

# **Southern Ocean meridional overturning and air-sea CO<sub>2</sub> flux variability in the CESM**

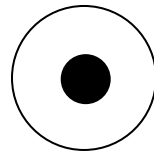
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# Motivation



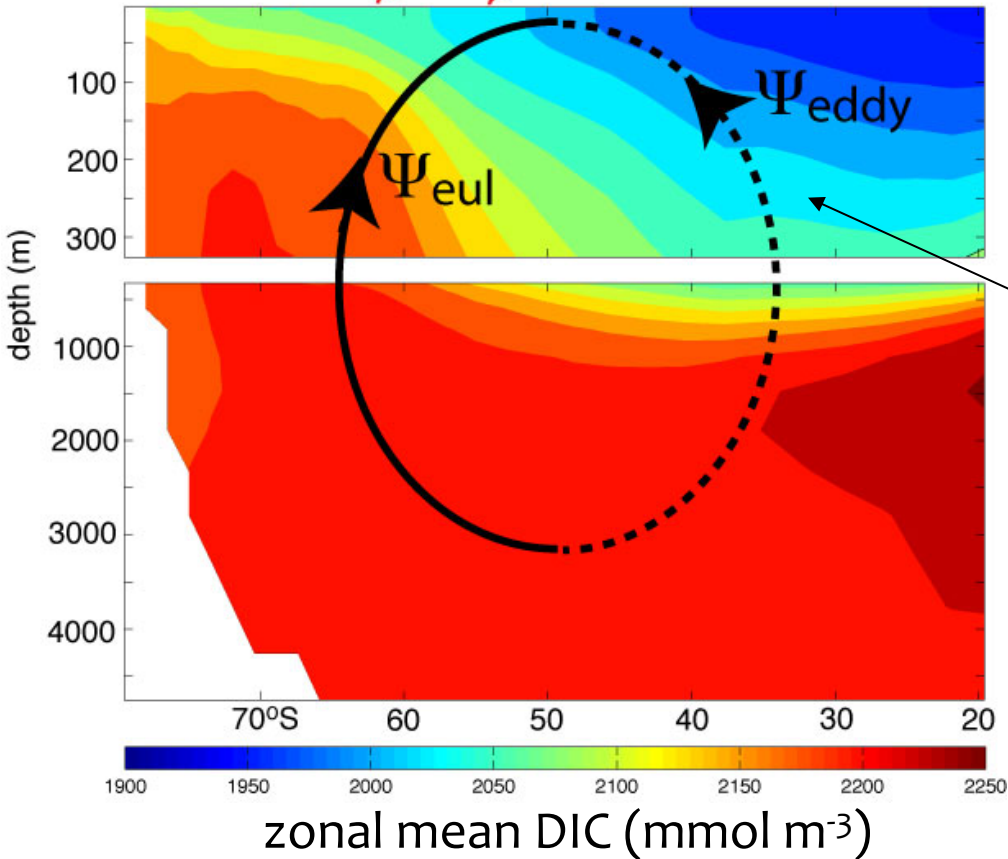
trend in surface wind

CO<sub>2</sub> outgassing



?

trend in sea-air CO<sub>2</sub> flux ?



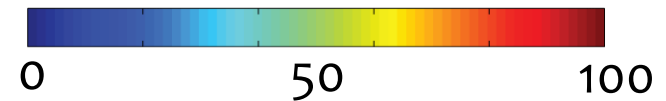
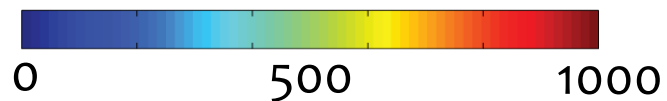
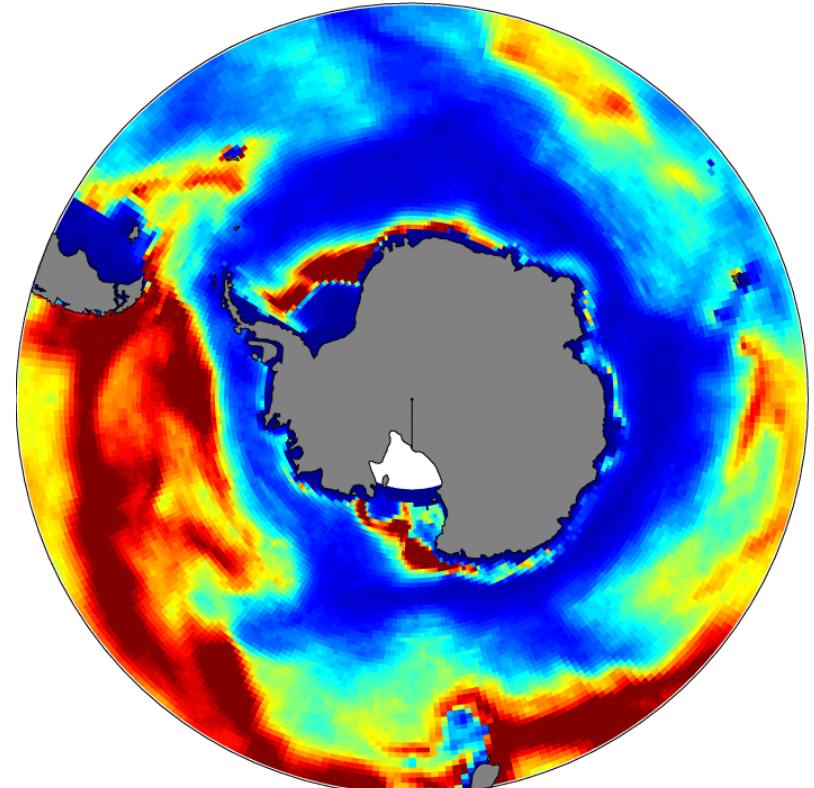
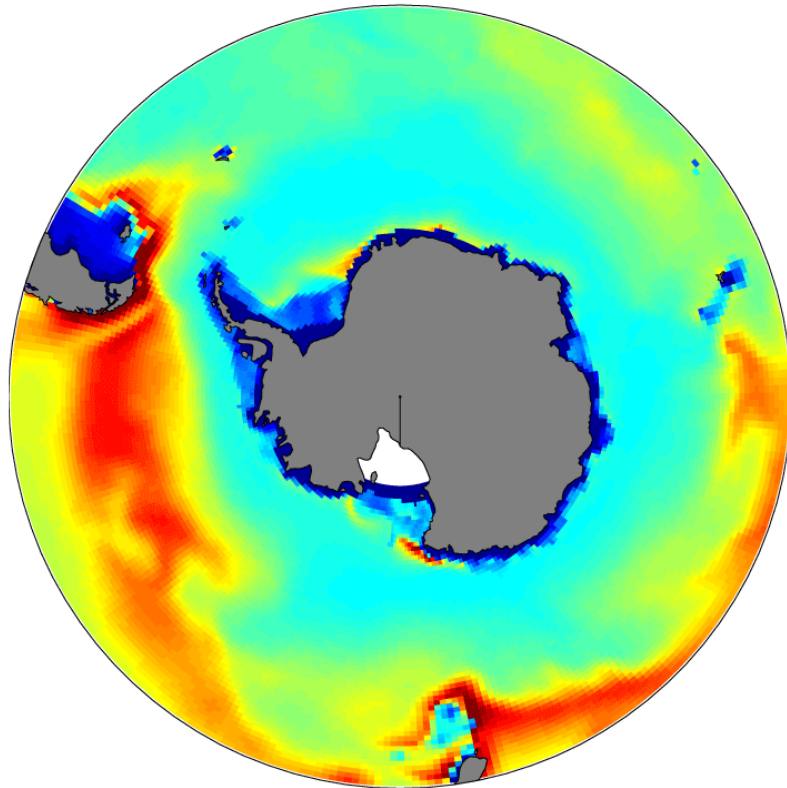
trend in overturning ?

adapted from Lovenduski et al. (2008)

# Eddy-induced advection coefficient, $\kappa$

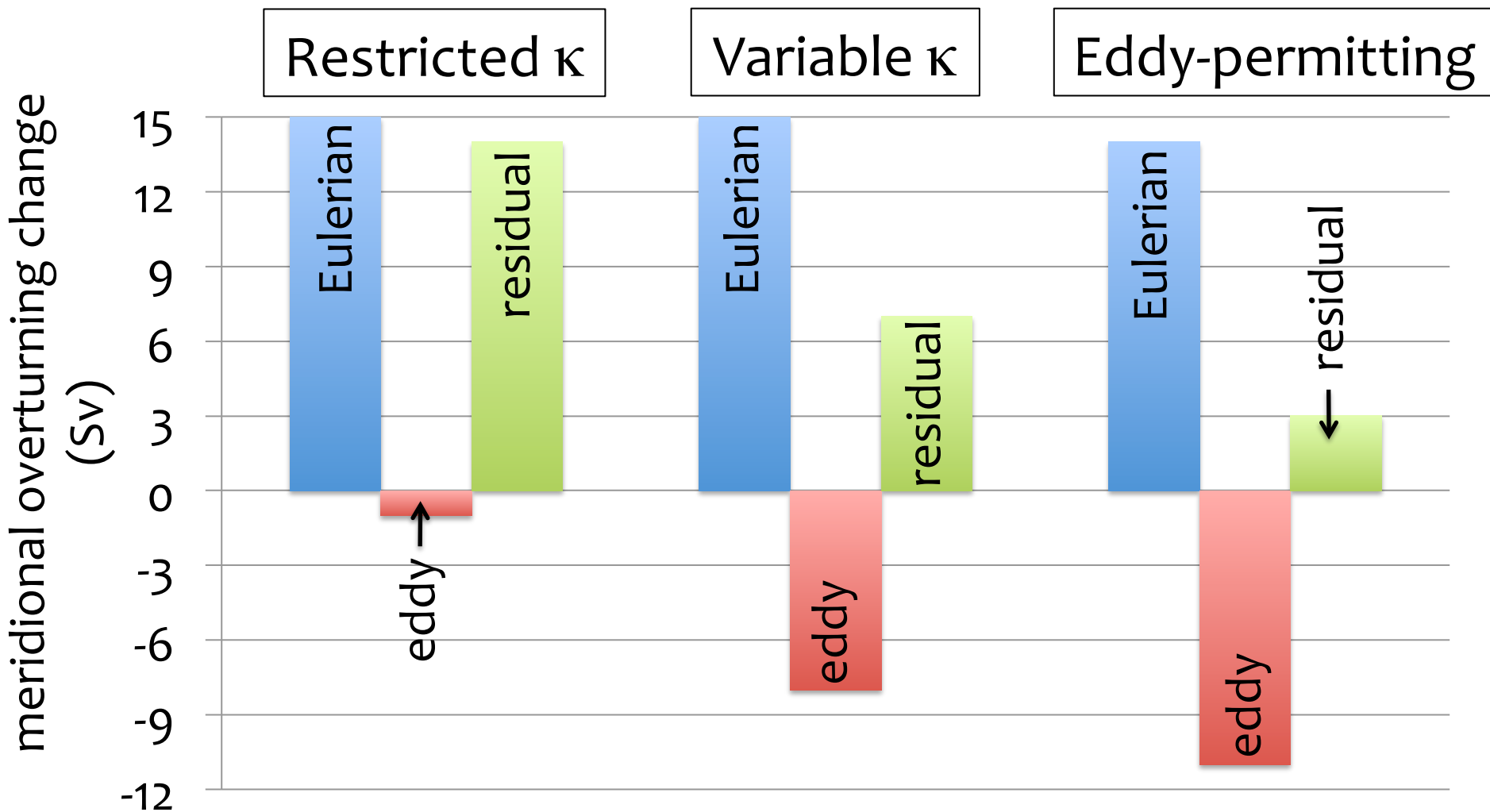
Mean value (top 1 km)

Standard deviation



( $\text{m}^2 \text{s}^{-1}$ )

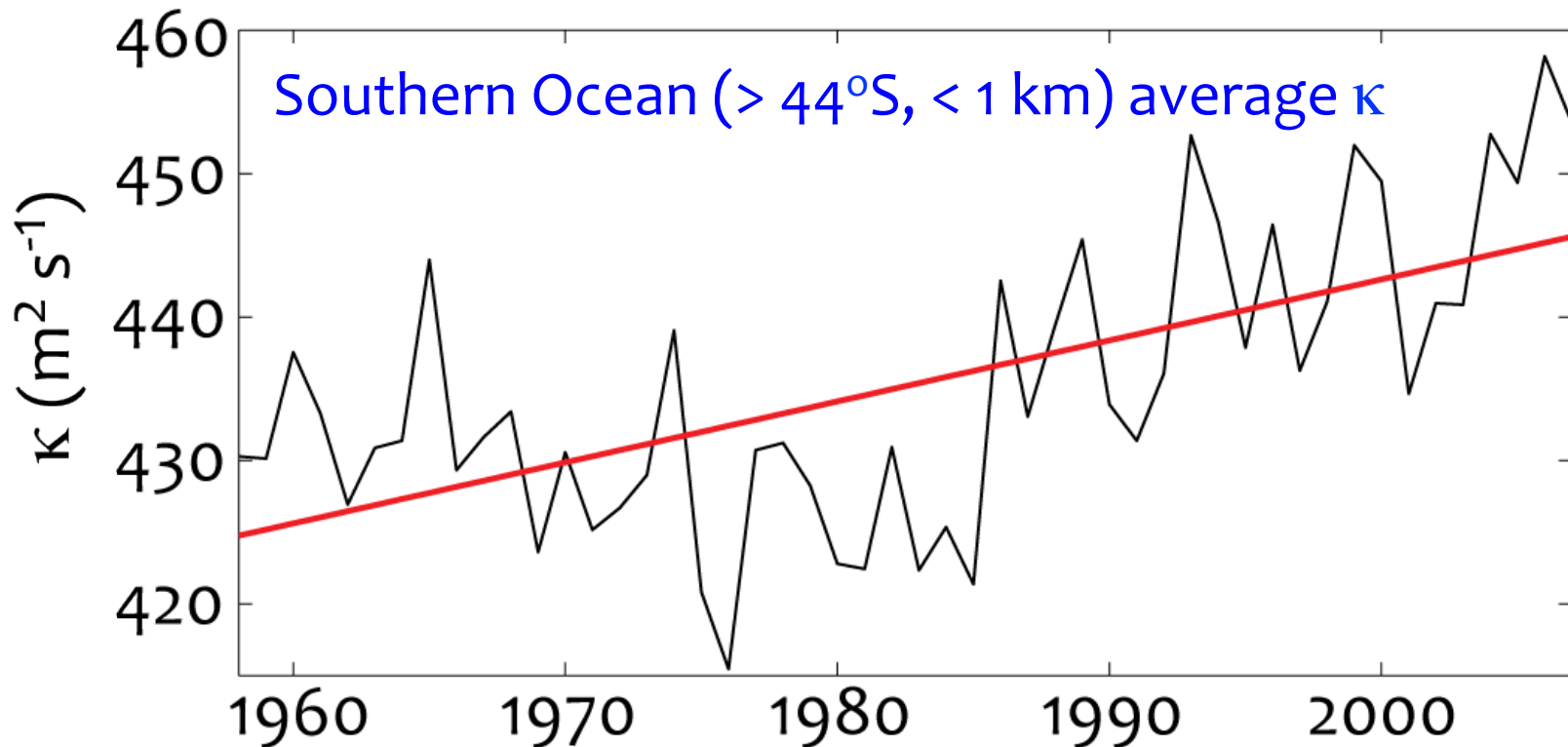
# Does $\kappa$ matter?



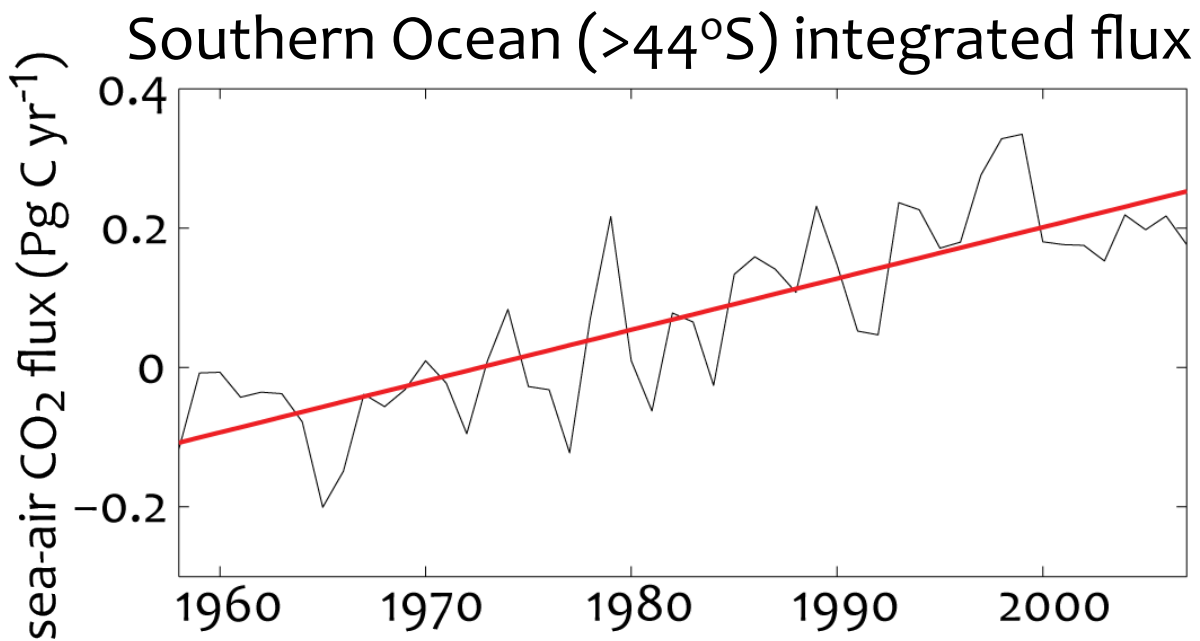
data from Farneti and Gent (2011)

# Community Earth System Model

- Coupled ocean-ice configuration
- Embedded biogeochemistry and ecology
- Forced with CORE winds, 1958-2007
- Atmospheric CO<sub>2</sub> = 285 ppm
- Variable eddy-induced advection coefficient,  $\kappa$



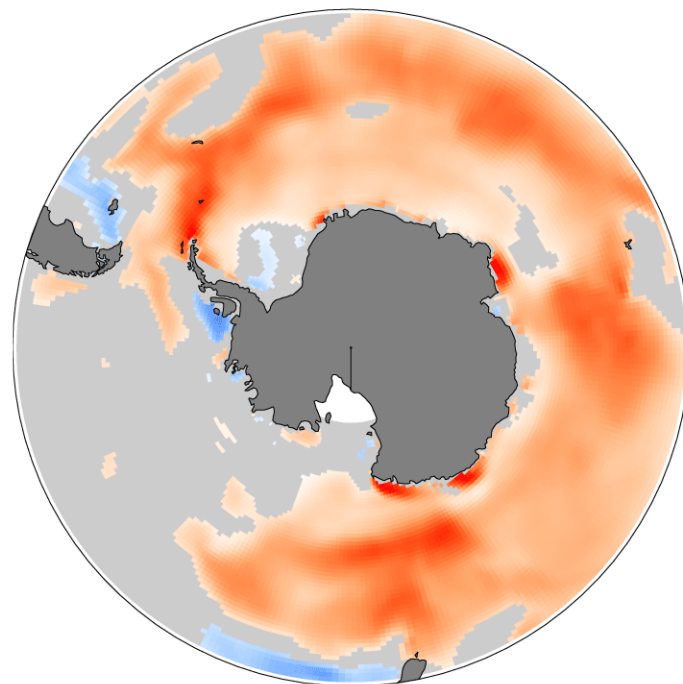
# Sea-air CO<sub>2</sub> flux



Linear trend  
1958-2007

CO<sub>2</sub> flux trend  
(mol C m<sup>-2</sup> yr<sup>-2</sup>)

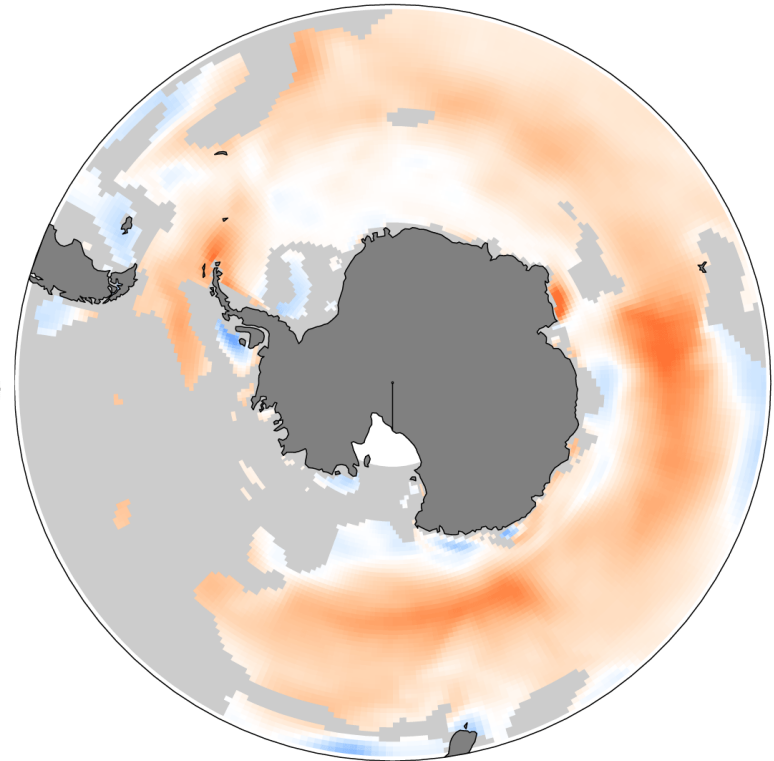
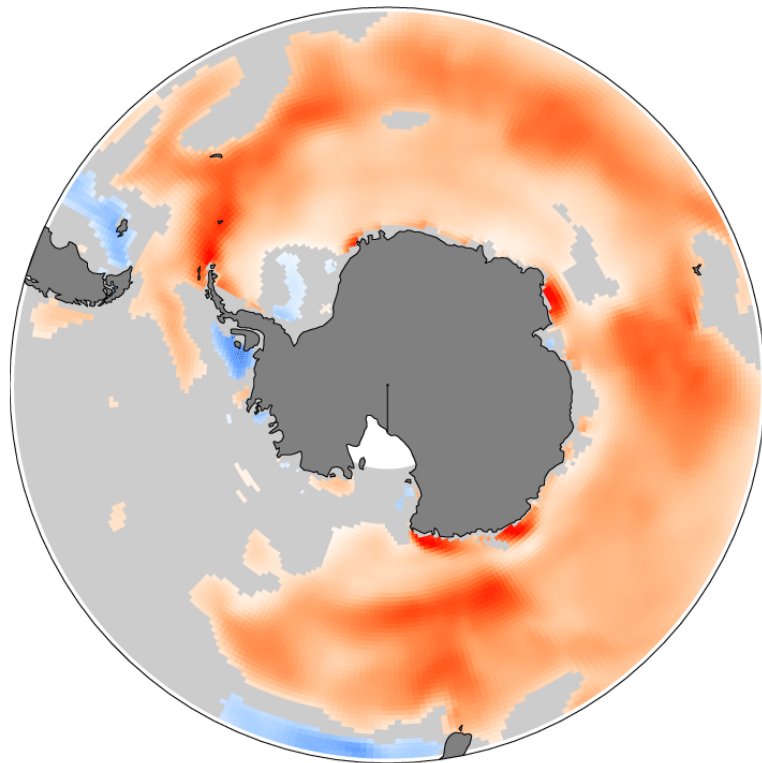
0.05  
0  
-0.05



# Sea-air CO<sub>2</sub> flux trend

Linear trend  
1958-2007

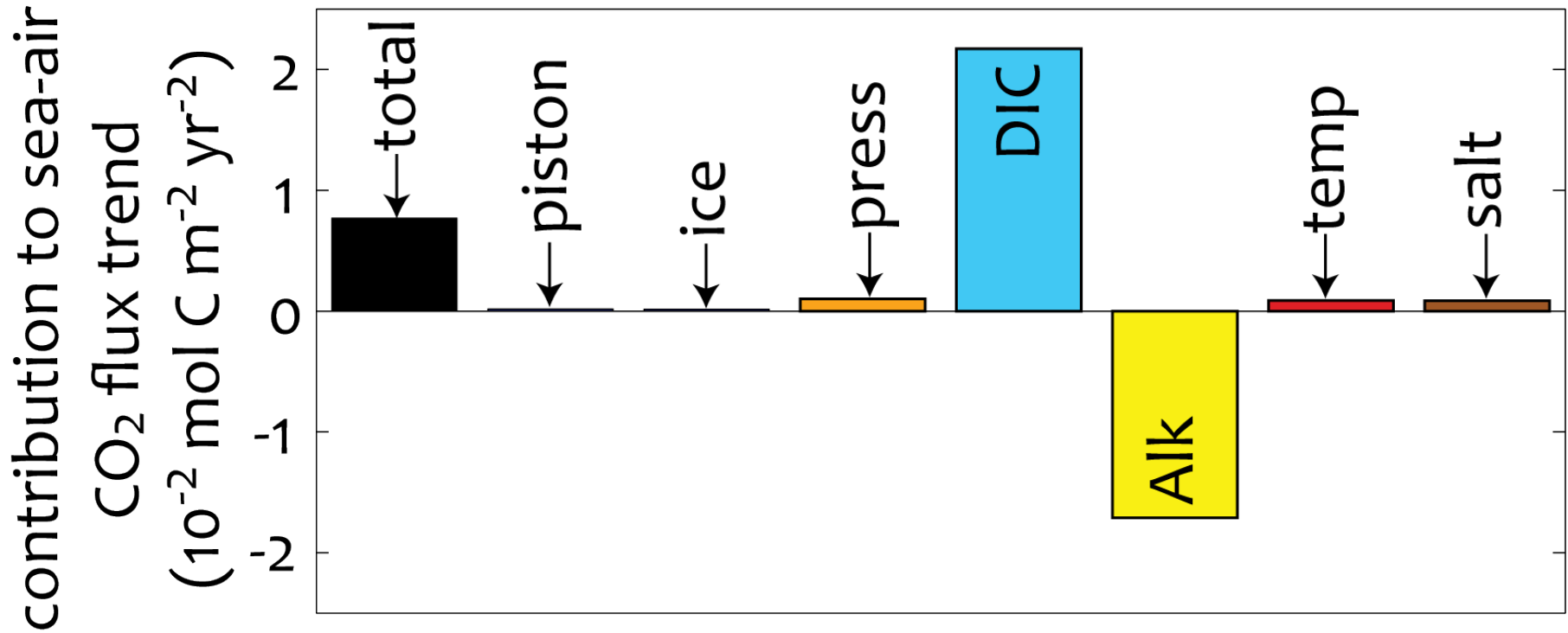
Trend congruent  
with wind



-0.05      0      0.05  
(mol C m<sup>-2</sup> yr<sup>-2</sup>)

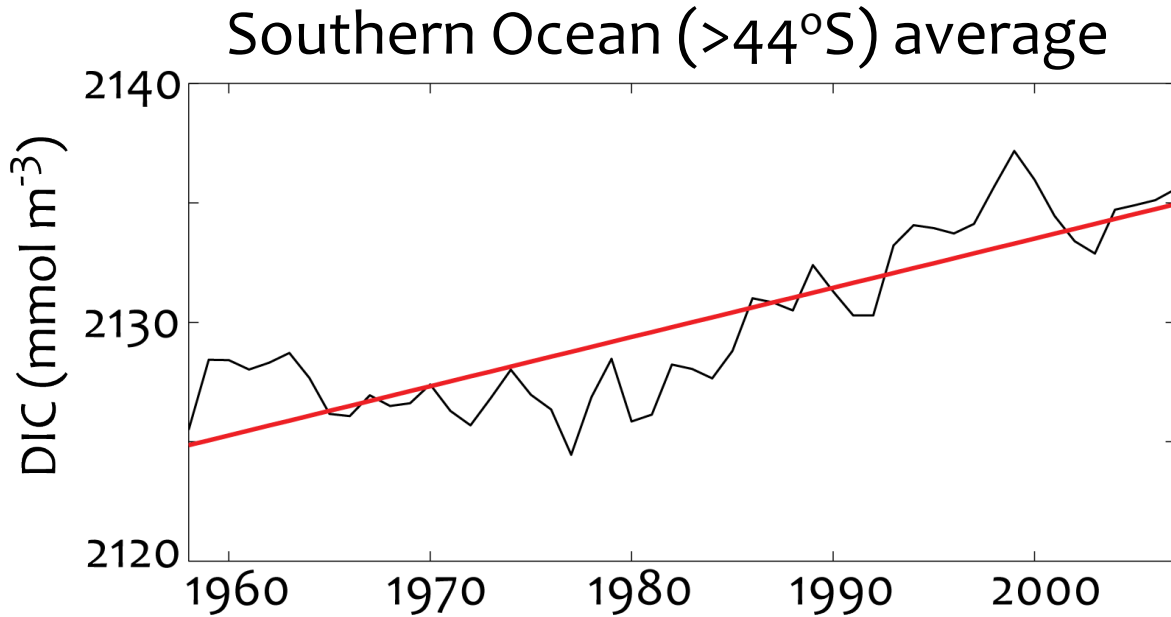
# What causes the trend in CO<sub>2</sub> flux?

Southern Ocean (>44°S) budget





# Dissolved inorganic carbon (DIC)



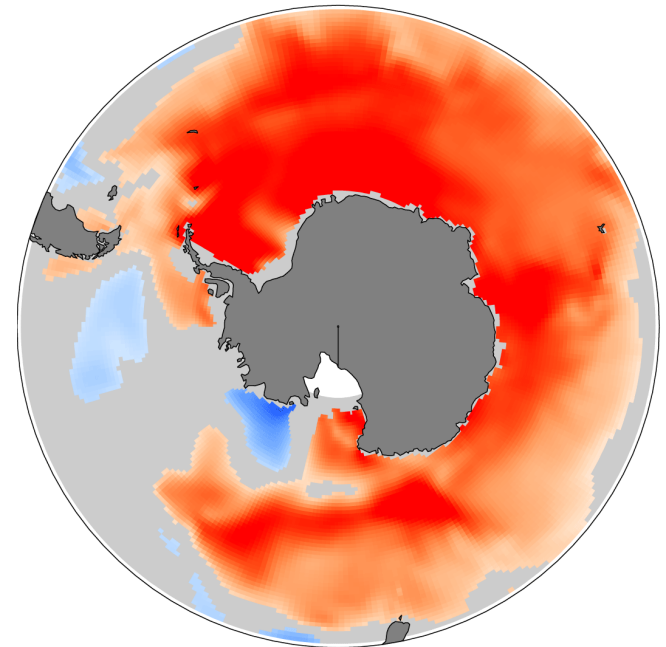
Linear trend  
1958-2007

surface DIC trend  
(mmol m<sup>-3</sup> yr<sup>-1</sup>)

0.5

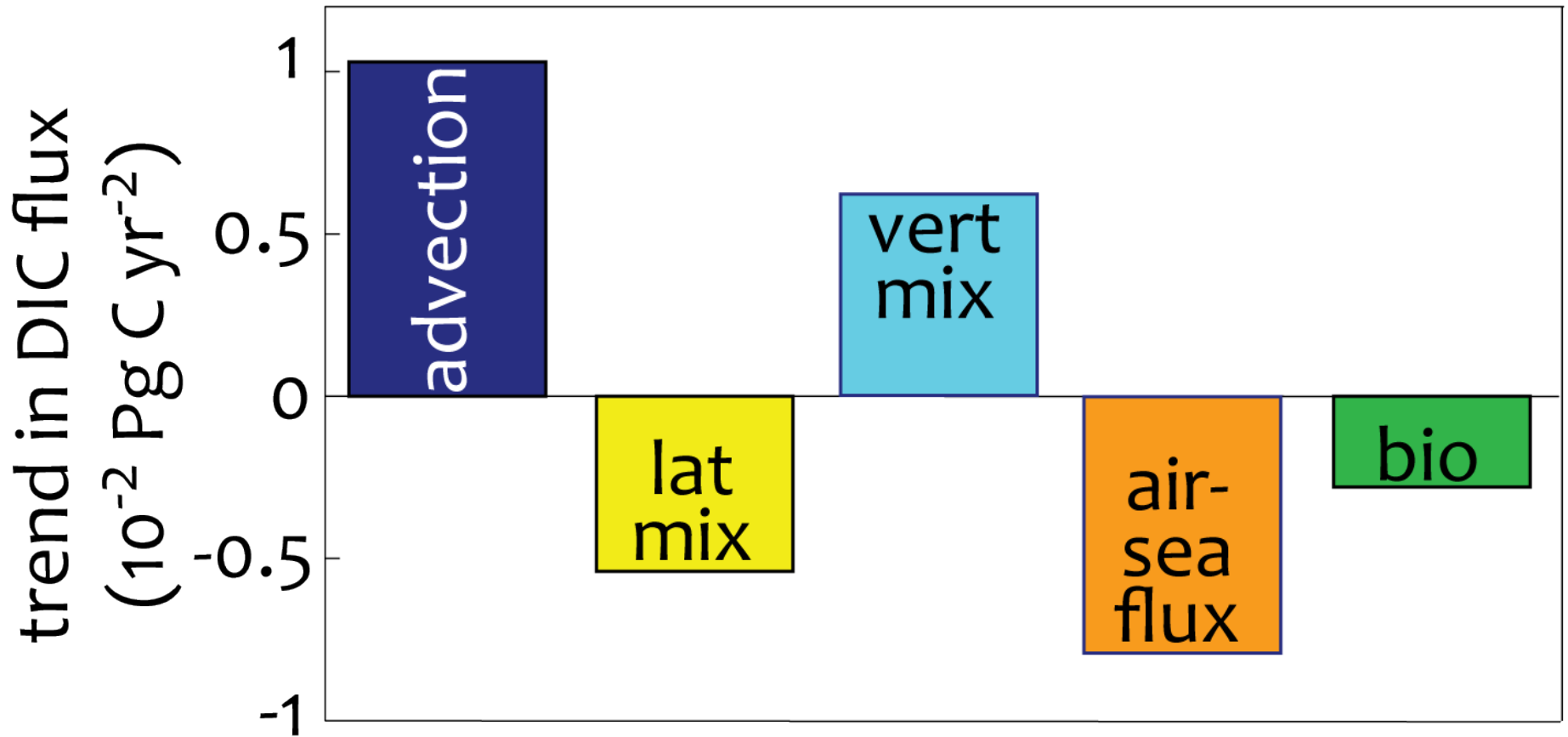
0

-0.5

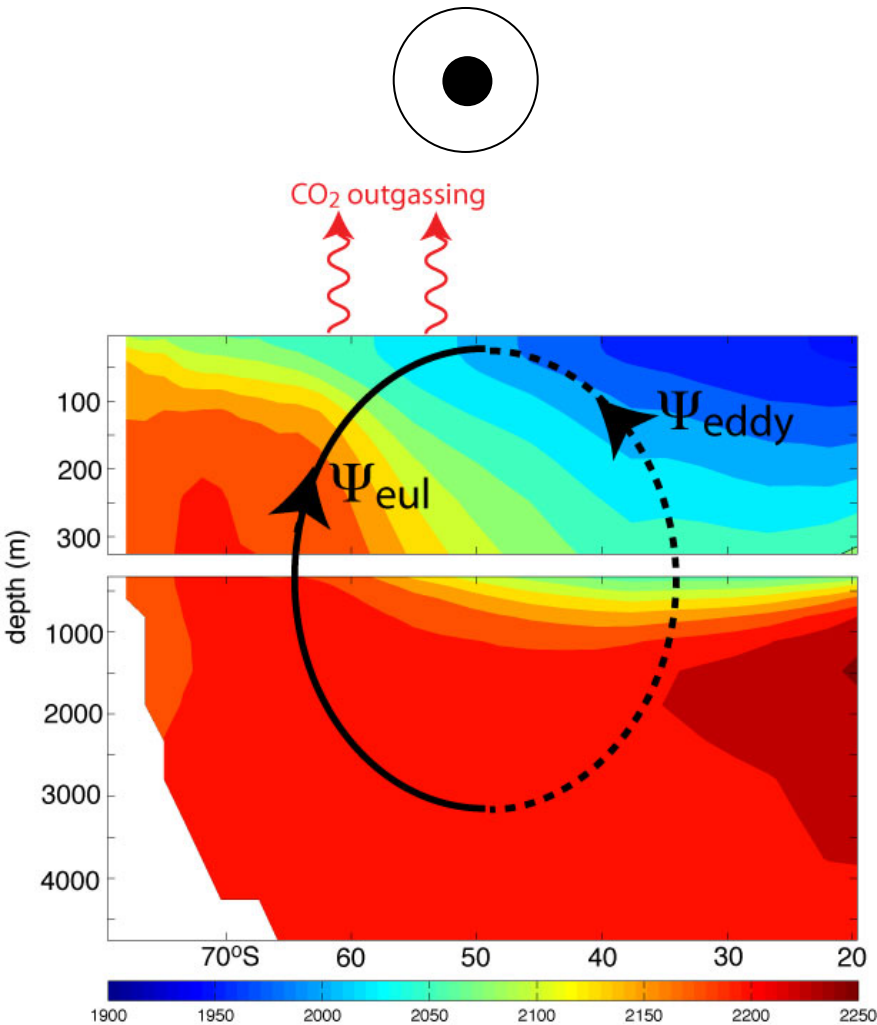


# What causes the trend in DIC?

Southern Ocean surface (> 44°S, < 100 m) budget



# Conclusions



Using a coarse-resolution ocean model with variable  $\kappa$ :

- Trend toward outgassing of natural CO<sub>2</sub> from Southern Ocean, caused by trend in surface DIC
- Trend in DIC primarily driven by trend in DIC advection
- Trend in DIC lateral mixing ( $\kappa$ -dependent term) opposes, but does not cancel, DIC advection trend