Shear driven turbulence in the natural environment

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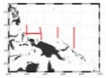
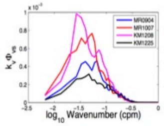
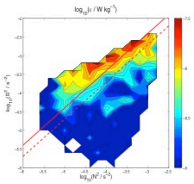
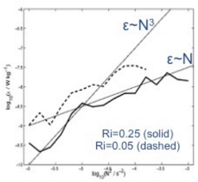


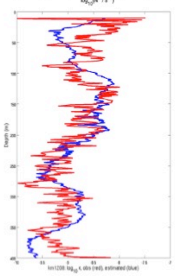
Observations

Observations of shear and microstructure in the Western Equatorial Pacific show the turbulence to be strongly associated with the shear of relatively small vertical scale flow features, SVSs (order 10m) that are not generally resolved in observations or models.









Writing:

$$\epsilon = \ell_v^2 N^3 f(Ri)$$

we note that $\epsilon \sim N$ for constant Ri (for $N^2 > 10^{-5}\ s^{-2}$), which implies the vertical length scale

$$\ell_v = \frac{u_t}{N}$$

The vertical diffusivity is then

$$\kappa_v = \frac{\gamma u_t^2 f(Ri)}{N}$$

We take the turbulent velocity scale

$$u_t \simeq 0.1\,\tilde{u}$$

where $\tilde{u}$ is the amplitude of the SVSs

Comparison of estimated and observed ϵ shows a good correspondence – see example in lower panel. We note there is a tendency for $\tilde{u}^2 \sim N$ making κ_v solely a function of Ri

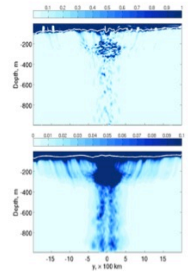
In this example inertial instability is likely playing a major role

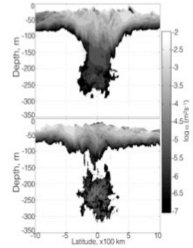
Process Studies

Idealized studies show high vertical shear, small vertical scale, features generated by

- Instabilities (inertial and PSI)
- Wind-generated inertia-gravity waves

Here we consider wind-generated waves





Wind-forced zonally symmetric model:

Froude number (S^2/N^2) **increased** close to the equator and in the thermocline (left) through a combination of

- Increased super-inertial input by the wind
- Increased transfer rate from ML to interior
- Amplification of waves as they travel through the thermocline
- Convergence of wave action at turning latitudes
- Wave-wave interactions

Increased Froude number leads to **enhanced vertical diffusivity** (with a Ri based parameterization) within the equatorial thermocline (left) regardless of the distribution of the wind forcing. Upper panel on-equatorial winds. Lower panel off-equatorial winds

GCMs

Accounting for the unresolved mixing in a coupled model (SINTEX-F2) reduces biases in the mean state and ENSO variability – a reduced cold tongue bias and improved skewness of ENSO. The response is not unduly sensitive to the details of the enhanced dissipation.