

SOUTHERN OCEAN FRESHWATER INPUT FROM ANTARCTICA

How can (future) melt from Antarctica impact ice, ocean, and climate?

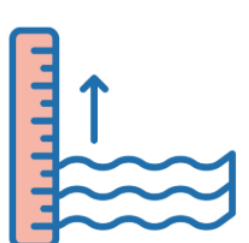
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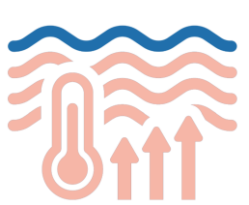
Motivation

- Grounded **ice sheets** and floating **ice shelves** in Antarctica are **melting** at an **accelerating rates** due to climate change^{1,2}
- This results in **freshwater release** into the Southern Ocean, which has **regional to global impacts**³

Primary Impacts



IPCC predicts **sea-level rise** of **0.04–0.34 m by 2100** under high-emission climate scenario (**SSP8.5**) due to Antarctic melt, however highly dependent on various **uncertainties**, e.g., Marine Ice Cliff Instability (MICI)²



Surface freshening & cooling

- increased **stratification**
- heat trapped under freshwater lid
- **subsurface warming**⁴

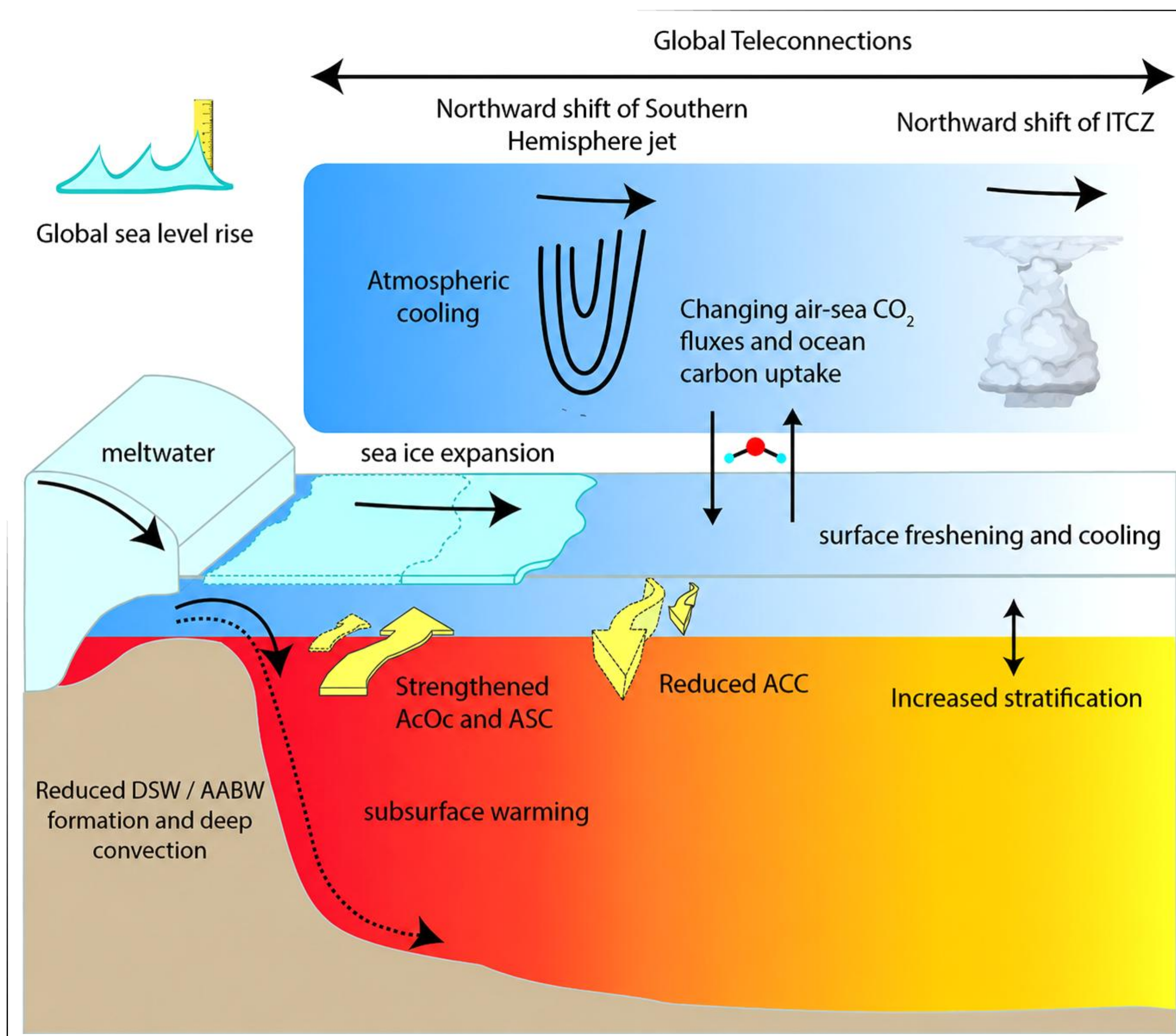


Figure by Swart et al. (2023)³ showing key impacts of Antarctic meltwater forcing on the climate system.

Potential Consequences

... of surface freshening & cooling



Sea ice growth (could explain past Antarctic sea ice growth)⁴, but extent & trends are **debated**³



Atmospheric cooling (mainly in the South) (*Negative Feedback!*)

→ Global teleconnections: **Northward shift of SH jet & Intertropical Convergence Zone (ITCZ)**⁴

... of subsurface warming



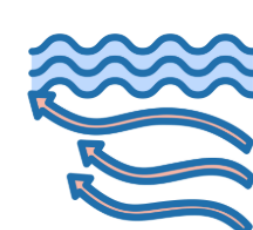
Subshelf melt → more meltwater from Antarctica (*Positive Feedback!*)⁴

... of surface freshening



Fresher/less Dense Shelf Water (DSW)

- **fresher/less Antarctic Bottom Water (AABW)**
- **reduced ventilation** of abyssal ocean
- **reduction of AMOC**⁵



Fresher DSW → **stronger density gradient** to saline open ocean

- **stronger Antarctic Coastal Current (ACoC) & Antarctic Slope Current (ASC)**⁶
- isolation from warm offshore waters
- **subsurface cooling** (*Negative Feedback!*)⁷

(Future) Modelling Efforts - The SOFIA Initiative³

- Almost all existing **coupled climate models** have **fixed ice sheets** → source and impacts of Antarctic melt are missing → **key uncertainty** in current **global climate change projections**
- SOFIA: **Multi-model ensemble** of simulations with common experimental design, open data archiving, and facilitated collaboration → better **constrain** our understanding of **climate system responses to Antarctic melt**



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¹ Shepherd, A., et al.: *Mass balance of the Antarctic Ice Sheet from 1992 to 2017*, Nature, 558, DOI: [10.1038/s41586-018-0179-y](https://doi.org/10.1038/s41586-018-0179-y), 2018.
² Fox-Kemper, B., et al.: *Ocean, cryosphere, and sea level change*, in: *Climate Change 2021: The Physical Science Basis. Contribution of WG I to the AR6 of the IPCC*, Cambridge University Press, DOI: [10.1017/9781009157896.001](https://doi.org/10.1017/9781009157896.001), 2021. ³ Swart, S., et al.: *The Southern Ocean Freshwater Input from Antarctica (SOFIA) Initiative*, Geoscientific Model Development, 16, DOI: [10.5194/gmd-16-7289-2023](https://doi.org/10.5194/gmd-16-7289-2023), 2023. ⁴ Bronselaer, B., et al.: *Change in future climate due to Antarctic meltwater*, Nature, 564, DOI: [10.1038/s41586-018-0712-z](https://doi.org/10.1038/s41586-018-0712-z), 2018.
⁵ Li, Q., et al.: *Abyssal ocean overturning slowdown and warming driven by Antarctic meltwater*, Nature, 615, DOI: [10.1038/s41586-023-05762-w](https://doi.org/10.1038/s41586-023-05762-w), 2023. ⁶ Ong, E., et al.: *Transient Antarctic Slope Current response to climate change including meltwater*. Geophys. Res. Letters, 52, DOI: [10.1029/2024GL113983](https://doi.org/10.1029/2024GL113983), 2025. ⁷ Beadling, R., et al.: *Importance of the Antarctic Slope Current in the Southern Ocean Response to Ice Sheet Melt and Wind Stress Change*, J. Geophys. Res.-Oceans, 127, DOI: [10.1029/2021JC017608](https://doi.org/10.1029/2021JC017608), 2022.



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