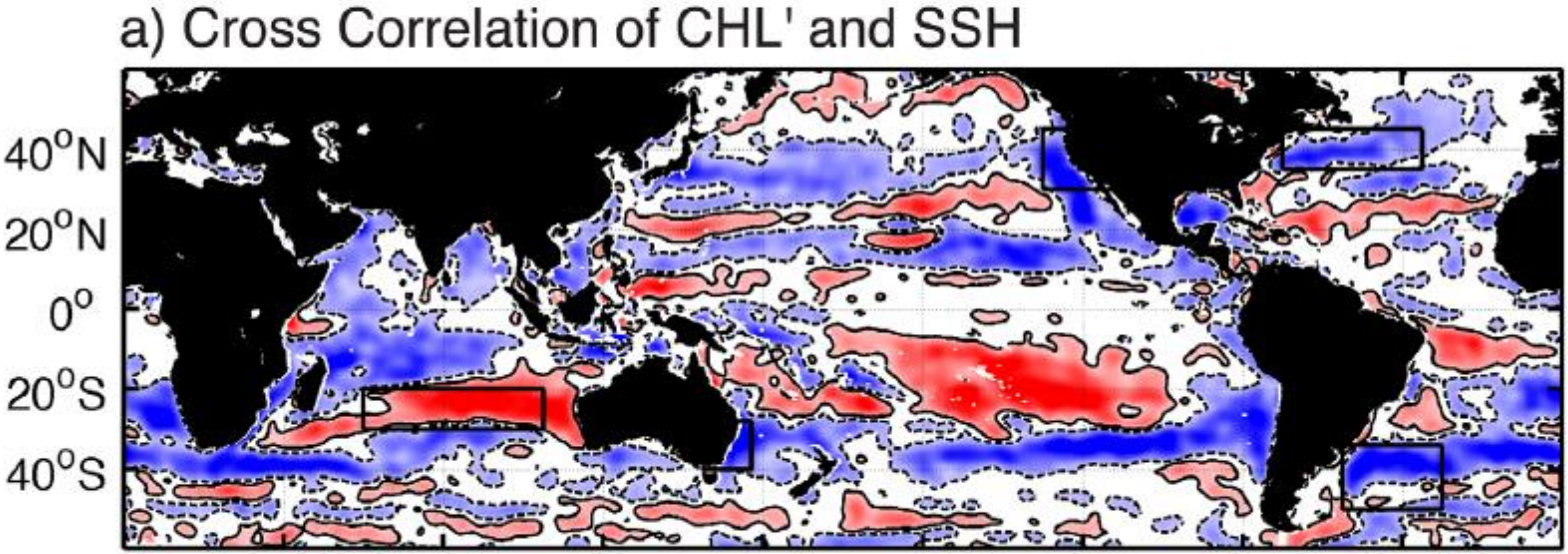
On the transfer of energy from the ocean interior to the surface in mesoscale eddies

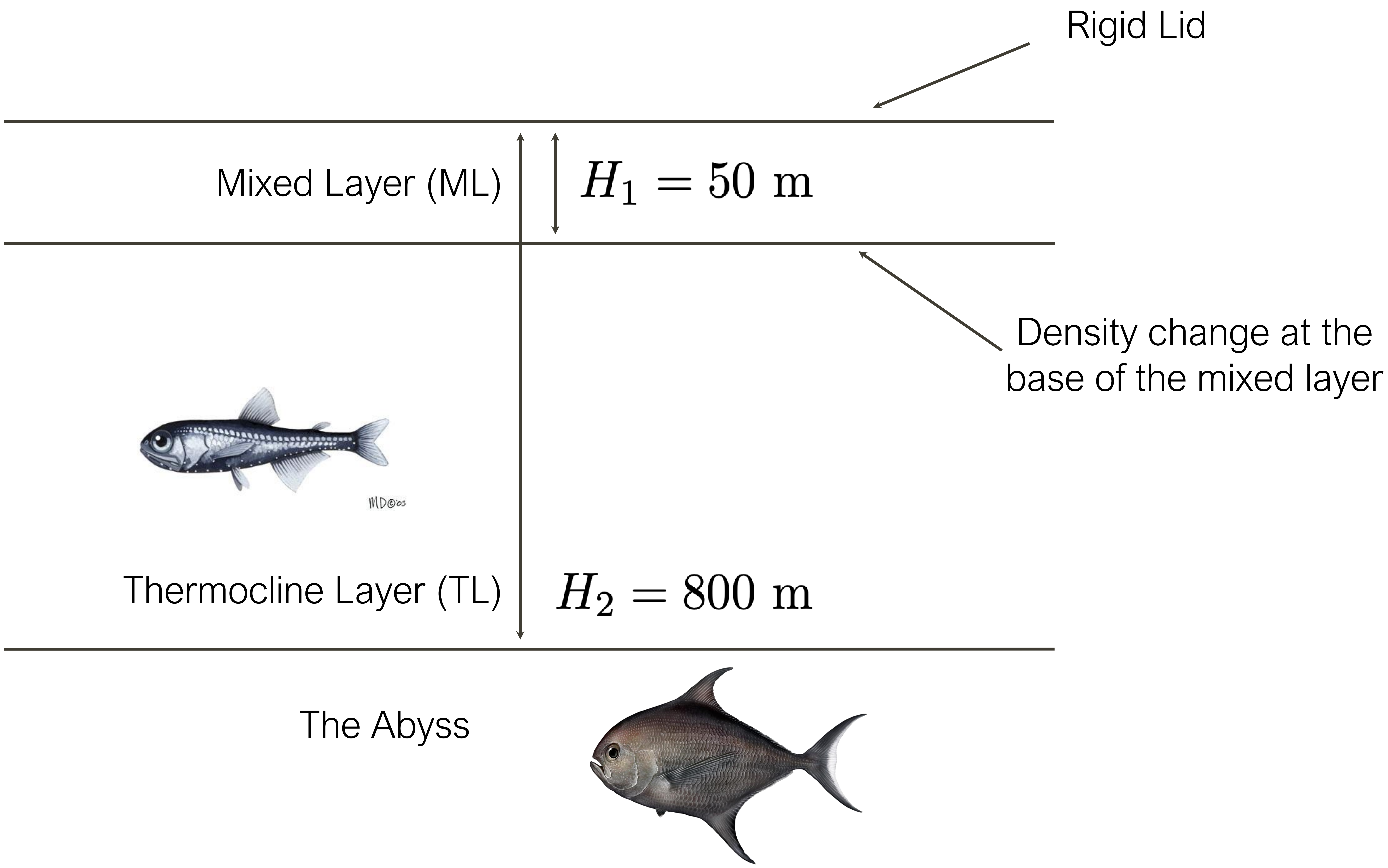
Peter Gaube, Jeffery Early, Alice Della Penna, Evan Mason, and Mike Behrenfeld

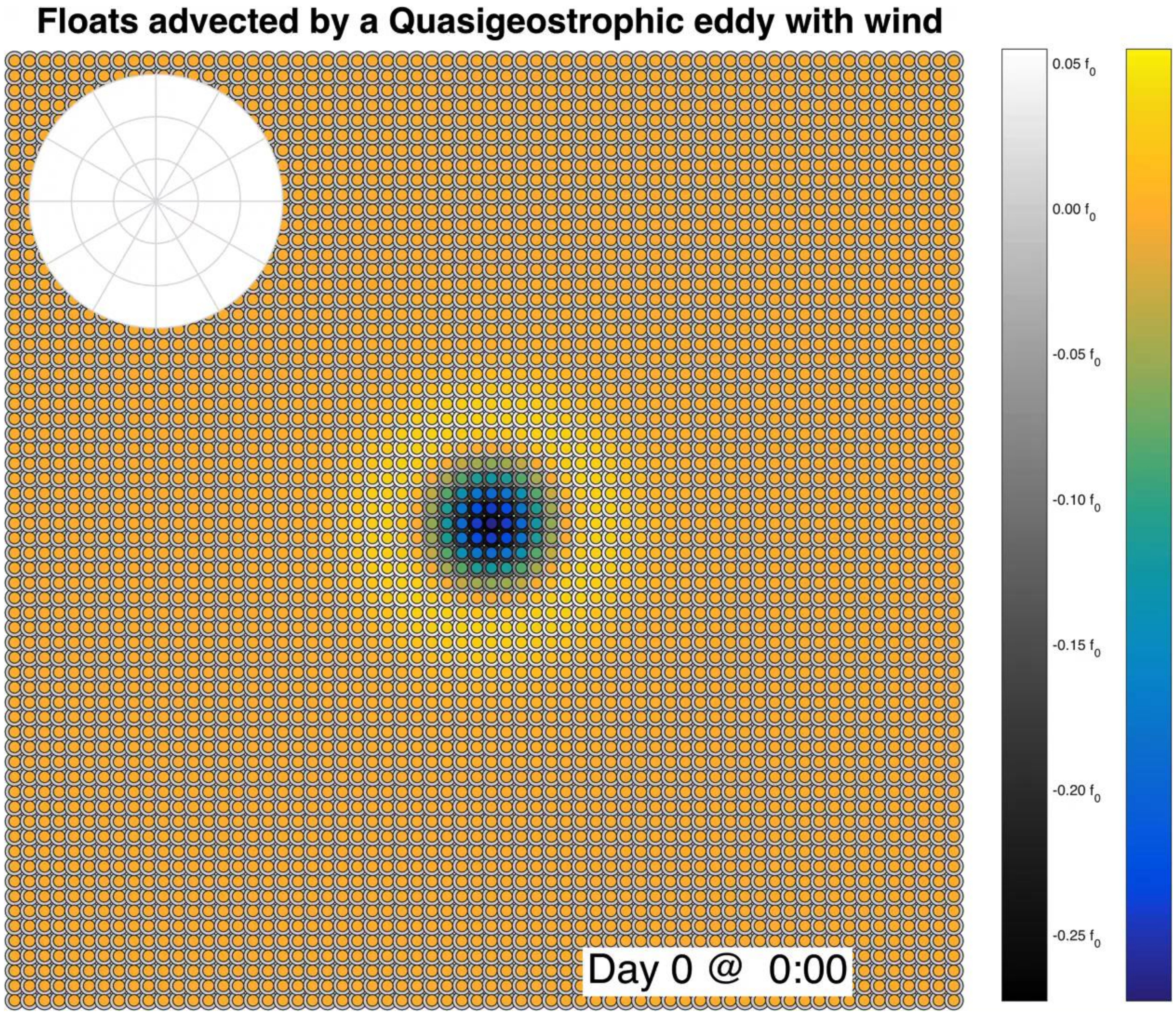


Gaube *et al* 2015

The influence of mesoscale eddies on CHL varies regional and is cannon be observed in many areas.

A simple QG damped-slab model of the ocean



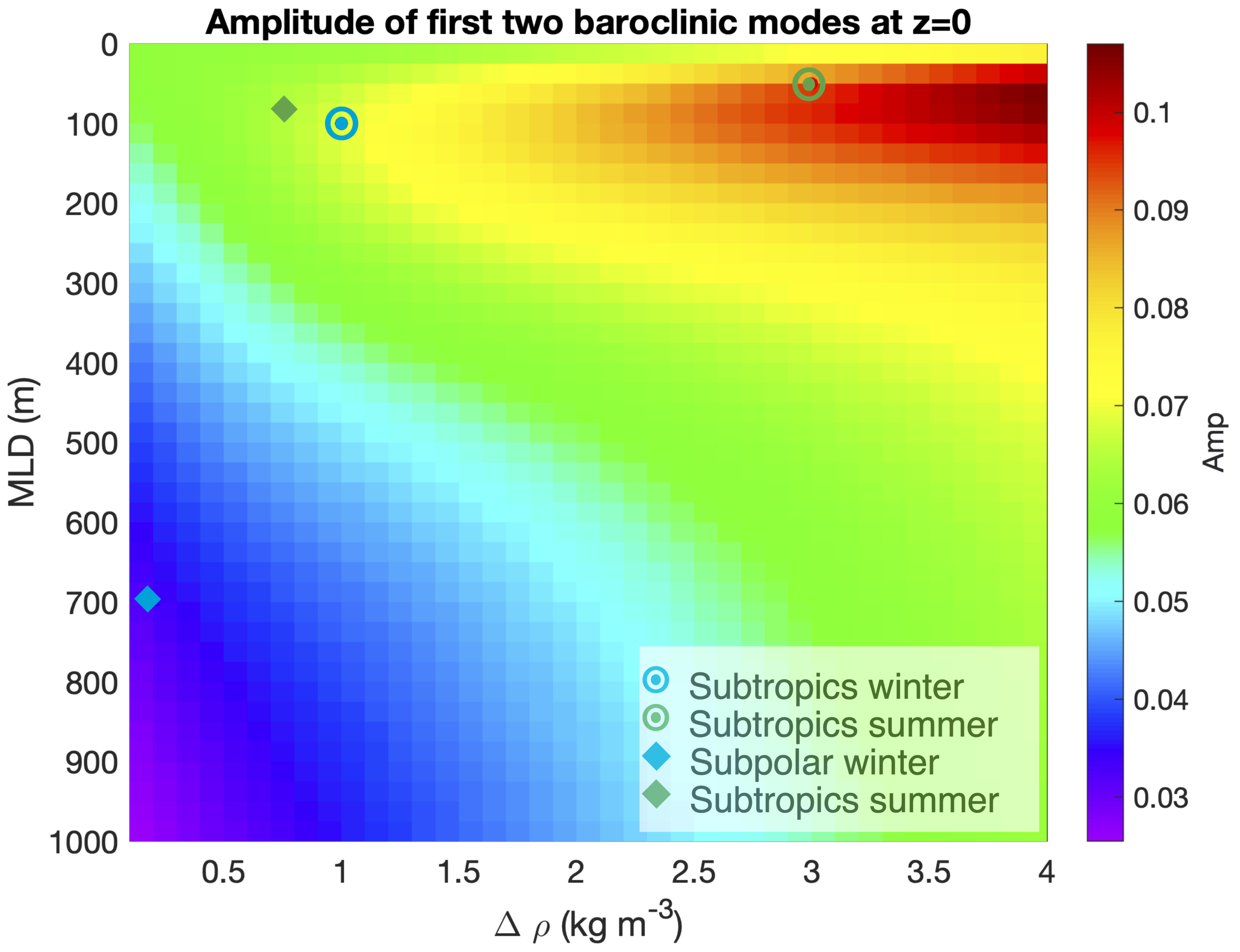


Drifters in the surface and subsurface are advected by wind, inertial motions and the eddy.

The “footprint” of the eddy remains visible at the surface

Our exploration of parameter space shows that the change in density at the base of the mixed layer and mixed layer depth are first order controls on energy transfer to the surface

$$N^2(z) = N_0^2 \exp\left[\left(\frac{z+D}{L} + \ln\frac{N_b}{N_0}\right)\left(1 - \tanh\left(\frac{z-z_p}{\delta_p}\right)\right)\right] + N_{\mathrm{ml}}^2 \operatorname{sech}^2\left(\frac{z-z_p}{\delta_p}\right),$$



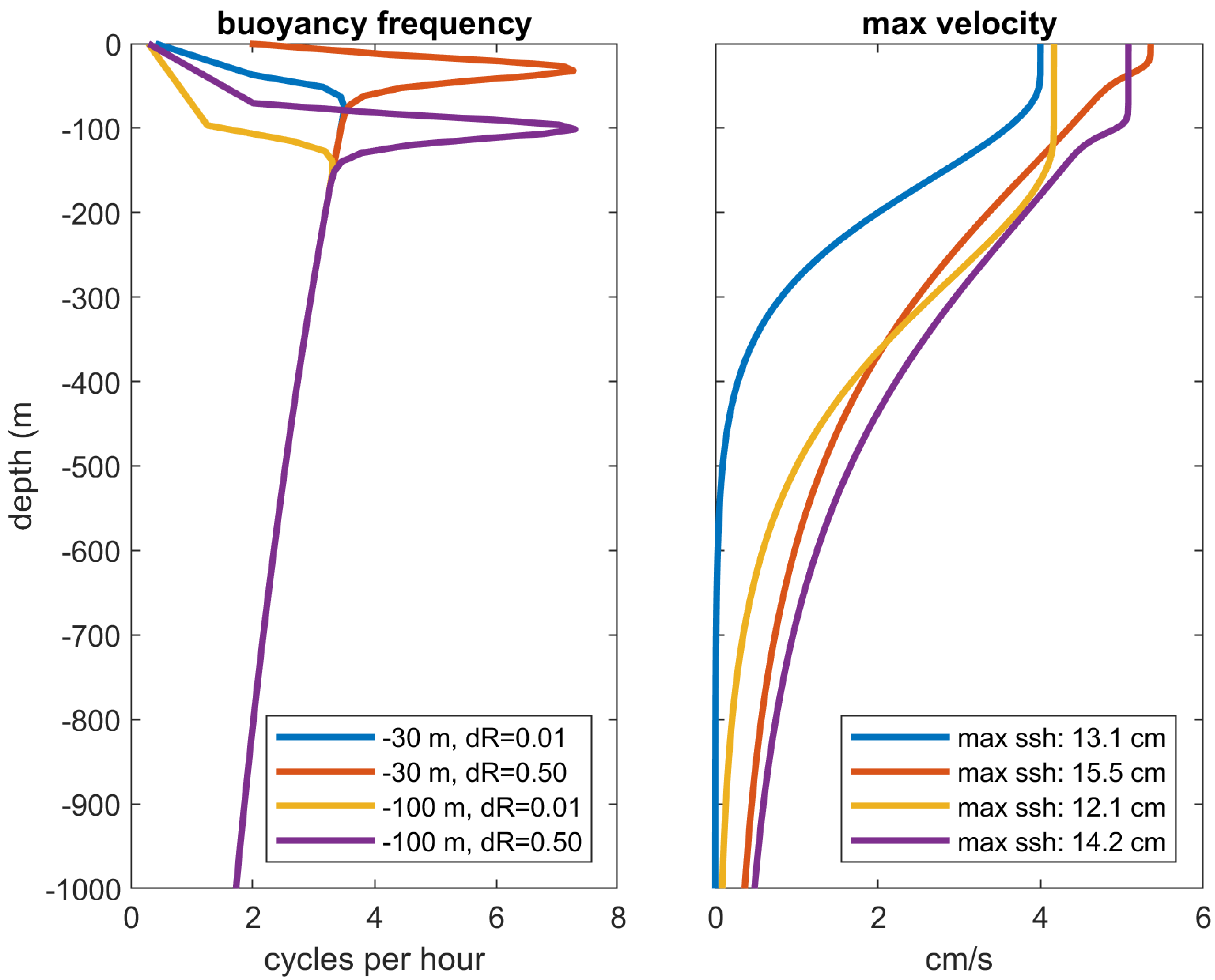
A universal eddy: fixing the energy to enstrophy ratio

$$\psi = A \exp\left[-\left(\frac{x}{L_e}\right)^2 - \left(\frac{y}{L_e}\right)^2\right] \cdot H(z)$$

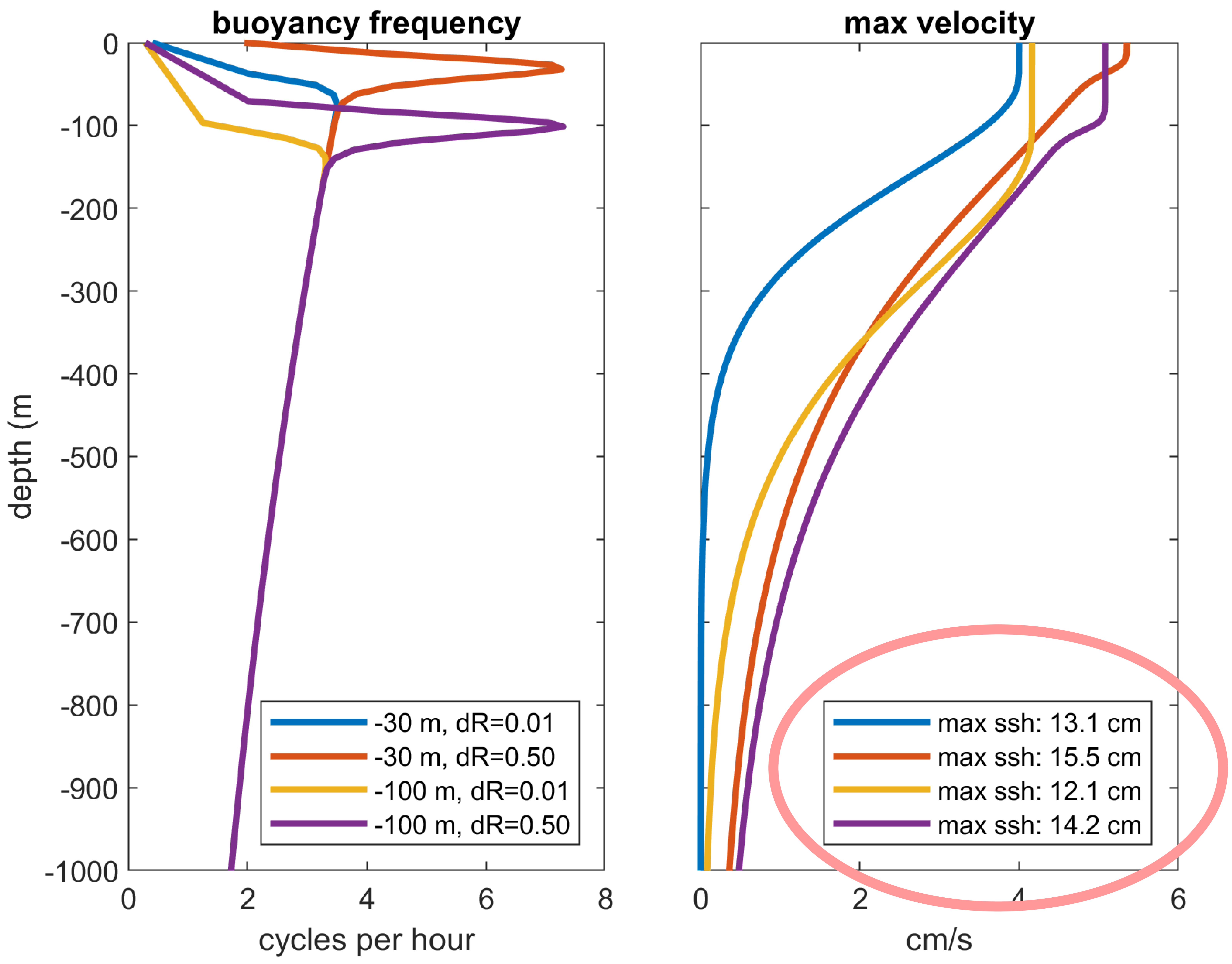
$$\begin{aligned}
\mathcal{E} =& A^2 L_e^2 \frac{\pi}{4} \frac{f^2}{g} \sum_i \left[\frac{2L_i^2}{L_e^2} + 1\right] H_i^2 \\
\mathcal{Z} =& A^2 \pi \frac{f^2}{g} \sum_i \left[\frac{2L_i^2}{L_e^2} + 1 + \frac{1}{4}\frac{L_e^2}{L_i^2}\right] H_i^2
\end{aligned}$$

$$\frac{L_e^2 \mathcal{Z}}{\mathcal{E}} = \frac{\sum_i \left[\frac{1}{4}\frac{L^2}{L_i^2}\right] H_i^2}{\sum_i \left[\frac{2L_i^2}{L^2} + 1\right] H_i^2}$$

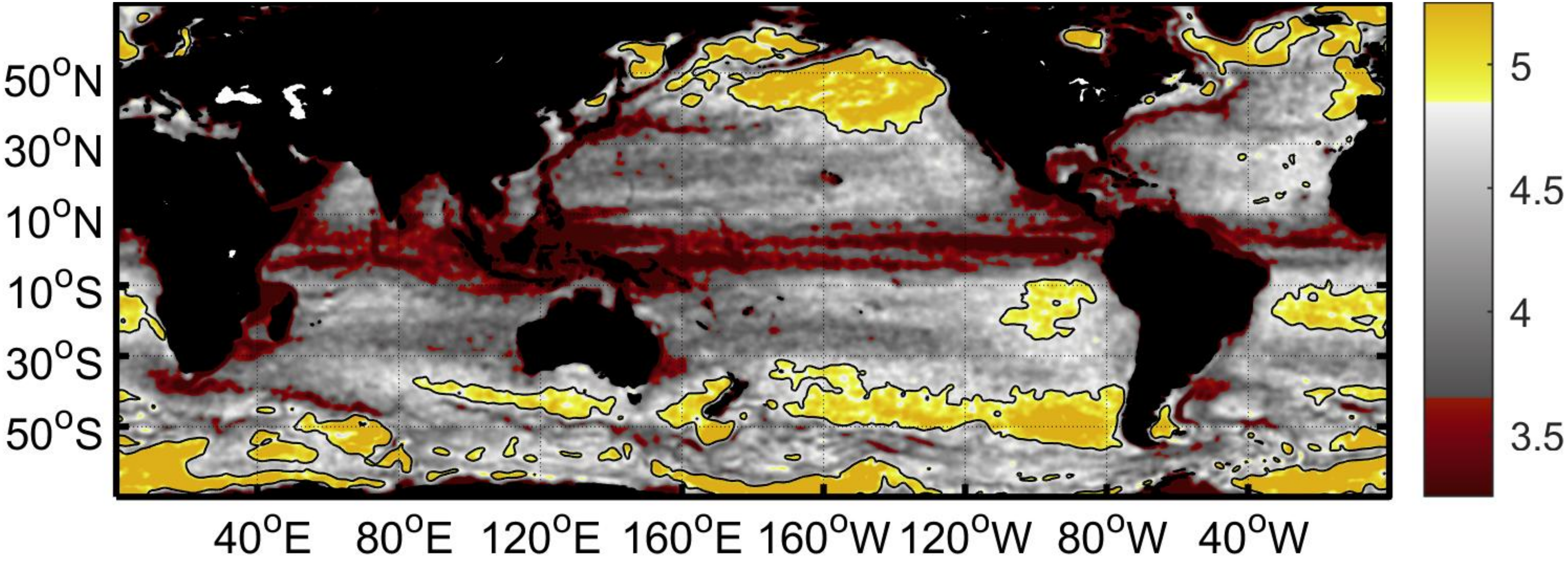
- Eddies with shallow MLD and large N2 have fastest surface velocity.
- Unfortunately, existing technology does not allow us to observe N2 and MLD from space, but there is hope.



- Both MLD and N2 modulate SSH
- This means we can use satellite SSH to compare interior ocean energy to that input at the surface.

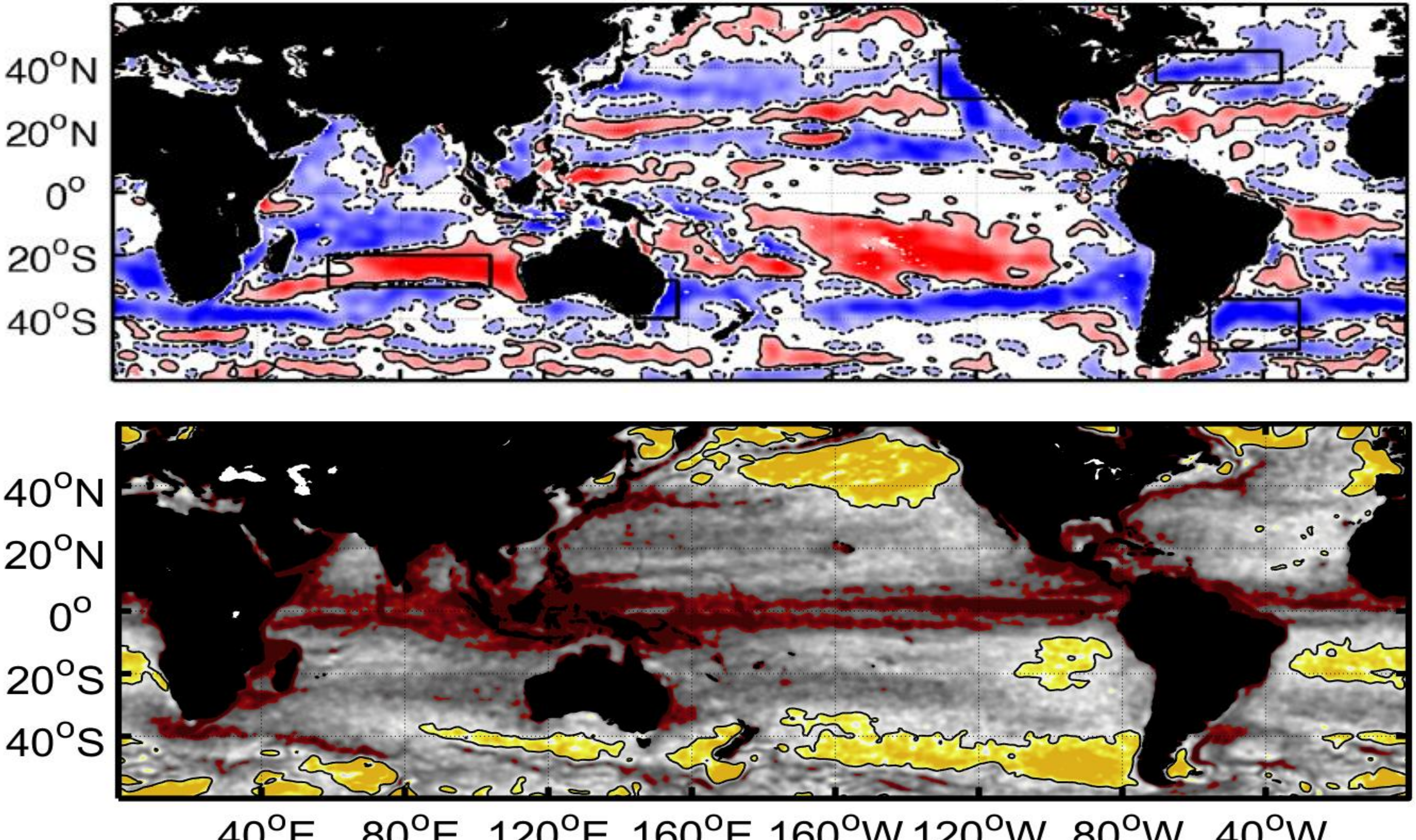


The Ekman Slip Factor



$$\frac{\mathrm{KE}_{\mathrm{Ek}}}{\mathrm{KE}_g} = \frac{1}{f^2\rho_0^2}\frac{\tilde{\tau}_x^2 + \tilde{\tau}_y^2}{u_g^2 + v_g^2}.$$

Comparing regions of large wind input to areas where eddies impact CHL



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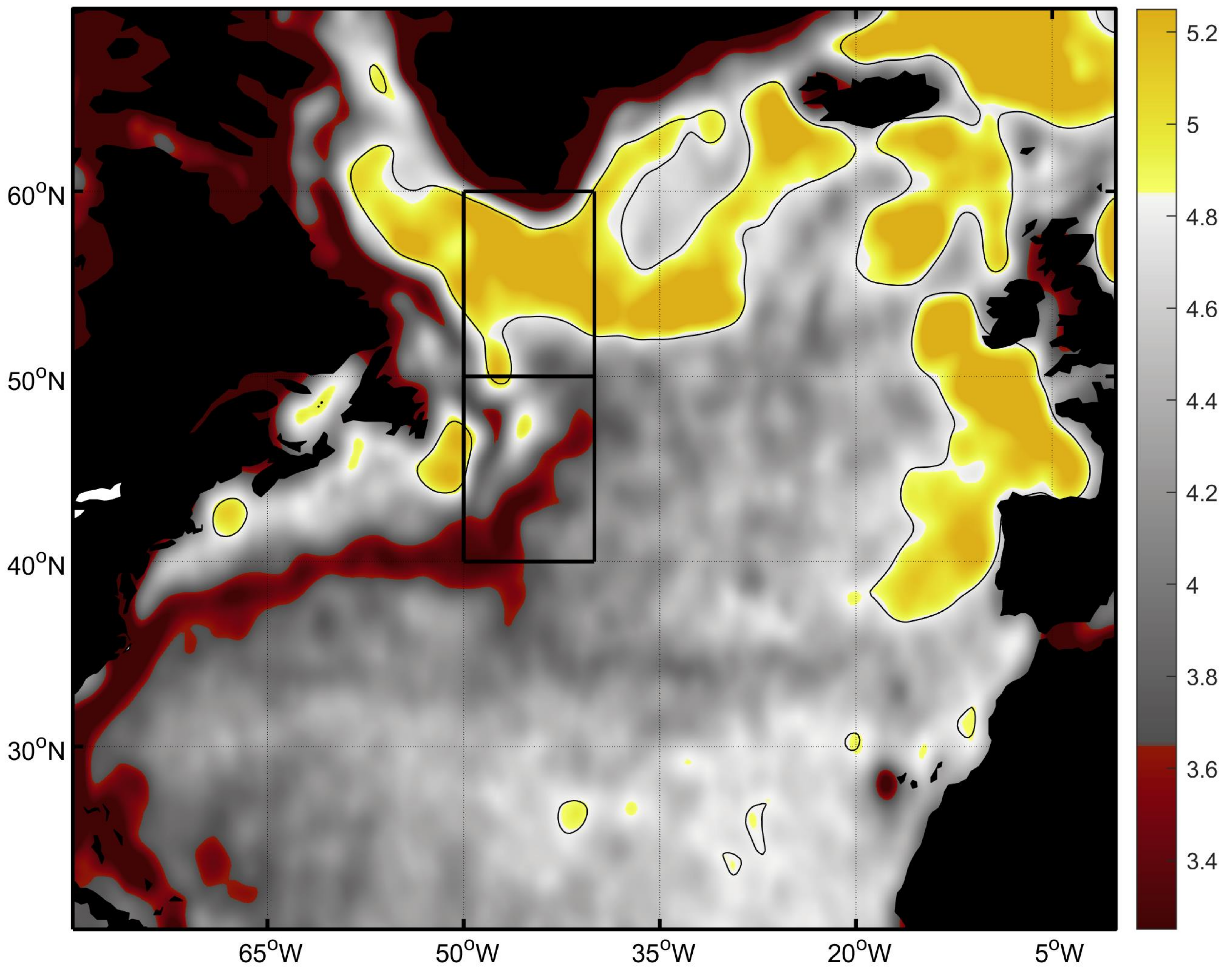

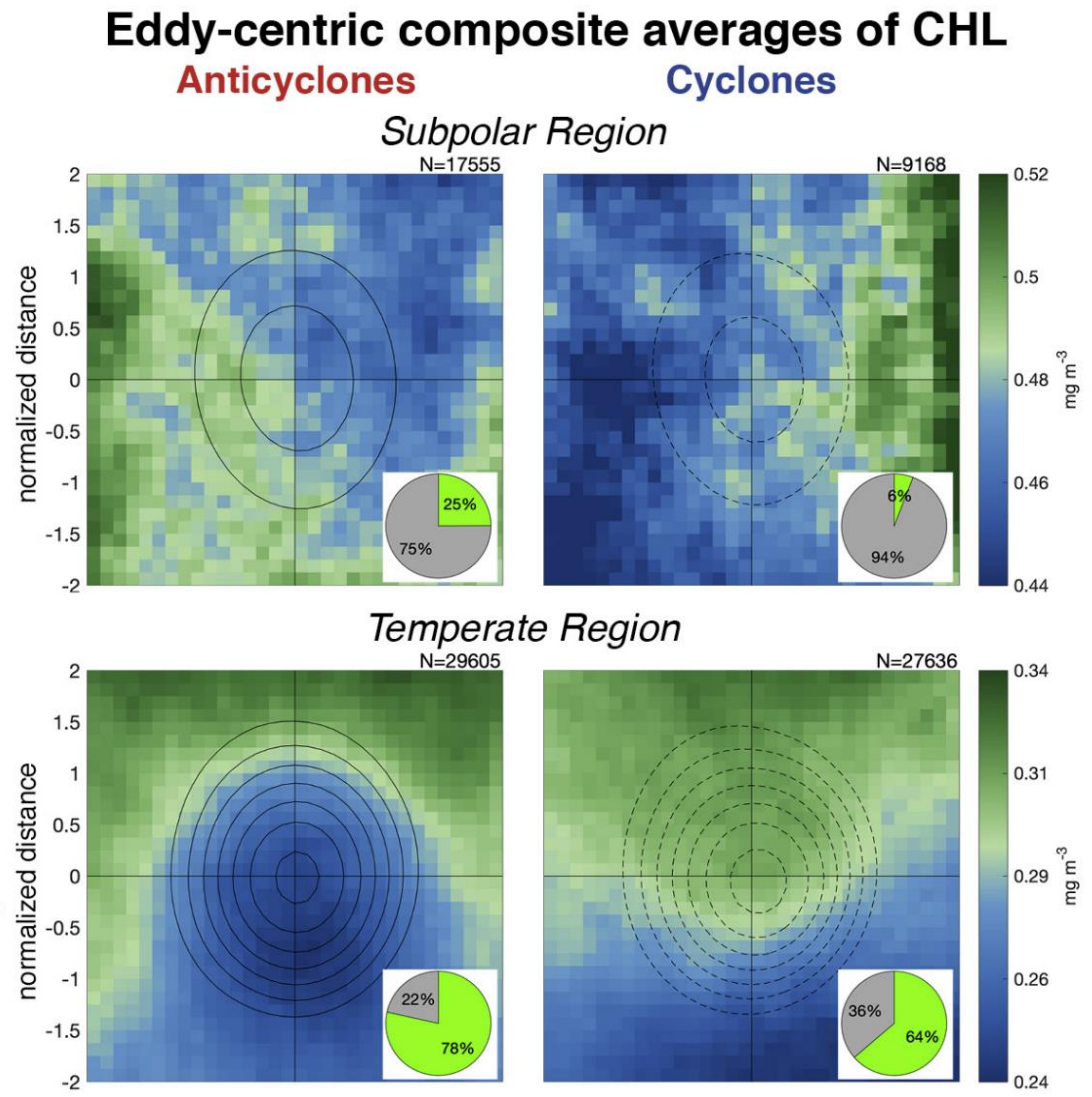

Conclusions

1. The density change at the base of the mixed layer and mixed layer depth, in that order, are the primary controls on the transfer of geostrophic energy from the oceans interior to the surface.
2. In regions where wind energy input at the oceans surface is much larger than that from the geostrophic interior eddy signatures are not always detectable at the surface.
3. The influence of density change at the base of the mixed layer and mixed layer depth on SSH allows for estimate of where eddies modulate surface currents from satellite observations.