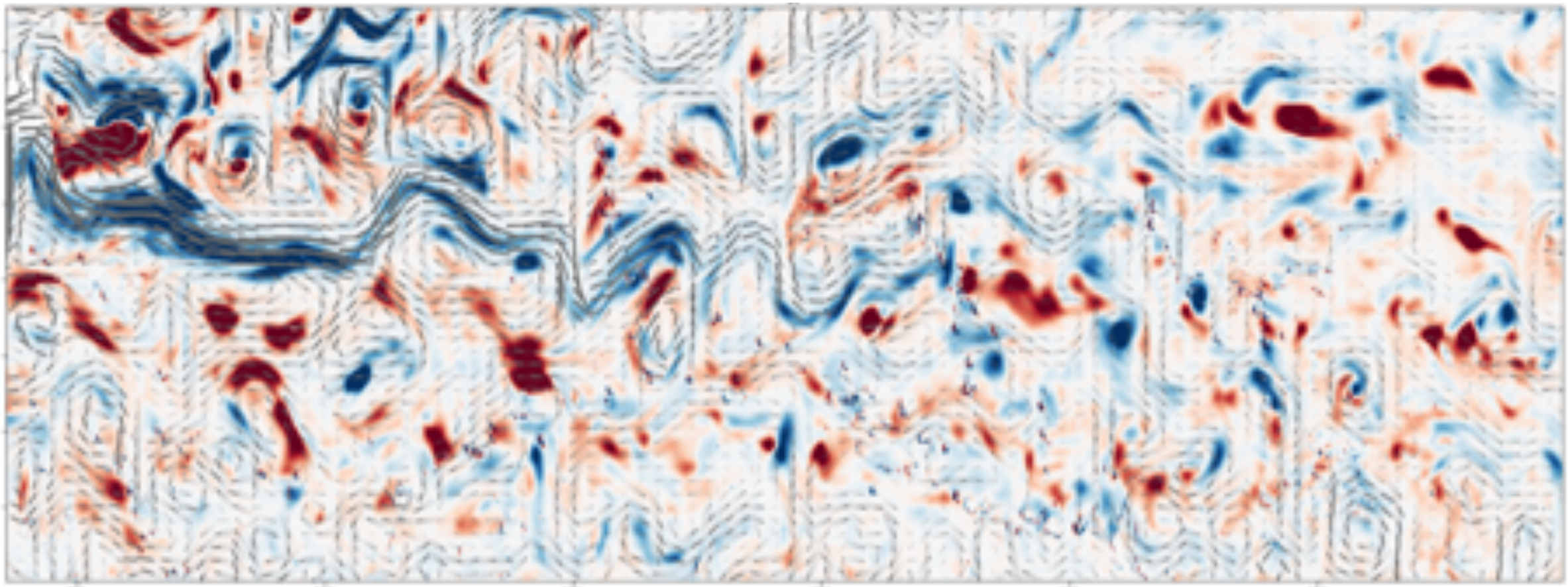
The propagation of near inertial internal waves within the mesoscale flow



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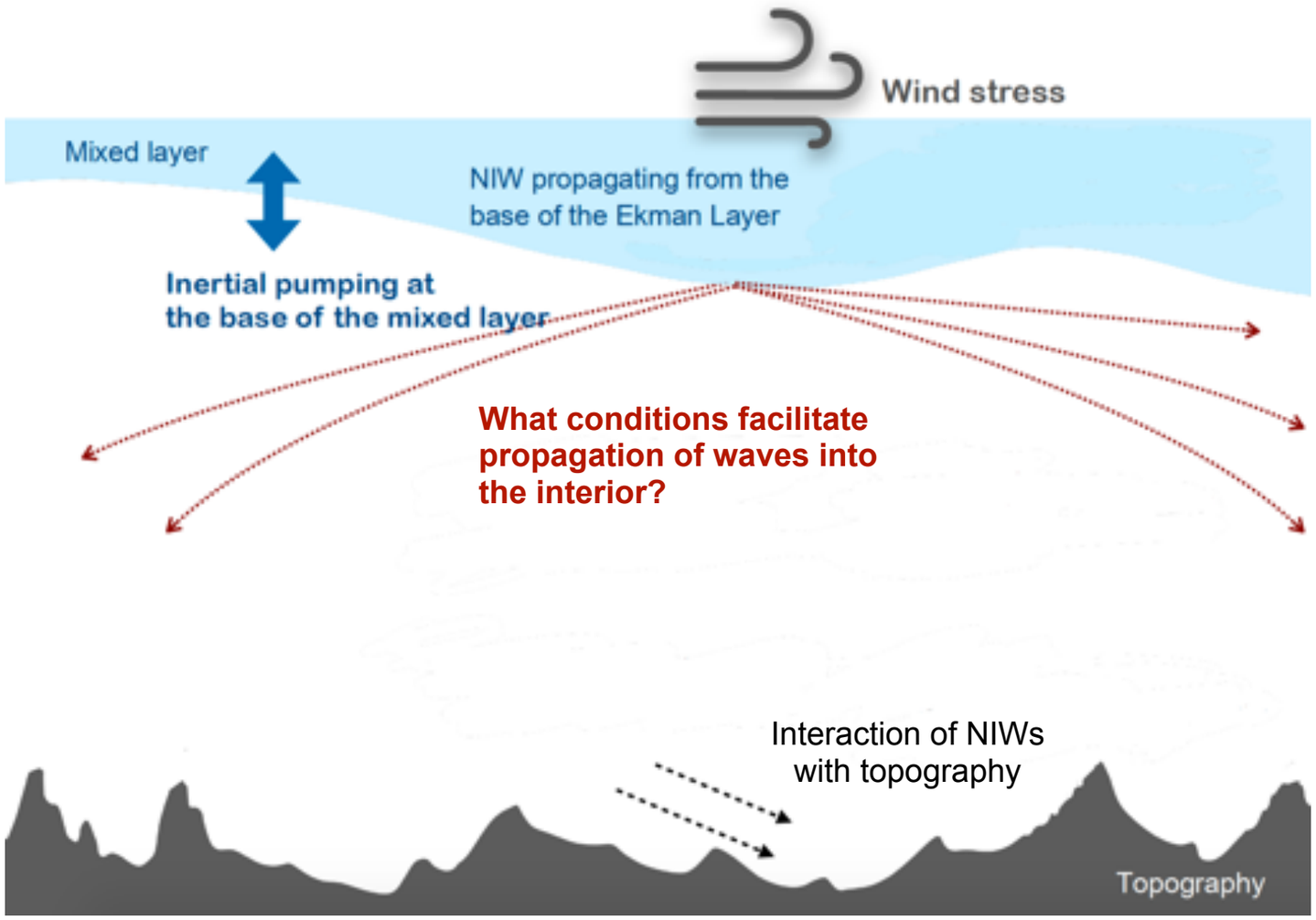
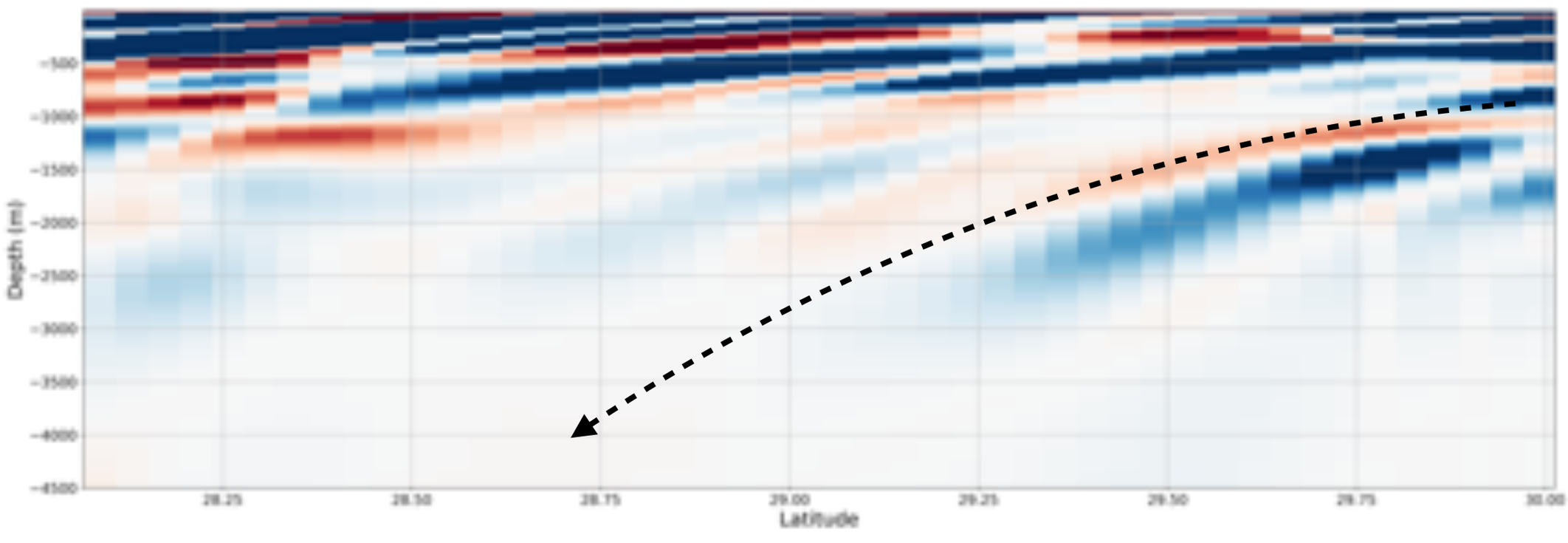
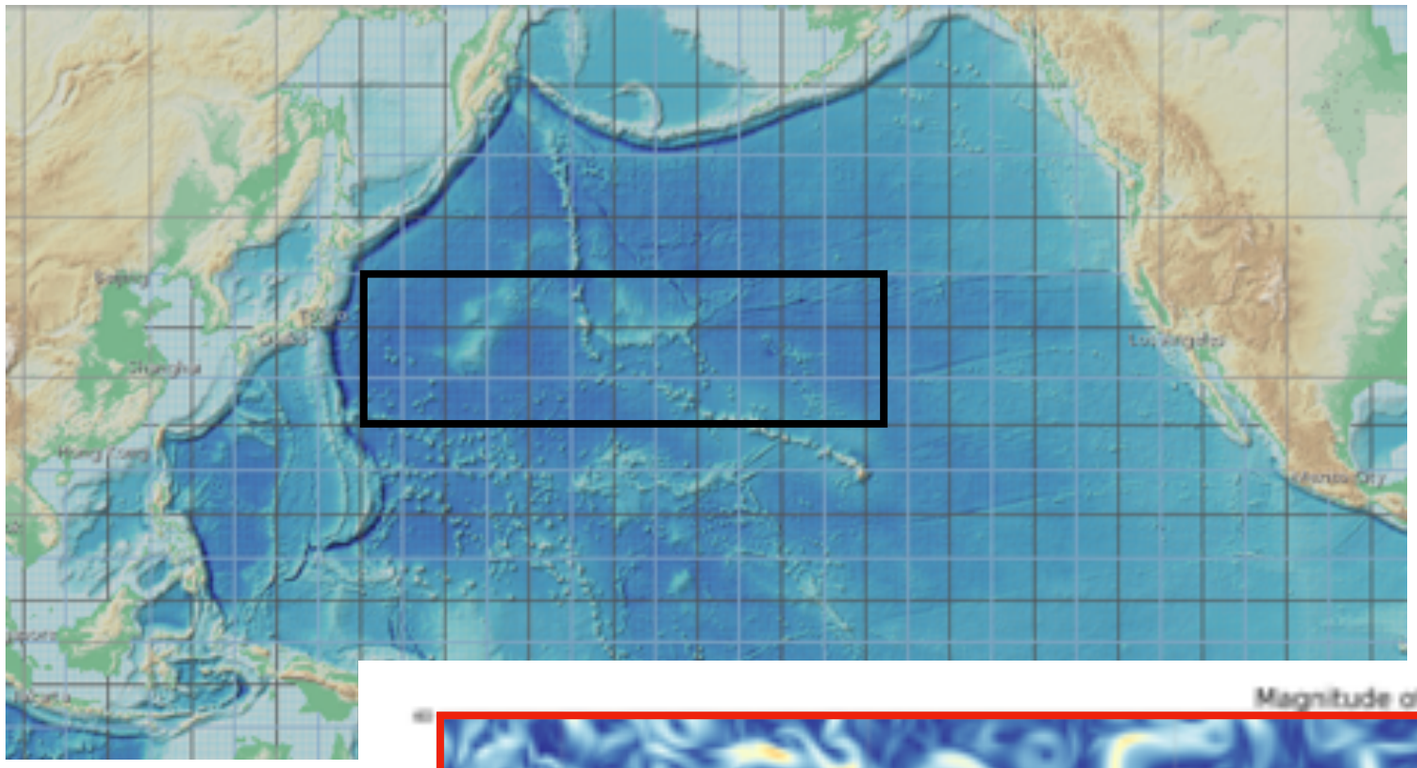
Generation of near inertial internal waves

- Winds impart momentum to the mixed layer
- Pumping of near inertial internal waves (NIWs) from the base of the mixed layer
- Propagating waves contribute to mixing in the interior



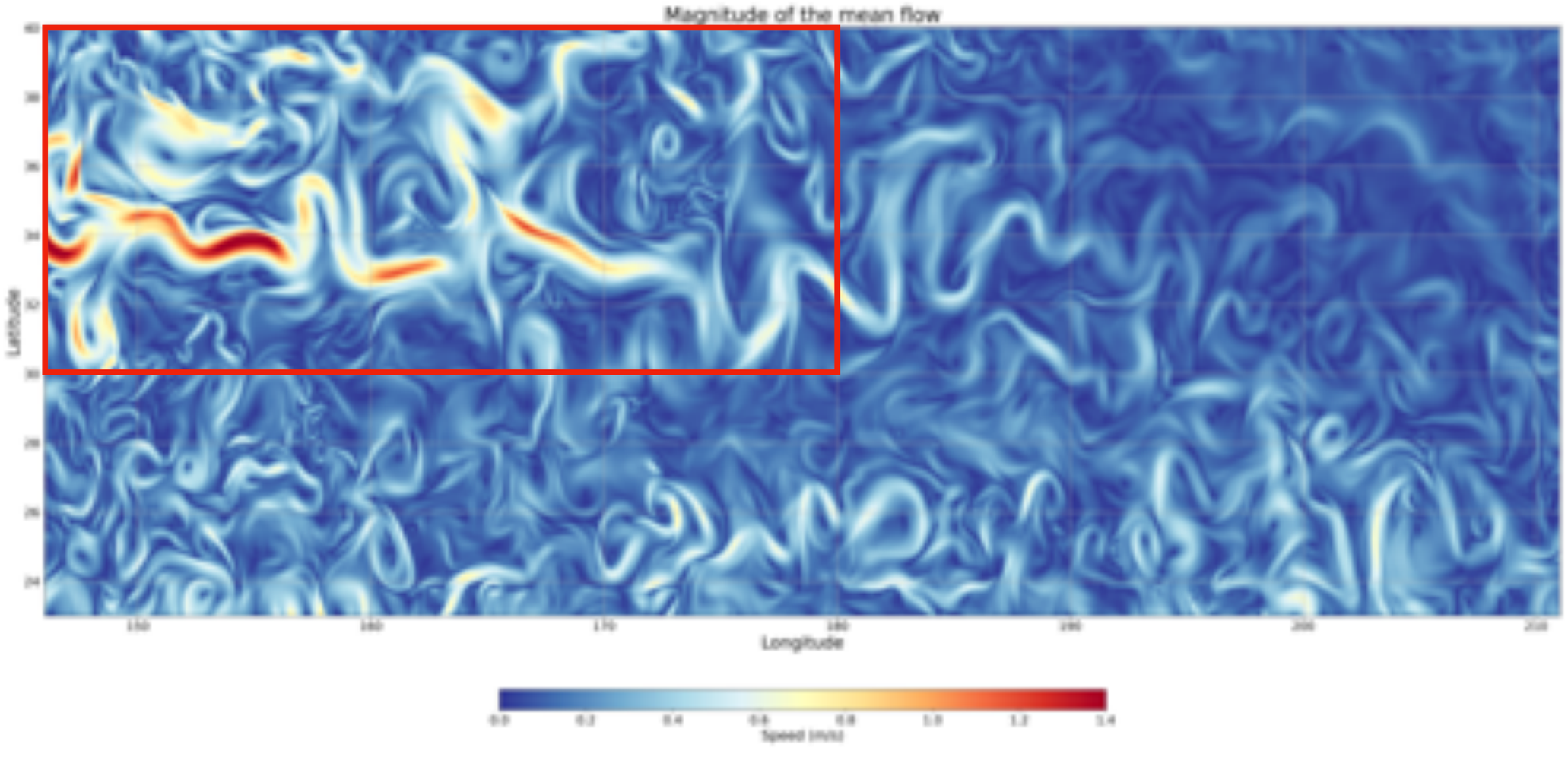


Model set up



- North Pacific
- Strong front (Kuroshio)
- Rich eddy field

- No tidal forcing
- Forcing at the boundaries (Copernicus)
- Hourly winds (ERA5)
- Net heat flux at the surface
- 5km horizontal grid spacing



Velocity, Pressure field

$$w = \overline{w} + w'$$
$$p = \overline{p} + p'$$

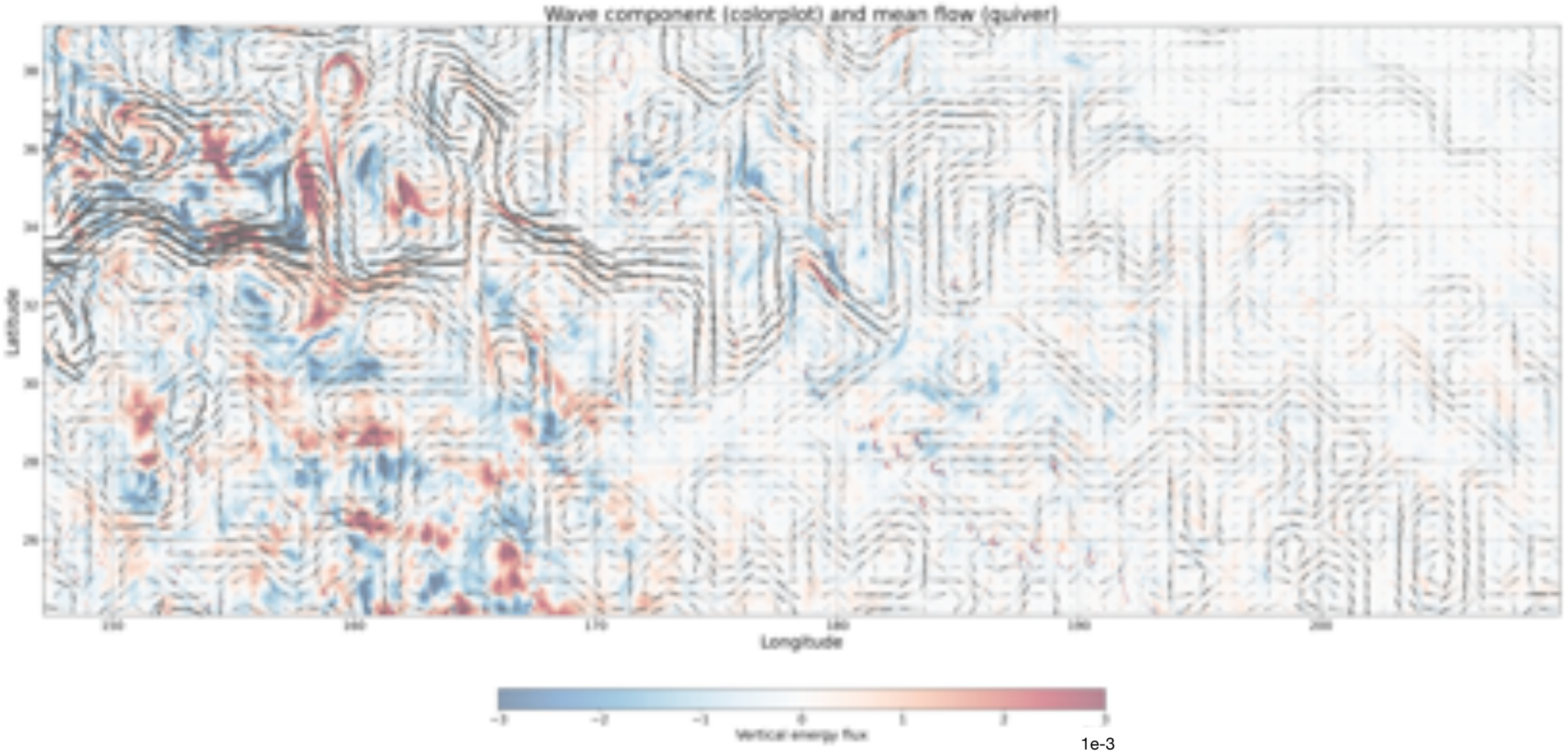
Lagrangian filtering

Mean flow

mean vertical energy flux = $\overline{w}\overline{p}$

Waves

wave vertical energy flux = $w'p'$



Velocity, Pressure field

Lagrangian filtering

Mean flow

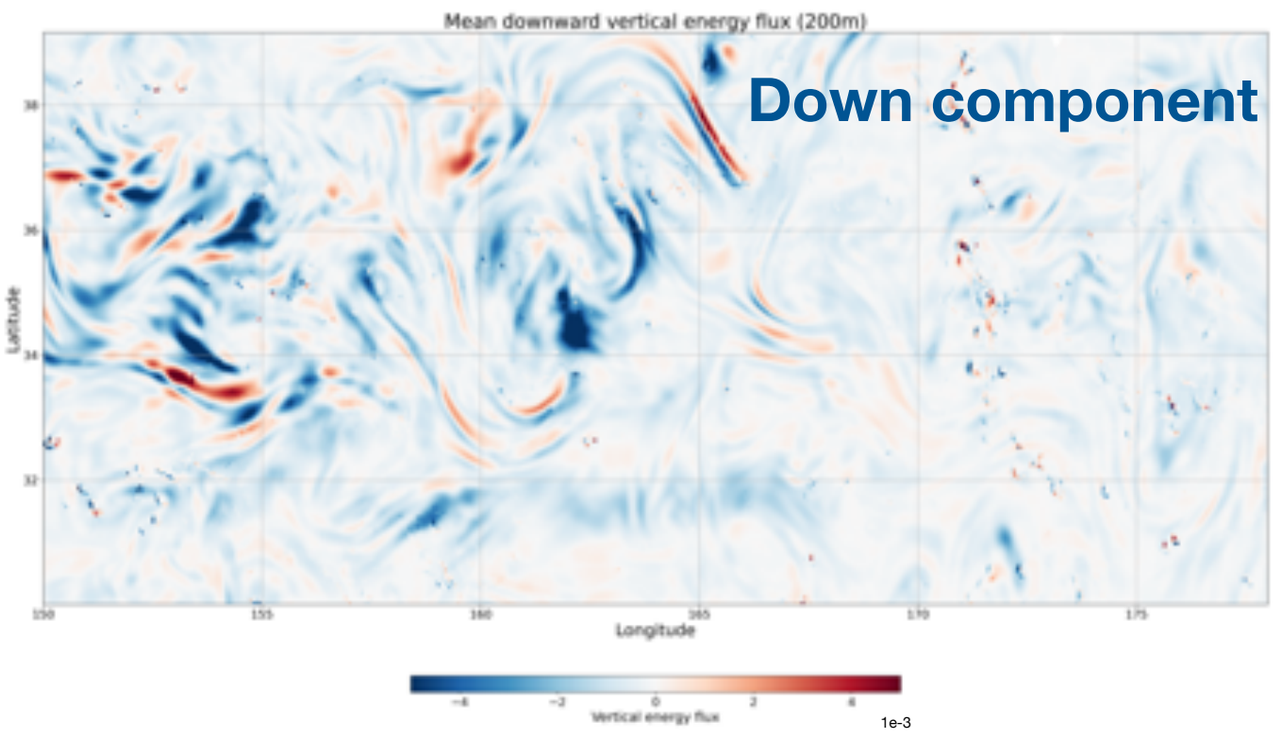
Waves

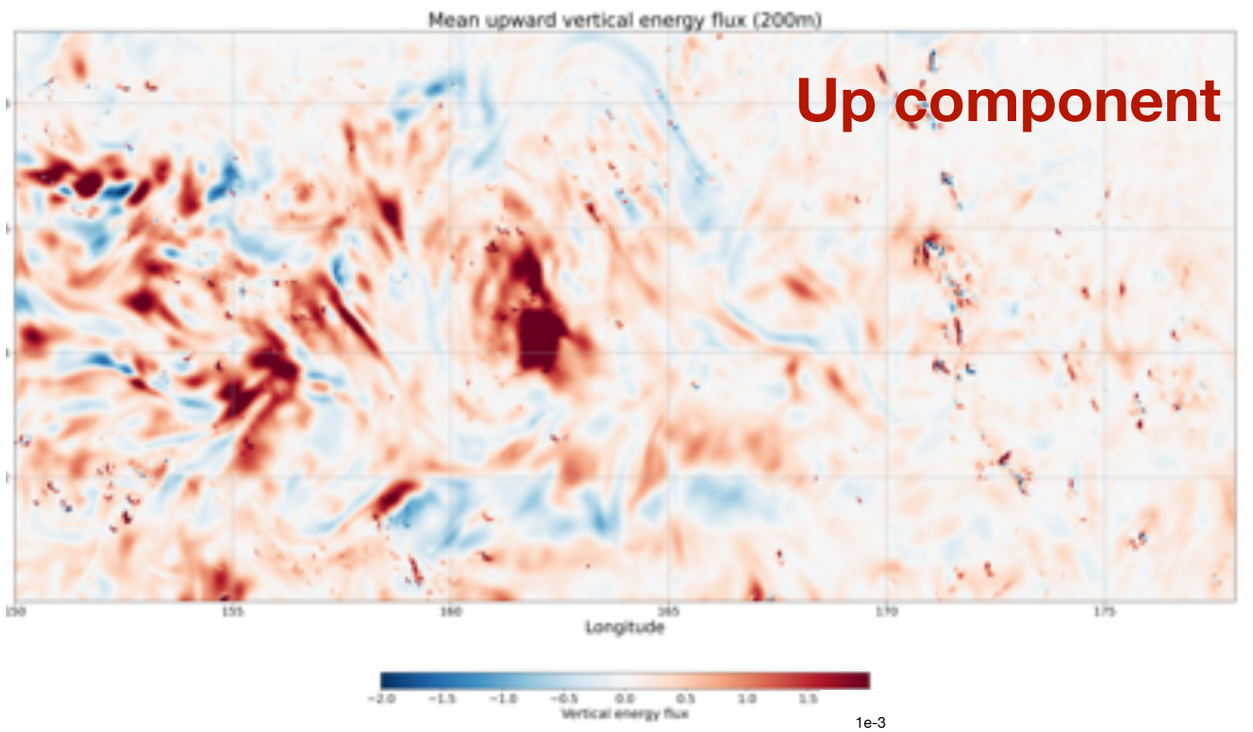
Wave separation from frequency (ω) and vertical wavenumber (m)

$$c_p = \frac{\omega}{m} \qquad (c_p\text{: phase speed, } c_g\text{:group speed})$$

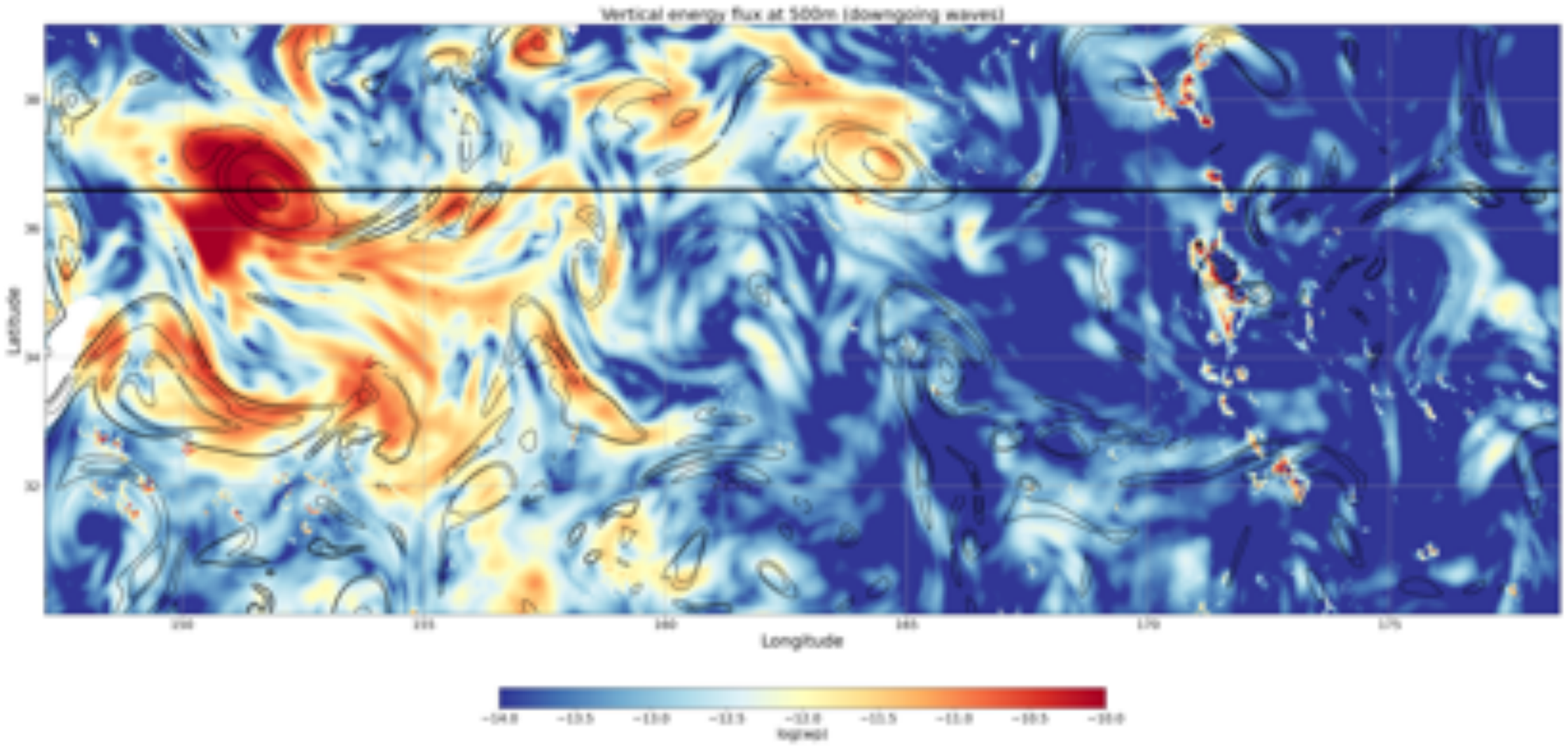
ω, m of same sign: c_p is +ve and c_g is -ve **(down)**

ω, m of opposite signs: c_p is -ve and c_g is +ve **(up)**



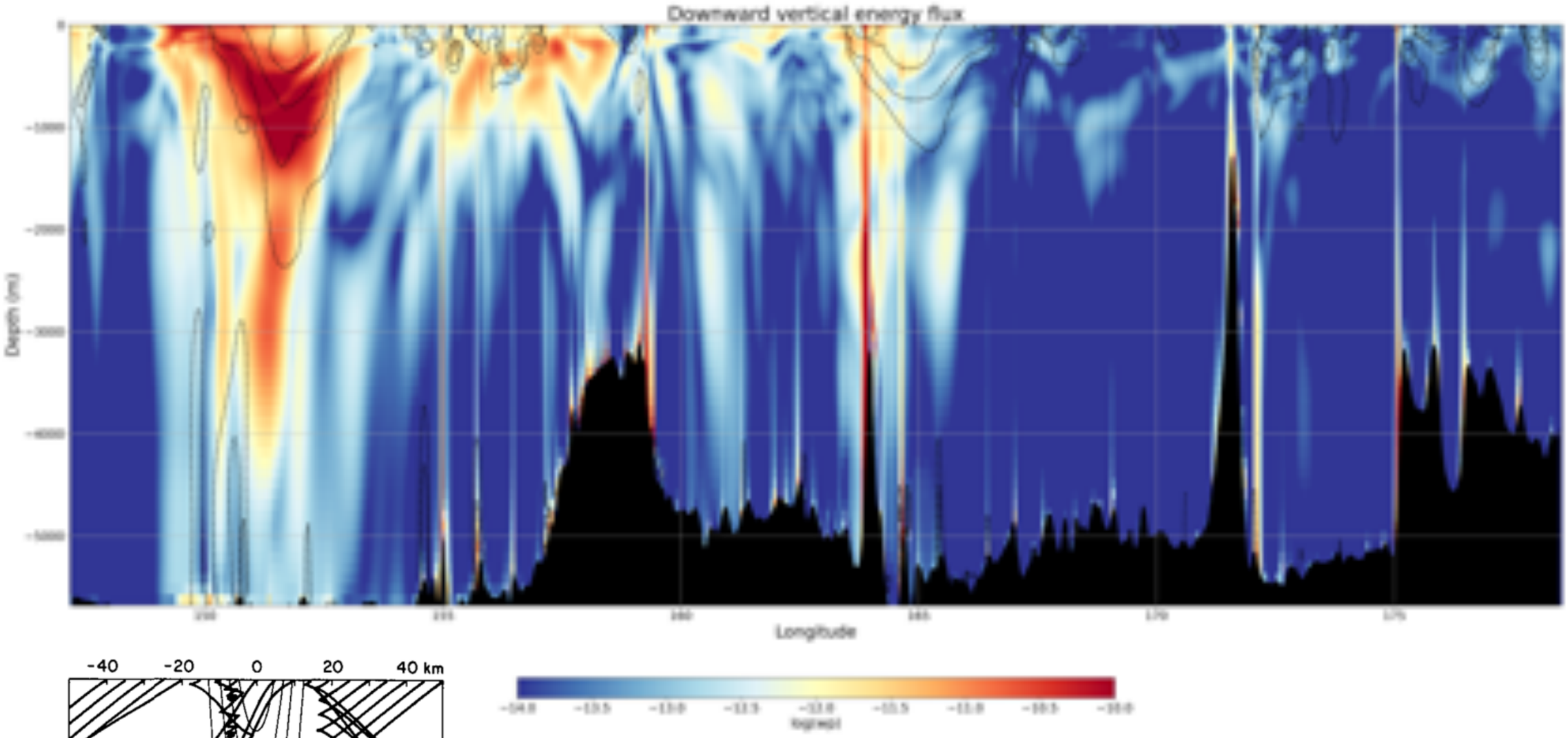


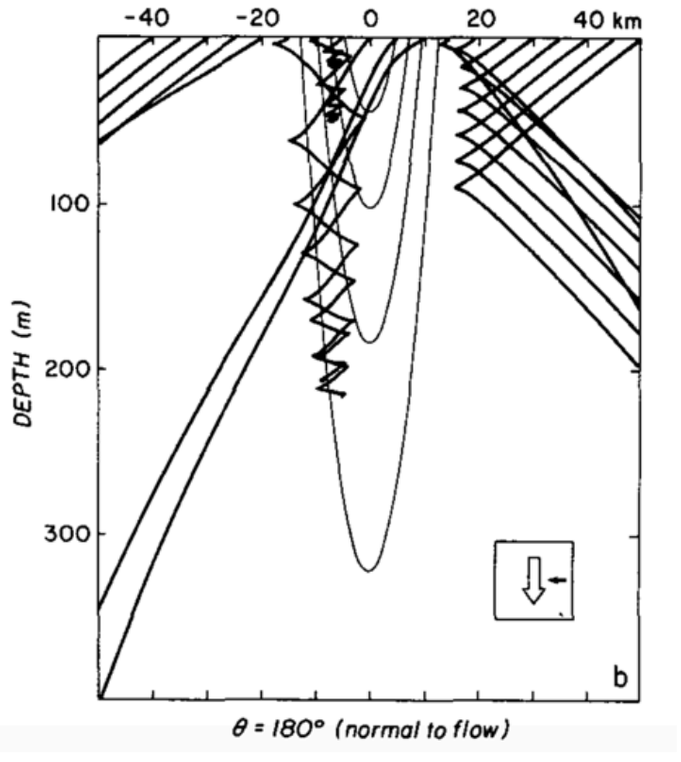
NIWs trapped in negative vorticity



Energy flux integrated over one week

NIWs trapped in negative vorticity



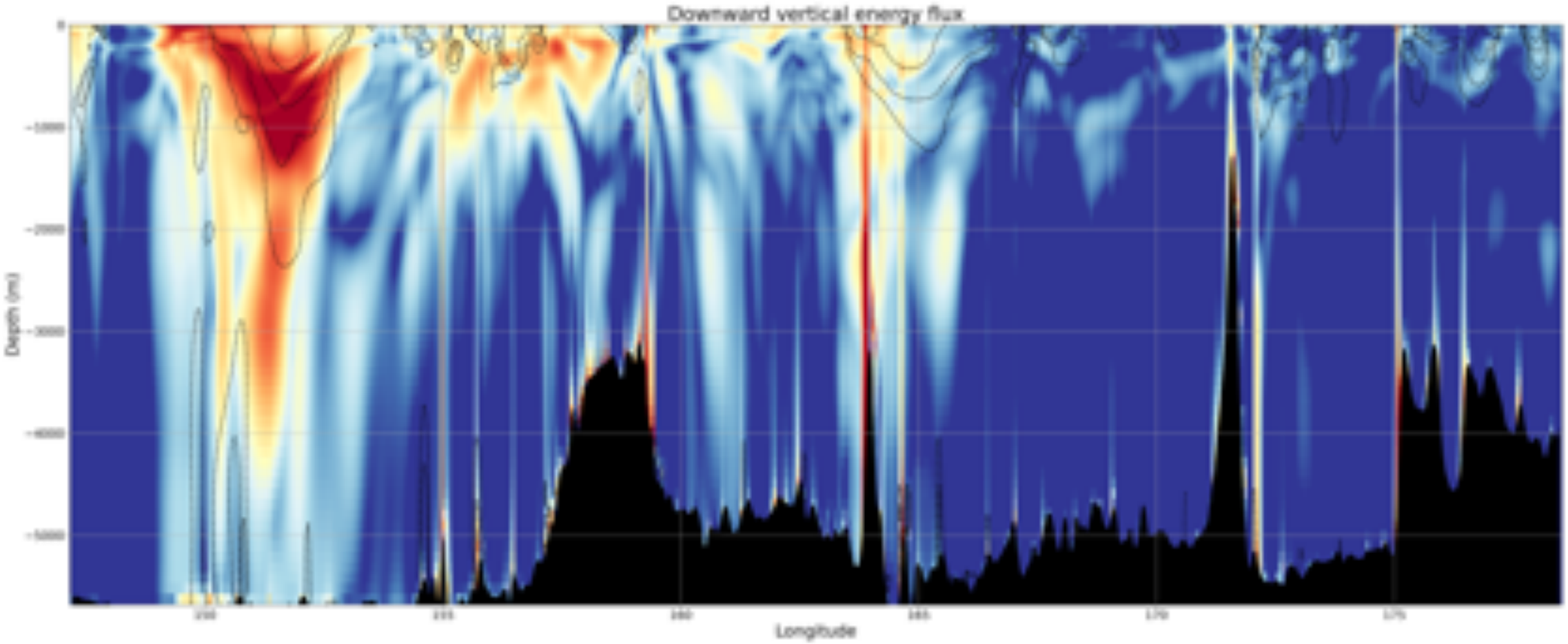


Wave propagation into a baroclinic jet (Kunze,1985)

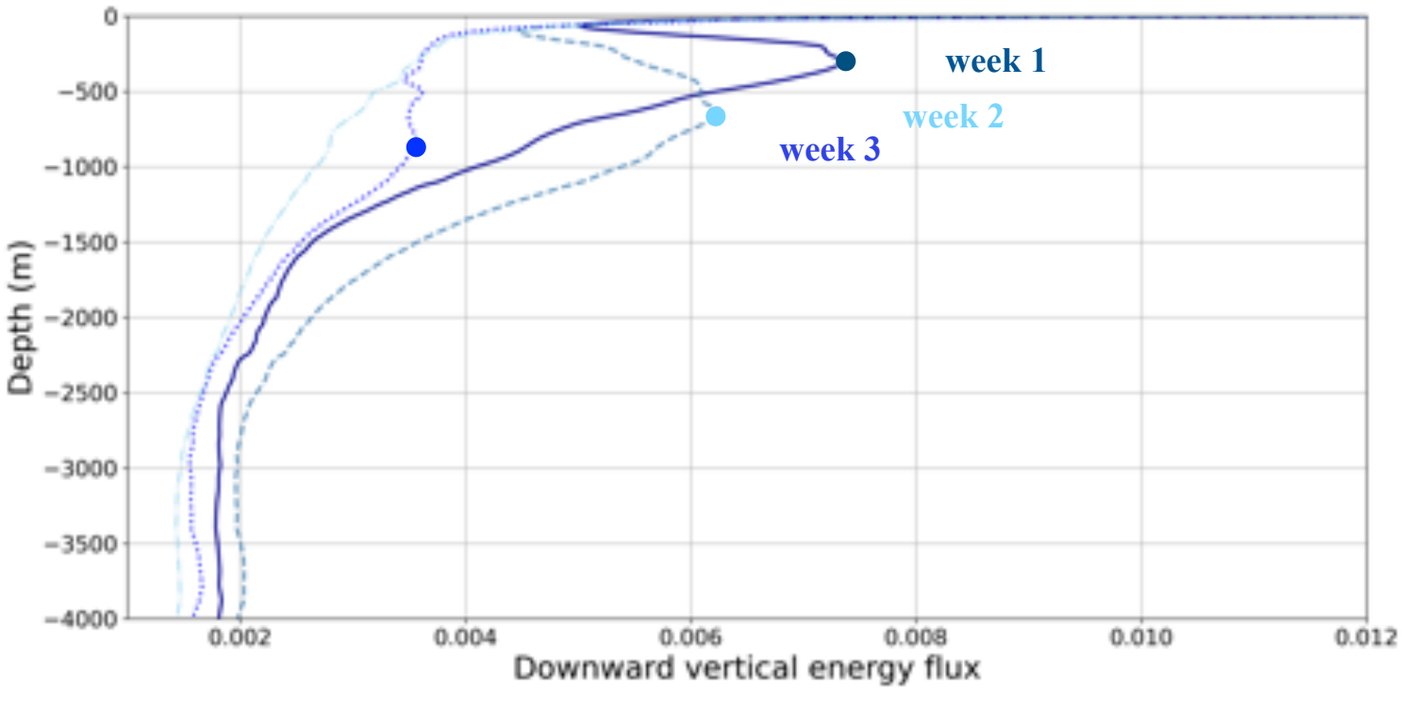
- Straining by the mean flow vorticity
- Effective Coriolis parameter; $f_{eff} = f + \zeta/2$

- Anticyclonic eddies lower f_{eff}; near inertial energy trapped and drained locally into the interior
-

NIWs trapped in negative vorticity

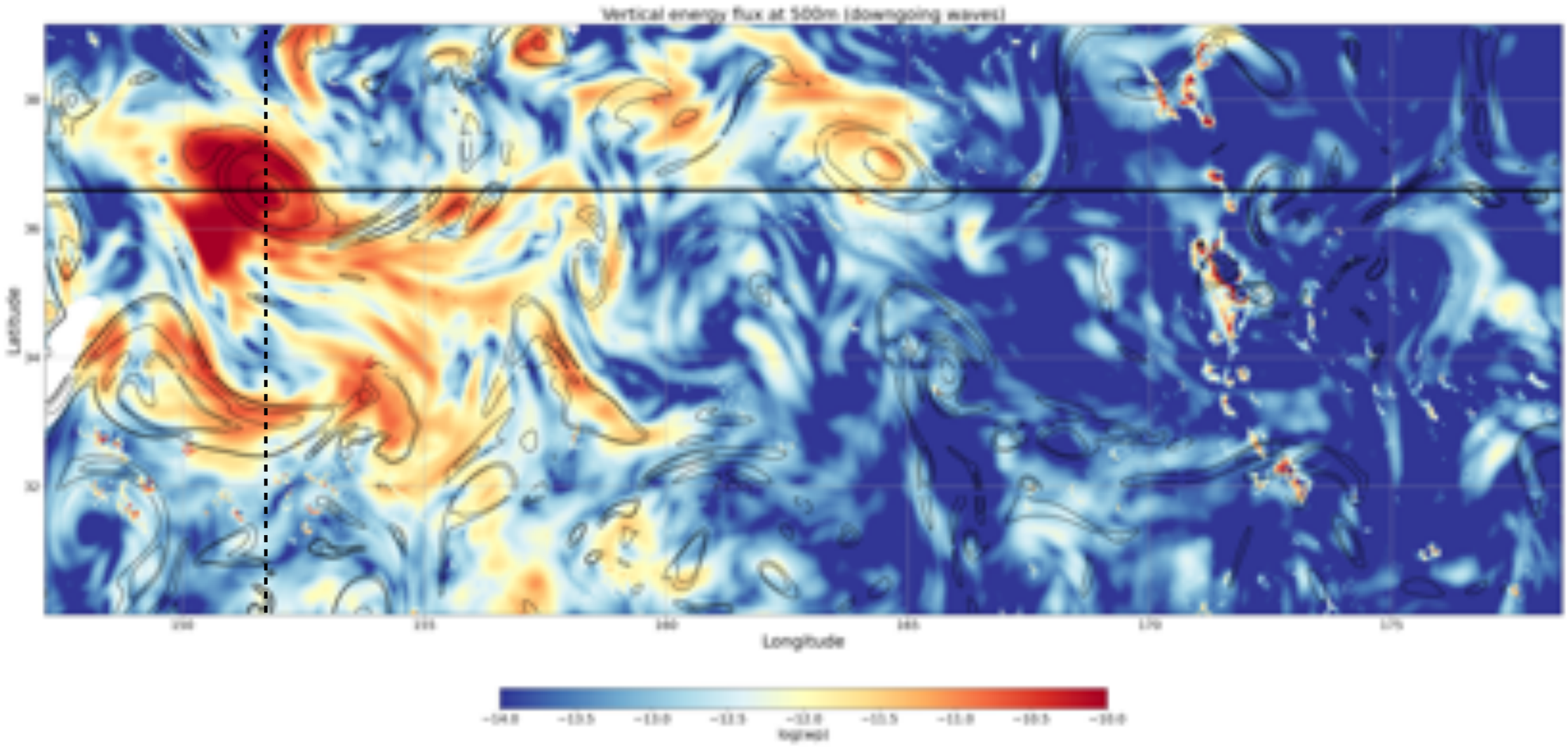


Ro < -0.1

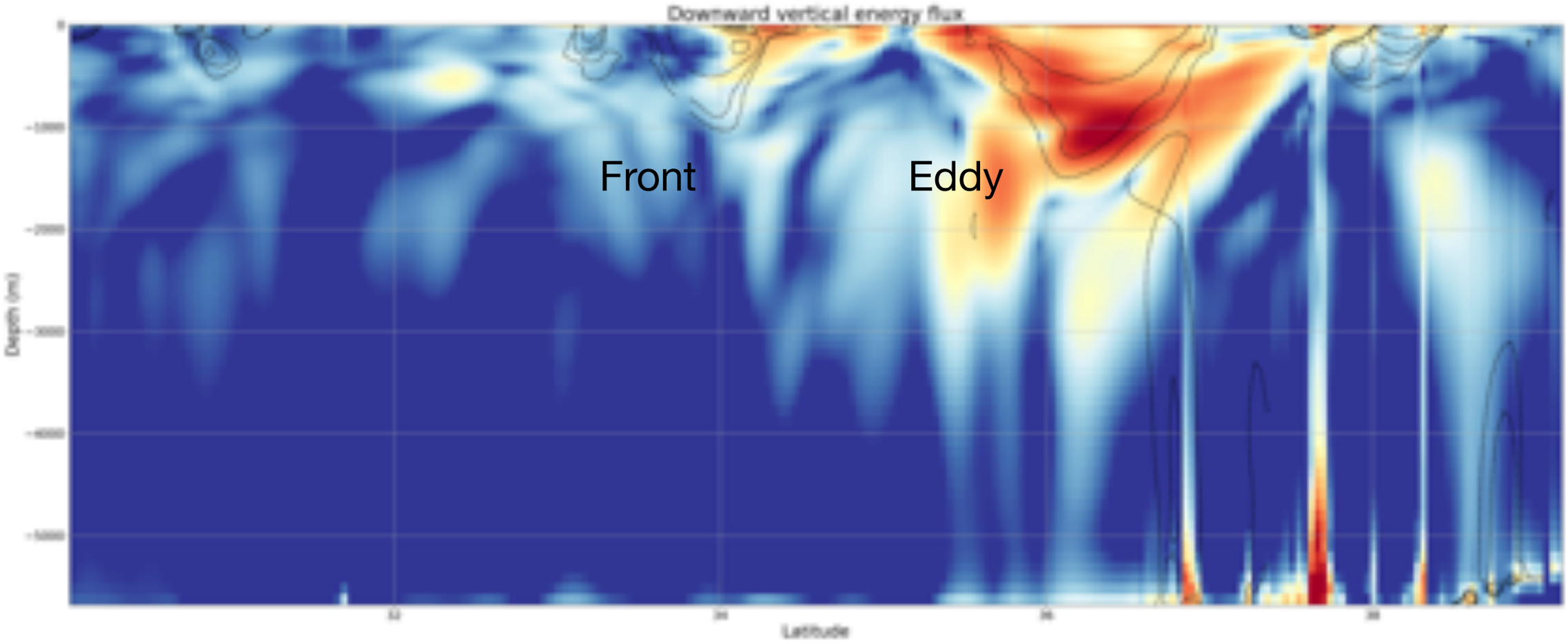


- High negative vorticity areas masked out
- Compute mean downward flux in those areas
- Maximum propagates to depths with time

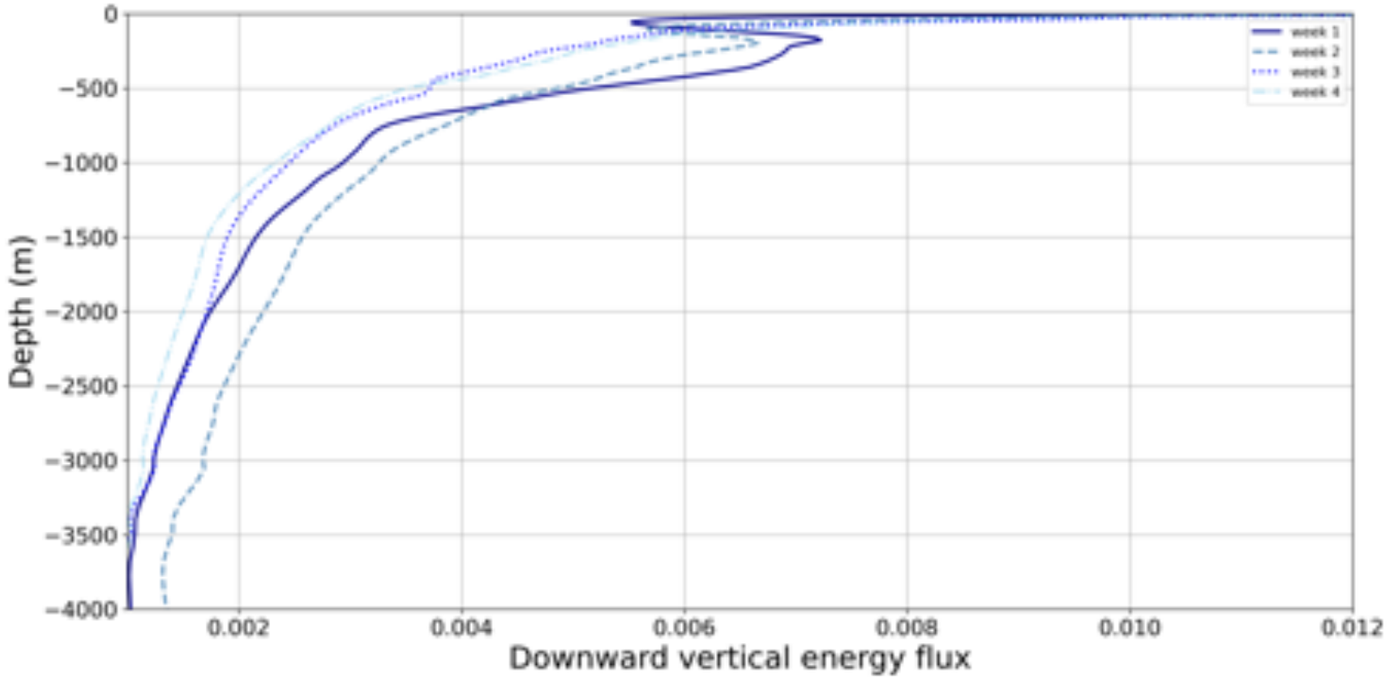
NIWs in negative vorticity but high shear



NIWs in negative vorticity but high shear

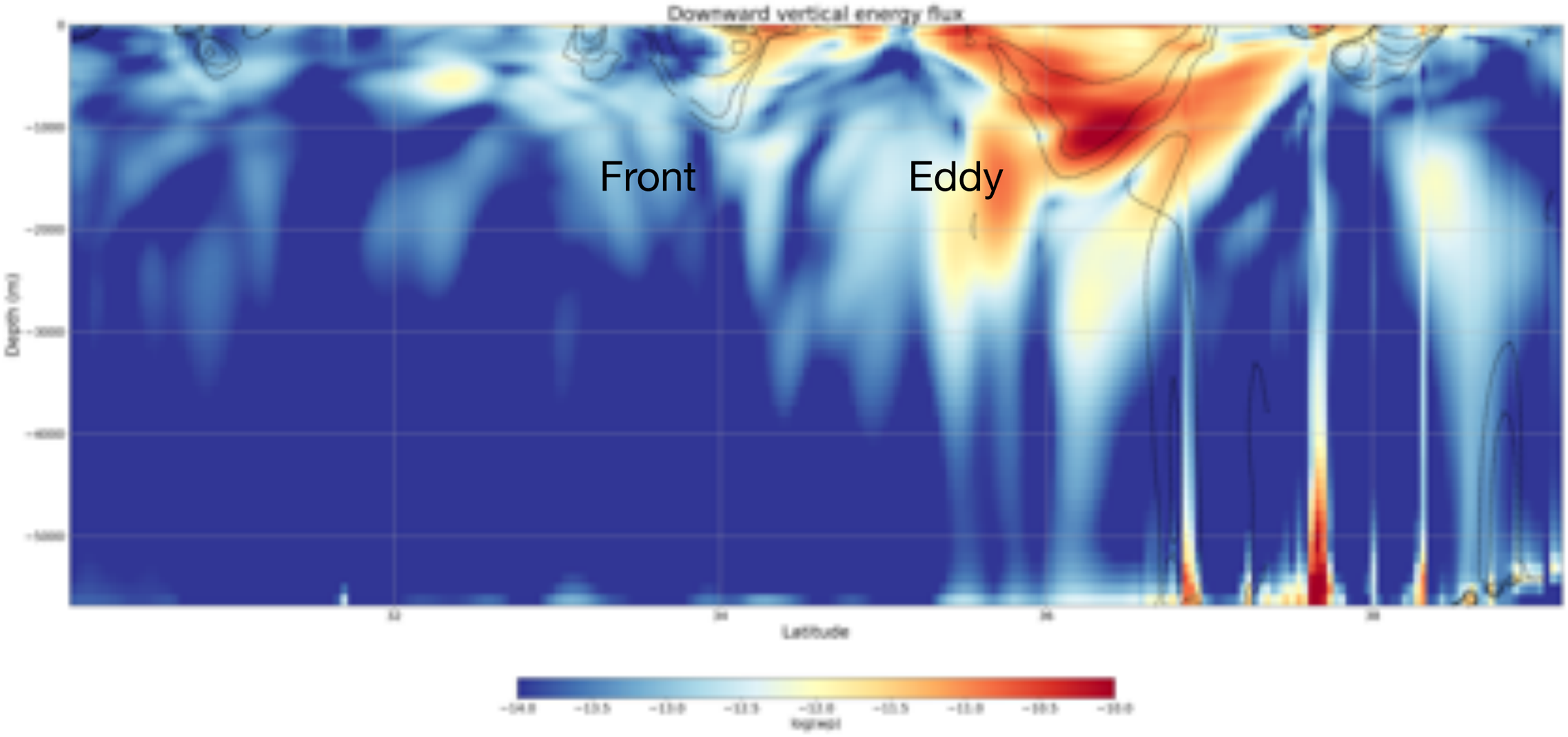


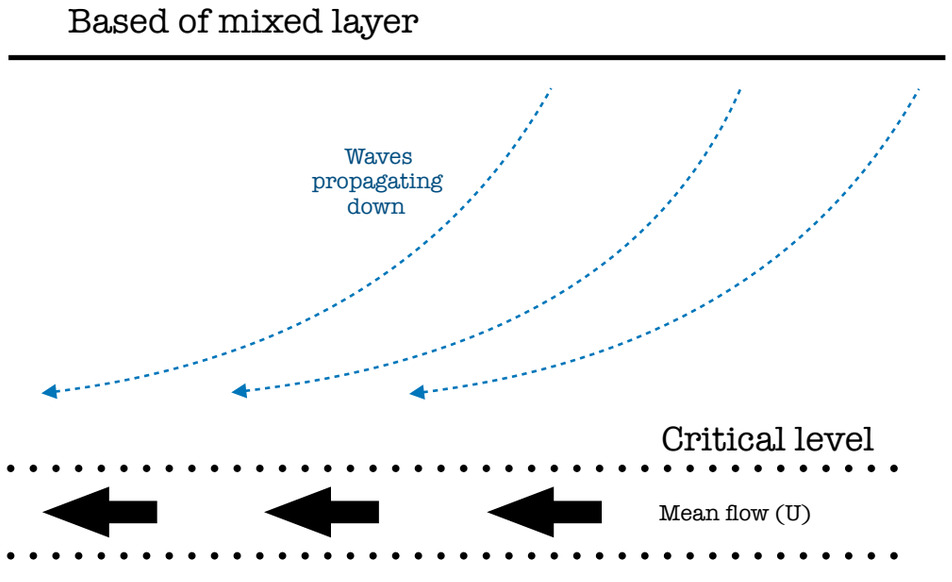
log(Ri) < 4



- High shear areas masked out
- Compute mean downward flux in those areas
- Maximum stays in the upper 500m

NIWs in negative vorticity but high shear





- **At critical level:**
- Phase speed (c_p) of wave = Mean flow speed (U)
- Waves get more and more horizontal, and ultimately get reabsorbed by the mean flow

Concluding remarks

- Method: Lagrangian filtering and wave separation (up and down)
- Deep and quick propagation of NIWS in areas of high negative vorticity (anticyclonic eddies)
- NIWs restricted to upper layer in regions of high shear (currents, fonts)
- What next? How about the upgoing wave component? How does the upgoing and the downgoing waves compare?