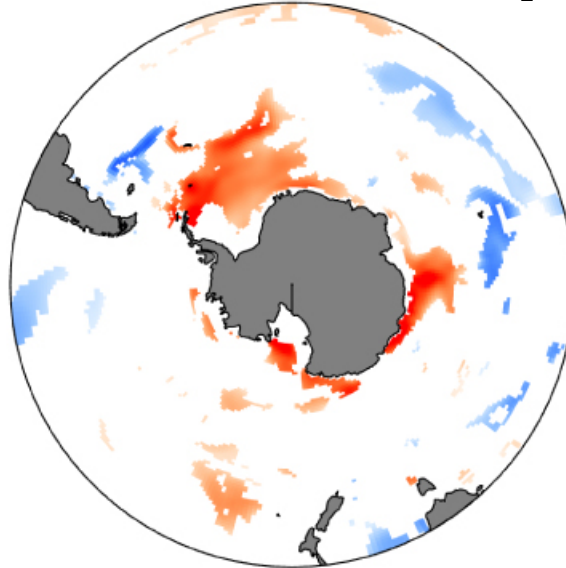


# Contributions to $\Delta\Delta\text{CO}_2$ flux

contribution from  $\Delta p\text{CO}_2$

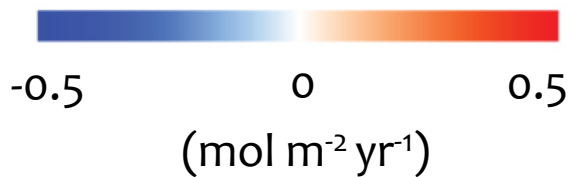
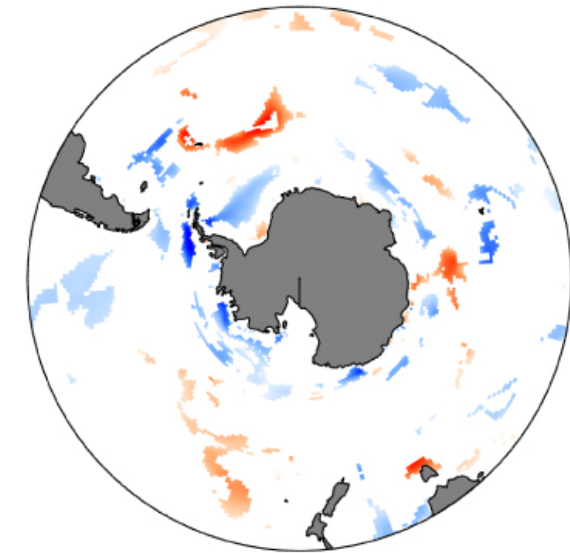
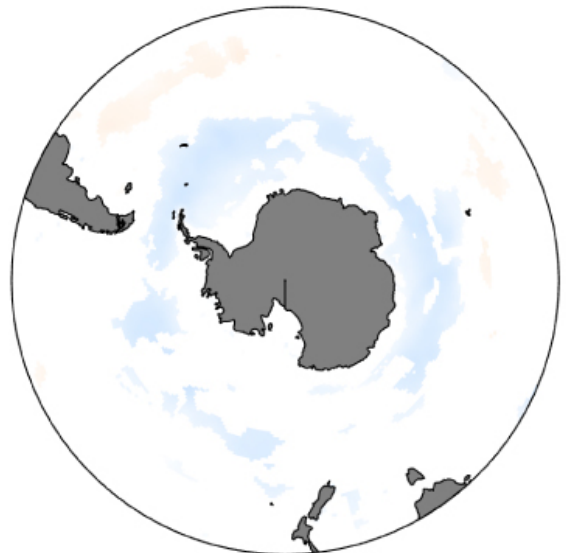
contribution from ice

ozone hole  
 $\Delta\text{CO}_2$  flux



contribution from piston velocity

contribution from solubility



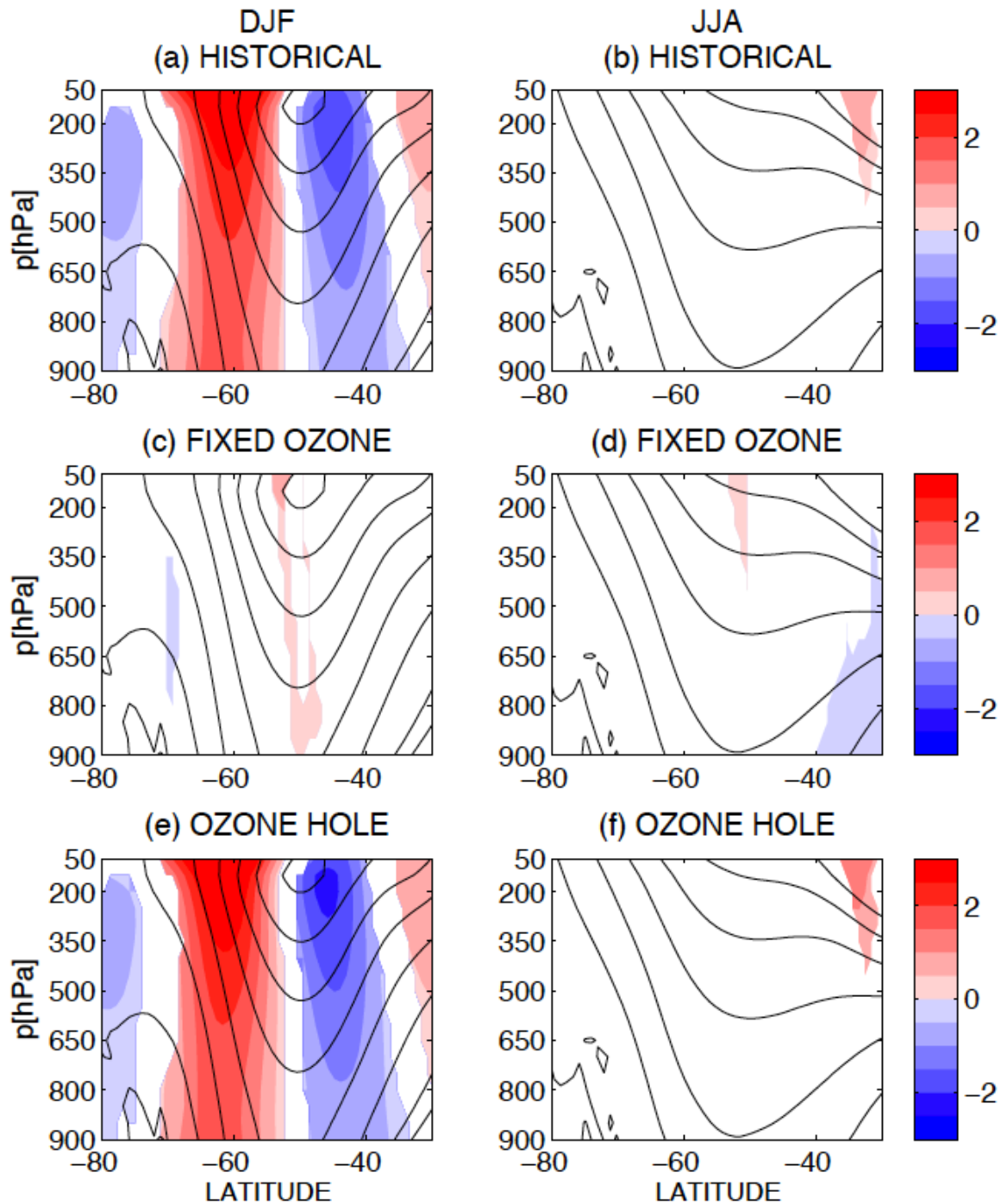
# Conclusions

- The CESM historical and fixed ozone ensembles suggest that the ozone hole has no significant impact on the Southern Ocean carbon sink from 1955-2005.
- Reasons for the lack of ozone impact:
  - Southern Ocean CO<sub>2</sub> flux variability is large across the ensemble members
  - The significant increase in surface ocean pCO<sub>2</sub> is masked by simultaneous increases in sea ice concentration and piston velocity

**The End!**

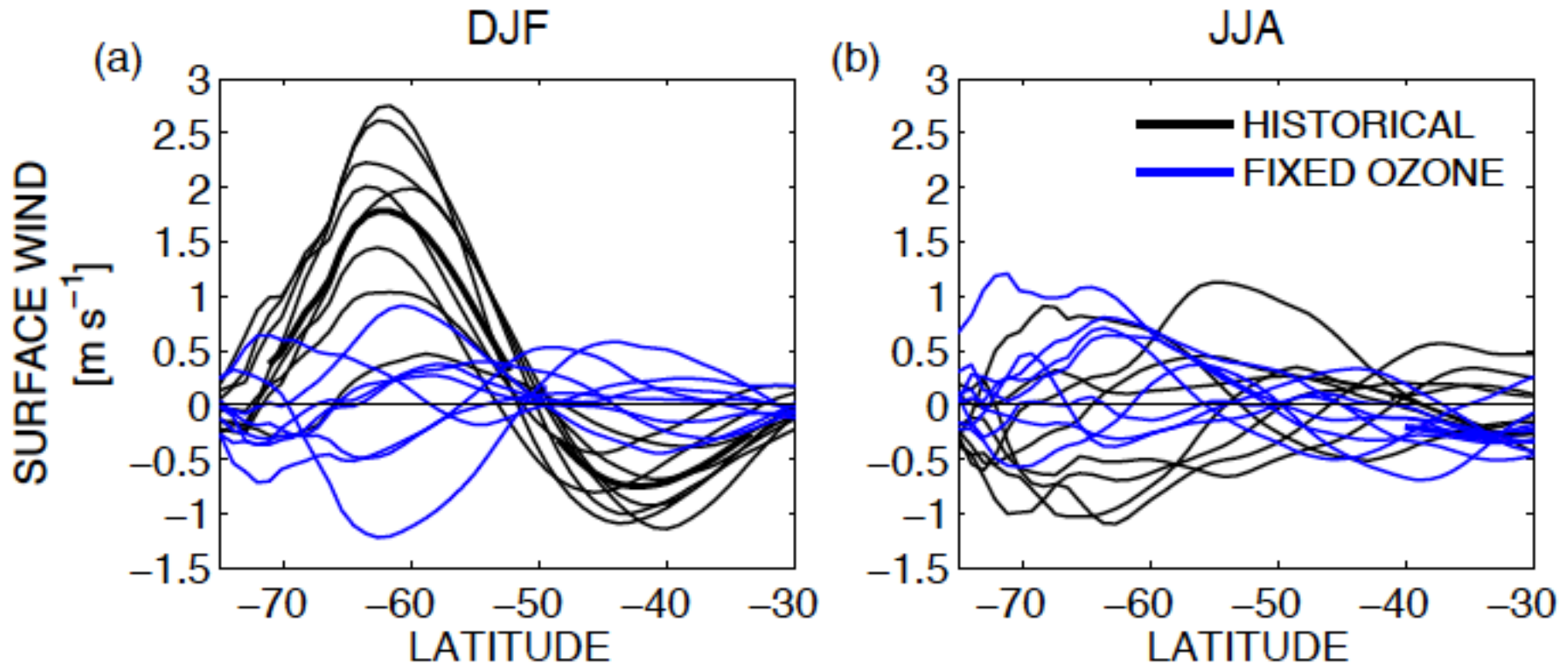


Change in wind speed  
[1996-2005]-[1955-1964]



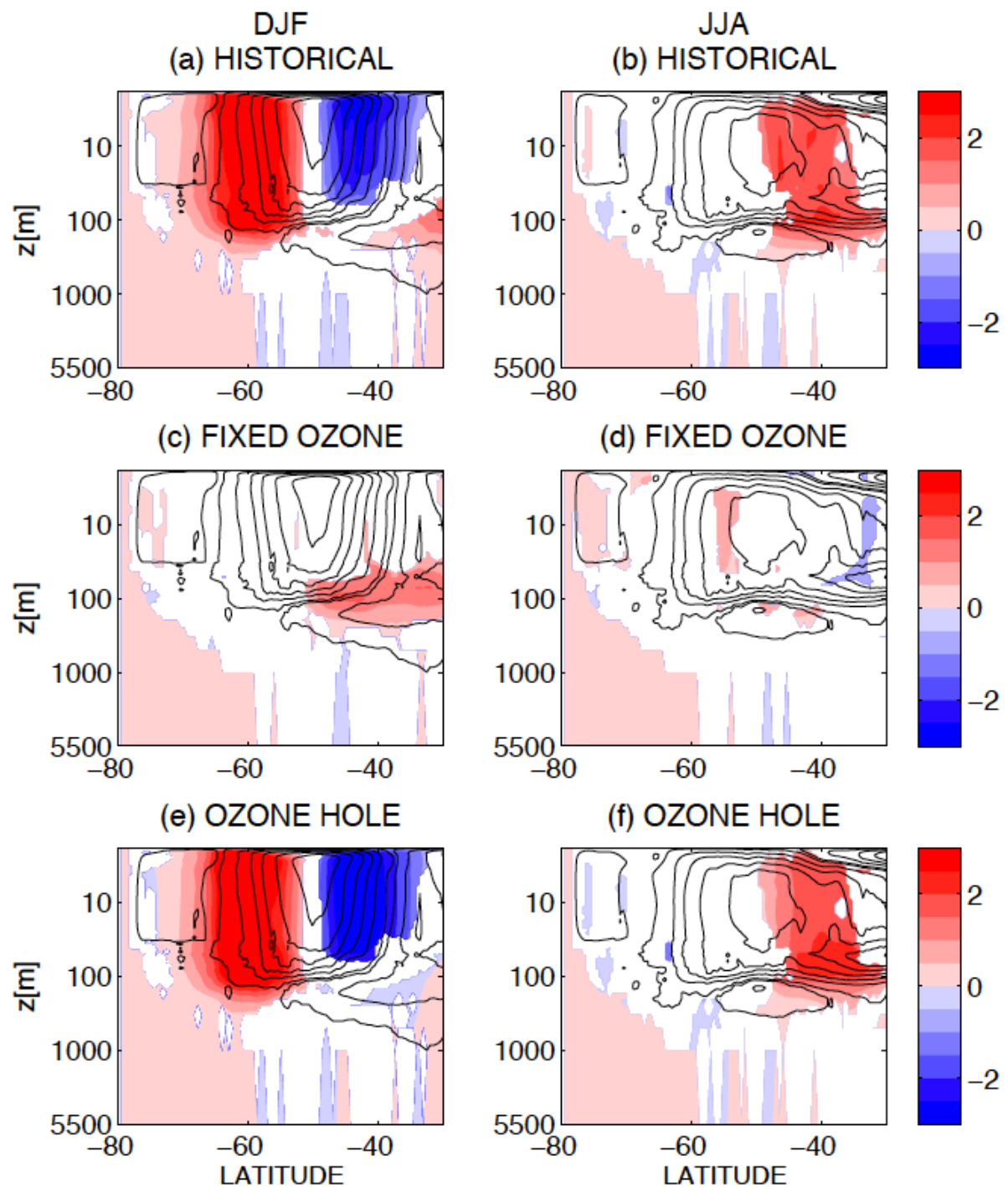
# Change in surface wind speed

[1996-2005]-[1955-1964]

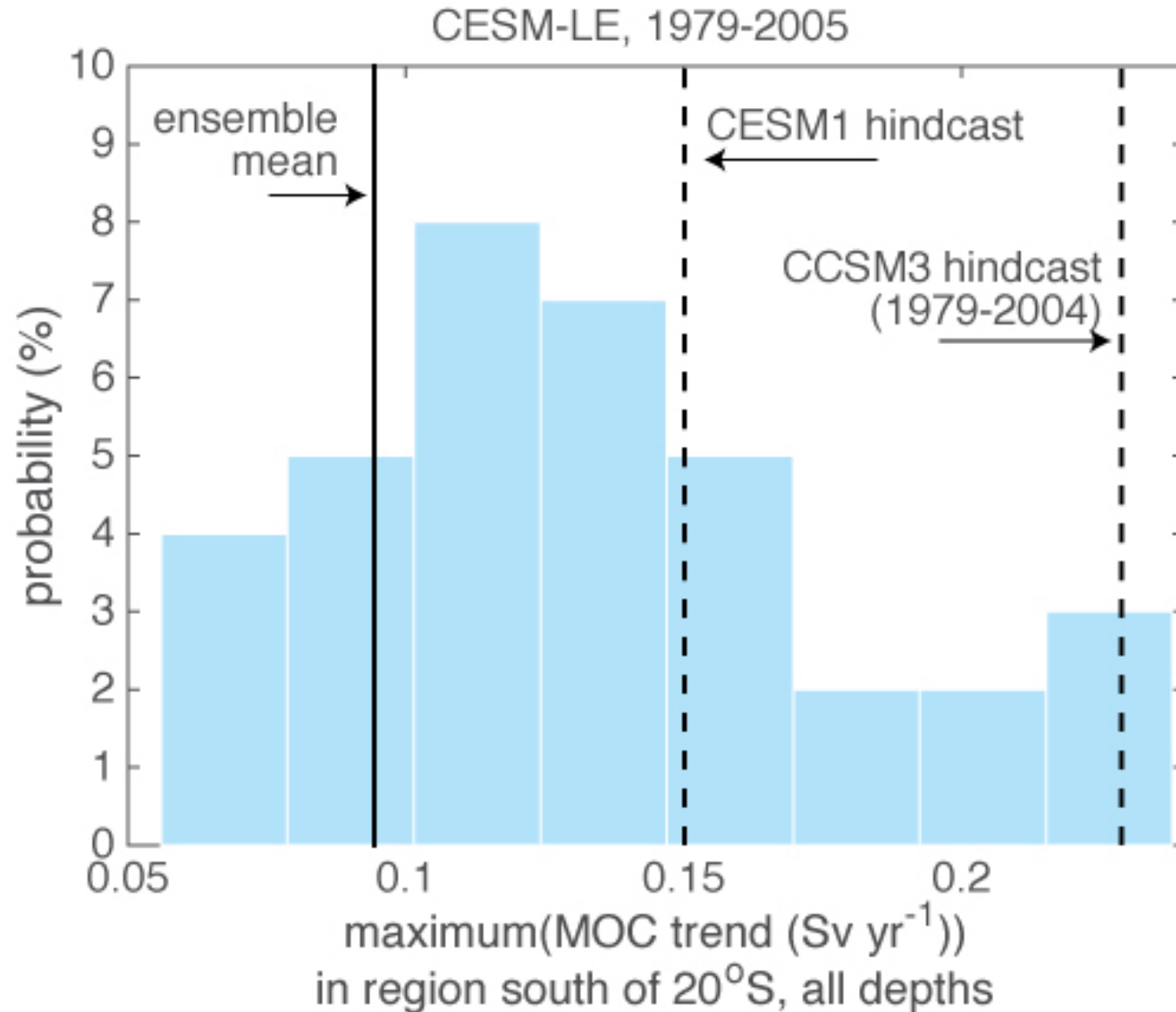




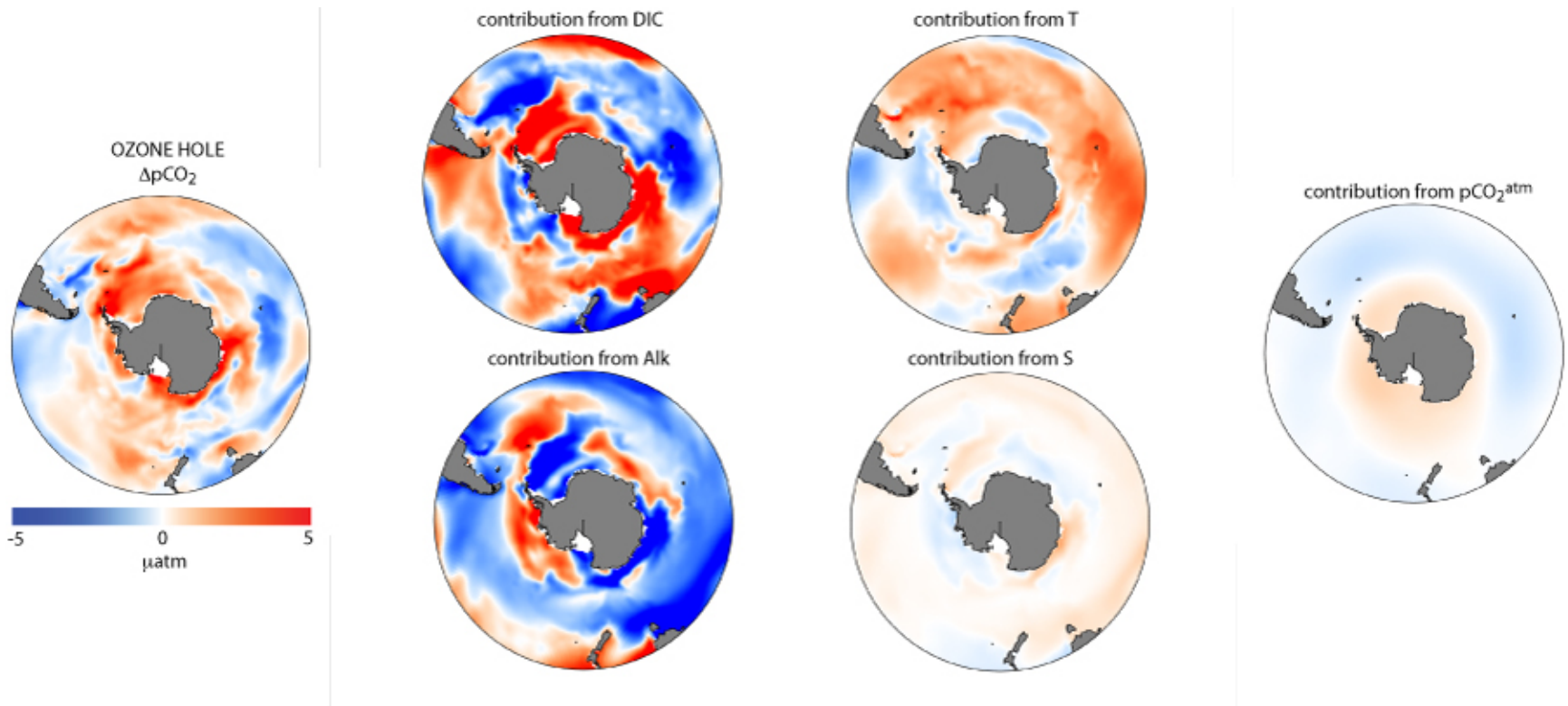
# Change in MOC [1996-2005]-[1955-1964]



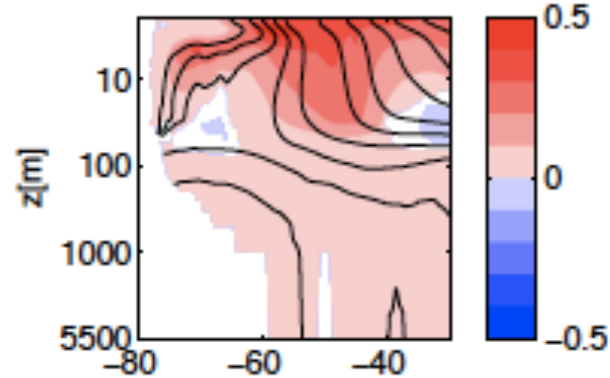
# MOC trend: how does it compare?



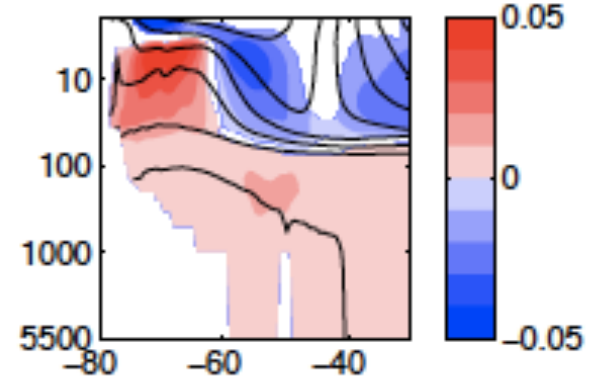
# Contributions to $\Delta\Delta\Delta p\text{CO}_2$



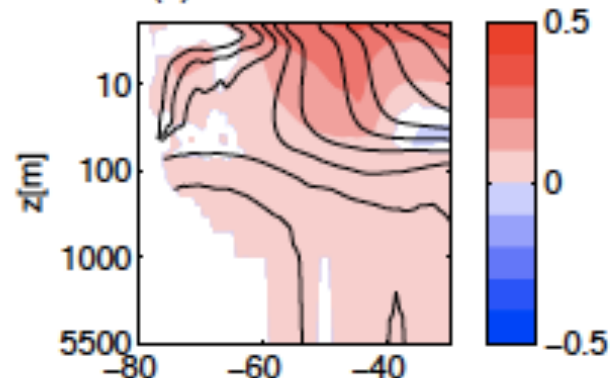
TEMPERATURE  
(a) HISTORICAL



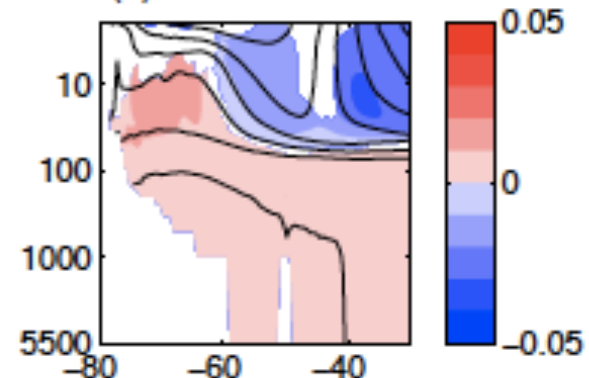
SALINITY  
(b) HISTORICAL



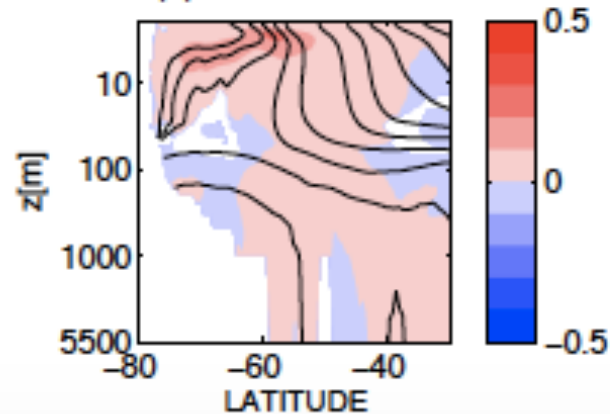
(c) FIXED OZONE



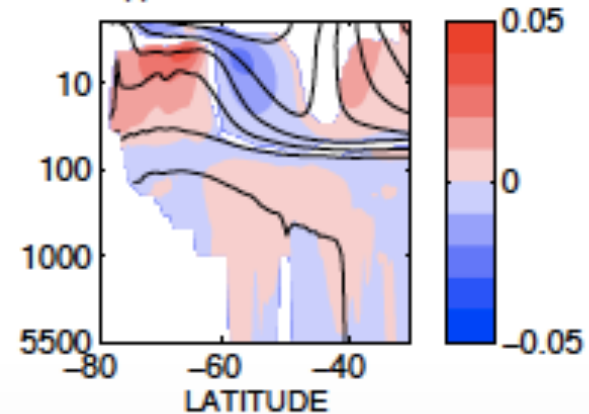
(d) FIXED OZONE



(e) OZONE HOLE



(f) OZONE HOLE



# What about “natural” CO<sub>2</sub> flux?

