Subduction in the Southern Ocean and the connection to Stationary Rossby Waves

Poster by:
Fritjof Terland Biørn, frbio5253@uib.no
Simon Grether, sigre7770@uib.no

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1 Motivation

- The ocean is a large carbon sink, absorbing about 25% of the annual anthropogenic carbon emission.
- The Southern ocean accounts for 40% of this uptake.
- Antarctic Circumpolar Current (ACC, Fig. 1) is the world's largest ocean current by transported water volume.
- Subduction drives carbon storage in the ACC.
- Poster outlines the research history of ACC subduction, from early descriptions to recent discoveries on Stationary Rossby waves (SRW).

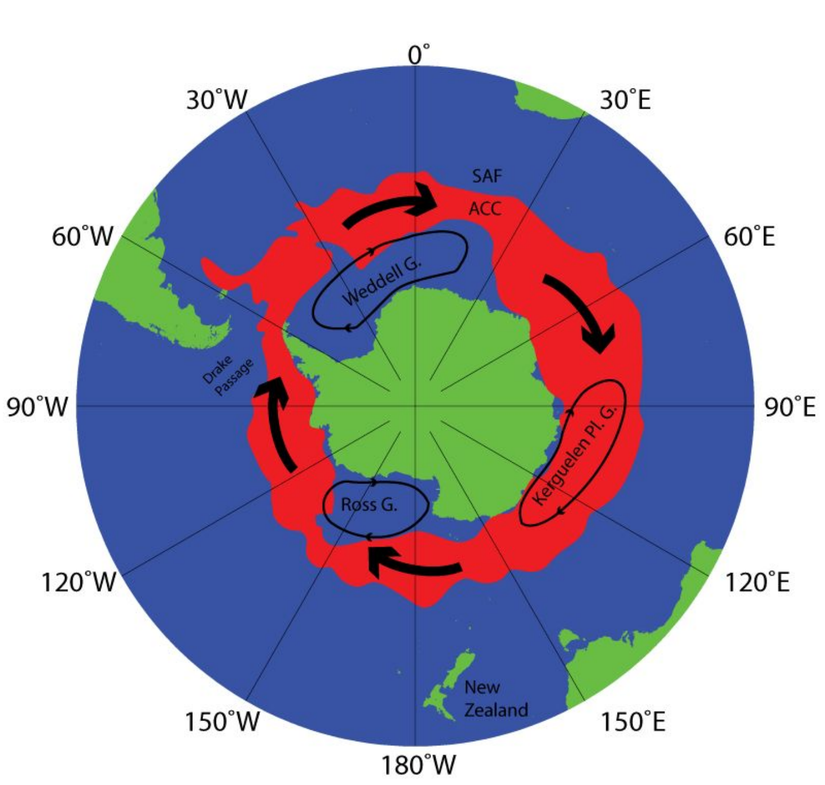

Fig. 1 Antarctic Circumpolar Current (ACC), source: http://calib.org/marine/currents/antarctic.html

2 Theory

- Subduction: transfer of surface water into the deeper ocean.
- One of the first descriptions and proves for the Southern Ocean is given in Fig. 2
- Rossby waves: slow, large-scale wave motion in the ocean.
- Rossby waves result of Earth's rotation and topography influencing the current.
- These waves create oscillations, which moves displaced water back towards equilibrium.

3 Phenomena

Fig. 3 shows two important contributions to carbon subduction in the Southern Ocean.

- **Large scale lateral induction** (horizontal subduction) occurs where the ACC "crashes" into regions with mixed layers
- This can either:
  Release carbon back into the mixed layer (negative subduction, blue)
  Transport carbon into the ocean interior (positive subduction, red)
- Large scale processes are captured by climate models
- **Small scale lateral induction** requires high-resolution model (panel d, Fig. 3)
- These features are connected to Stationary Rossby waves:
  Northward: Carbon rich water is forced below the mixed layer
  Southward: Opposite
- Peaks in subduction occur near major seafloor obstacles, which generate SRWs (Fig. 4).

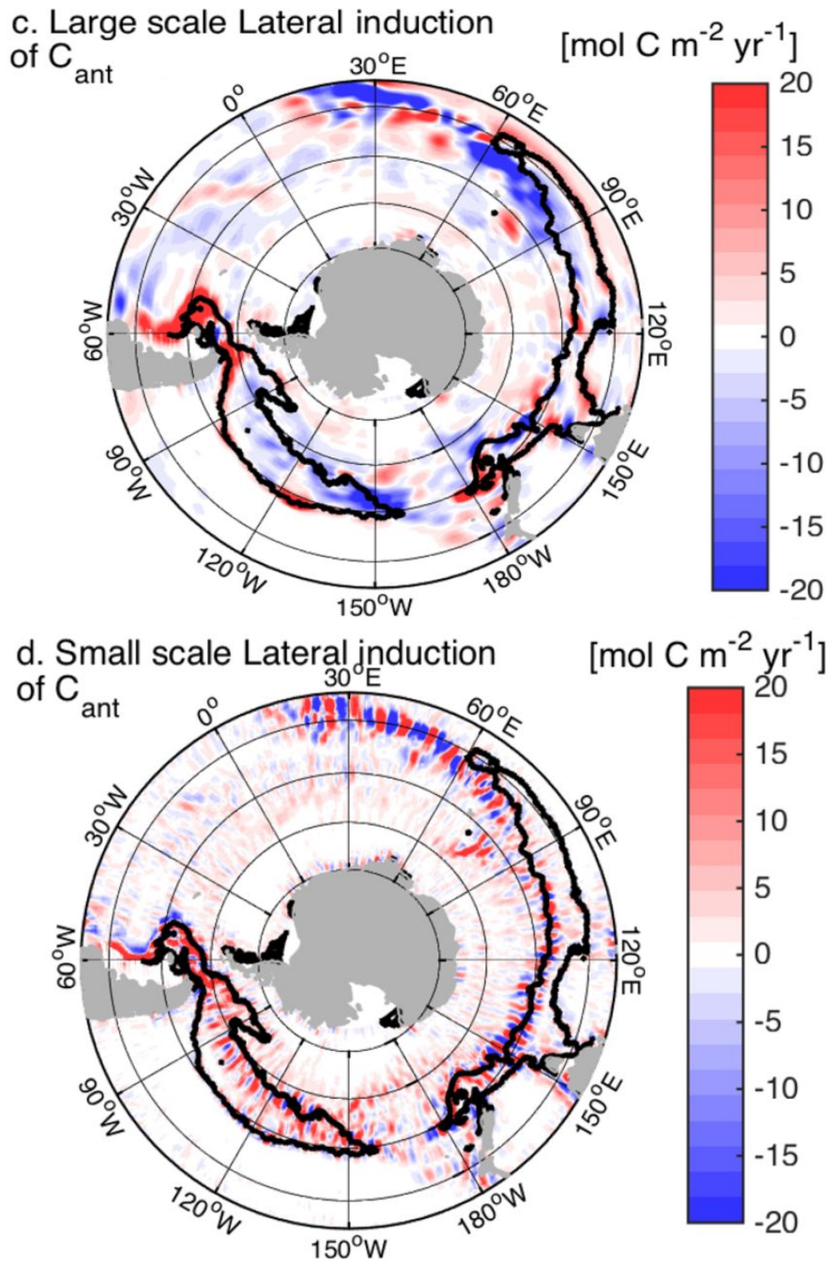

Fig. 3 Subduction of anthropogenic carbon into (+) and out of (-) the ocean interior.

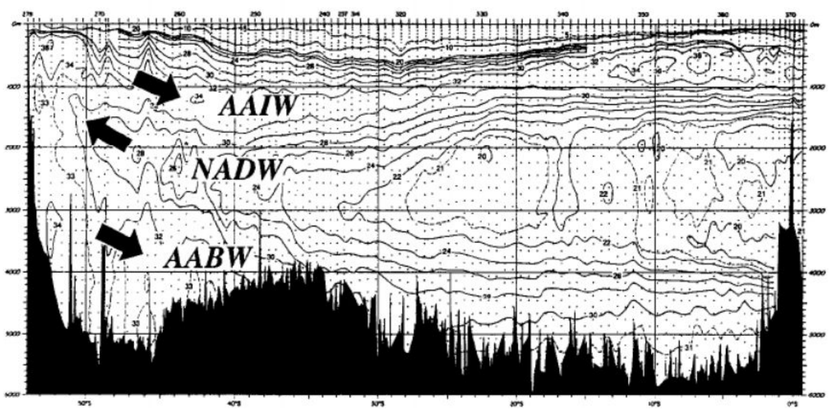

Fig. 2 First illustrations of subduction in the Southern Ocean. The existence was proven by Nitrate tracer measurements, illustrated in the black profile.

4 Importance and Conclusion

- Accurate carbon subduction improves climate model accuracy
- High-resolution models can resolve important small-scale effects
- Subduction stores carbon in deeper ocean layers
- This helps reduce atmospheric CO_2 growth and slows climate change
- On the other hand, the uptake of CO_2 leads to an acidification of the oceans.

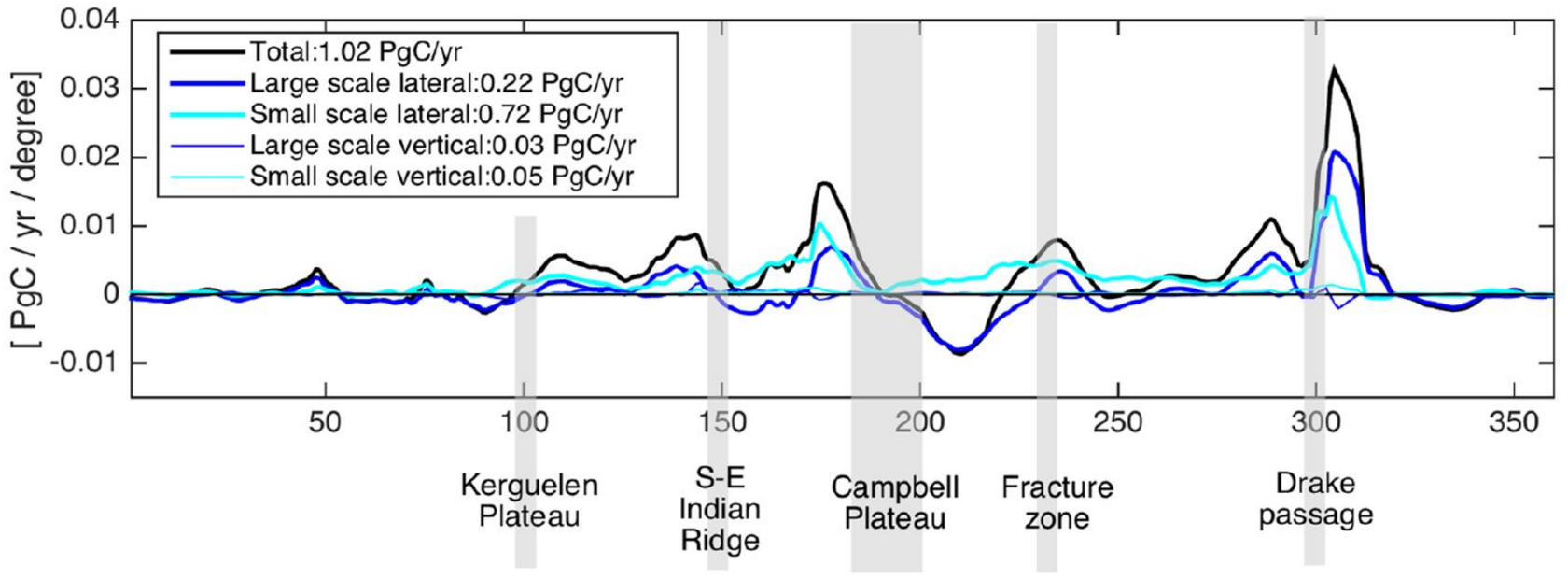

Fig.4 Regional subduction caused by SRWs. Longitude on x-axis, topographic obstacles in grey areas.

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Sources:
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- Marshall, D. (1997). *Subduction of water masses in an eddying ocean*. Journal of Marine Research, 55(2), 201–222. https://doi.org/10.1357/0022240973224373