Southern Ocean heat uptake, redistribution and storage in a warming climate: The role of meridional overturning circulation

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Not collocated peaks of OHU and OHS $\rightarrow$ Heat advection (by the MOC)
Passive tracer by climatological MOC? MOC changes (shading in panel f)

Scientific Question:
Can we separate and qualify the contributions of wind effect (via changing MOC) & direct CO₂ effect (w/o wind changes) to SO heat uptake and storage?
Partial coupling approach

Natural coupling

ATM
OCN

Overriding

ATM overriding
OCN

Wind effect + Drift!
Partial coupling approach II

Overriding

Experiment 1
ATM overriding
OCN

-3 -2 -1 0 1 2 3

Drift (not depend on background states)

Experiment 2
ATM overriding
OCN

-3 -2 -1 0 1 2 3

Wind effect + Drift

Wind effect = Experiment 2 – Experiment 1
Total response (4xCO$_2$-Ctrl)

Wind Stress (MOC)

Wind Speed (turbulent HF) [very small!]

Direct CO$_2$ effect (w/o wind stress & speed changes)

![Graph showing total, wind stress, and direct CO$_2$ effects over depth and latitude.](image-url)
Zonally integrated full-depth Ocean Heat Budget

- Total
- Wstr
- Wspd
- dirCO₂
- Sum
Conclusion

• The overriding technique enable us to decompose the total ocean response to CO\textsubscript{2} increase into two major components: due to wind changes and due to direct \textit{CO}\textsubscript{2} effect.

• The poleward-intensified winds shift and strengthen the Deacon Cell and hence the residual \textit{MOC}, contributing \textasciitilde20\% to the total OHS maximum.

• The direct CO\textsubscript{2} effect very slightly alters the residual MOC but primarily warms the ocean, contributing \textasciitilde80\% to the OHS maximum.

Reference