THE UNIVERSITY OF RHODE ISLAND
GRADUATE SCHOOL OF OCEANOGRAPHY

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The Polar Front in Drake Passage:
A composite-mean stream-coordinate view

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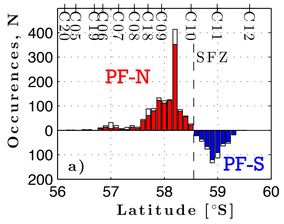
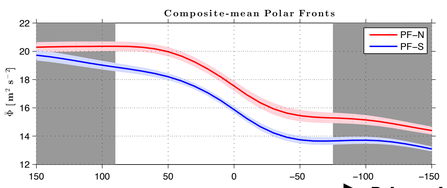
1) Stream coordinates

We develop a stream-coordinate system based on:

- **Core location** = latitude of $\max \nabla \Phi$ along the C-Line
- **Angles** for projection and rotation calculated from altimetry SSH
- **Time periods** when PF flows within 20° of perpendicular to C-Line (~65% of 4-year time series)

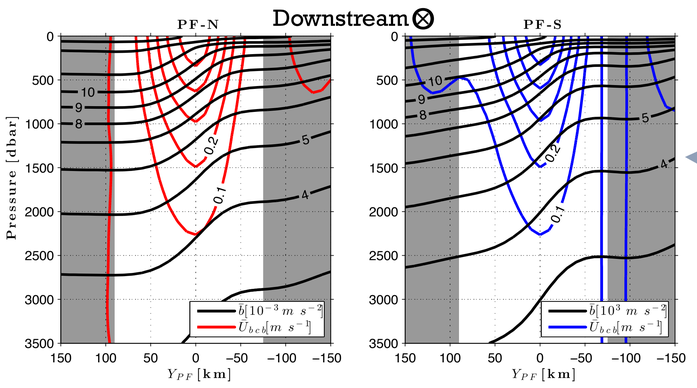




Core difference is equivalent to **17 cm of geopotential height**

2) Baroclinic fields

Downstream baroclinic velocity surface **maximum of 0.59 m/s**



	PF-N	PF-S
T_{bcb} [Sv]	49.5 ± 4.9	49.3 ± 3.8

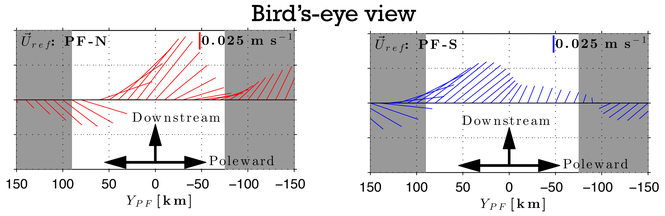
Velocity **decreases almost exponentially** from 0.3 m/s at 1000 dbar to zero at 3500 dbar

3) Reference velocity

	PF-N	PF-S
T_{ref} [Sv]	19.2 ± 2.4	19.8 ± 3.7

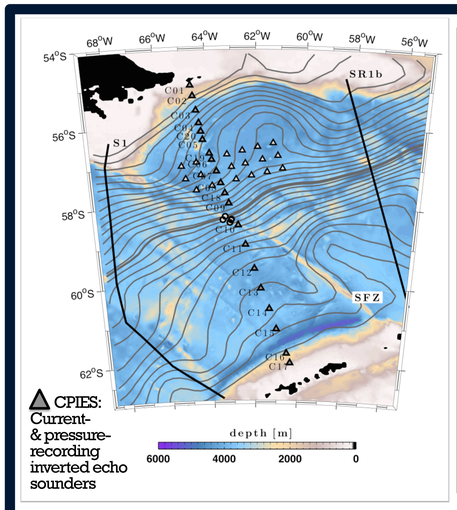
Differences between the two jets appear in **locally influenced** deep flow structures

Bird's-eye view



Poleward flow sets up **triple-connection**:[1]

- Warm-water advection across PF
- Upwelling along isoneutrals
- Veering velocity vectors with depth



The cross-stream structure of the Polar Front is characterized using CPIES maps of geopotential anomaly and directly measured bottom velocities.

1) PF core location is bimodal in latitude - separated by the Shackleton Fracture Zone (SFZ) and 1° of latitude.

2) A composite-mean northern and southern PF have same core velocity, width, and vertical shear.

3) Downstream reference velocities are 10-15% of their surface baroclinic counterparts, and cross-stream flow is poleward everywhere within the PF.

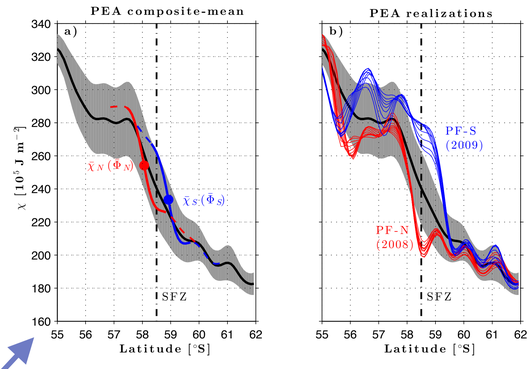
4) PF-N and PF-S alternately carry 85% of the region's baroclinic transport rather than share it equally between them.

5) The PF core is a barrier to small-scale mixing and preserves its frontal structure, while remaining susceptible to mixing by mesoscale eddies from baroclinic instability.

4) Transport

Baroclinic transport is equivalent to the change in **Potential Energy Anomaly, χ,** across the PF[2]

$$\chi(Y_{PF}, t) = \int_0^{3500} p\delta dp$$



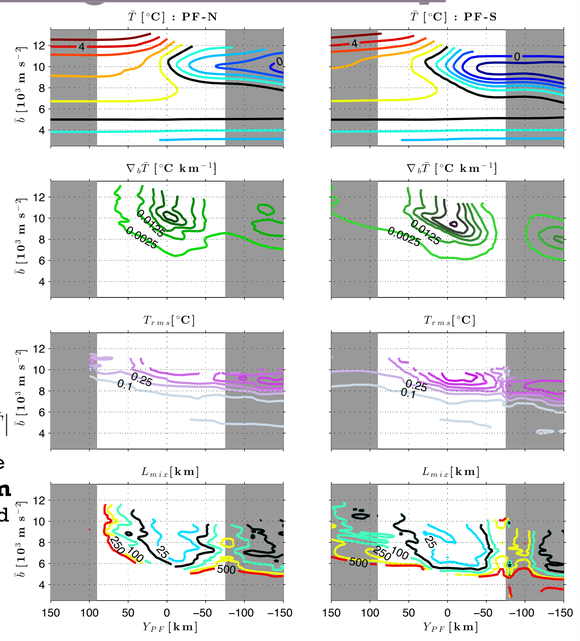
50 Sv of baroclinic transport alternates between the PF-N and PF-S, a **great majority** of the average transport carried by the broader PF-region (57-60°S)

5) Mixing and stability

Suppressed mixing lengths[3] and enhanced cross-stream potential vorticity gradient at the core implies PF **inhibits mixing**

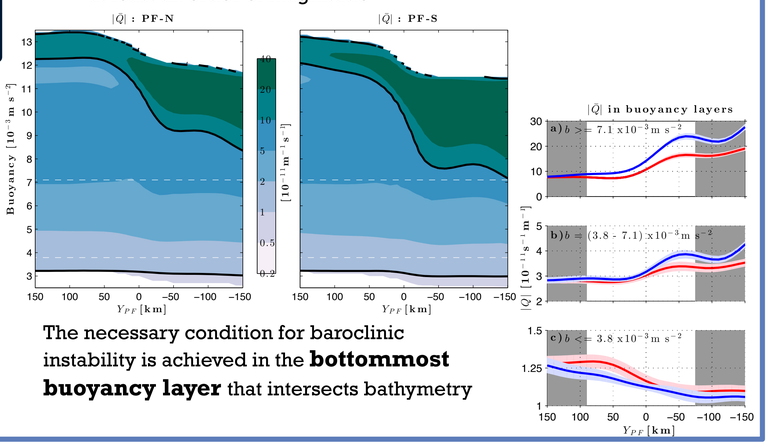
$$L_{mix} = T_{rms}/|\nabla_b \bar{T}|$$

Mixing lengths are **less than 50 km** (black line) around the PF core and in waters more buoyant than 6×10^{-3} m/s²



Terms of potential vorticity **successively decrease** by at least an order of magnitude

$$Q = g^{-1}(fb_z - U_Y b_z + U_z b_Y)$$



The necessary condition for baroclinic instability is achieved in the **bottommost buoyancy layer** that intersects bathymetry

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We thank Karen Tracey for her time, patience, and insight.

For more details see **Foppert et al, 2016** (JGR-Oceans).

References:

[1] Lindstrom, et al. (JGR, 1997). Vertical motion in the Gulf Stream and its relation to meanders.
[2] Rodrigues, et al. (JMR, 2010). South Atlantic mass transports obtained from surface float and hydrographic data.
[3] Naveira-Garabato, et al (JGR, 2011). Eddy stirring in the Southern Ocean.