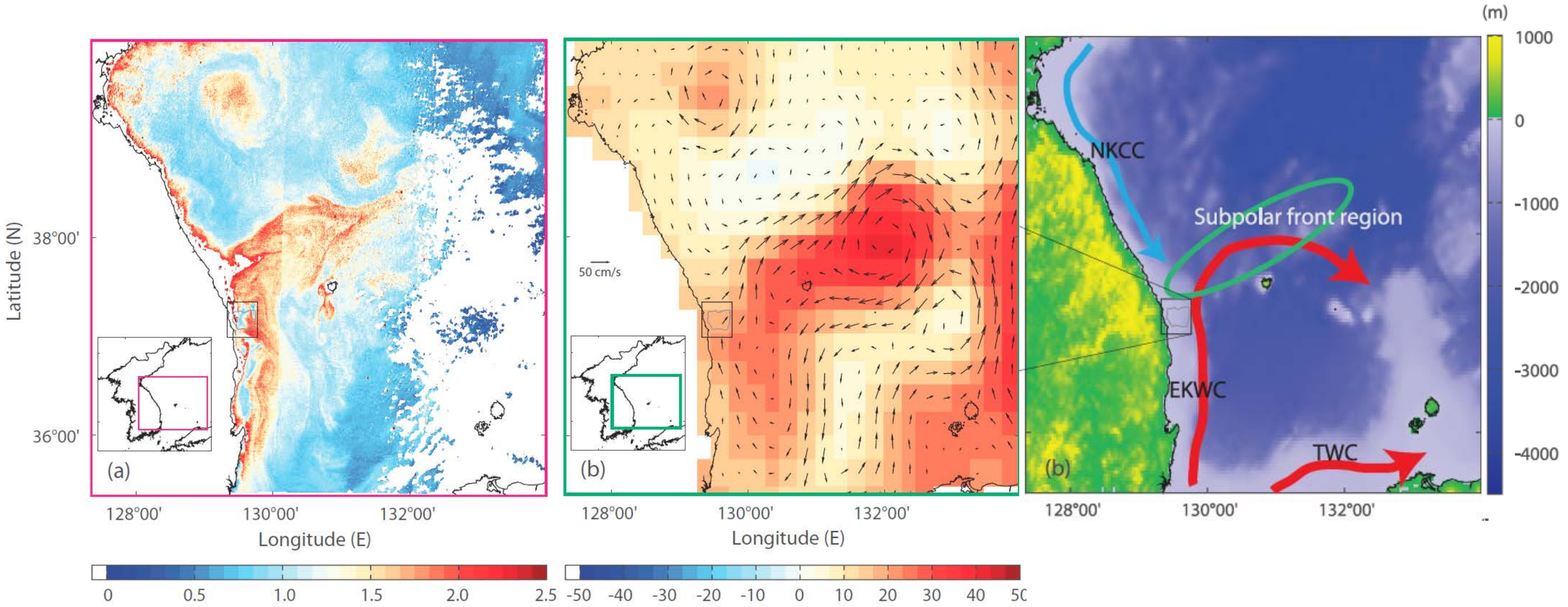
Spectral descriptions of coastal submesoscale surface currents and chlorophyll concentrations in an observational view



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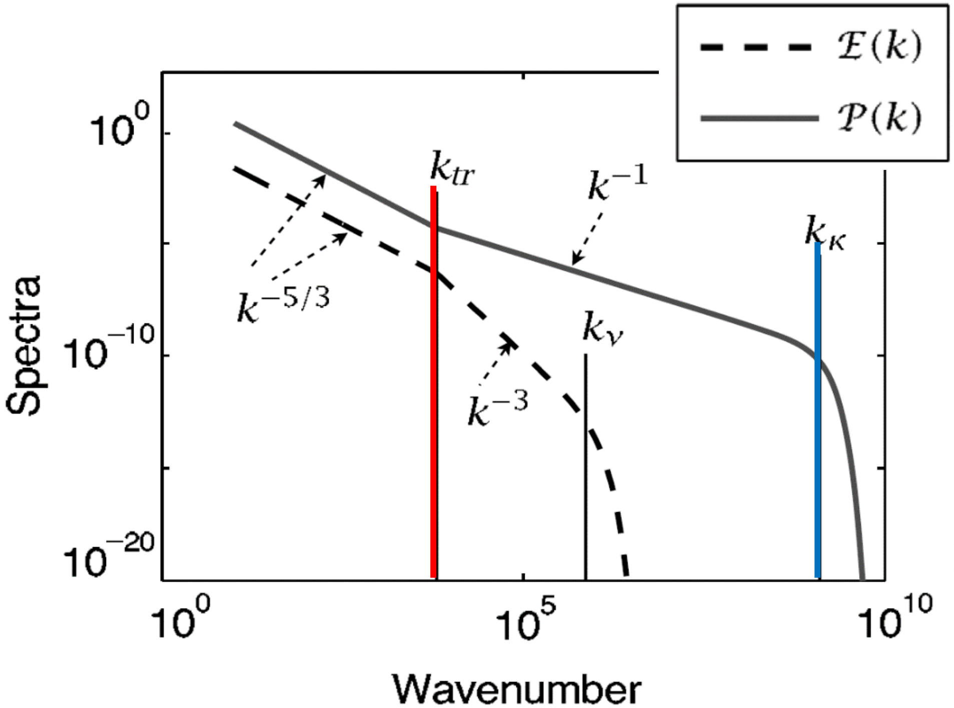
Outline

- Introduction
  - Submesoscale processes
  - Forward and inverse energy cascades
- Diagnostic characteristics of submesoscale coastal surface observations
  - Energy spectra of surface currents and surface chlorophyll concentrations off the east coast of Korea
  - Injection and dissipation scales from the wavenumber domain energy spectra
- Summary

Kinetic energy (KE) spectra and fluxes (1/2)

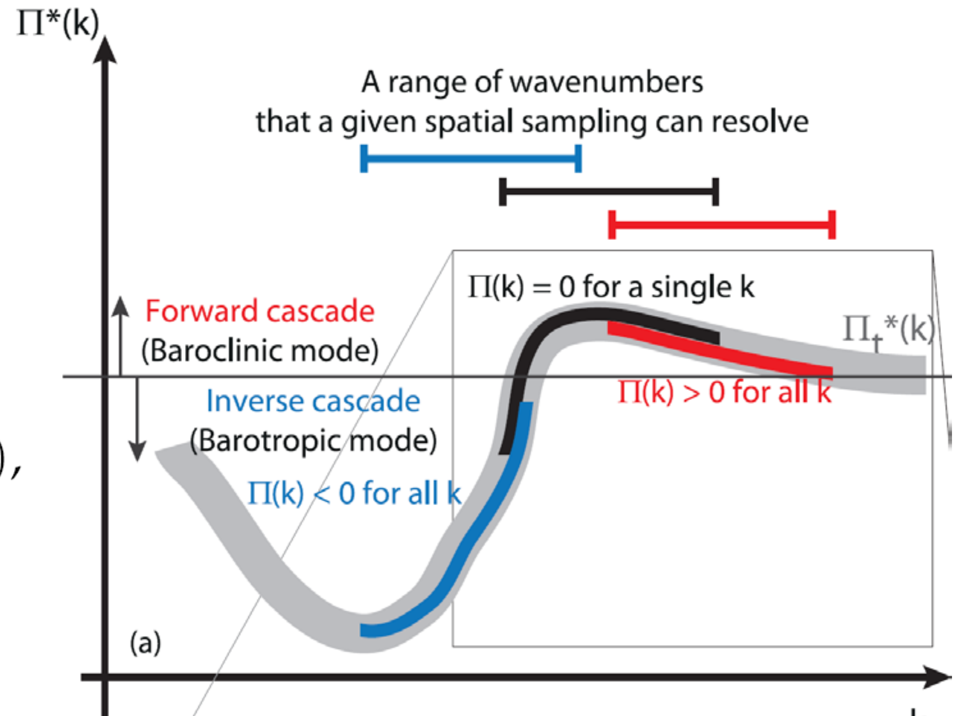


(Vallis, 2000; not scaled)

- Kinetic energy (KE) spectra of currents [E(k)]
- Energy spectra of passive tracers [P(k);]
- Transition (injection) scale and dissipation scale

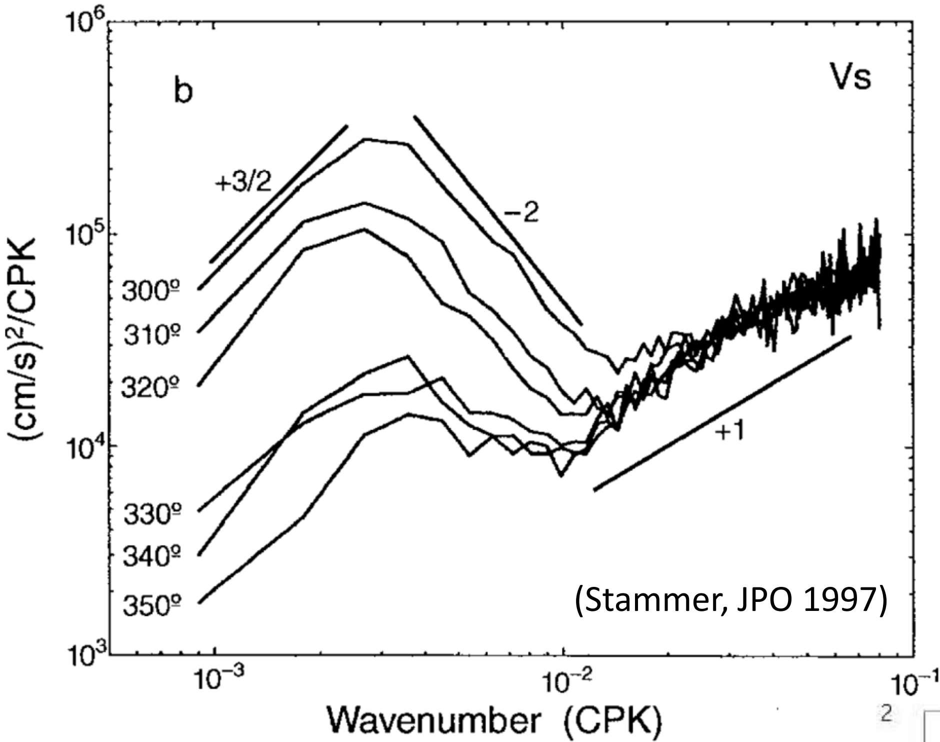
$$\frac{\partial}{\partial t}E(k^*) + \Pi(k^*) = -2\nu\Omega(k^*) + F(k^*),$$

(Frisch 1995)



(Soh and Kim 2018; submitted)

Kinetic energy (KE) spectra and fluxes (2/2)

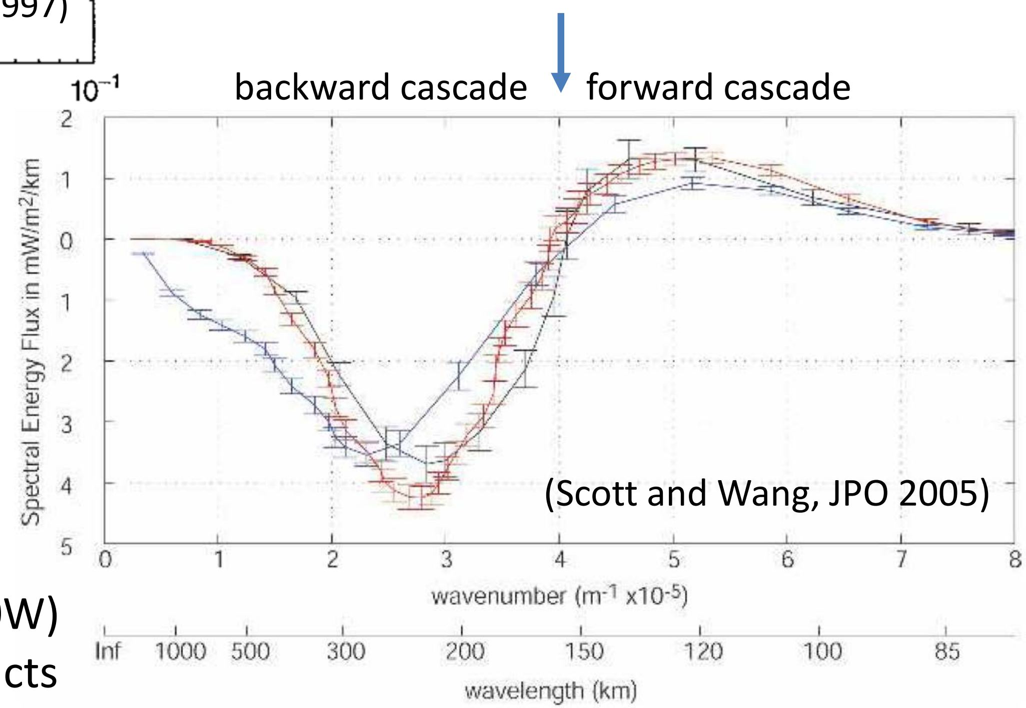


(Stammer, JPO 1997)

- What can be the decay slope of KE spectra and the injection scales to have zero crossing in the KE flux below 100 km scale?

Wavenumber KE spectra of altimeter-derived cross-track geostrophic currents (30N to 40 N)

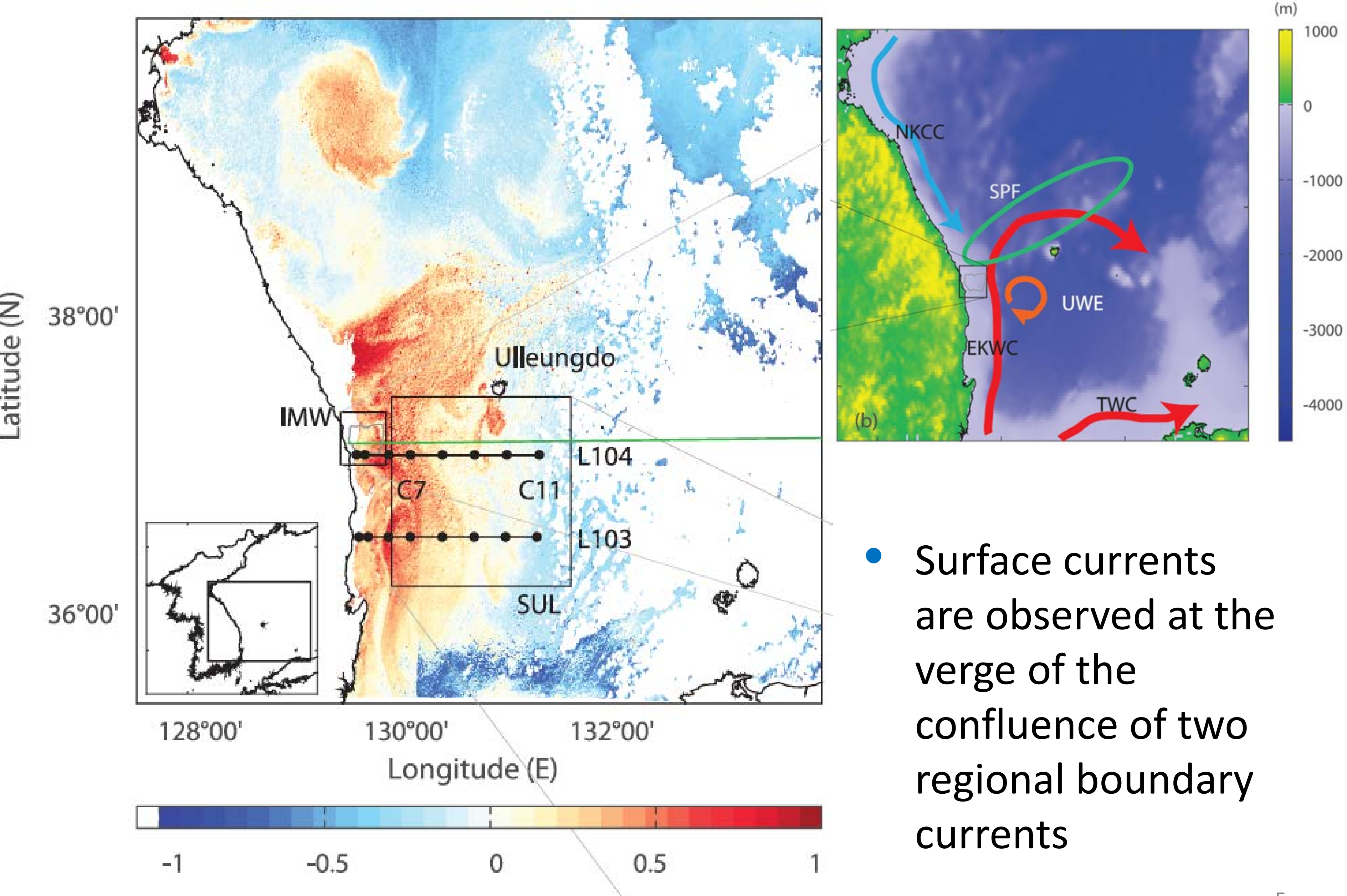
$$S_{\mathbf{u}_\perp}(k_\parallel) = \left(\frac{g}{f_c}\right)^2 \left(2\pi k_\parallel\right)^2 S_{\boldsymbol{\eta}_\parallel}(k_\parallel),$$



(Scott and Wang, JPO 2005)

Kinetic energy flux in ACC region (57S, 120W)
Optimally interpolated 1/3° AVISO products

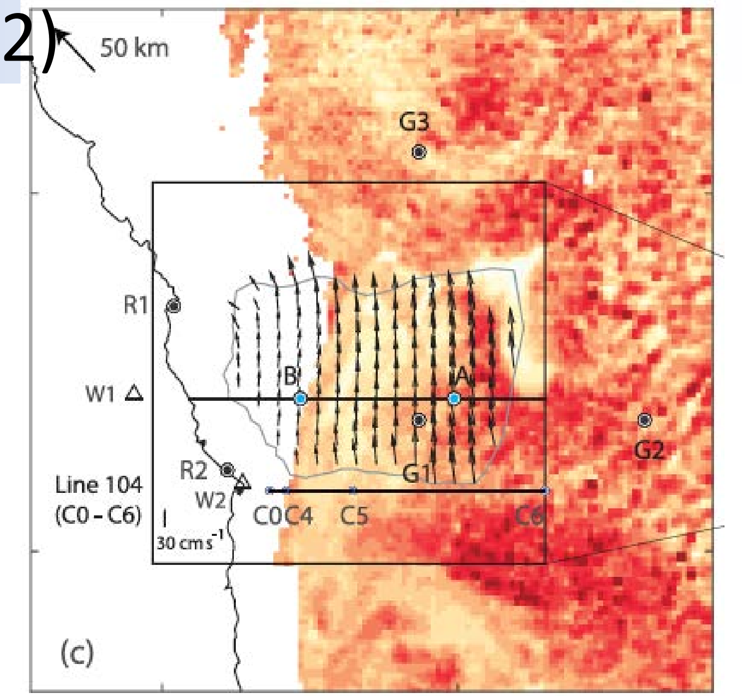
Study domain and observations (1/2)

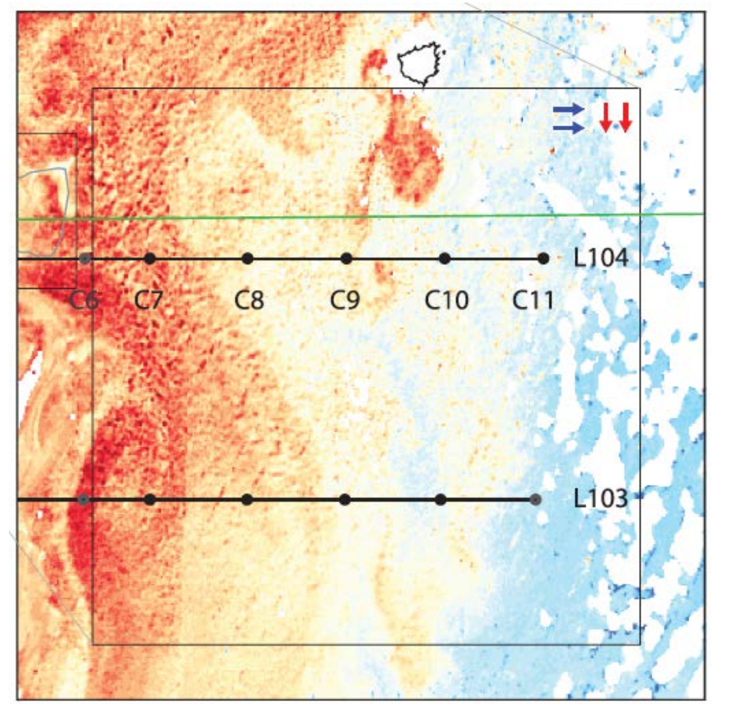


- Surface currents are observed at the verge of the confluence of two regional boundary currents

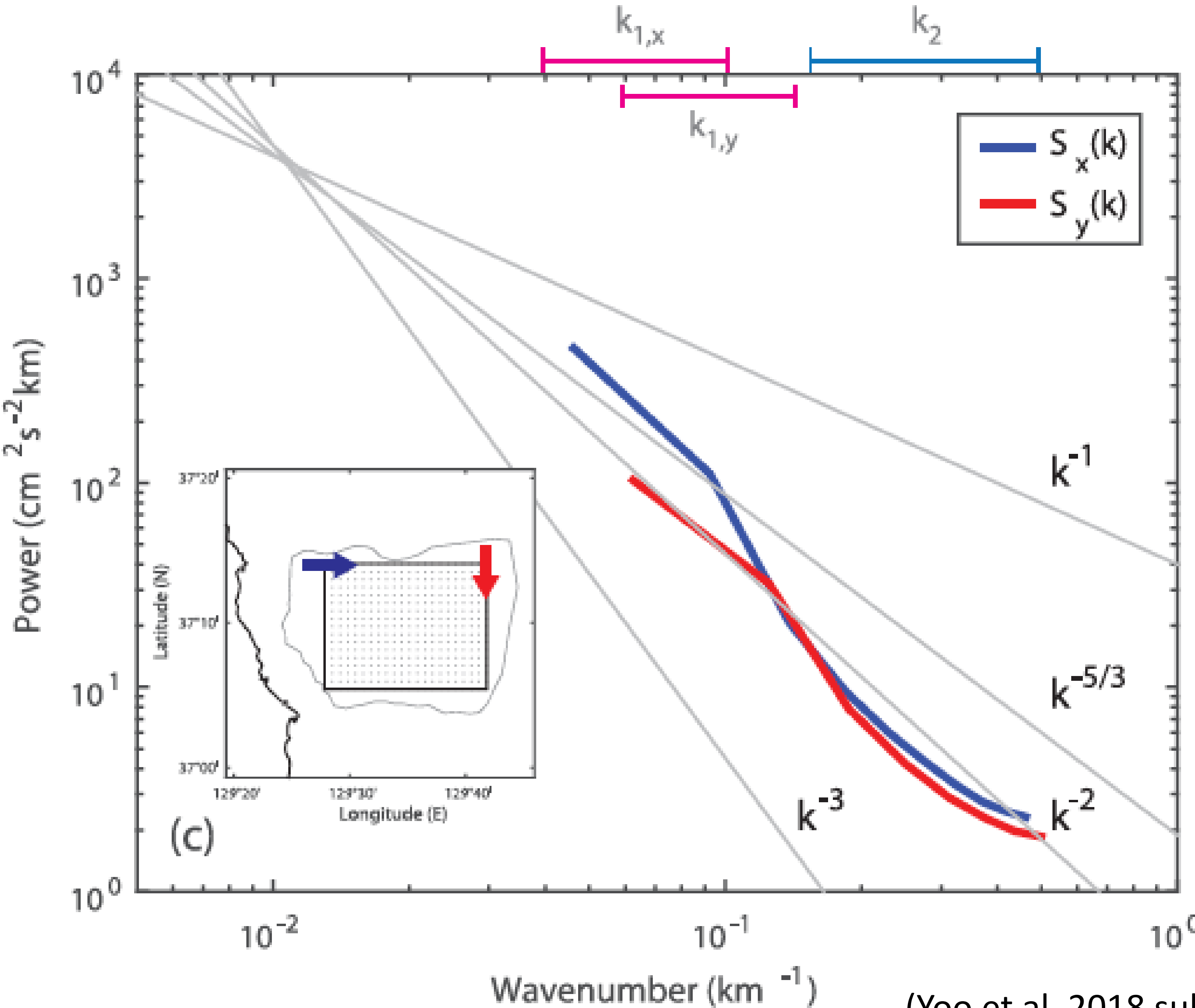
Study domain and observations (2/2)

- Hourly and 1-km resolution HFR-derived surface currents for one year (2013)
- Geostationary Ocean Color Imagery (GOCI)-derived chlorophyll concentrations at resolutions of an hour (during a day; approx. 8 samples a day) and 0.5 km for 5 years (2011 to 2015)
- Bi-monthly CTD (temperature, salinity, and nutrients) sampling at the C0 to C11 stations (1960 to currents) are used to derive the climatology of stratification.



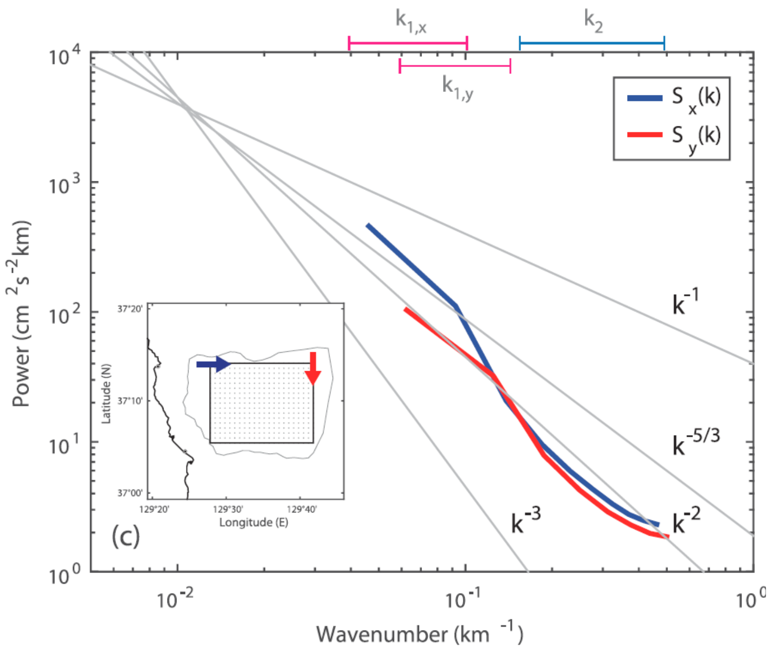


KE spectra of submesoscale surface currents (1yr-avg.)

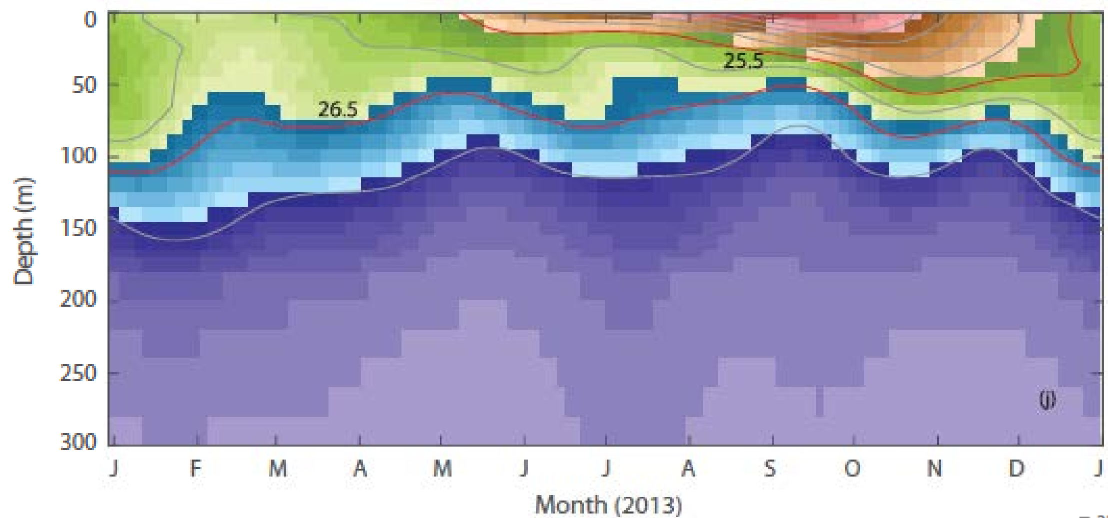


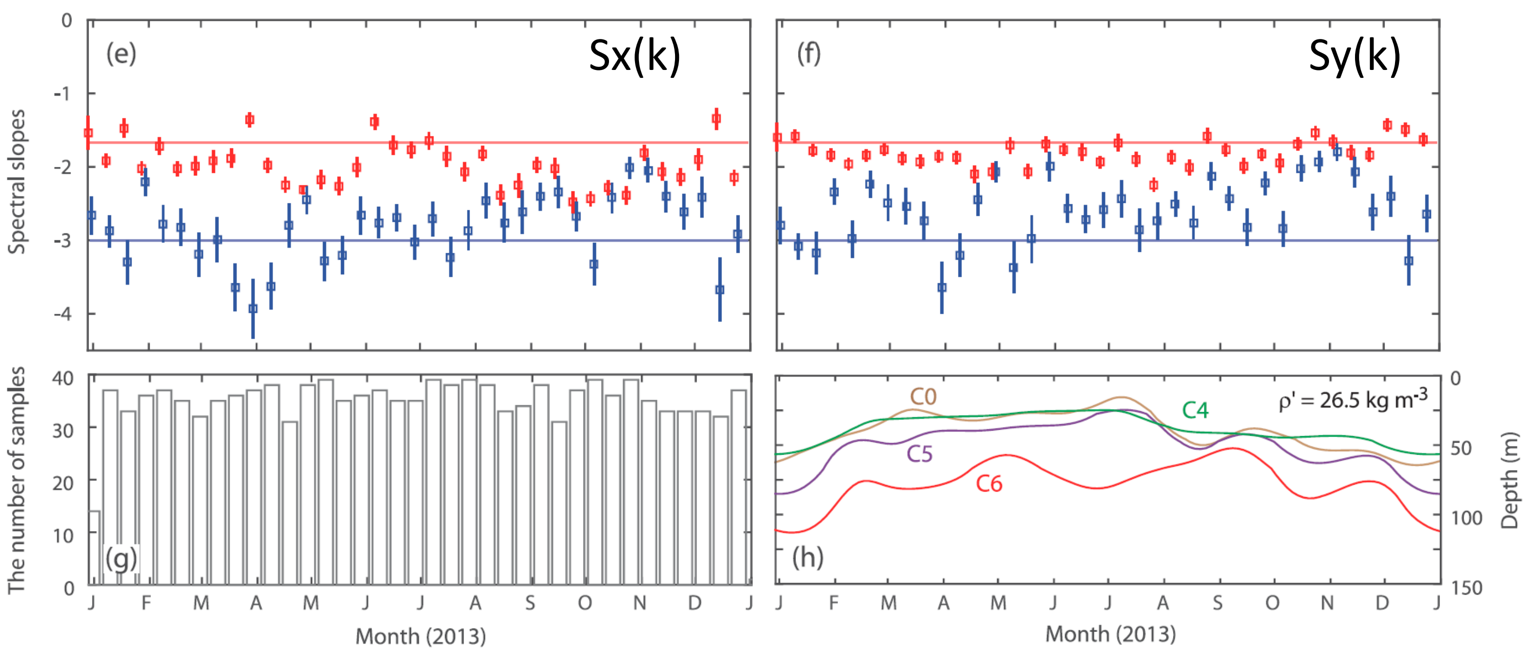
(Yoo et al, 2018 submitted)

KE spectra, stratification, and spectral slopes

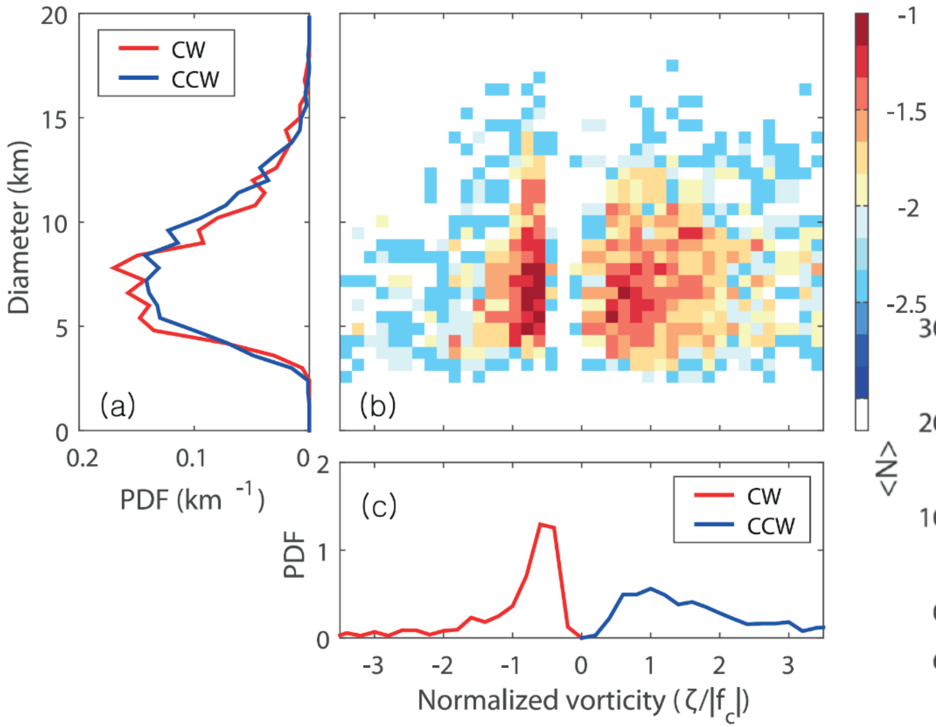


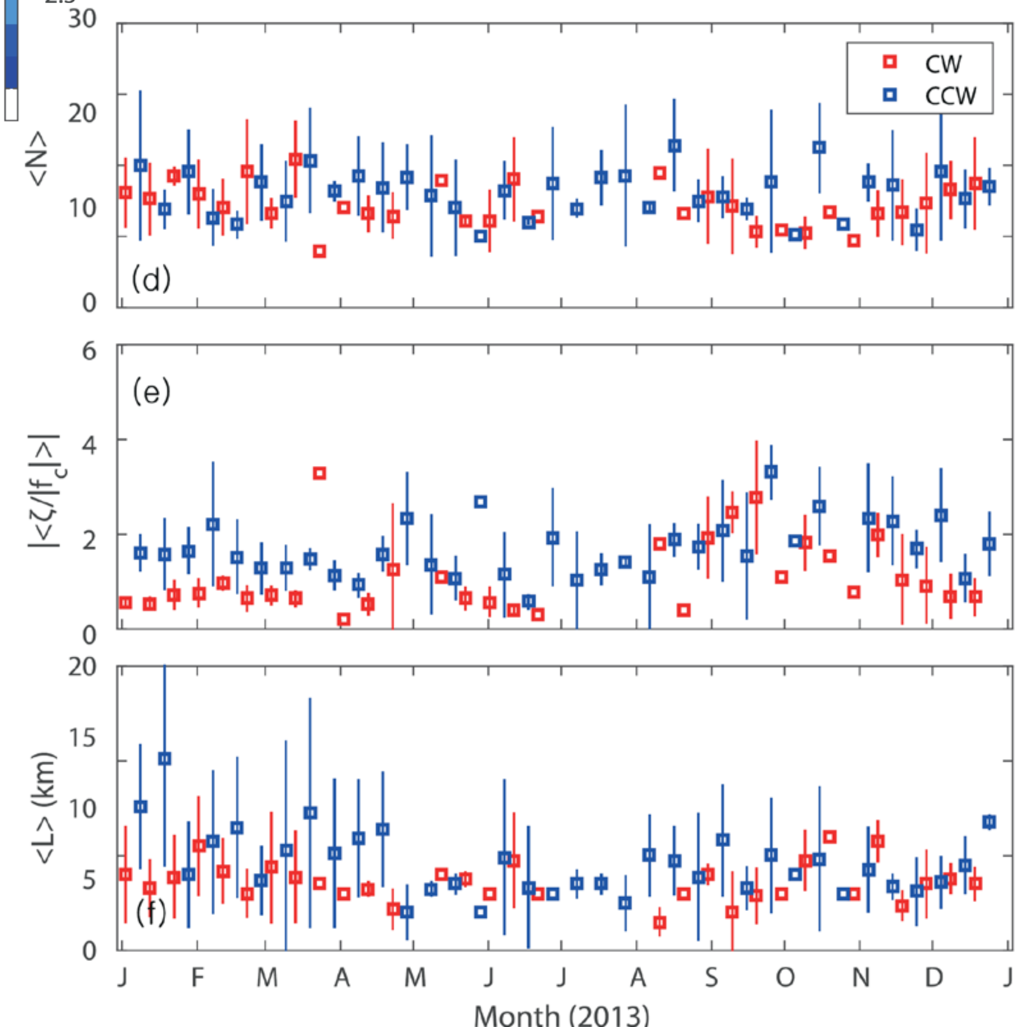
Temperature profiles at the C6 station





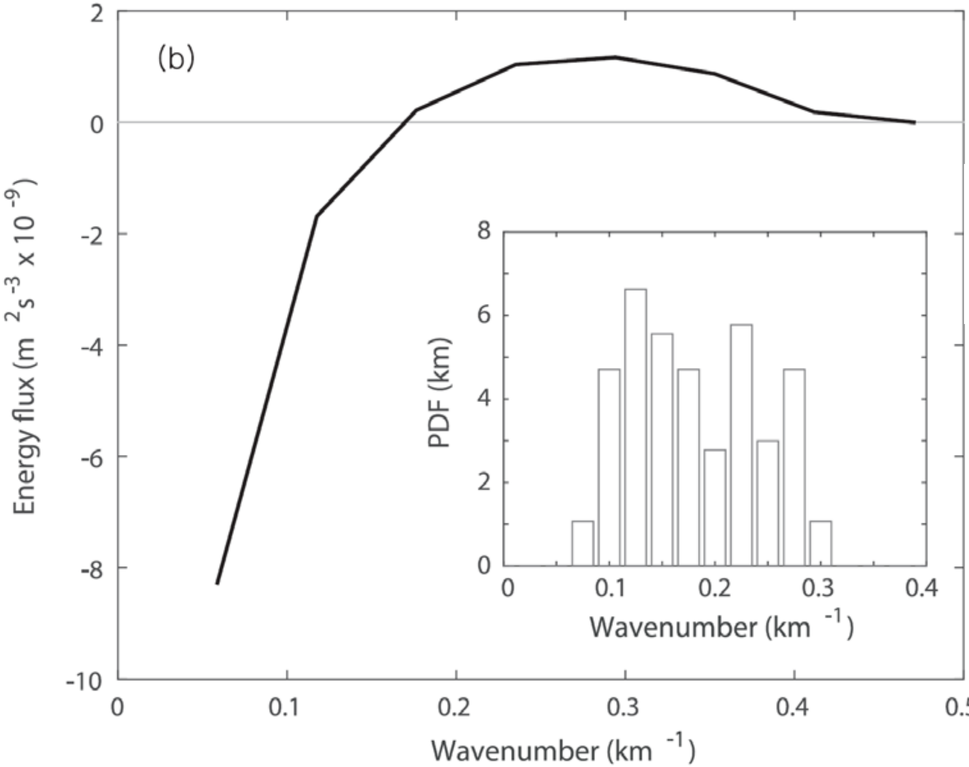
Variability of regional submesoscale eddies





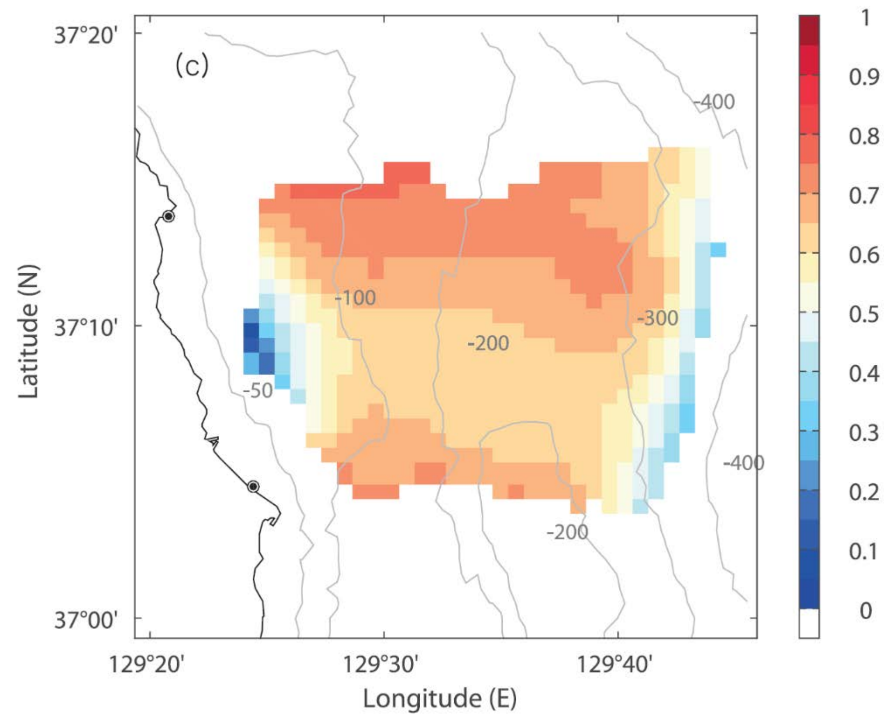
- 5-12 km diameter eddies
- Anitcyclonic eddies (CW) become unstable when the vorticity <-1
- Weak seasonality

Averaged KE fluxes and anisotropy



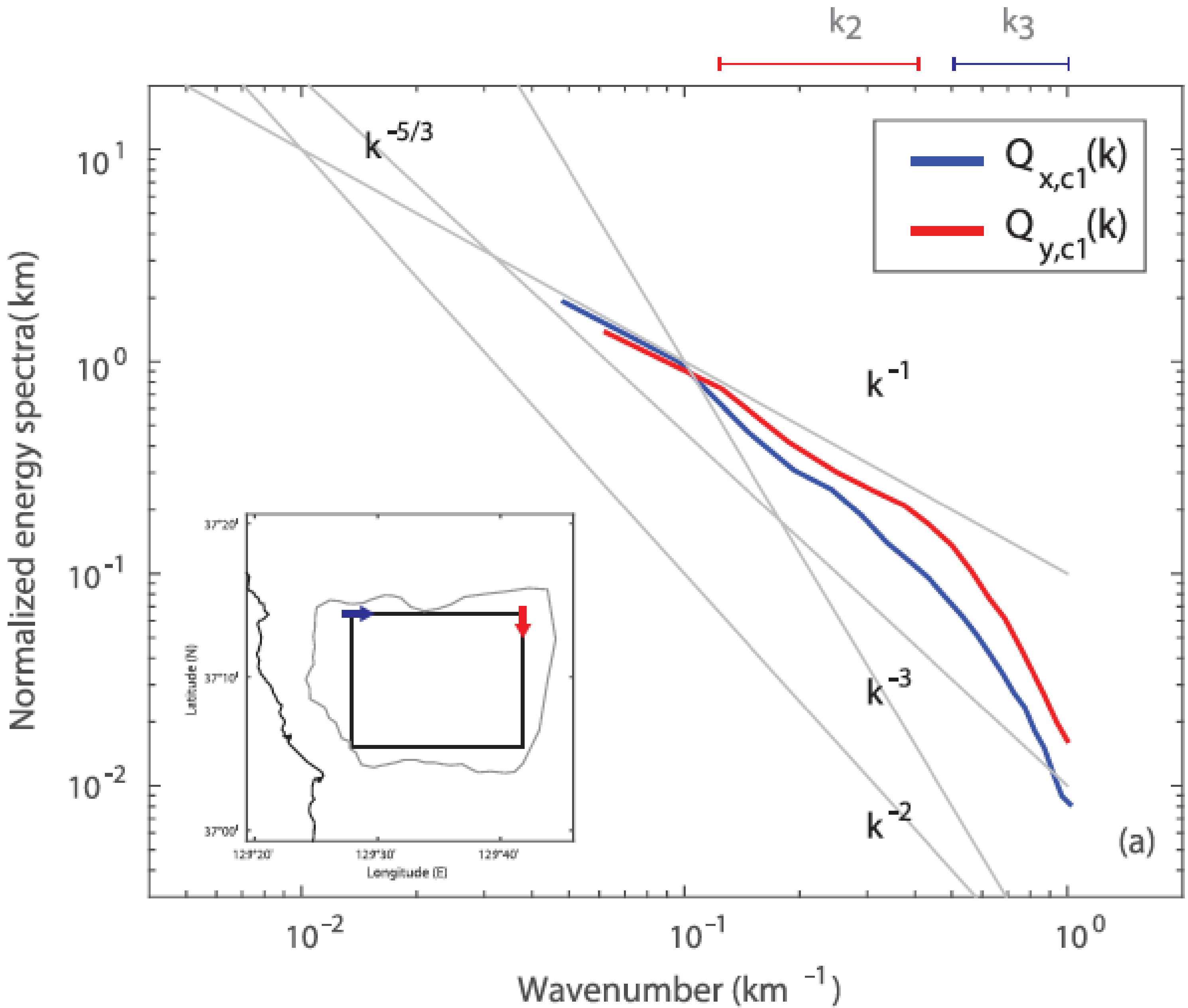
$$\frac{\partial}{\partial t}E(k^*) + \Pi(k^*) = -2\nu\Omega(k^*) + F(k^*),$$

$$\kappa = \frac{\sqrt{(\langle u'^2\rangle - \langle v'^2\rangle)^2 + 4\langle u'v'\rangle^2}}{\langle u'^2\rangle + \langle v'^2\rangle},$$



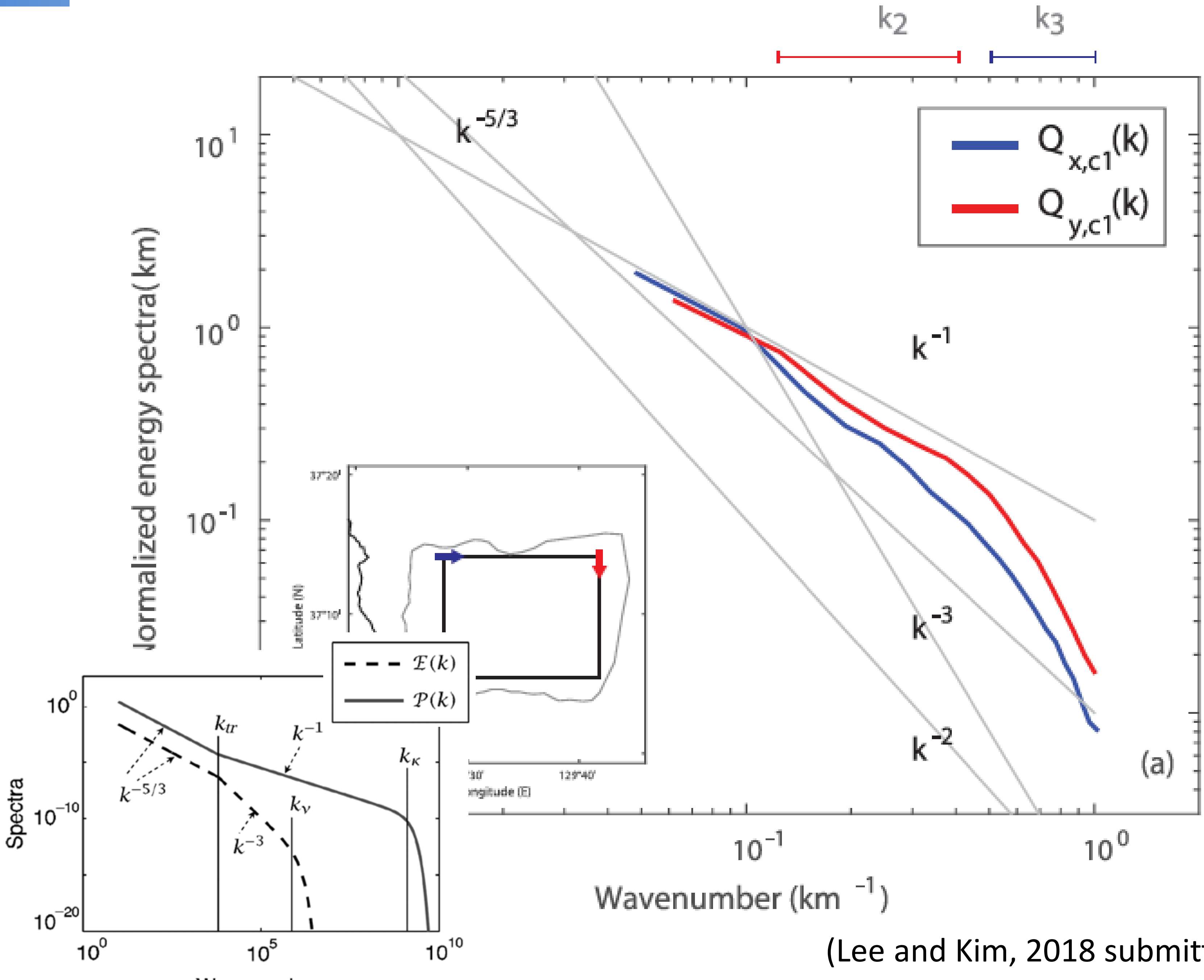
- Injection scales estimated from KE fluxes appear 3 to 8 km
- Most of anisotroy > 0.7

Spectra of submesoscale surface CHLs (1/2)



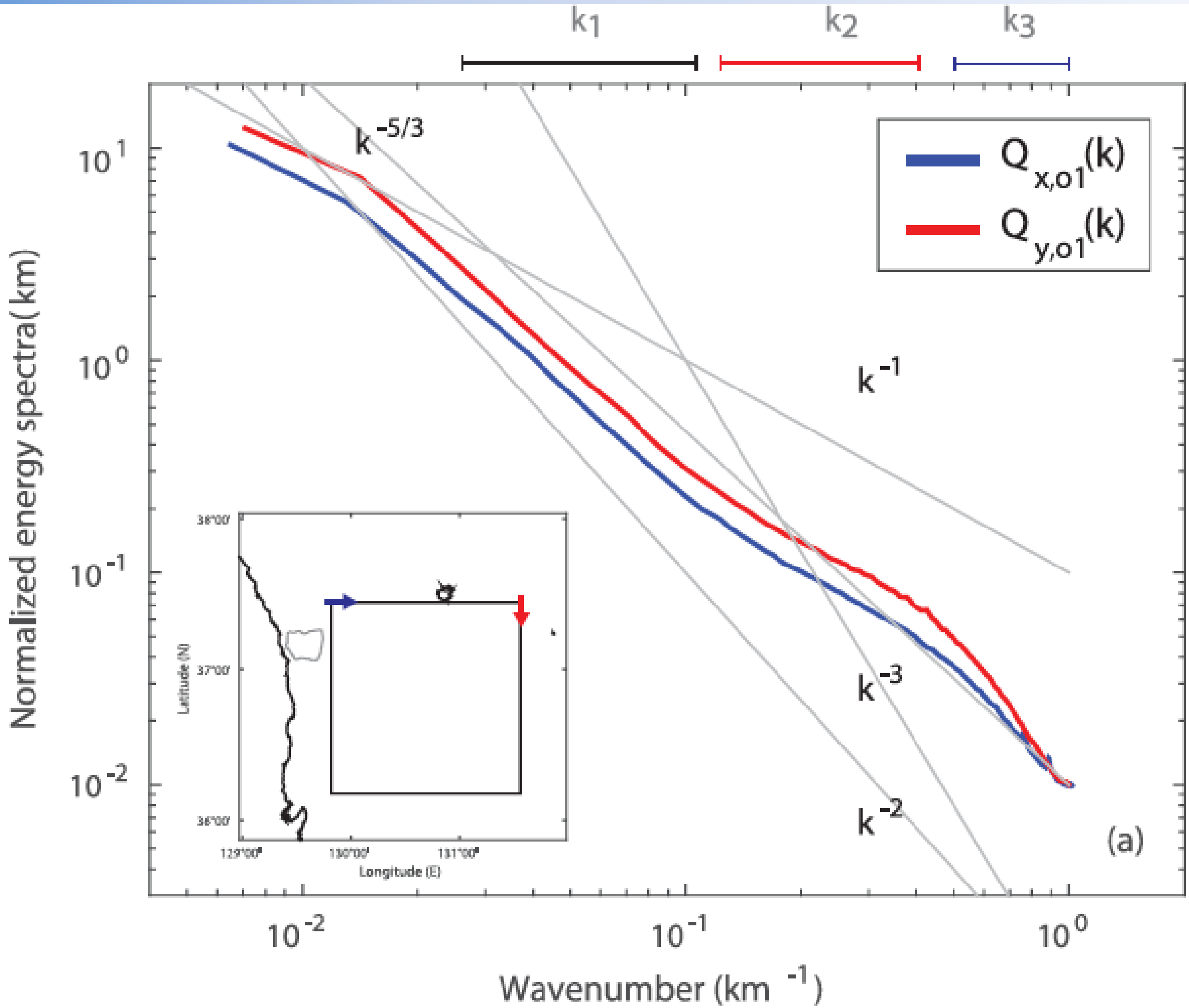
(Lee and Kim, 2018 submitted)

Spectra of submesoscale surface CHLs (1/2)



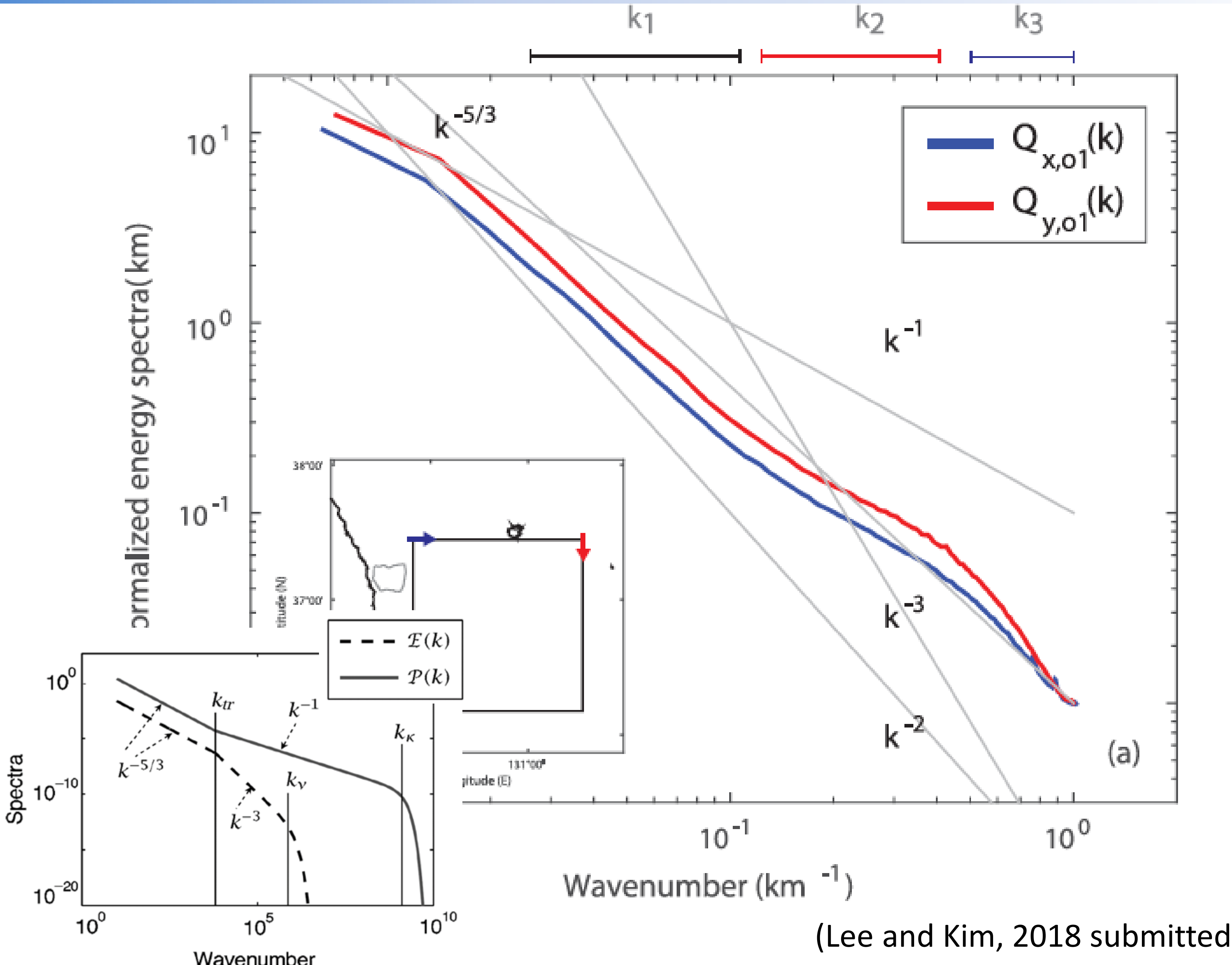
(Lee and Kim, 2018 submitted)

Spectra of submesoscale surface CHLs (2/2)



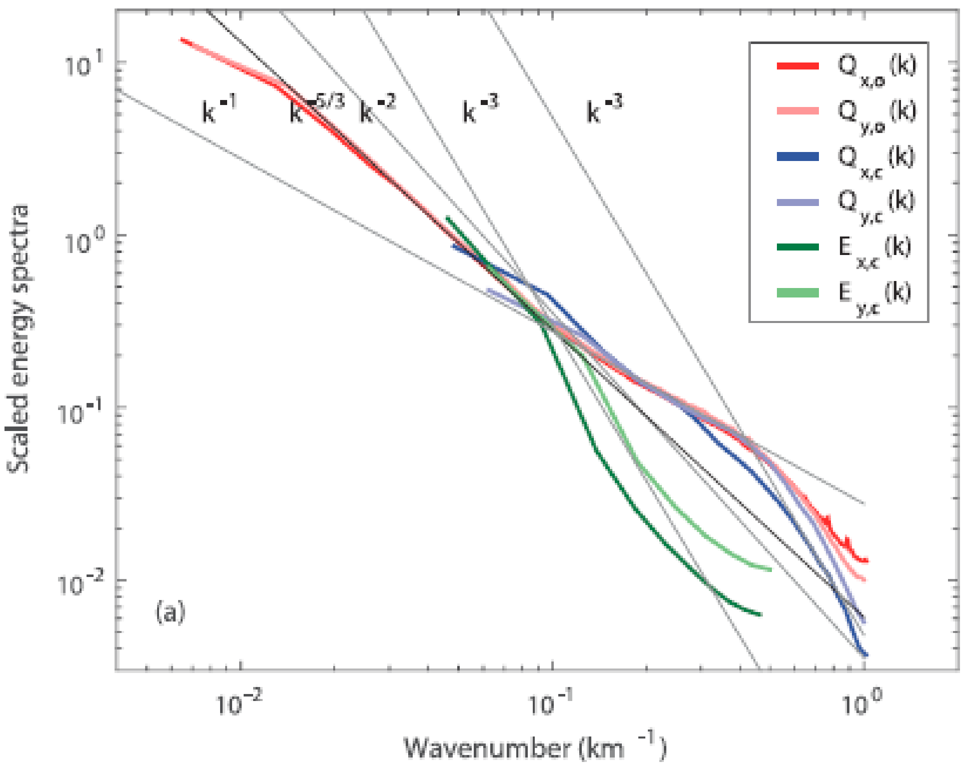
(Lee and Kim, 2018 submitted)

Spectra of submesoscale surface CHLs (2/2)

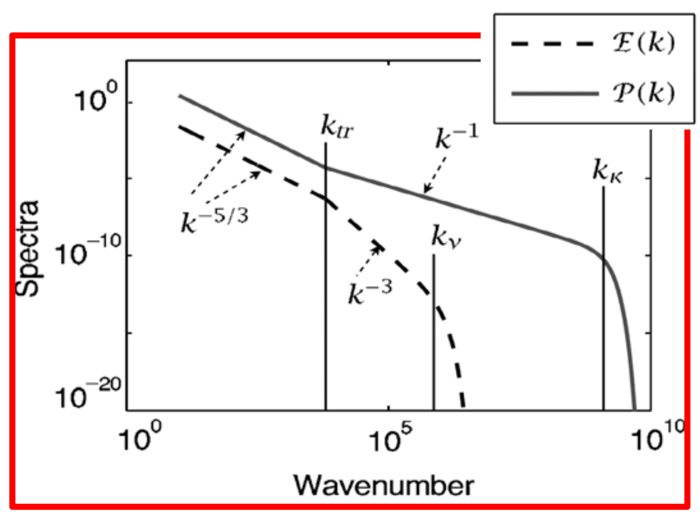


(Lee and Kim, 2018 submitted)

Scaled (KE) spectra of surface currents and CHLs



- Transition and dissipation scales appear near 10 km and 2 km, respectively



Summary

- Kinetic energy (KE) spectra and fluxes of submesoscale surface currents show the decay slopes of k^{-2} and k^{-3} and the injection scale as O(10) km.
- Consistently, the spectra of passive tracers (CHL) exhibit the injection scale of ~10 km and dissipation scale of ~ 2 km under a cautionary consideration of the use of bloomed CHLs as a passive tracer.
- Both results are more consistent with quasi-geostrophic (QG) turbulent theory than others (sQG, semi-QG, fsQG, etc).
- The baroclinic instability in the mixed layer plays a dominant role in the regional submesoscale driver rather than the mesoscale eddy-derived surface frontogenesis at a scale of O(100) km.