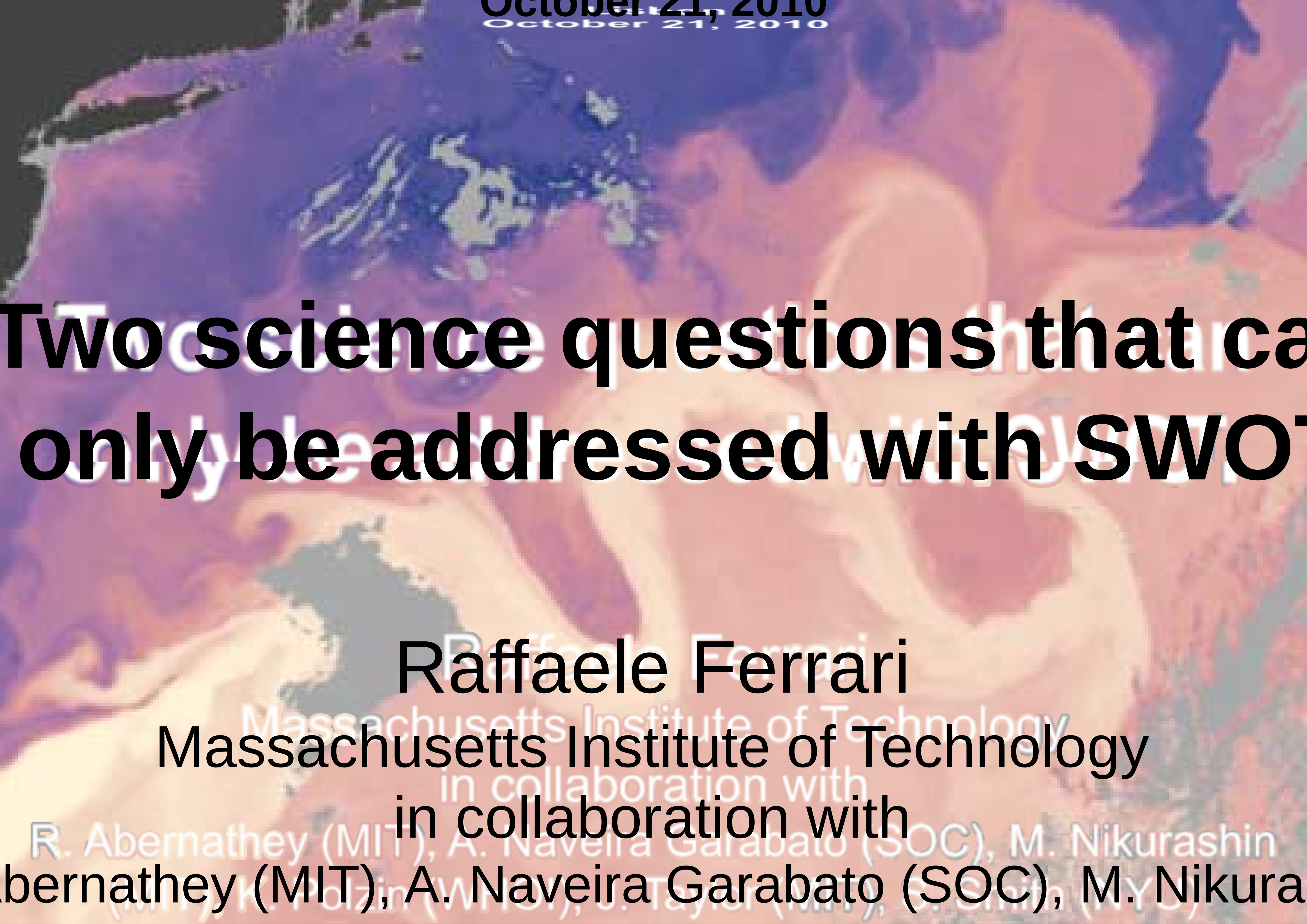


October 21, 2010

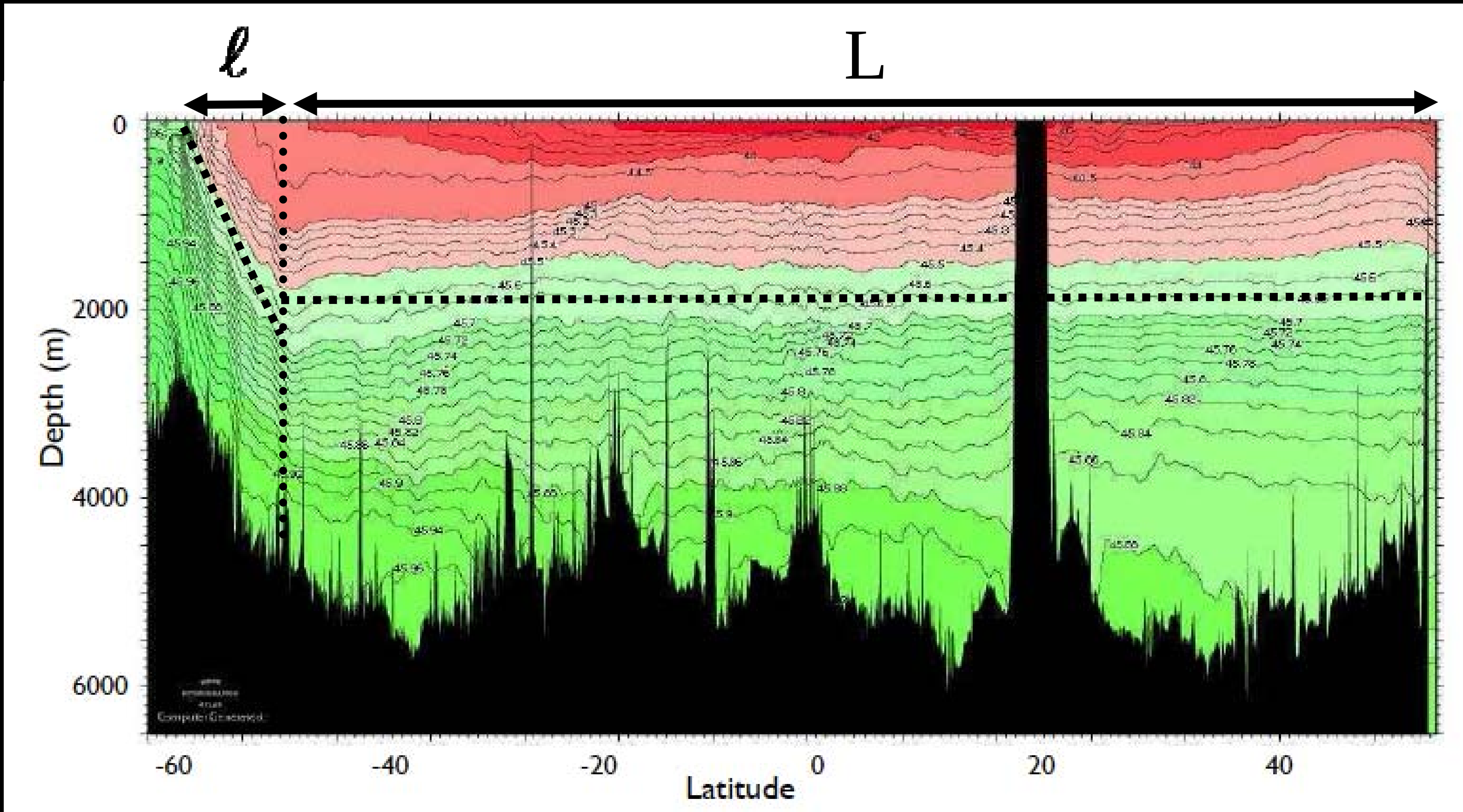
Two science questions that can only be addressed with SWOT

Raffaele Ferrari
Massachusetts Institute of Technology
in collaboration with
R. Abernathey (MIT), A. Naveira Garabato (SOC), M. Nikurashin

Outline

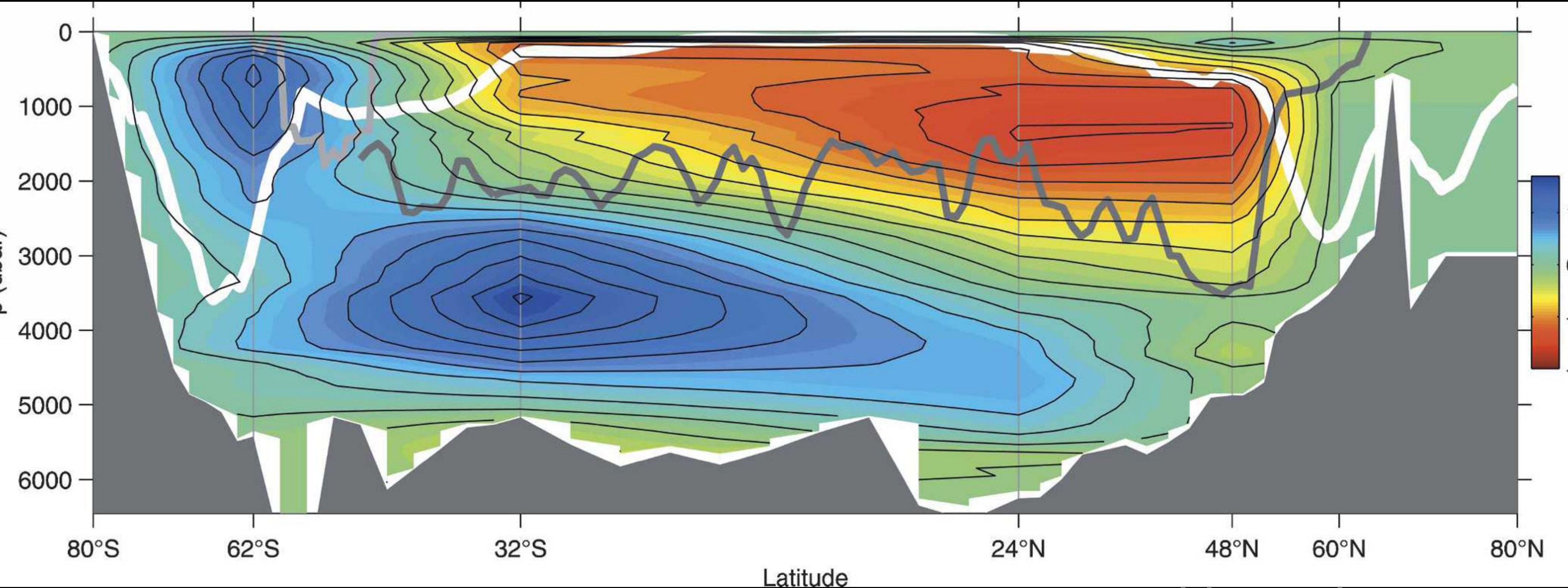
1. Lateral eddy transport
2. Vertical eddy transport

Eddies and winds in the Southern Ocean (SO) set the global ocean stratification below the surface thermoclines (Wolfe and Cessi, '10)



$$\text{Slope of isopycnals in SO} = \frac{\tau_{SO}}{f K_{SO}}$$

Eddies and winds in the Southern Ocean set the strength of the meridional overturning circulation (Wolfe and Cessi, ’10; Nikurashin and Vallis, ‘10)



Lumpkin and Speer, ’0

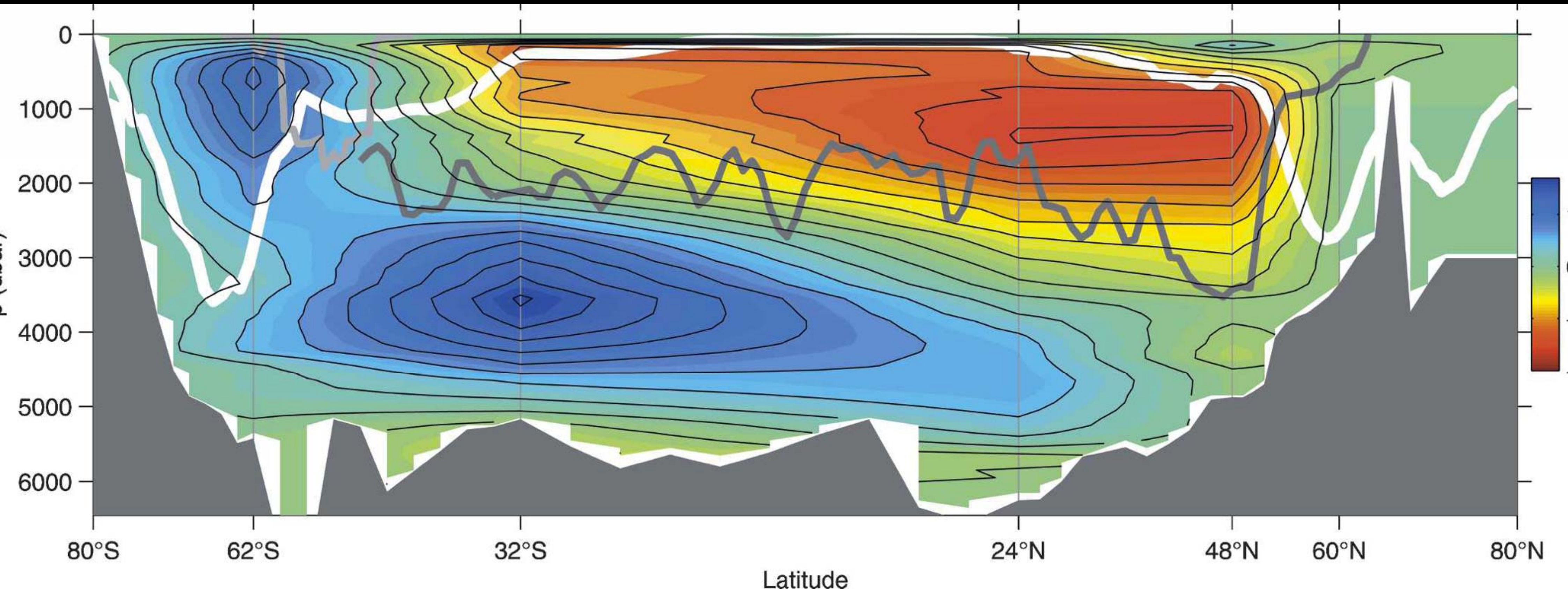
$$\Psi_{red} = \left(\frac{\ell}{f}\frac{\tau_{SO}}{K_{SO}}\right)^2 \frac{\Delta_H b}{f}$$

$$L\kappa\, K_{SO}$$

nds over the Southern Ocean have strengthened over the last 30 ye
ompson and Solomon, '02)

s unclear whether ocean CO_2 uptake will increase or decrease in
ponse to wind increase (Le Quéré et al., '07; Meredith and Hogg, '06)

take depends on how K_{SO} changes in response to wind change



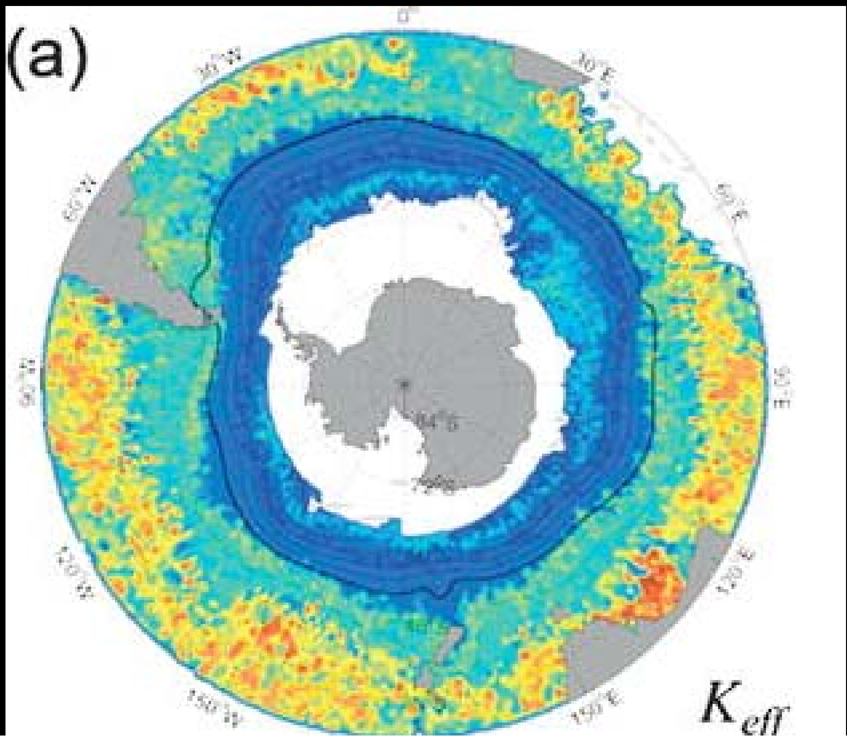
$\left(\ell \ \tau_{SO} \right)^2 \Delta_H b$ $\quad$ $L \kappa \ K_{SO}$

ere are spatial variations in K_{SO}

K_{SO} is suppressed in the core of the Antarctic Circumpolar Current

K_{SO} is enhanced at depth below the core of the ACC

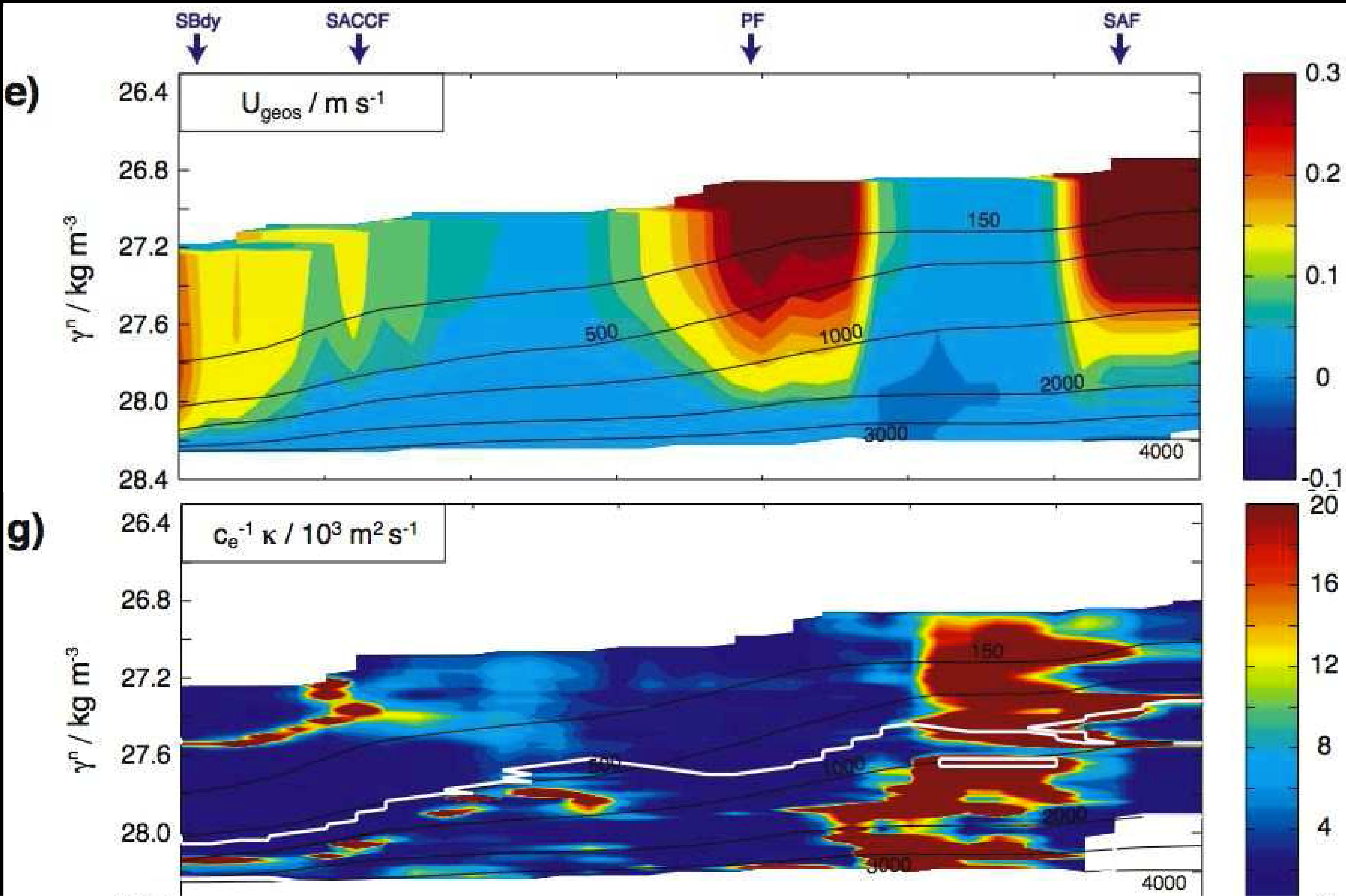
$$K_{SO} = 0.32\frac{g}{f}\frac{\sqrt{\overline{\eta'^2}}}{1+8|\nabla\overline{\eta}|^2/\overline{|\nabla\eta'|^2}} = 0.32\frac{g}{f}\frac{\sqrt{\overline{\eta'^2}}}{1+8U^2/EK}$$



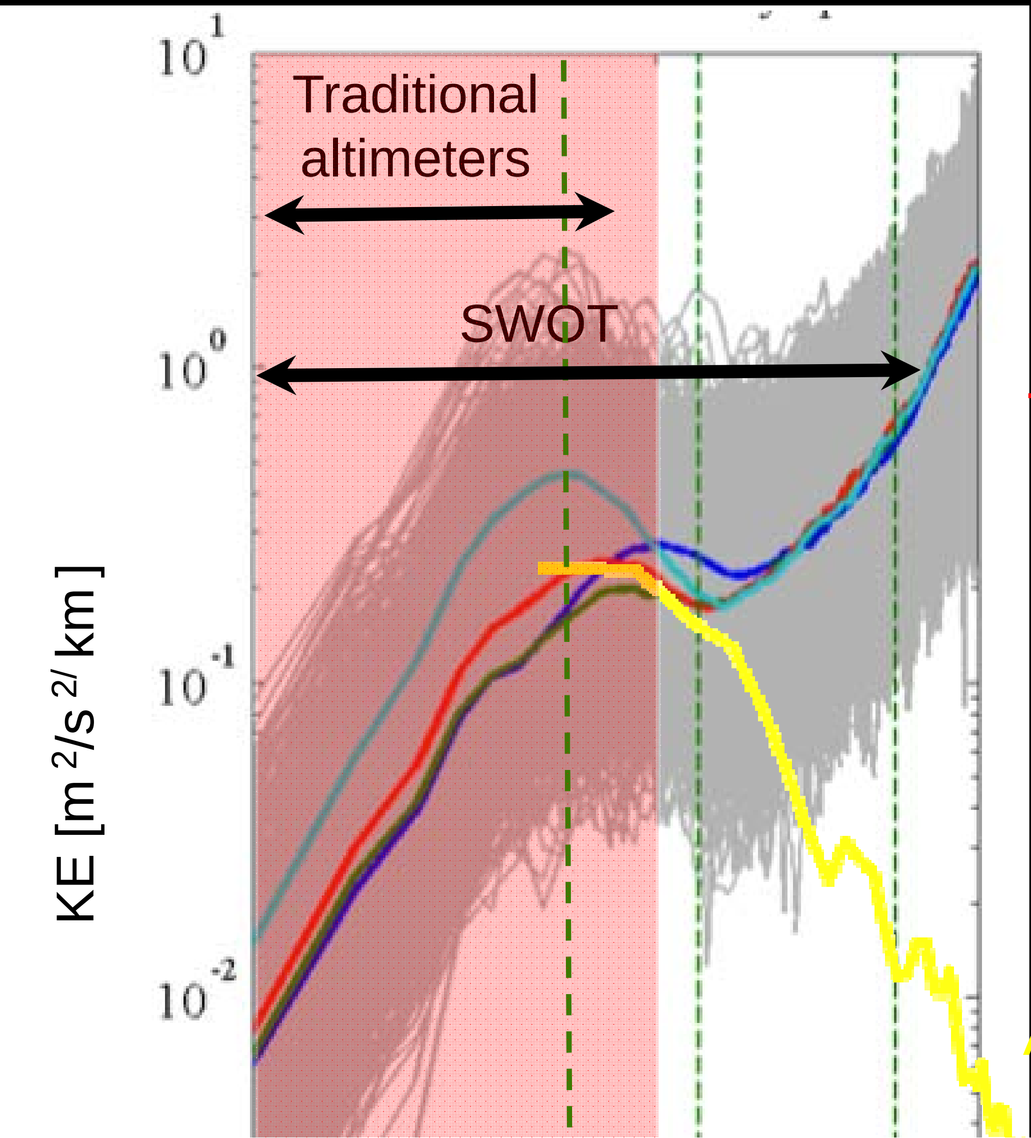
Marshall et al., ‘04

uppression of K_{SO} is confined to ACC frontal jets
ontal jets have scales of 50-100km

Drake Passage Section (WOCE) from Garabato and Ferrari, '10



aditional altimeters have a resolution of O(100)km
ACC fronts cannot be resolved
WOT will have a resolution of O(10)km
ACC fronts will be resolved
magnitude and structure of K_{SO} will be measured for the first time



T/P velocity spectrum (Labrador Sea, 50° – 60° N)

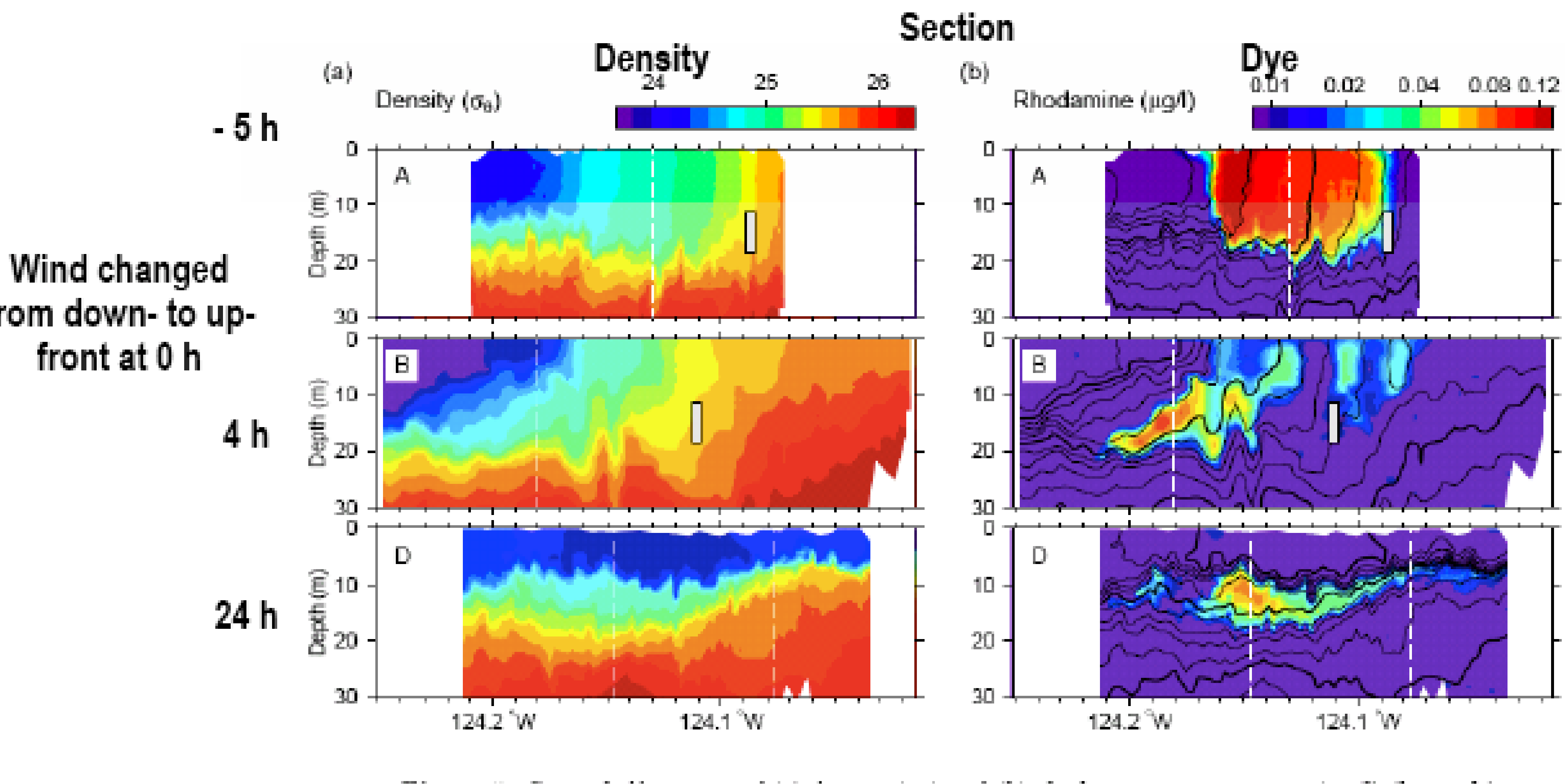
ADCP velocity spectrum (North Atlantic, 50°

Outline

1. Lateral eddy transport
2. Vertical eddy transport

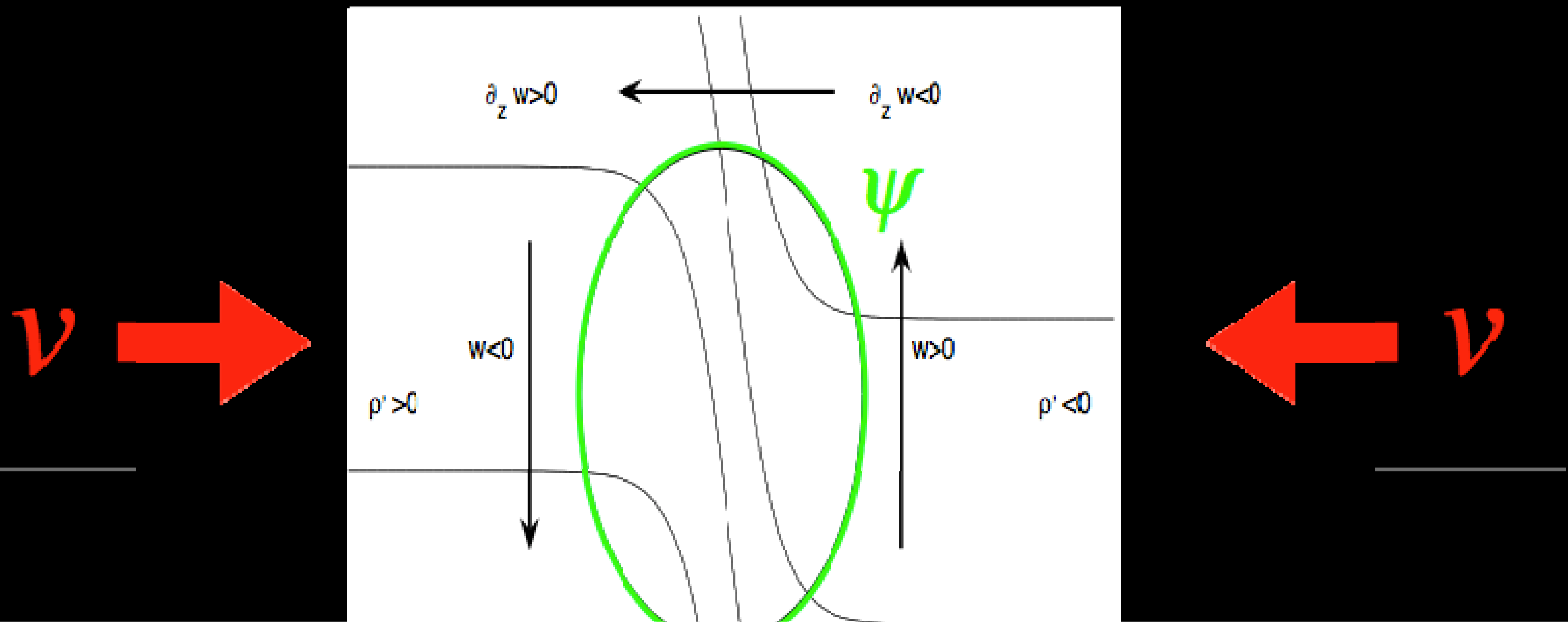
change of tracers and nutrients between the ocean surface and inte
centrated at fronts
onts are speculated to regulate primary productivity in the ocean

Lateral dispersal of tracer - due to the slumping of a ML front



rtical transport at fronts in the QG approximation is determined by
horizontal density gradients
horizontal velocity shears
oth quantities are dominated by frontal scales of O(1-50)km
peyre and collaborators suggested to use SWOT and QG theory to i
ical transport of tracers from sea surface height

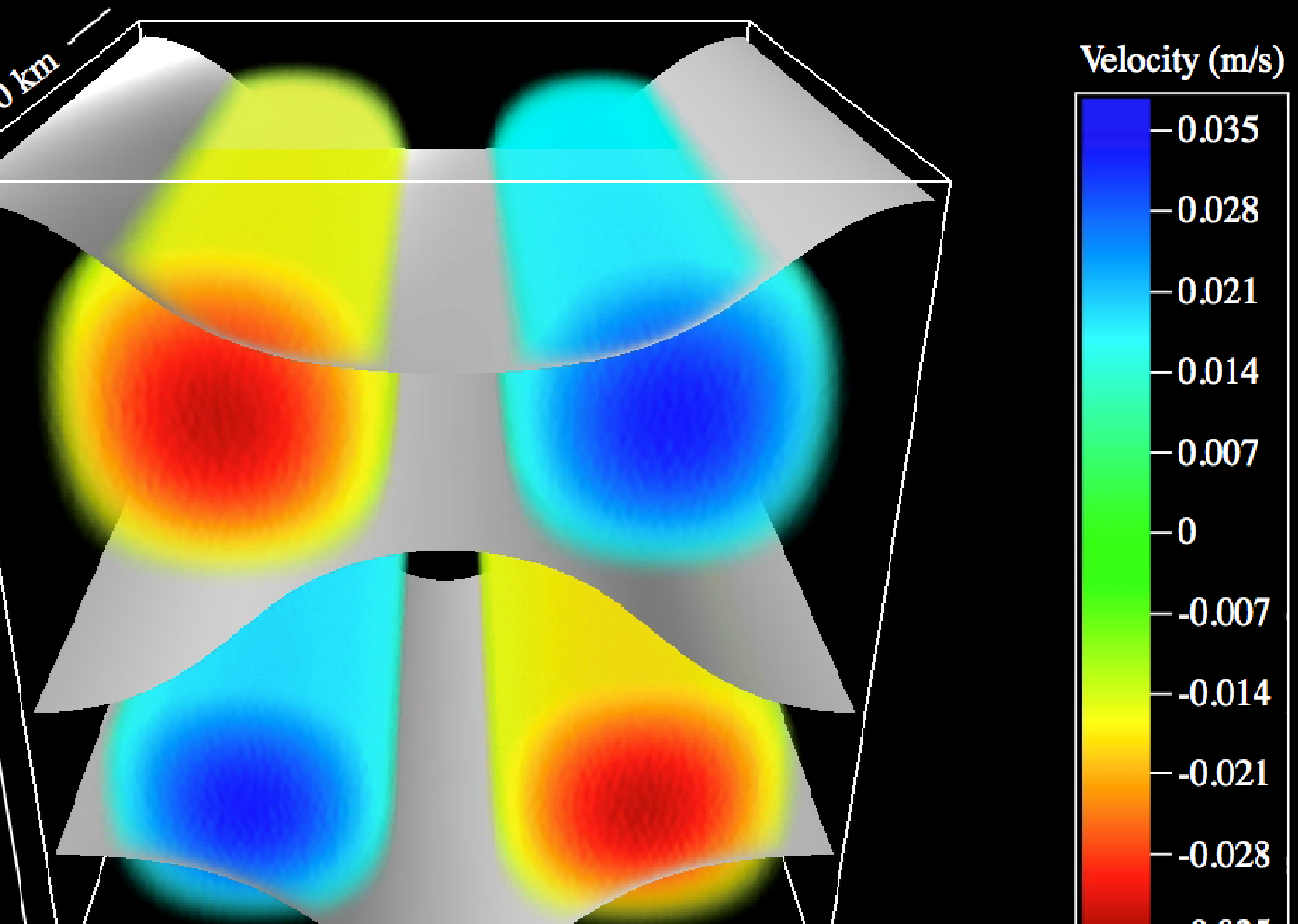
$$f^2 \psi_{zz} + N^2 \psi_{yy} = -2 v_y b_y$$



Are QG estimates of vertical transport accurate?

mulations of baroclinically unstable fronts are run with a QG model a
nitive Equation model

e goal is to test whether a QG model captures accurately the vertica
sport of tracers



$$b = N^2 z + \frac{M^2}{\ell_0} \cos \ell_0 y \; c$$

$$u = \frac{M^2}{f m_0} \sin \ell_0 y \sin m_0 z$$

$$Ro = \frac{M^2}{N f}$$

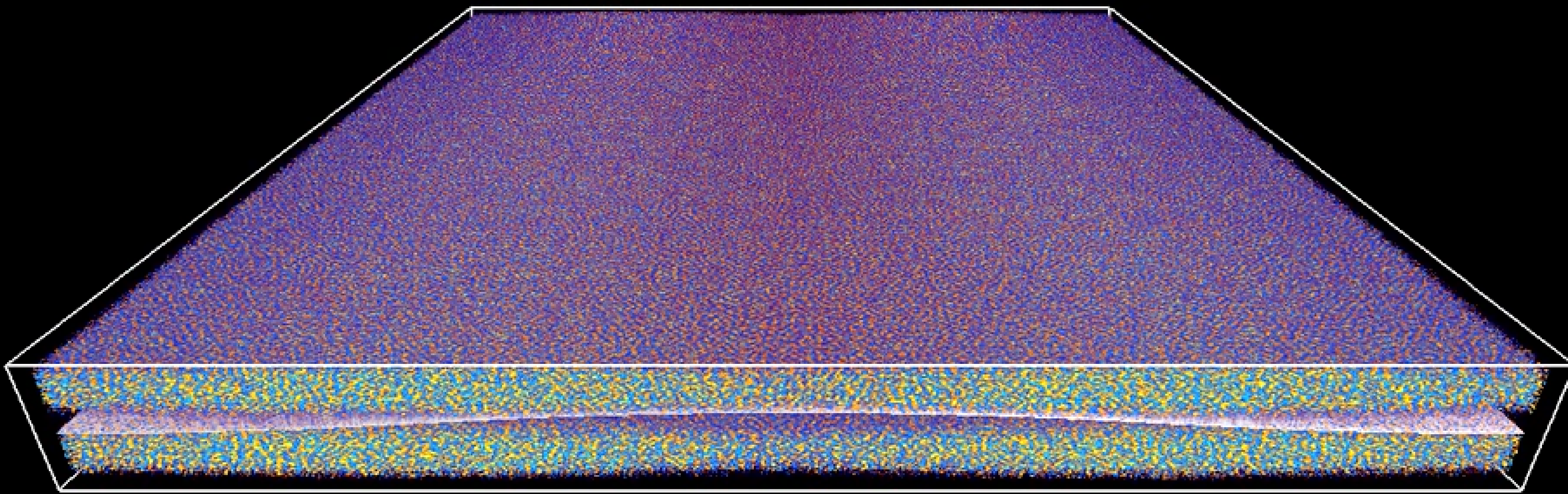
$$Ri = Ro^{-2}$$

Are QG estimates of vertical transport accurate?

accurate?

mulations of baroclinically unstable fronts are run with a QG model a nitive Equation model

e goal is to test whether a QG model captures accurately the vertica sport of tracers

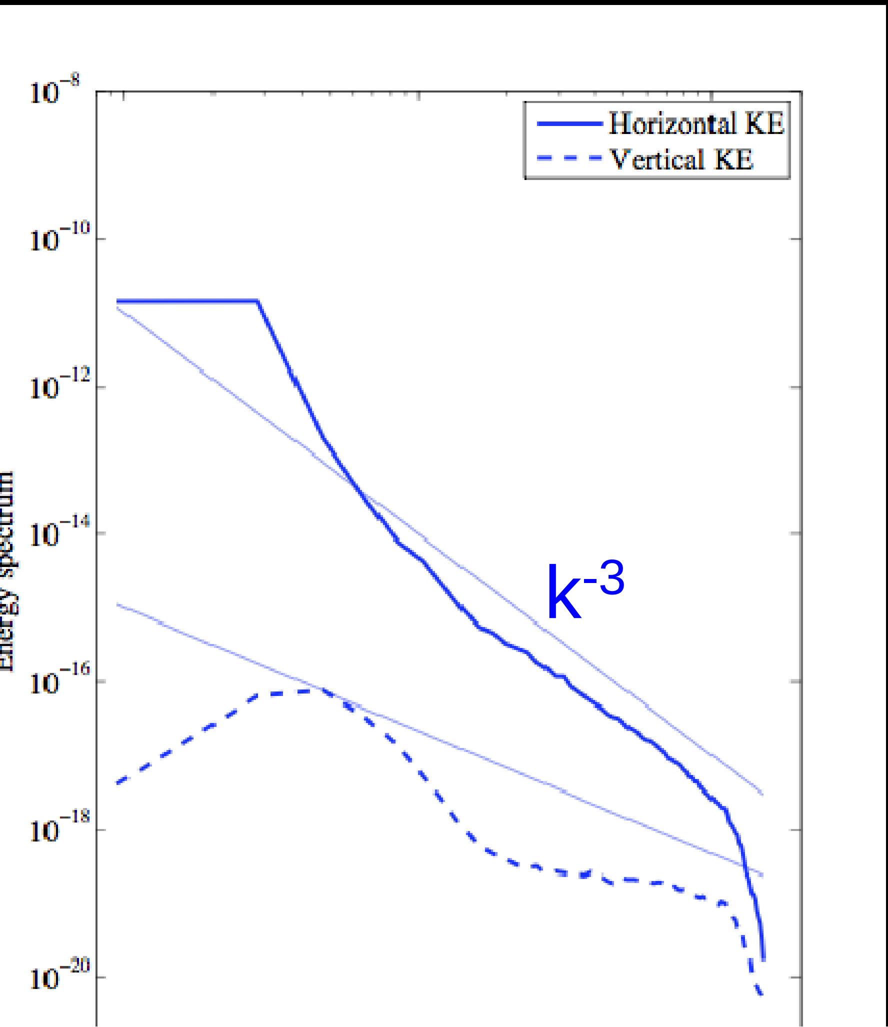


Ro simulations are QG-like

eep horizontal KE spectrum (k^{-3})

$$\frac{w^2}{{}^2+v^2} \ll 1$$

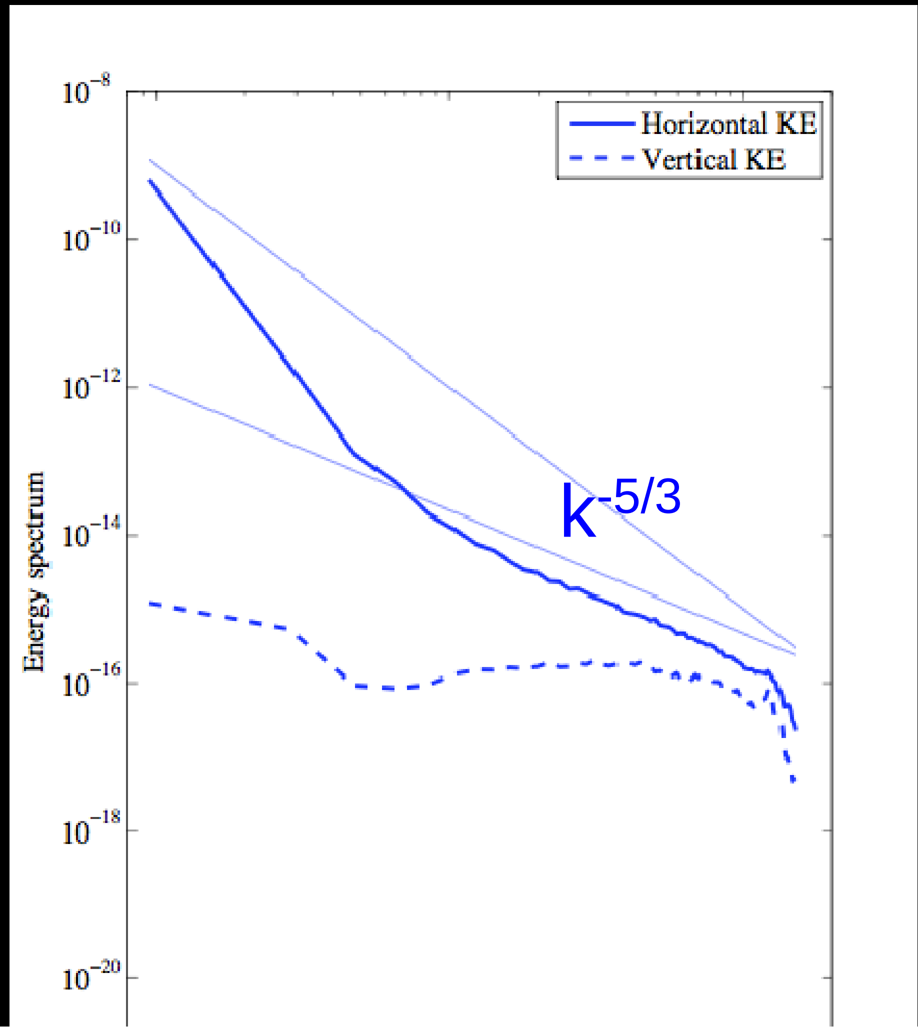
Ro=0.13, Ri=64



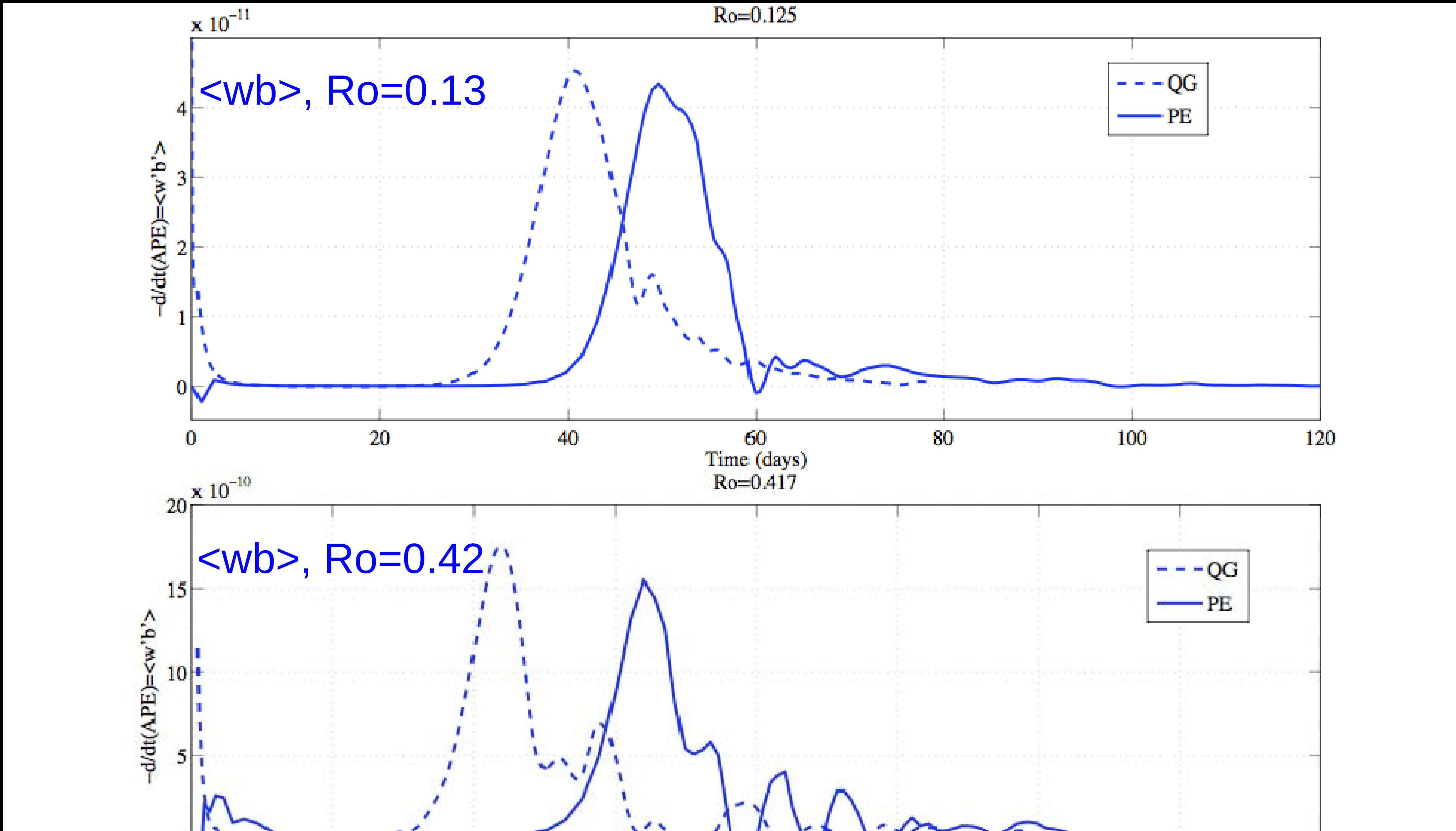
High Ro simulations are not QG-

- flat horizontal KE spectrum (k$^{-5/}$
- $\frac{w^2}{u^2+v^2}$ approaches 1

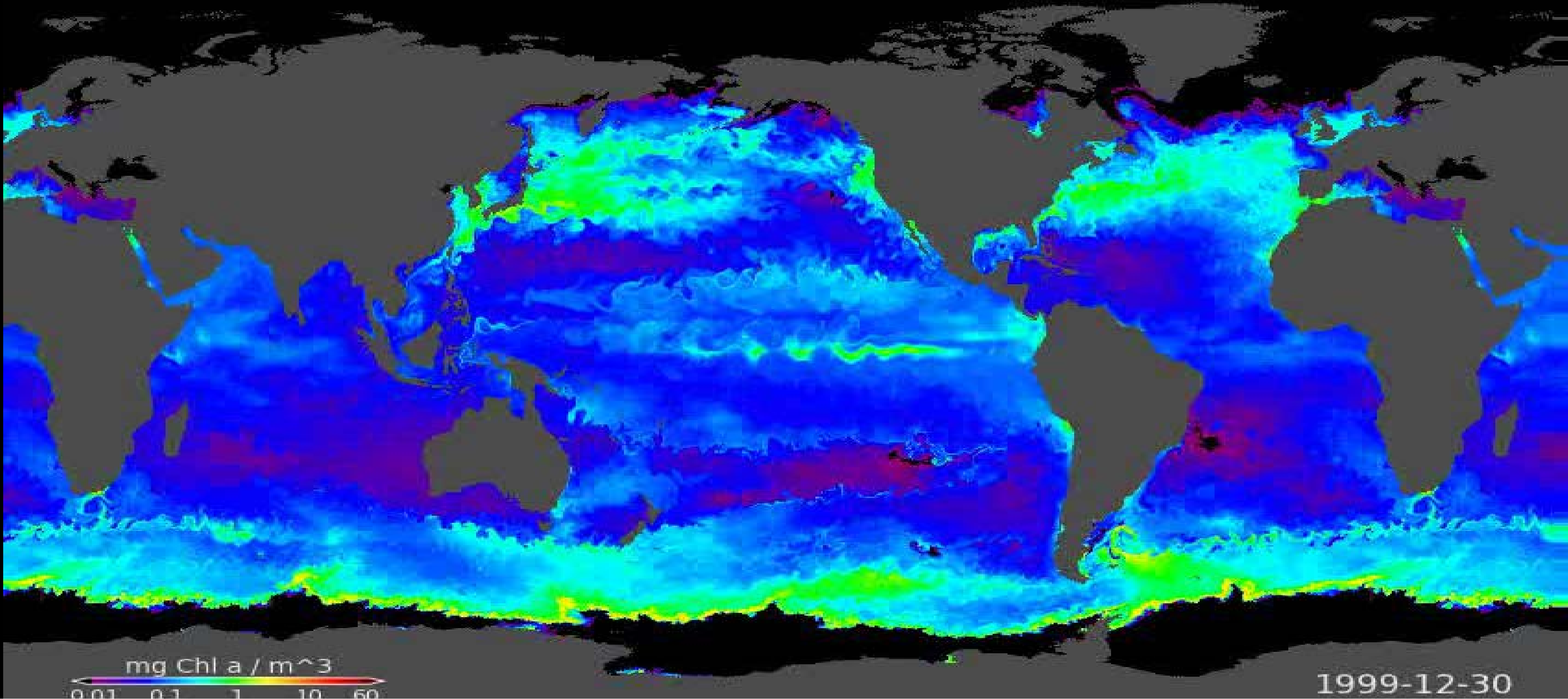
Ro=0.42, Ri=5.7



rtical velocity is underestimated by QG approximation at Ro=O(1)
rtical tracer transport of tracers is well captured by QG approximatio
n for Ro=O(1)



Full resolution of lateral eddy diffusivity
Partial resolution of vertical transport at fronts
A new window on ocean productivity



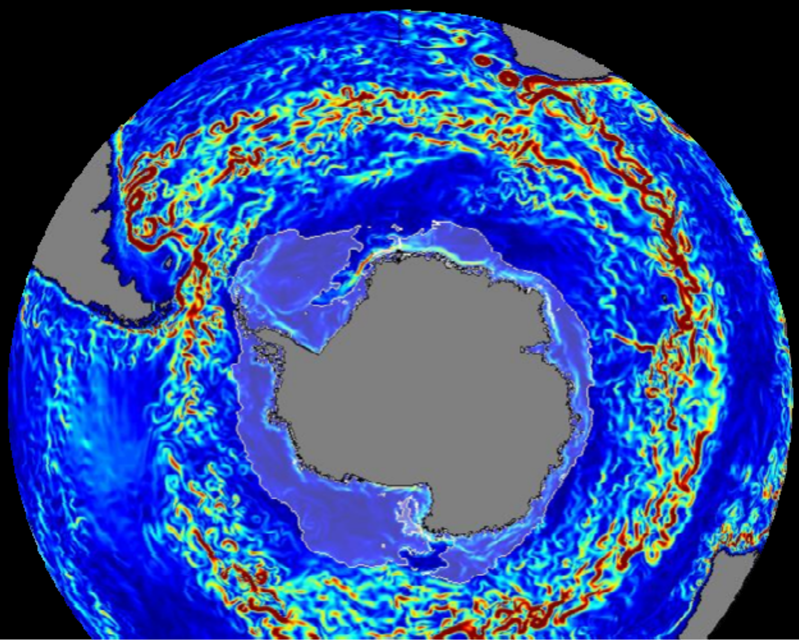
Matthew Mazloff (Ph.D. thesis)

78^0 South to 24.7^0 South

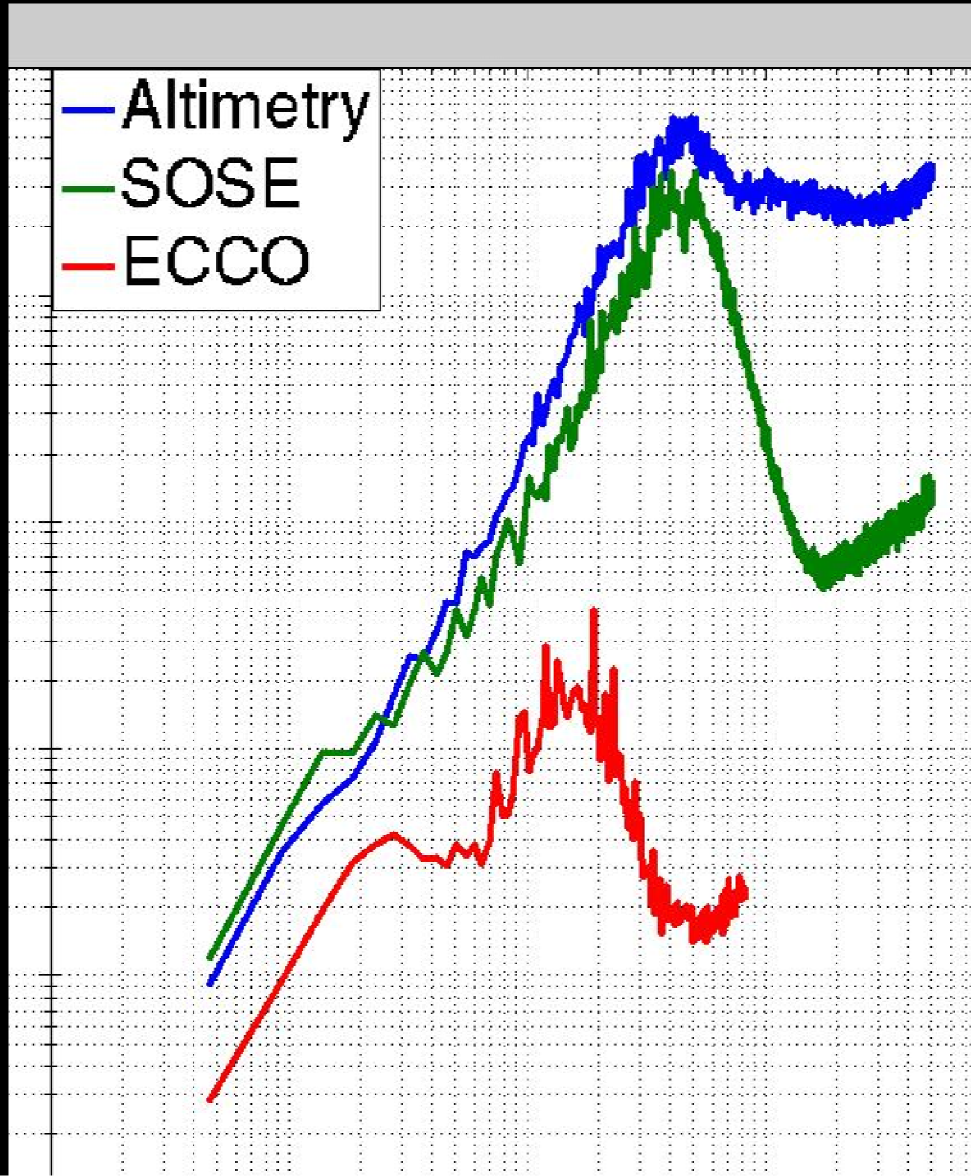
1/6^0 Horizontal resolution;

42 depth levels (partial cells)

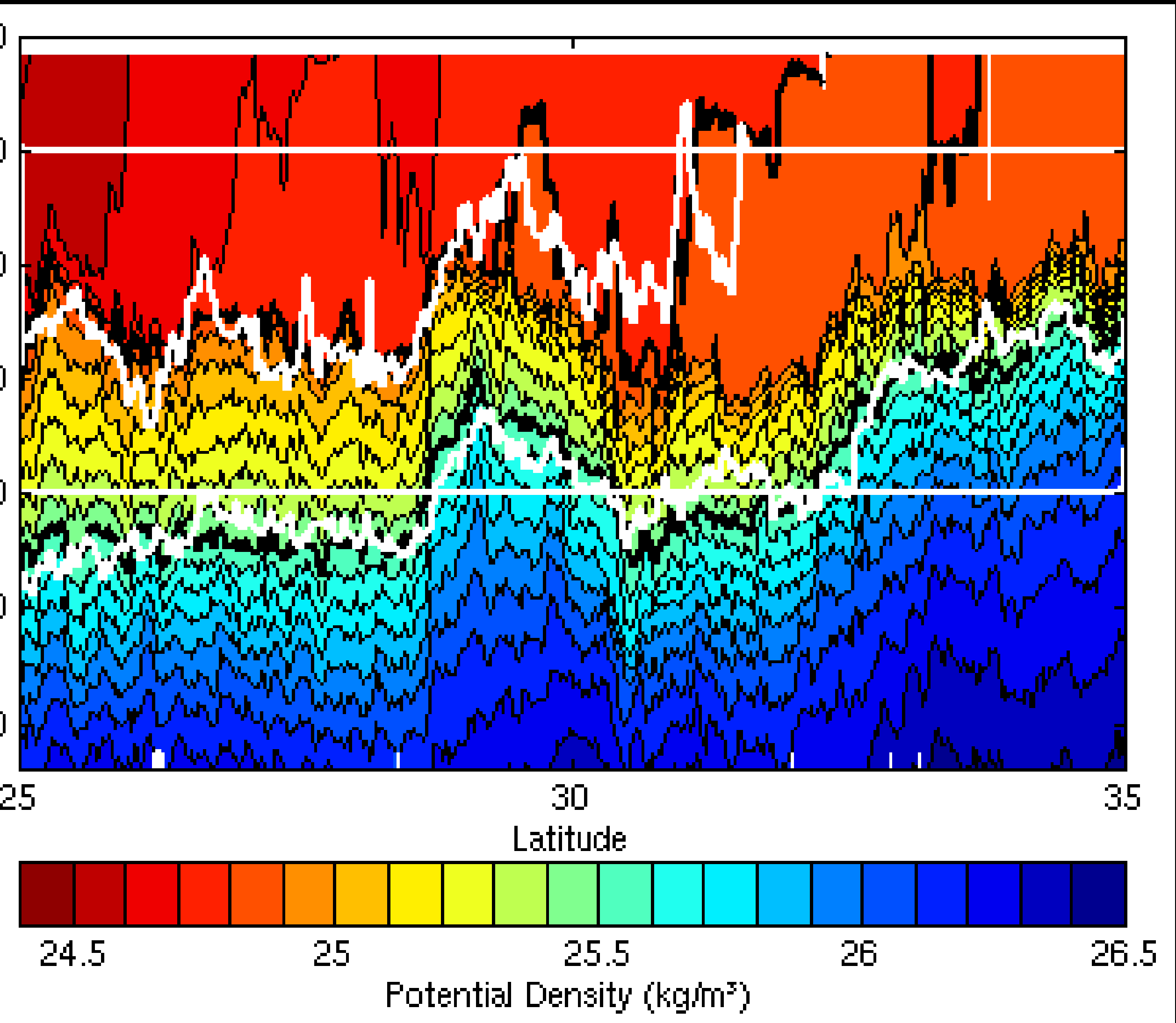
similar setup to ECCO-GODAE



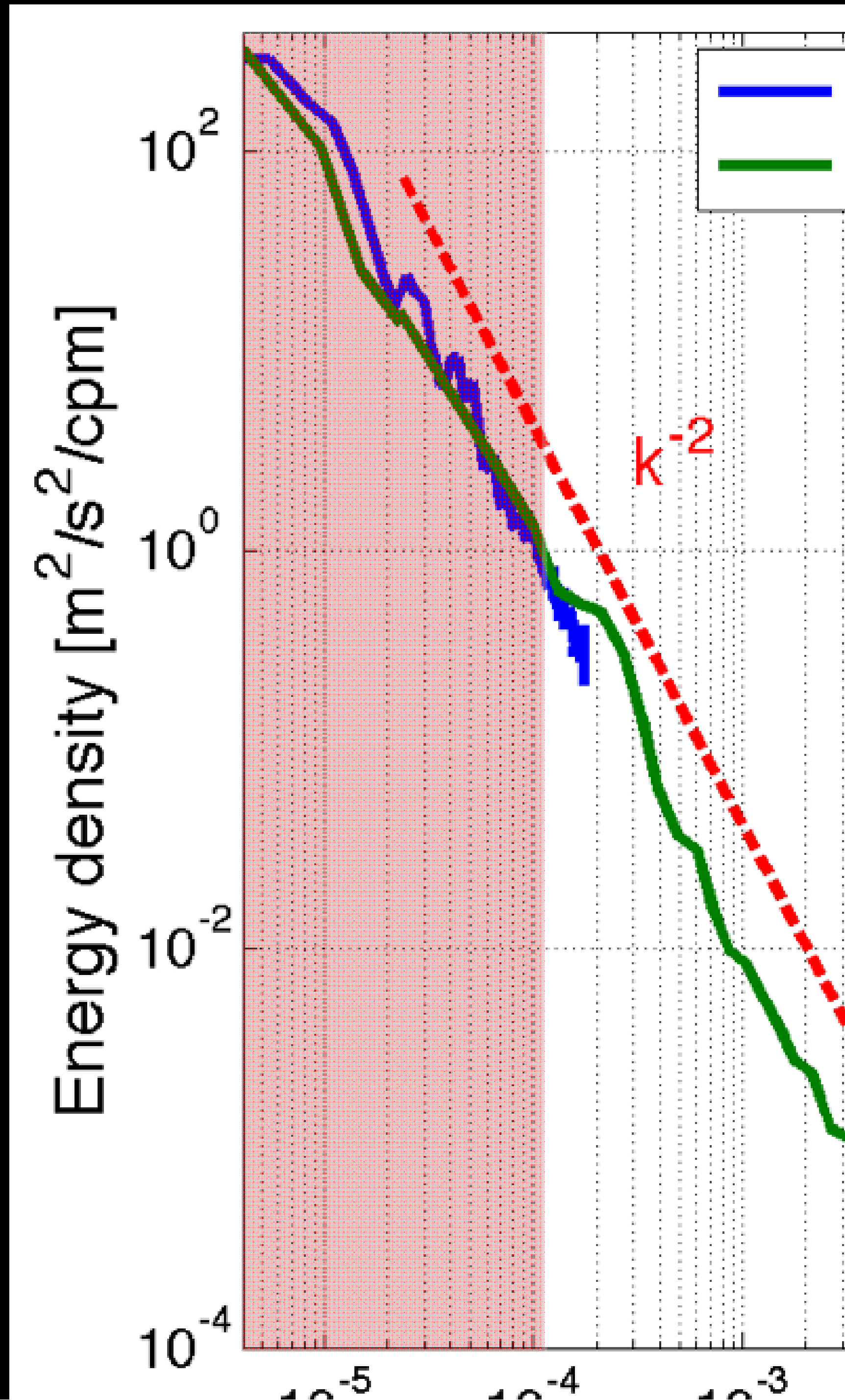
Kinetic Energy



Horizontal SeaSoar section



KE and PE horizontal sp

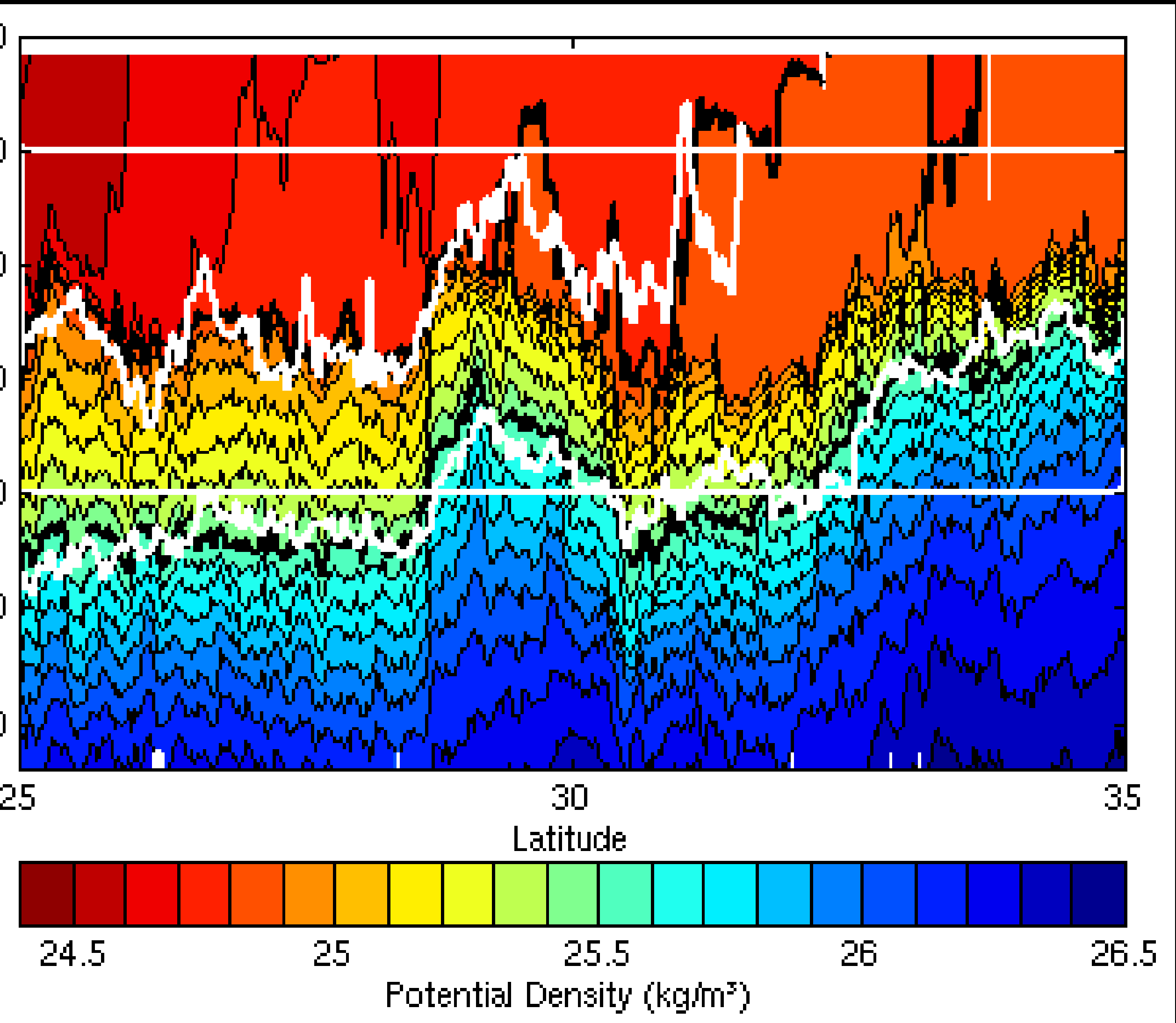


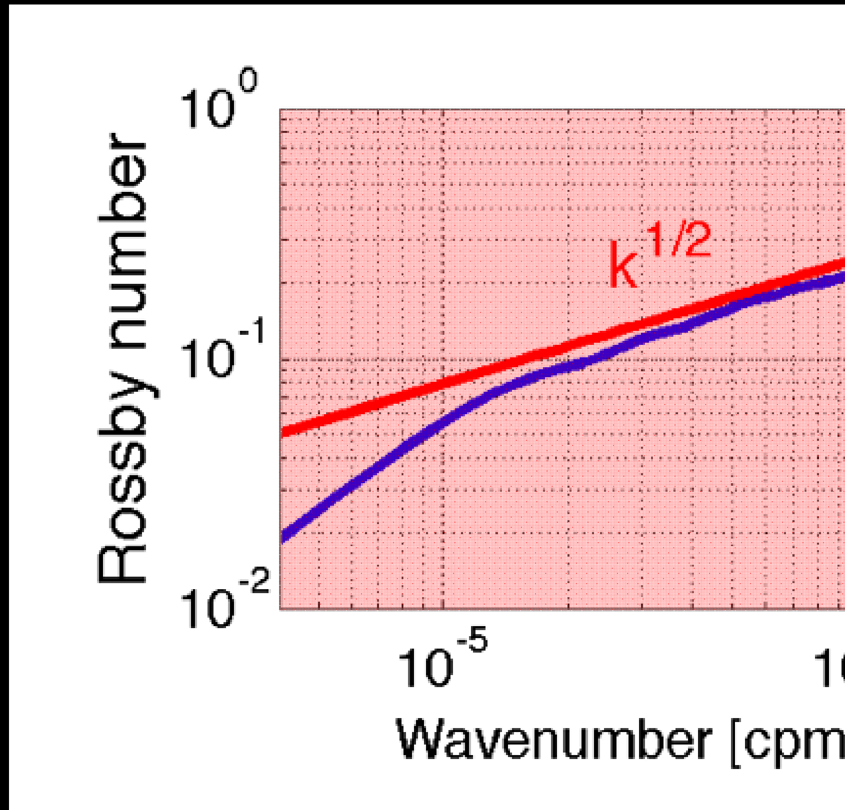
Equipartition of KE and PE

Spectral rolloff of k-2

Horizontal SeaSoar section

Rossby number





Equipartition of KE and PE

Spectral rolloff of k-2

Eddies and winds in the Southern Ocean set the strength of the meridional overturning circulation (Nikurashin and Vallis, '10)