# Mesoscale and submesoscale dynamics from ocean gliders

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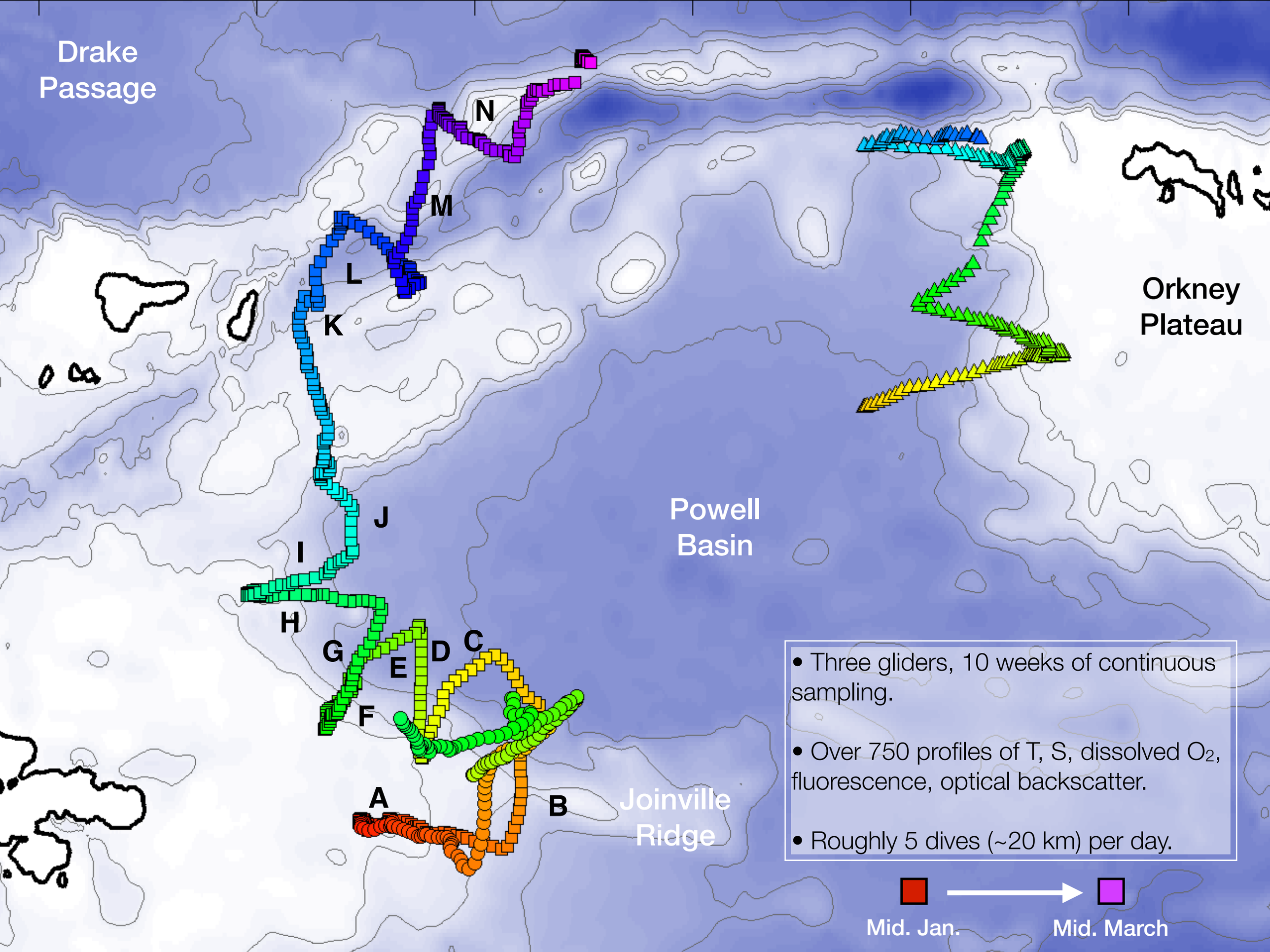
Caltech

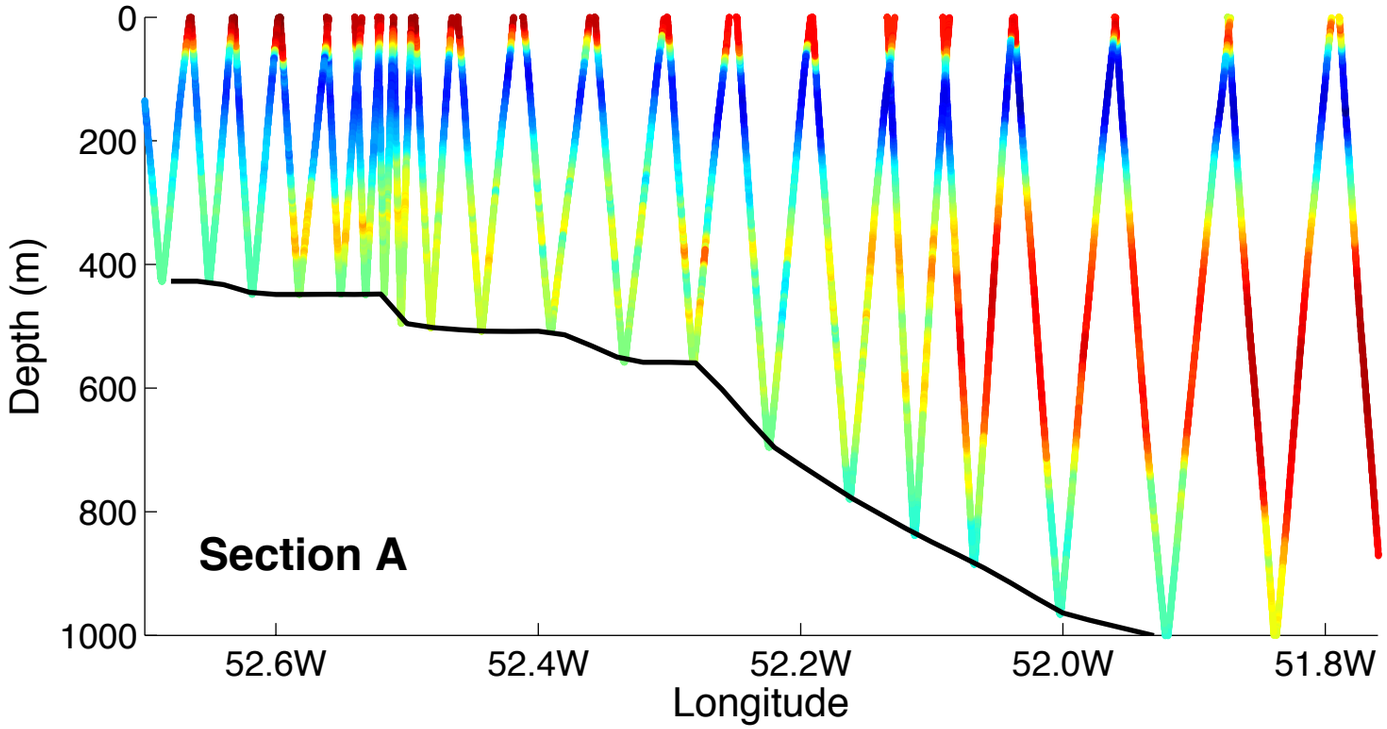
12 March, 2014
ORCAS Planning Meeting

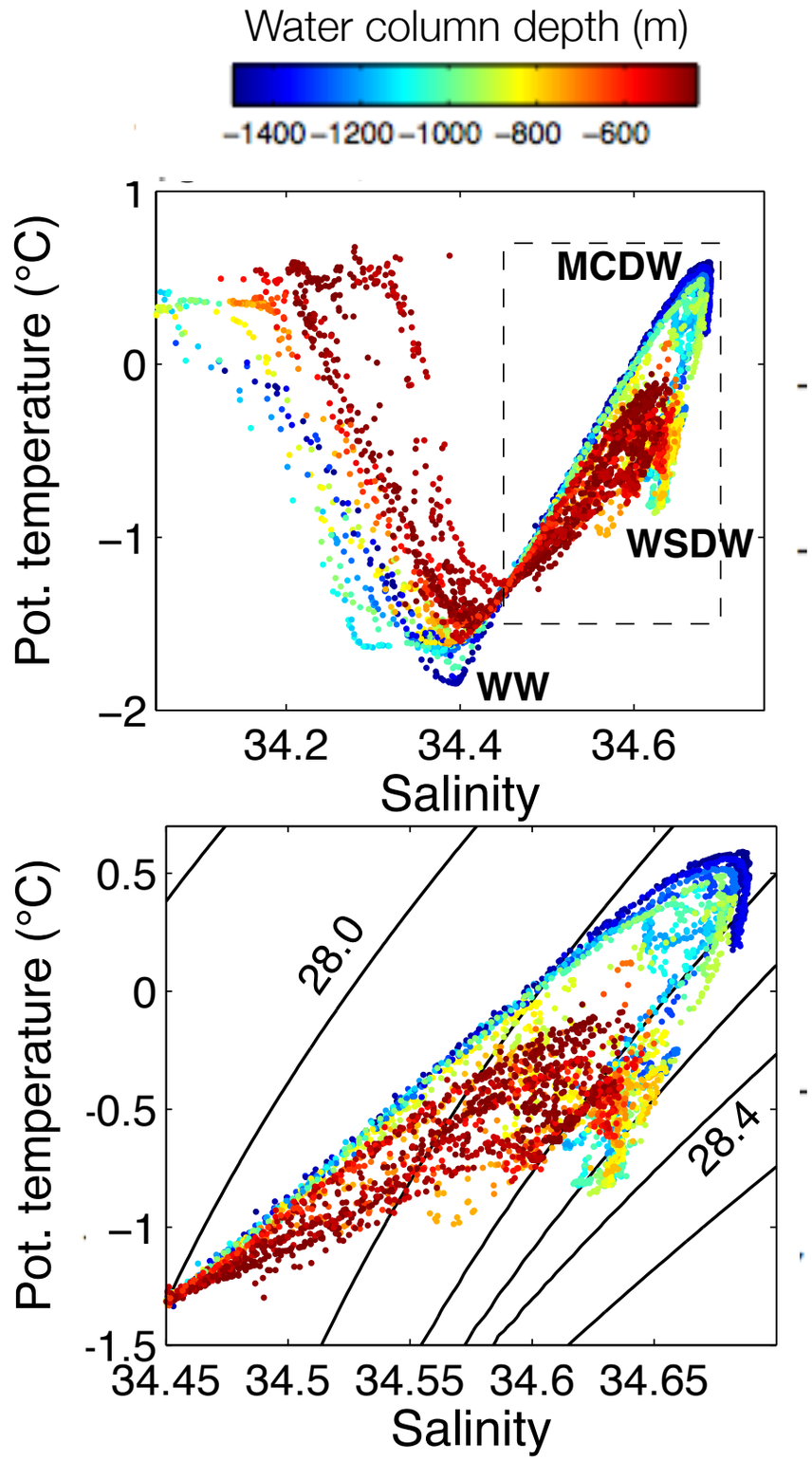
**GENTOO Project**
**January - March, 2012**
**Weddell Sea**

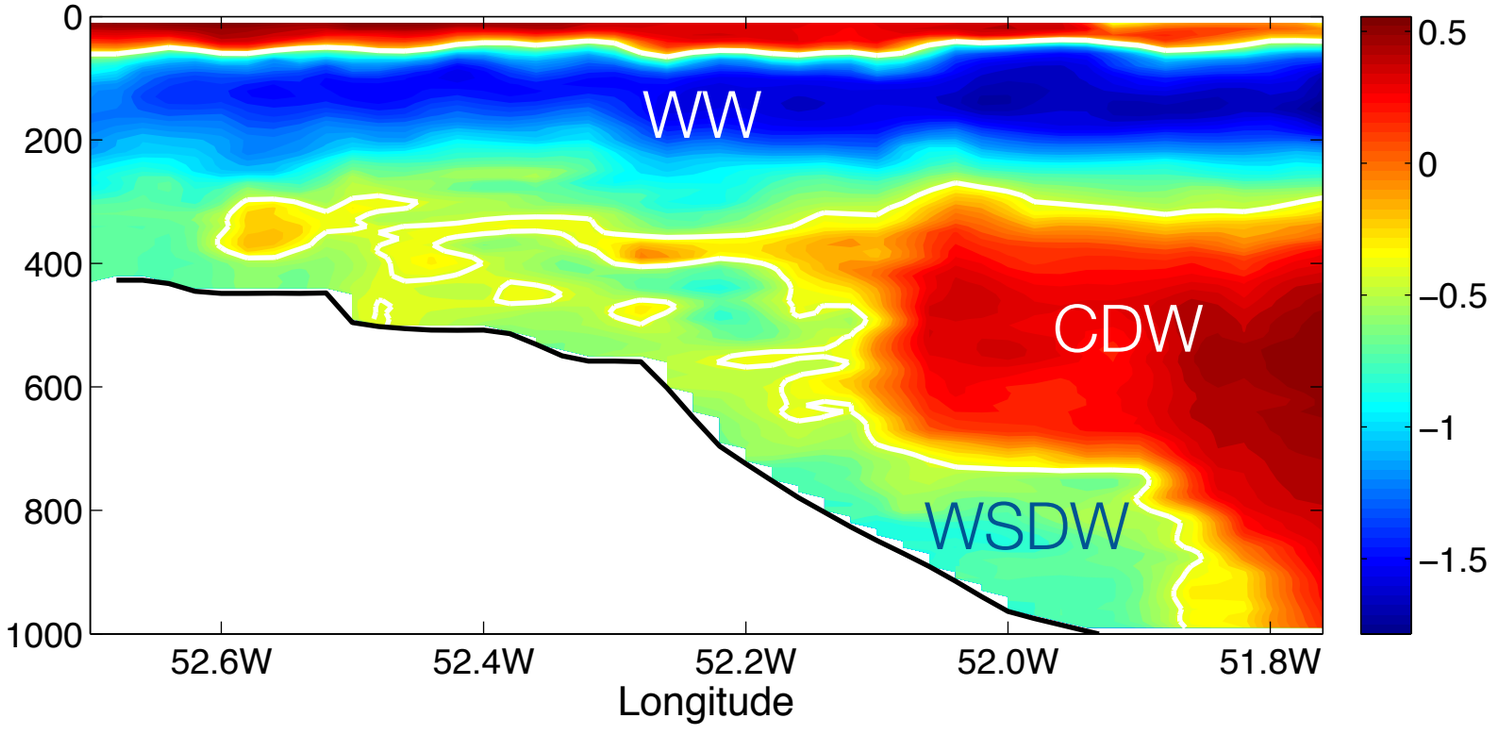

Drake
Passage
N
M
L
K
J
I
H
G
E
D
C
F
A
B
Powell
Basin
Joinville
Ridge
Orkney
Plateau
• Three gliders, 10 weeks of continuous sampling.
• Over 750 profiles of T, S, dissolved $O_2$, fluorescence, optical backscatter.
• Roughly 5 dives (~20 km) per day.
Mid. Jan.
Mid. March

# Properties

T., Heywood, Schmidtko (2014)

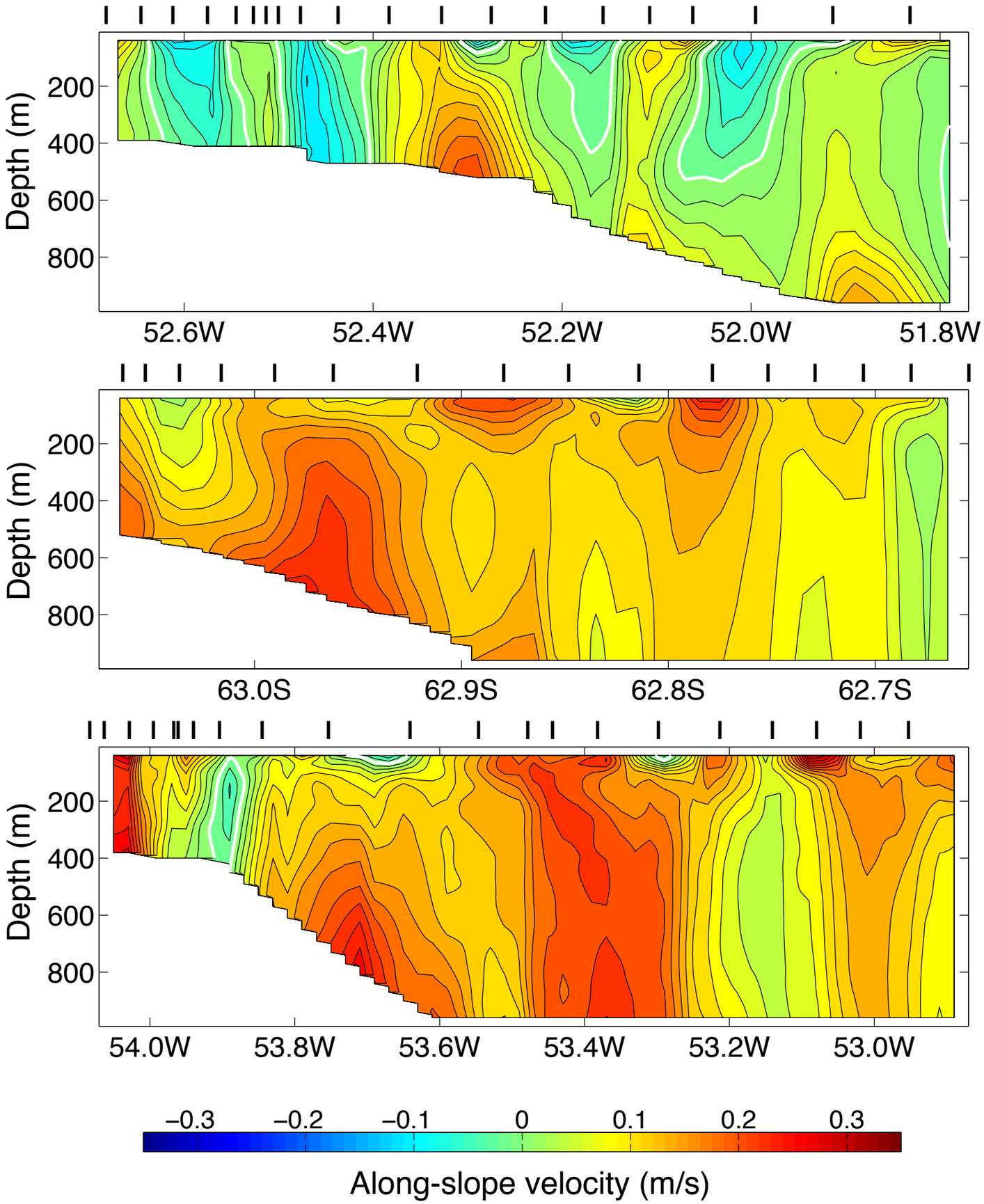



Evidence of Weddell Sea Bottom Water south of Powell Basin; mixing between slope and shelf waters.

# Antarctic Slope Current: frontal structure




The shelf break is dominated by a series of multiple narrow fronts comprising the Antarctic Slope Current.

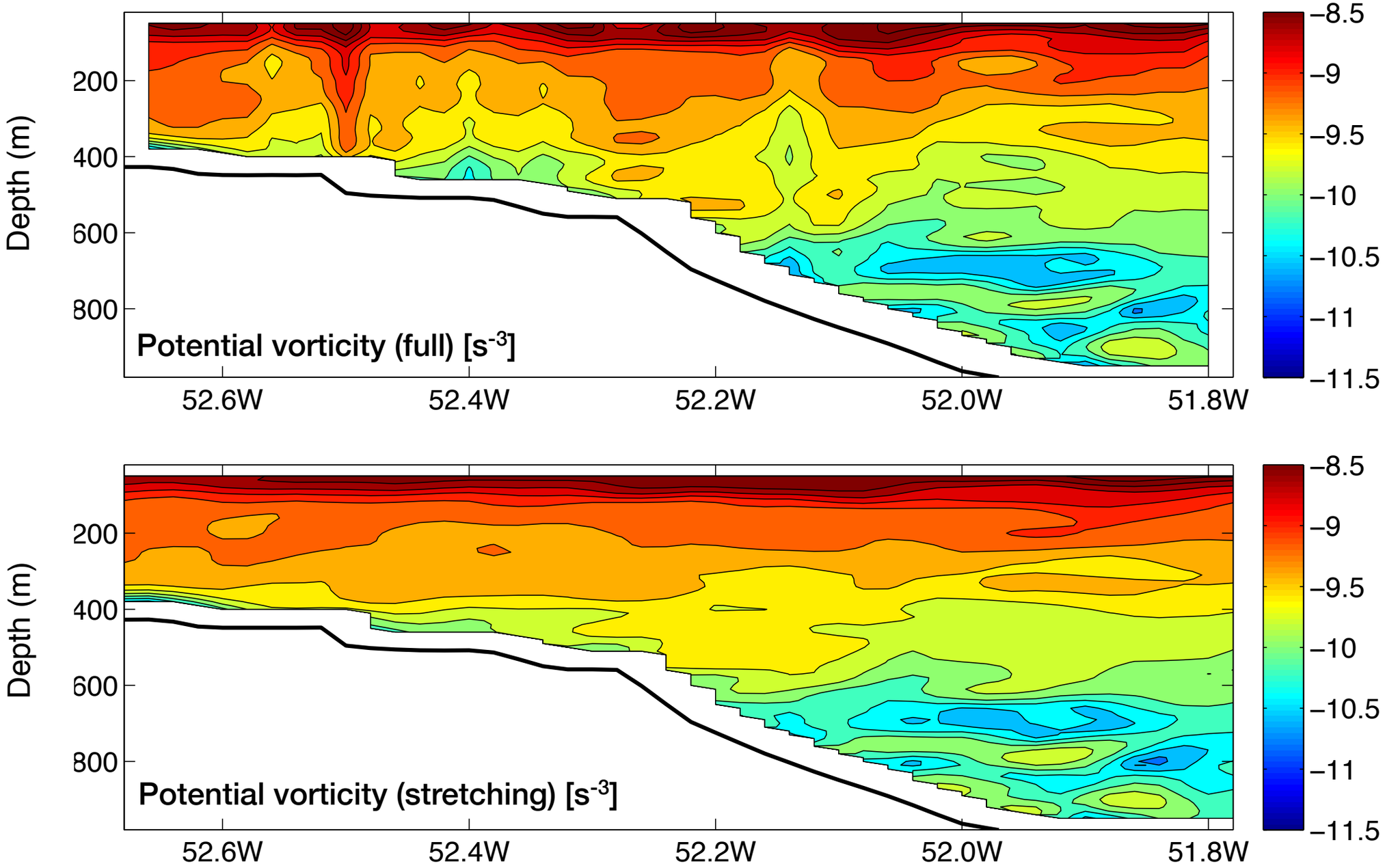
A Rhines scale analysis:

$$\ell_R \sim \sqrt{\frac{U_e}{\beta^*}}$$

$$U_e \sim \frac{g'H}{fL} \qquad \beta^* \sim \frac{f}{H} s_b$$

$$\ell_R \sim \left(\frac{g'H^2}{f^2 \Delta h}\right)^{1/2} \sim 10 - 30 \text{ km}$$

# Antarctic Slope Current: potential vorticity




Potential vorticity:

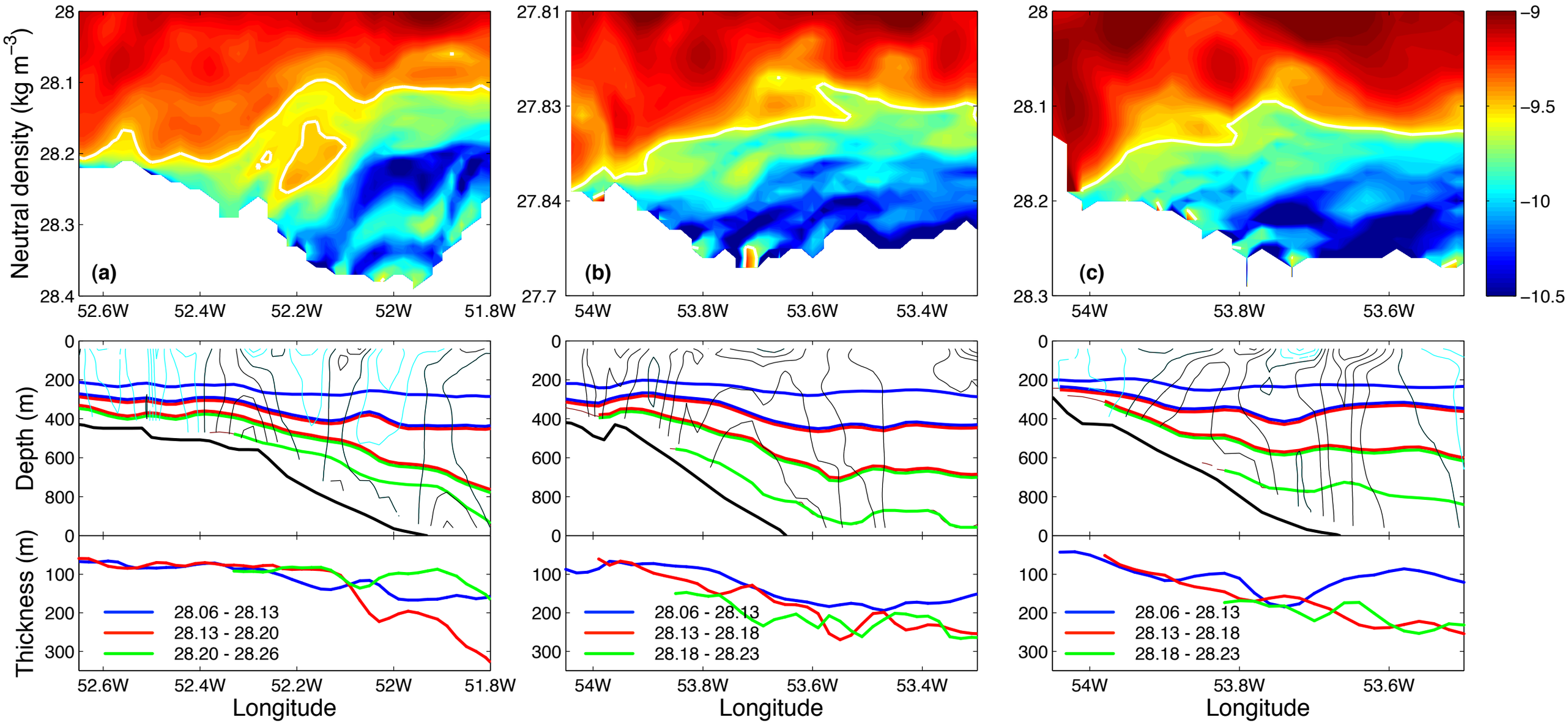
$$Q = (\mathbf{f} + \nabla \times \mathbf{u}) \cdot \nabla b$$

$$Q \approx f b_z + u_z b_y - u_y b_z$$

$b =$ buoyancy

$b_z = N^2$

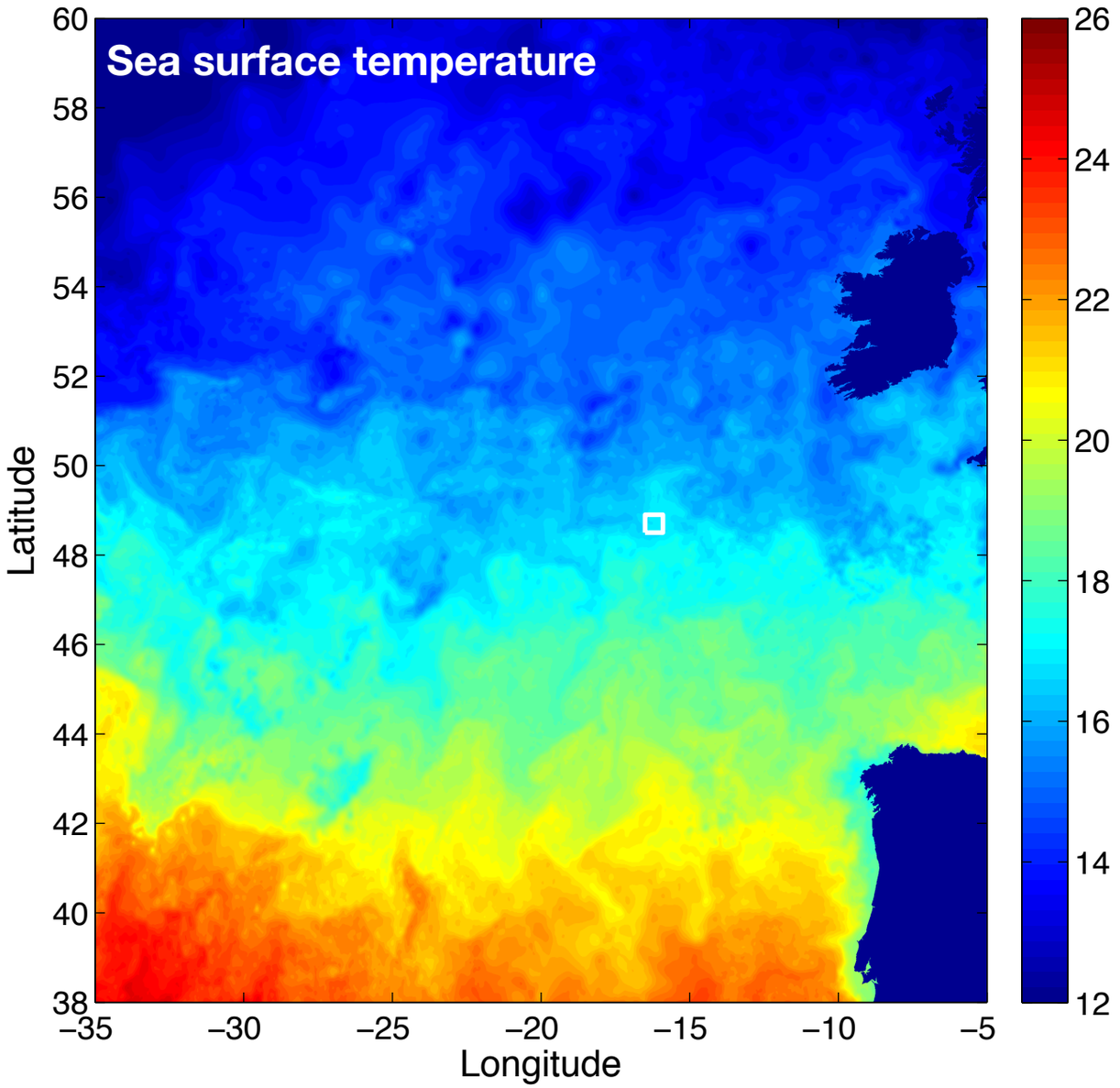
# Uniform properties

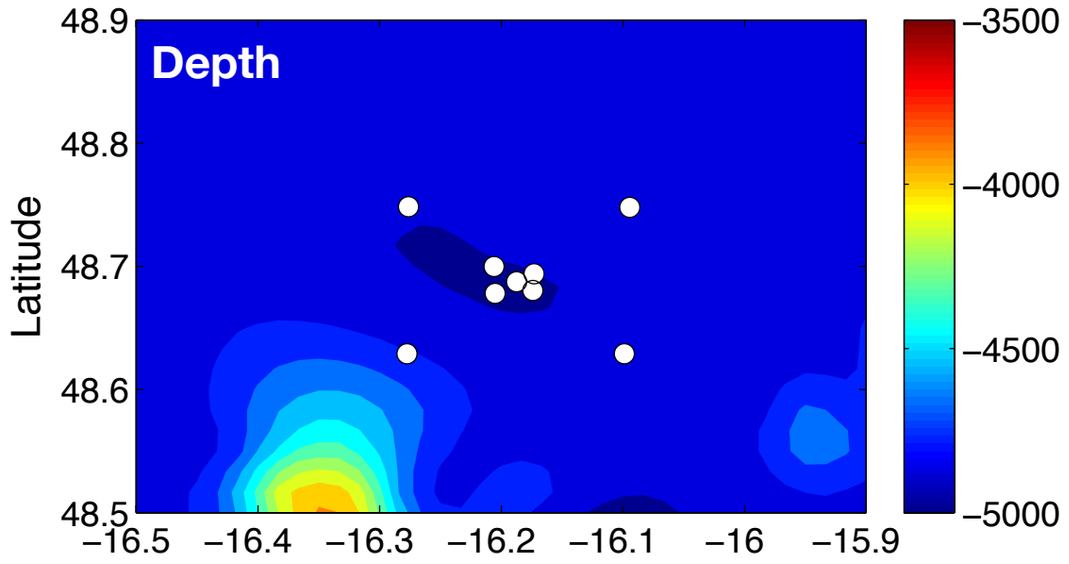


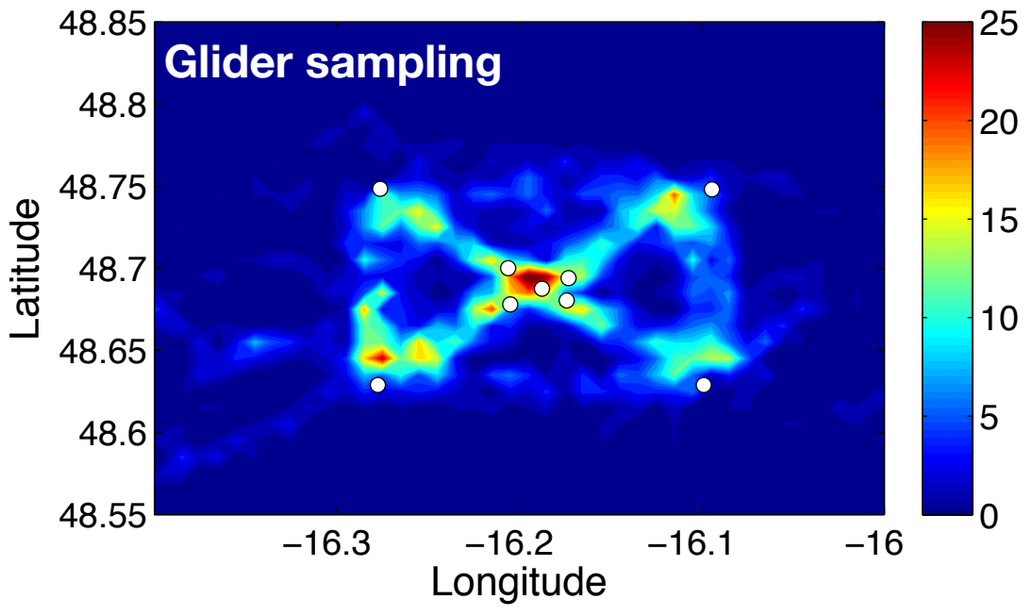

Multiple front structure creates regions of Ekman transport convergence/divergence over the slope.

Interior eddy thickness fluxes are required to close the overturning across the slope/shelf.

# OSMOSIS: Ocean Surface Mixing, Ocean Submesoscale Interaction Study



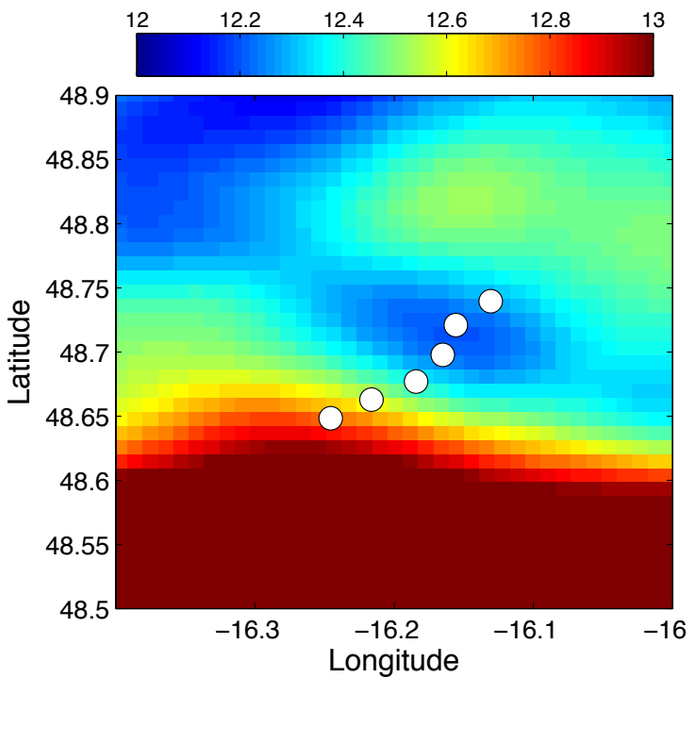




- **Year-long study to resolve seasonal variations in upper ocean turbulence as submesoscale resolution.**
- Location:  Porcupine Abyssal Plain;  Duration: Septmber 2012 - September 2013.
- 9 moorings, 7 glider deployments.
- OSMOSIS site occupied by two gliders throughout the year, sampling temperature, salinity, dissolved oxygen, fluorescence, backscatter and PAR.

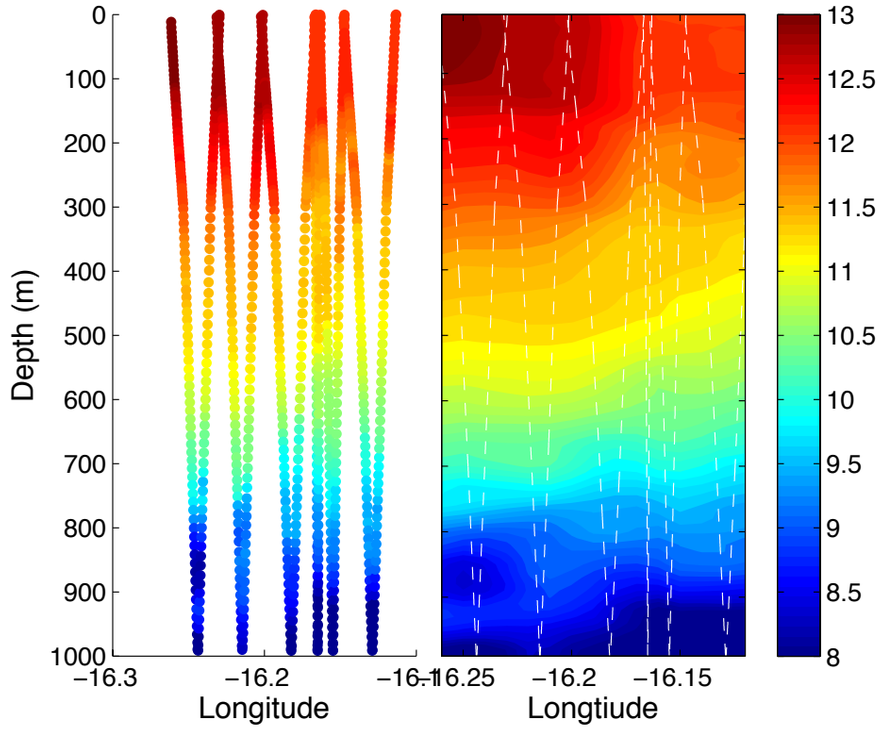
[Provide details on the depth and frequency of glider sampling.]

# Symmetric instability

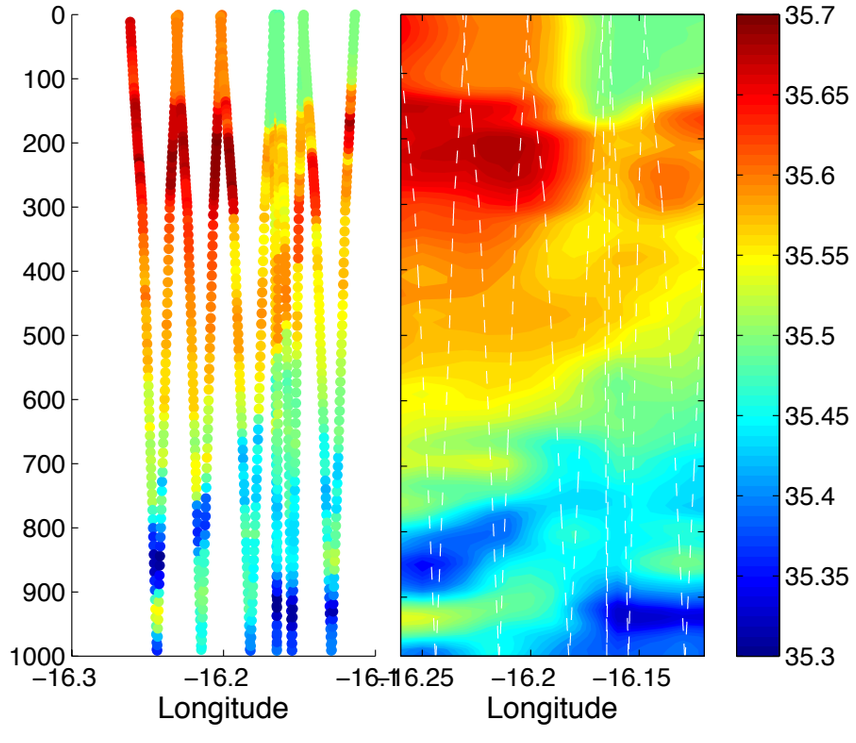
SST

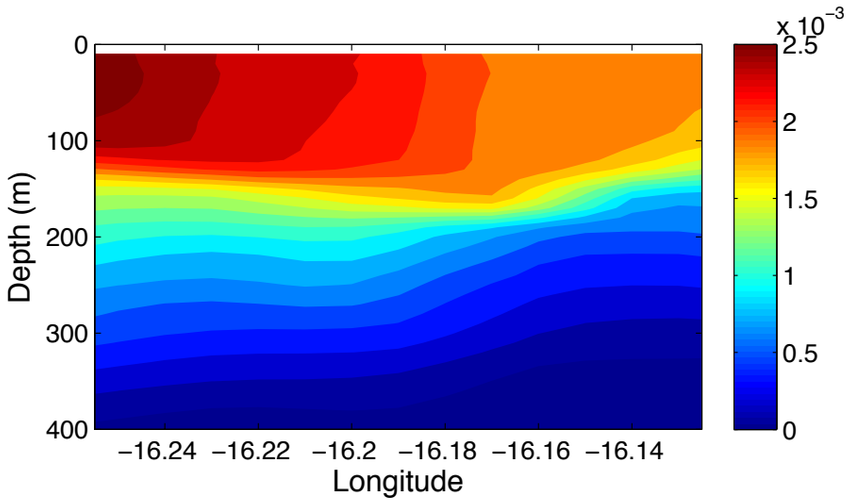



Temperature

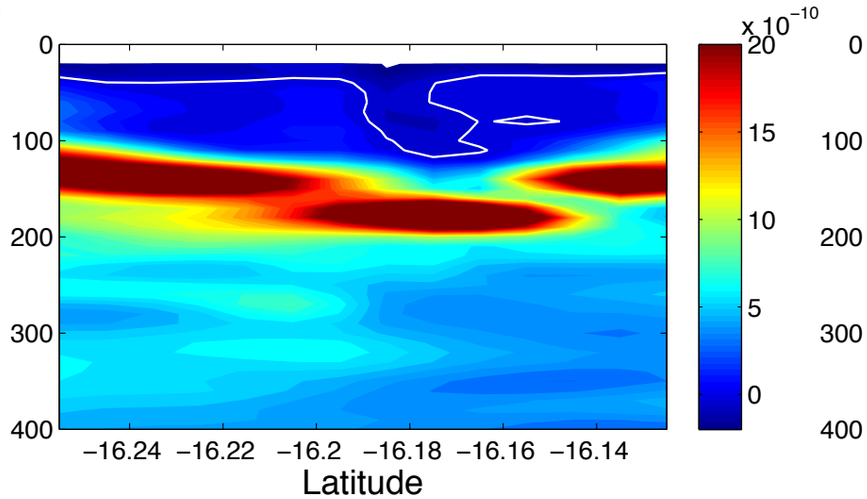



Salinity

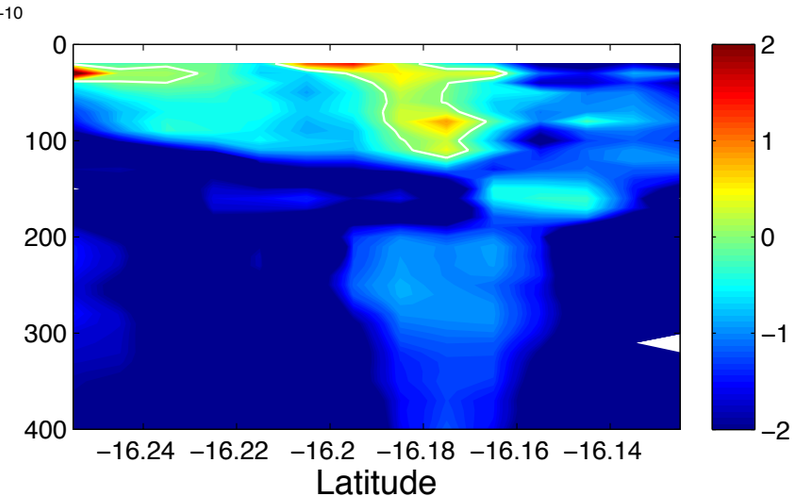



Buoyancy



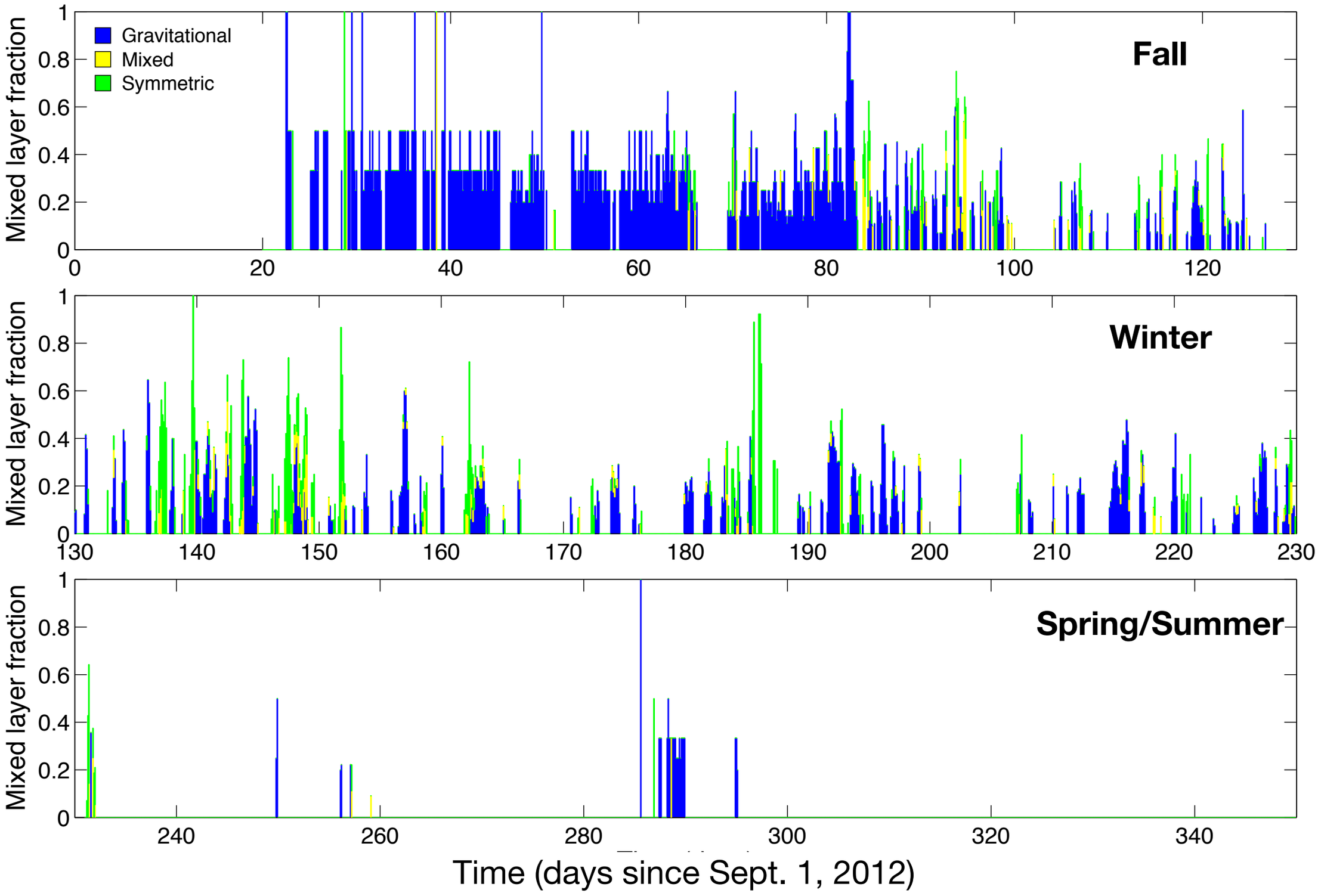

Potential vorticity



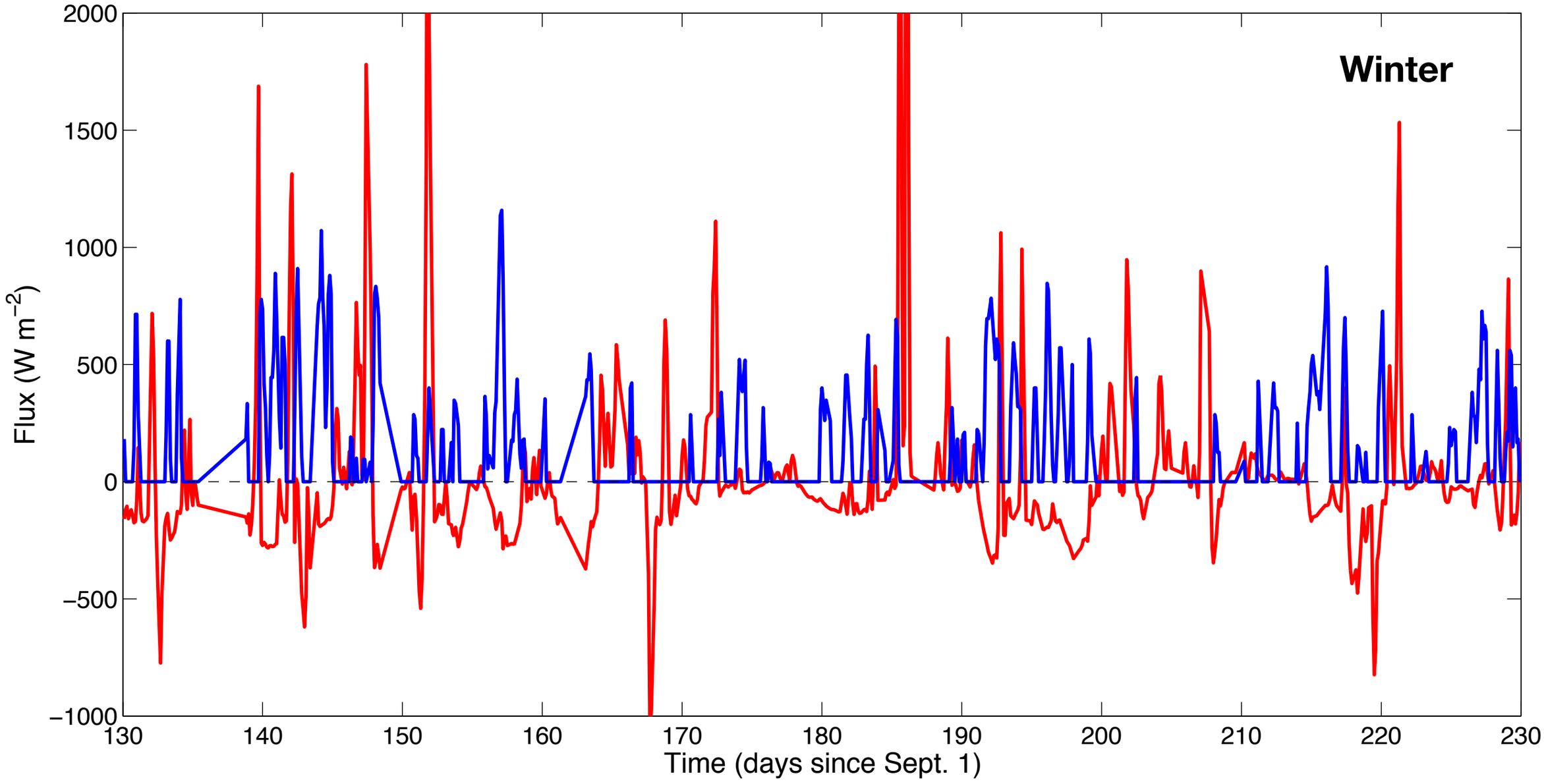

$M^4 / f^2N^2$

Inverse Richardson number

# Richardson angle



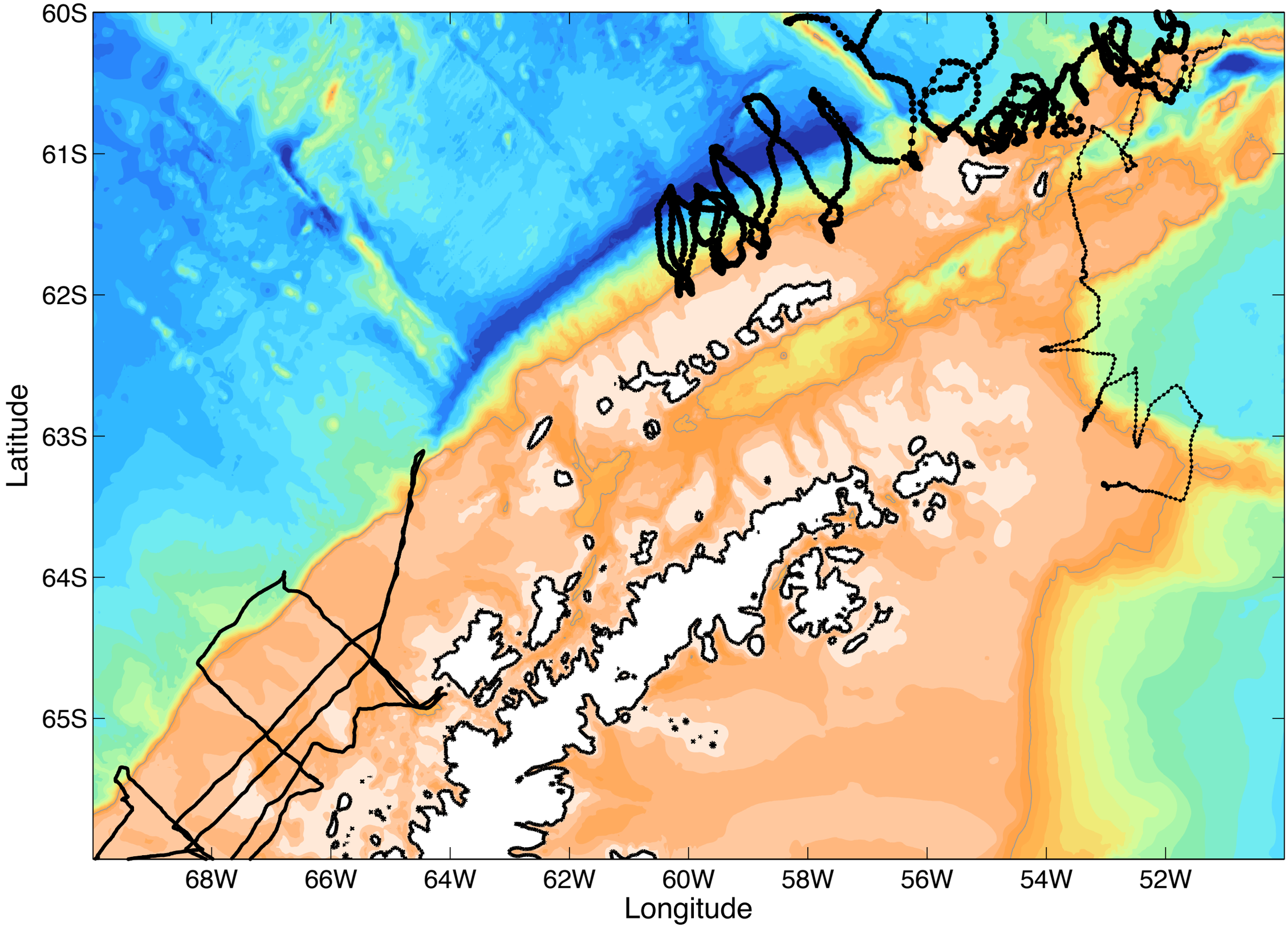
# Total surface buoyancy flux




Total buoyancy forcing: surface heat flux, Ekman buoyancy flux, mixed layer instability

Strength of convective instability (no units)

# ChinStrAP: Changes in Stratification at the Antarctic Peninsula



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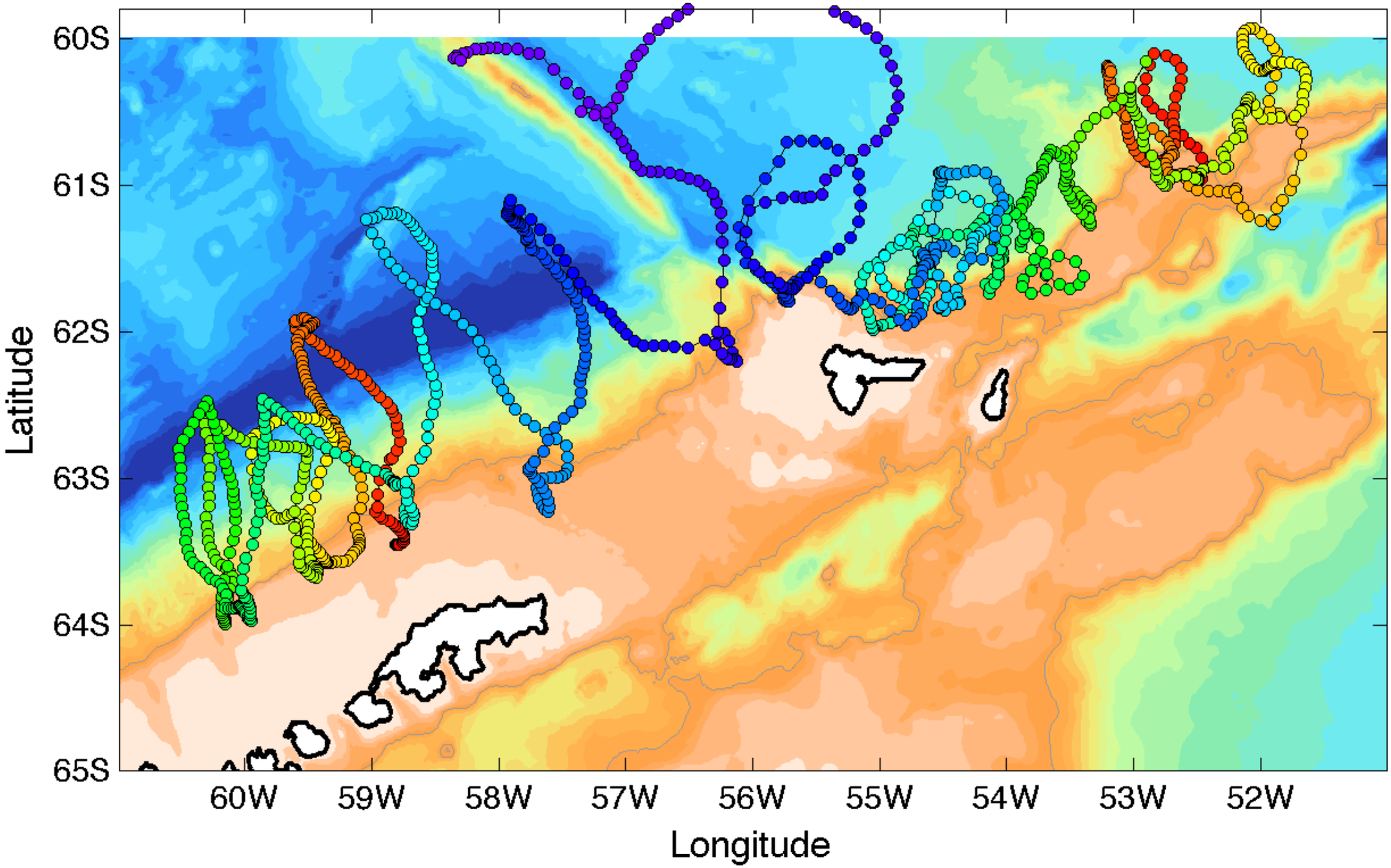


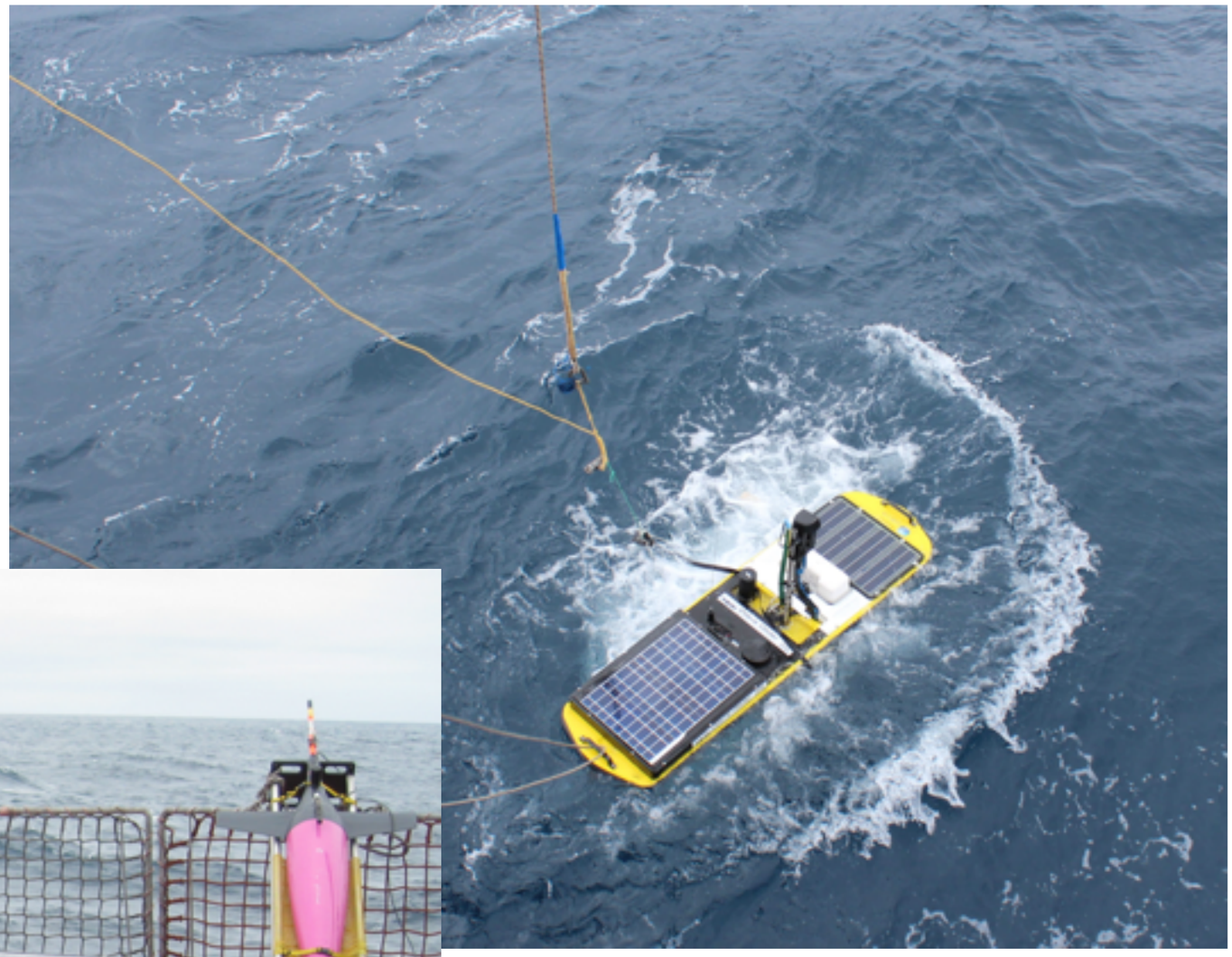

- 2 Seagliders:  deployed on 5 and 8 December; recovery mid-April.
- To date, 632 dives on SG566 (Drake Passage), 602 dives on SG539 (Scotia Sea).
- Temperature, salinity, dissolved oxygen, fluorescence, optical backscatter.
- Multiple crossings of the Antarctic Slope Front and the southern boundary of the Antarctic Circumpolar Current.
- **How does mesoscale / submesoscale variability impact isopycnal outcropping and ventilation?**

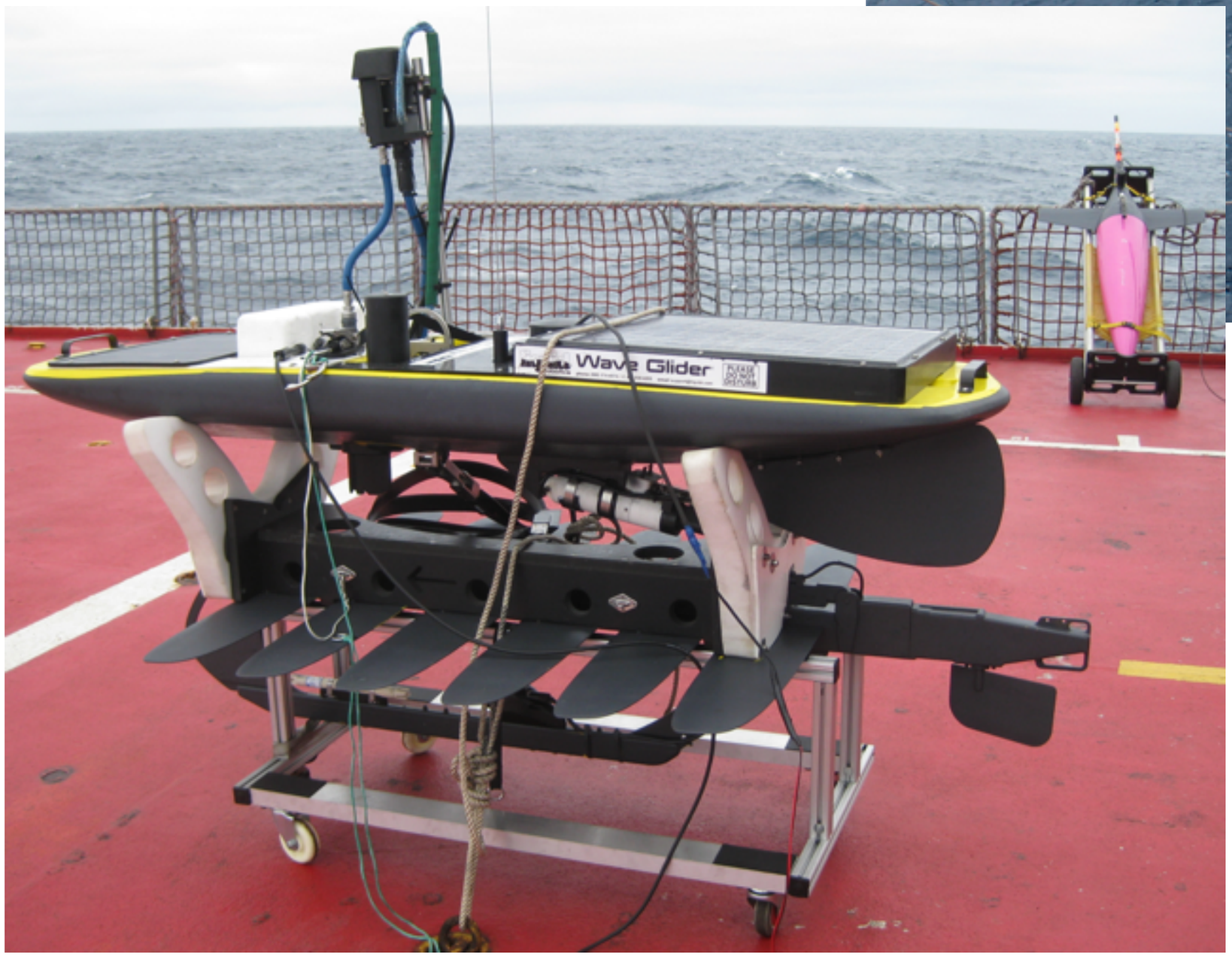
# Waveglider

- Surface temperature, salinity, dissolved oxygen.

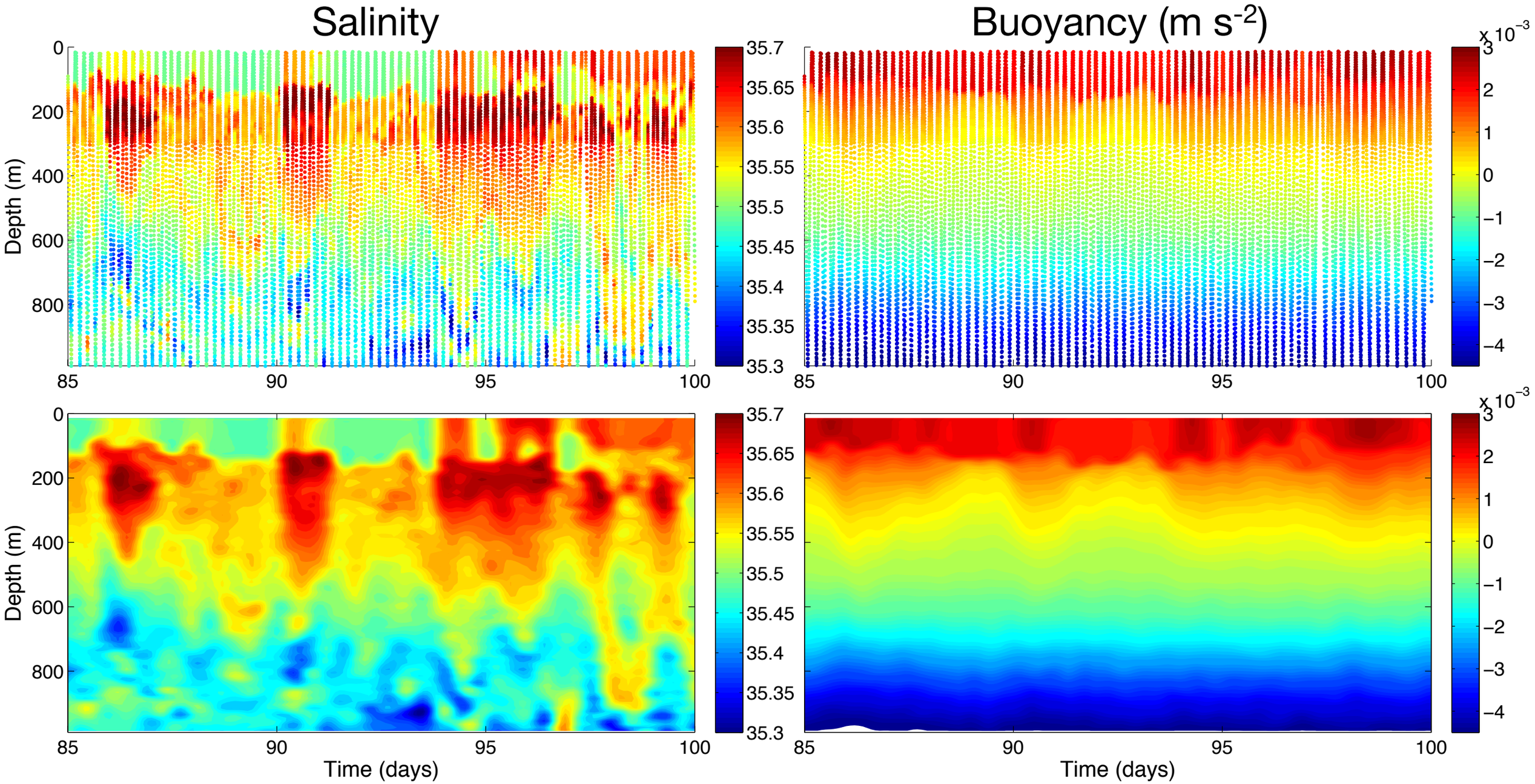
- Met sensor to measure surface wind speed and orientation.

- Possibility to collect surface pCO2.



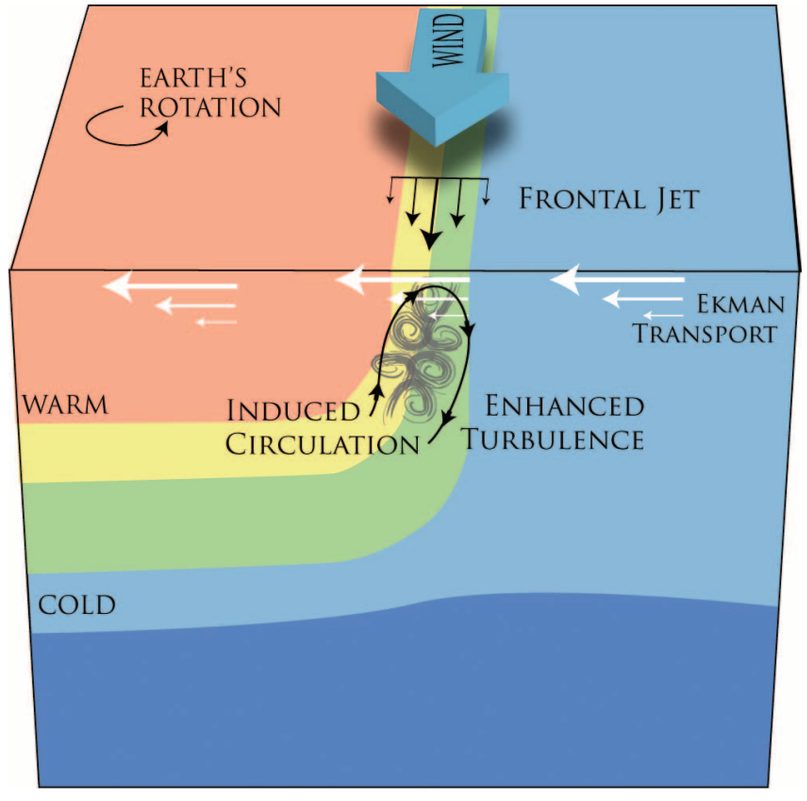


# Example data



# Motivation

Submesoscale instabilities, such as symmetric instability, are common features of the ocean's strong frontal currents, e.g. the Gulf Stream, Kuroshio [and an important contributor to turbulent dissipation].




D'Asaro et al. (2011)

Mesoscale eddies may generate strong, narrow buoyancy gradients throughout the ocean, although their orientation is less systematic.

**The prevalence of submesoscale instabilities in the open ocean and their seasonal variability is poorly understood.**