Role of the atmosphere in Southern Ocean trends

John C. Fyfe

Eby, England, Gillett, Saenko, Scinocca, Sigmond, Swart, Weaver, Zickfeld
Main topics

- Southern ocean response to GHG ↑
- GCM wind bias and carbon uptake
- SO role in surface response to O$_3$ ↓
- Antarctic sea ice response to O$_3$ ↓
Surface zonal wind stress

c.i. = 0.025 hPa
Residual mean theory

Surface zonal wind stress

LatITUDE

hPa

Control
2xCO₂
4xCO₂
2xCO₂ − Control
4xCO₂ − Control

Latitude

-60 -40 -20 0 20 40 60

Saenko et al. (2005)
Residual overturning (Sv)

Control

4xCO₂

Saenko et al. (2005)
Response along 140°E

Mass transport

Baroclinic potential energy
Ekman transport

Fyfe and Saenko (2006)
Temperature trends: 1930s to 90s
35°S-65°S, 700-1100 m

Temperature change (°C)

Models • Data

Decade

1940 1960 1980 2000

Fyfe (2006)
$4^\circ$C isotherms at 2100
Zonal wind stress (Pa)

Swart and Fyfe (2011)
Ocean carbon anomaly (Pg)

Swart and Fyfe (2011)
Atlantic carbon and overturning

Swart and Fyfe (2011)
Zero curl verses Agulhas leakage

Swart and Fyfe (2011)
% $O_3$ depletion, $65^\circ$-$90^\circ$S, 1979-2005

Sigmond et al. (2010)
SAM variability

Uncoupled

Coupled

Sigmond et al. (2010)
SAM response

Uncoupled

Coupled

Sigmond et al. (2010)
SAM response

Sigmond et al. (2010)
Sea ice extent

Sigmond and Fyfe (2010)
Sea ice and air temperature

Sigmond and Fyfe (2010)
Sea ice, surface wind & air temperature

Sigmond and Fyfe (2010)
GHG and ODS forcing

Sigmond et al. (2011)
SAM response (hPa)

Year

GHG

ODS

Sigmond et al. (2011)
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MITgcm simulations with eddies

Swart and Fyfe (2012)