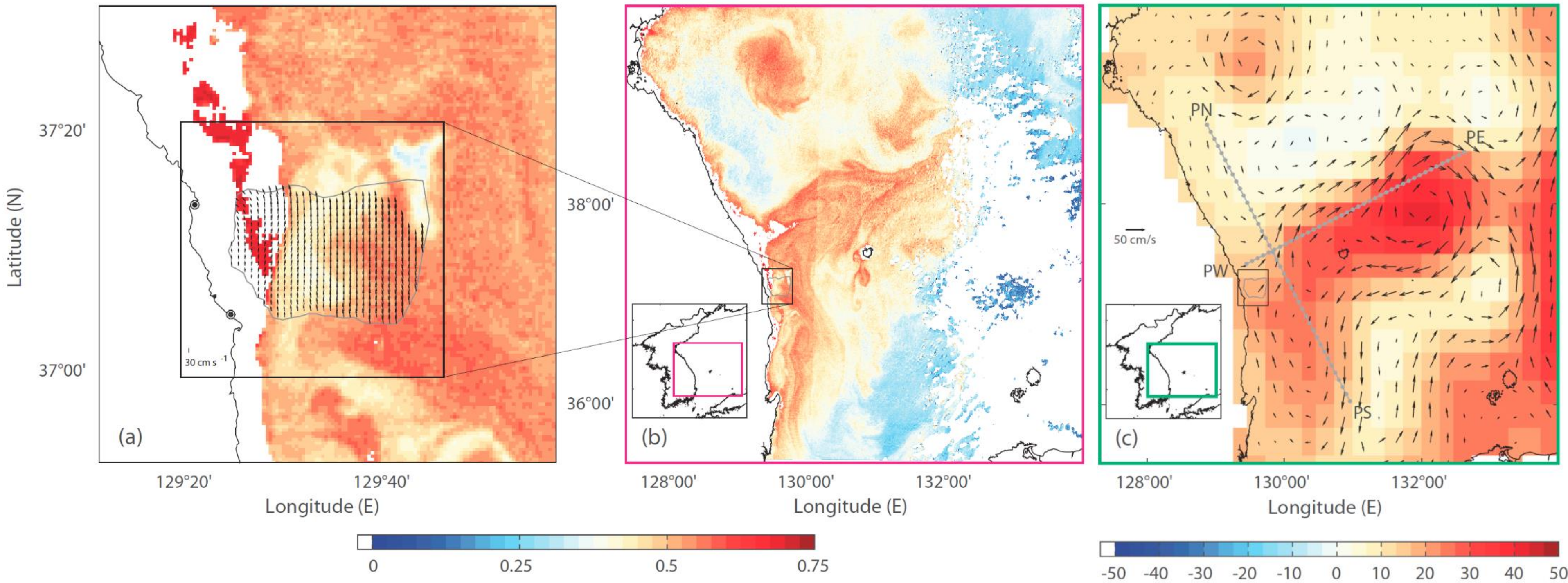
Spectral descriptions of submesoscale coastal surface circulation in a coastal region off the East Coast of Korea



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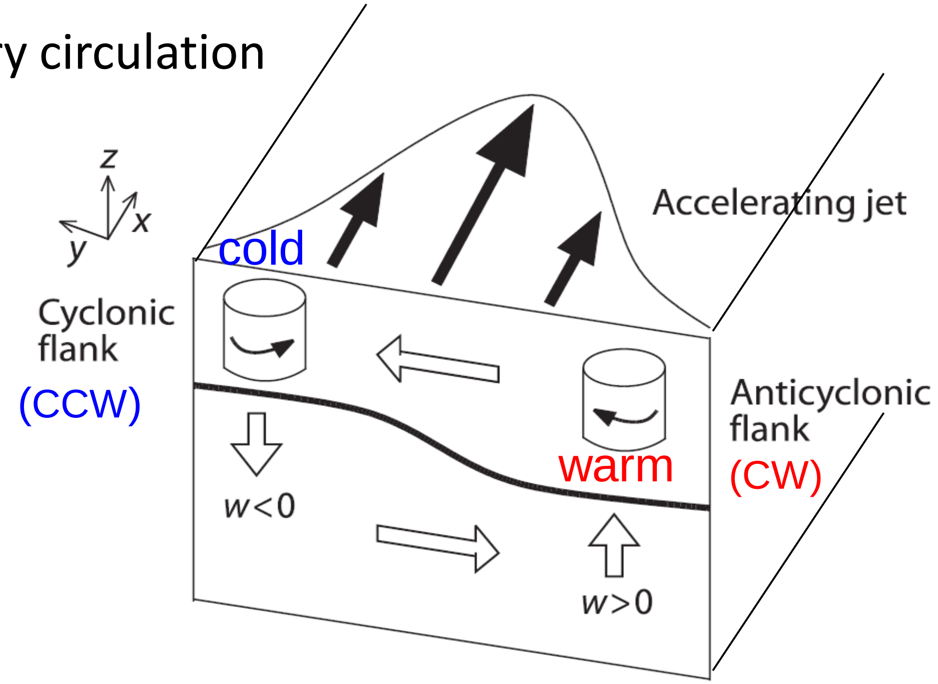
Outline

- An overview on submeoscale processes
- Surface current data and their QAQC
- Spectral contents and maps
  - Rotary spectra
  - Magnitude of surface currents in the frequency band(s) of interest
  - Low-frequency and near-inertial surface currents
- Summary

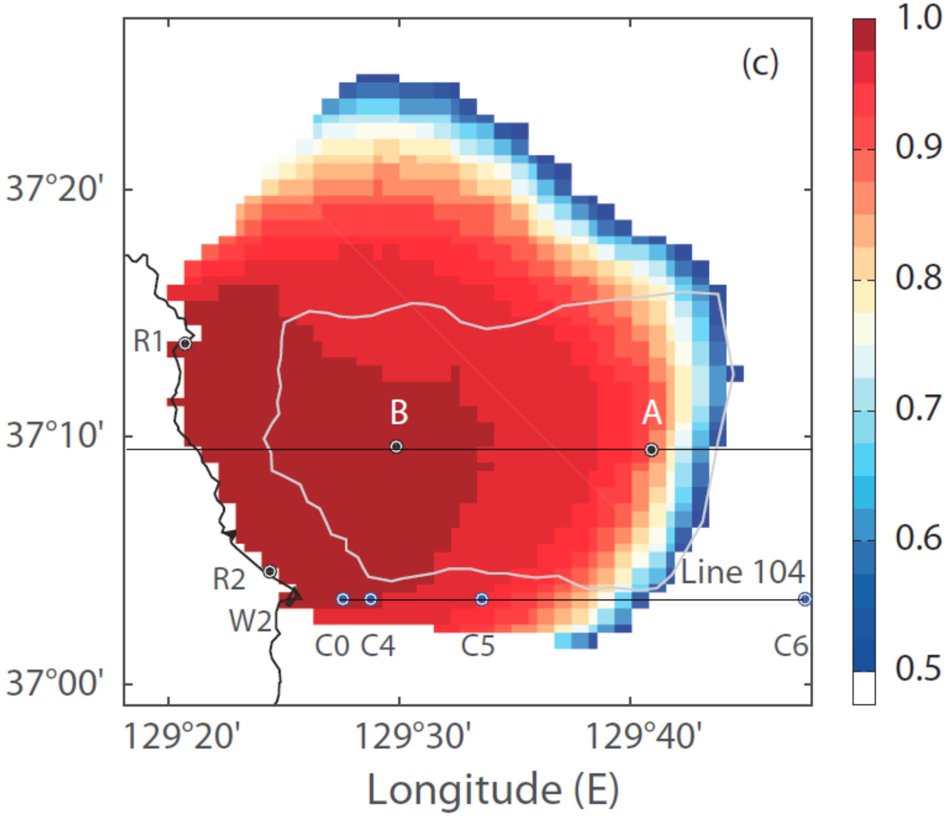
Submesoscale processes

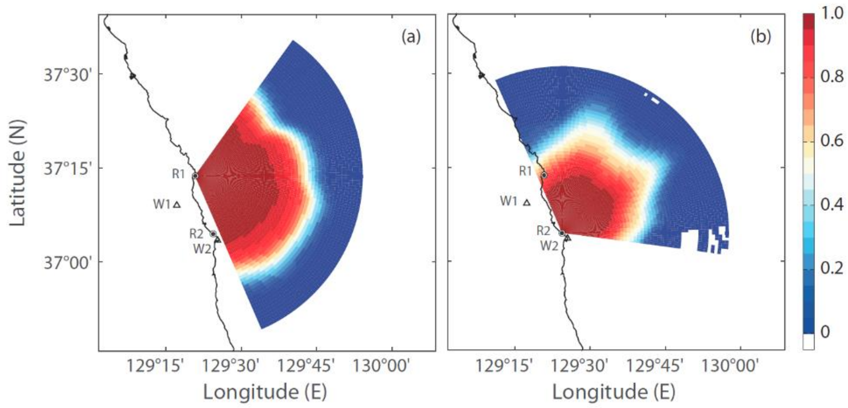
- O(1) Rossby number [Ro = ζ/f]
- A horizontal scale smaller than the first baroclinic Rossby deformation radius; O(1-10) km
- Frequently observed as fronts, eddies, and filaments
- Contribute to the vertical transport of oceanic tracers, mass, and buoyancy and rectify the mixed-layer structure and upper-ocean stratification
  - e.g., vertical frontal scale secondary circulation



(Williams and Follows, 2003)

Data availability





- Hourly surface current maps at a 1-km resolution grid obtained from two HF radars (WERA; phased-array system) for one year (2013)
- Effective spatial coverage and QAQC'd region
- Intermittent missing data in time
- CTD profiles in Line 104 for seasonal stratification

Uncertainty of radial observations

$$r_A = u\cos\theta_A + v\sin\theta_A + \varepsilon_A$$
$$r_B = u\cos\theta_B + v\sin\theta_B + \varepsilon_B$$

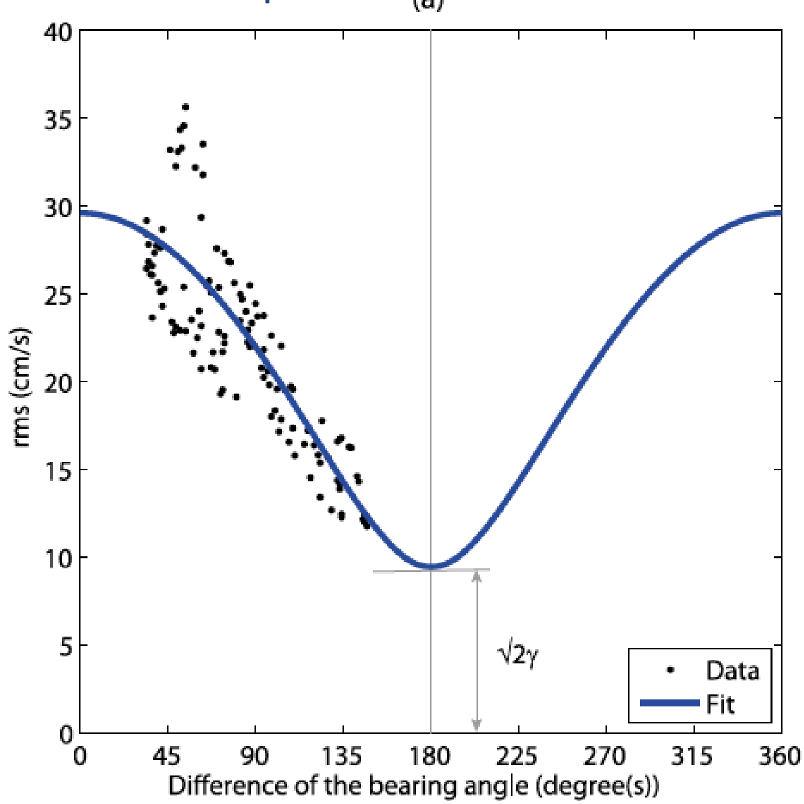
$$\rho = \frac{\langle r_A r_B^{\dagger} \rangle}{\sqrt{\langle r_A^2 \rangle}\sqrt{\langle r_B^2 \rangle}} = \kappa\cos\delta$$

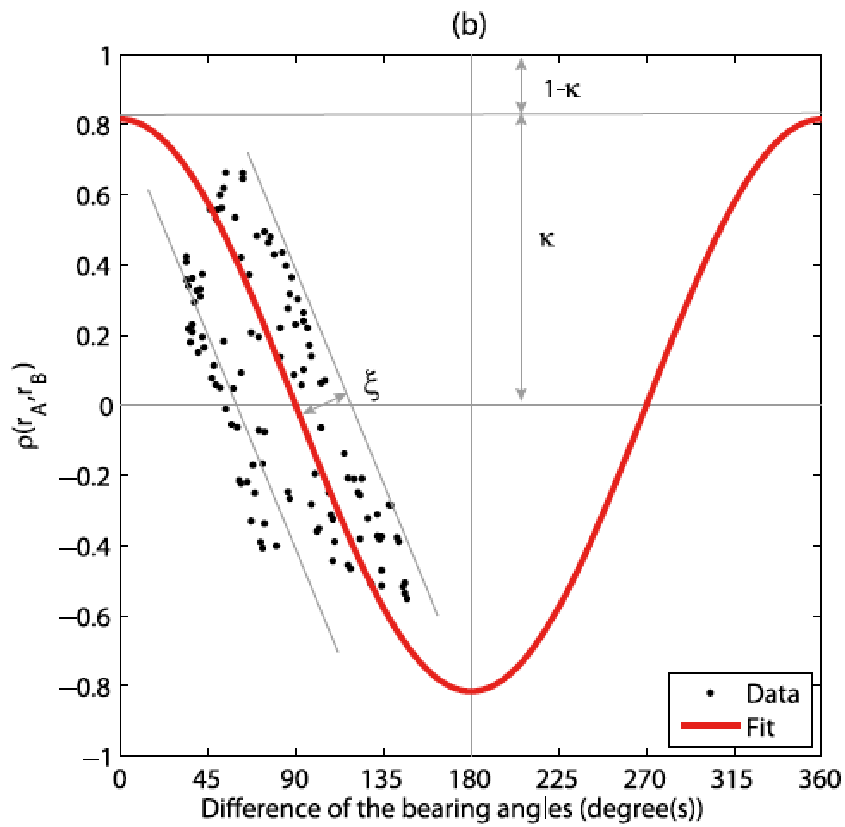
correlations of paired radials

$$\lambda = \sqrt{\langle (r_A + r_B)^2 \rangle} = \sqrt{4\sigma^2\cos^2\frac{\delta}{2} + 2\gamma^2}$$

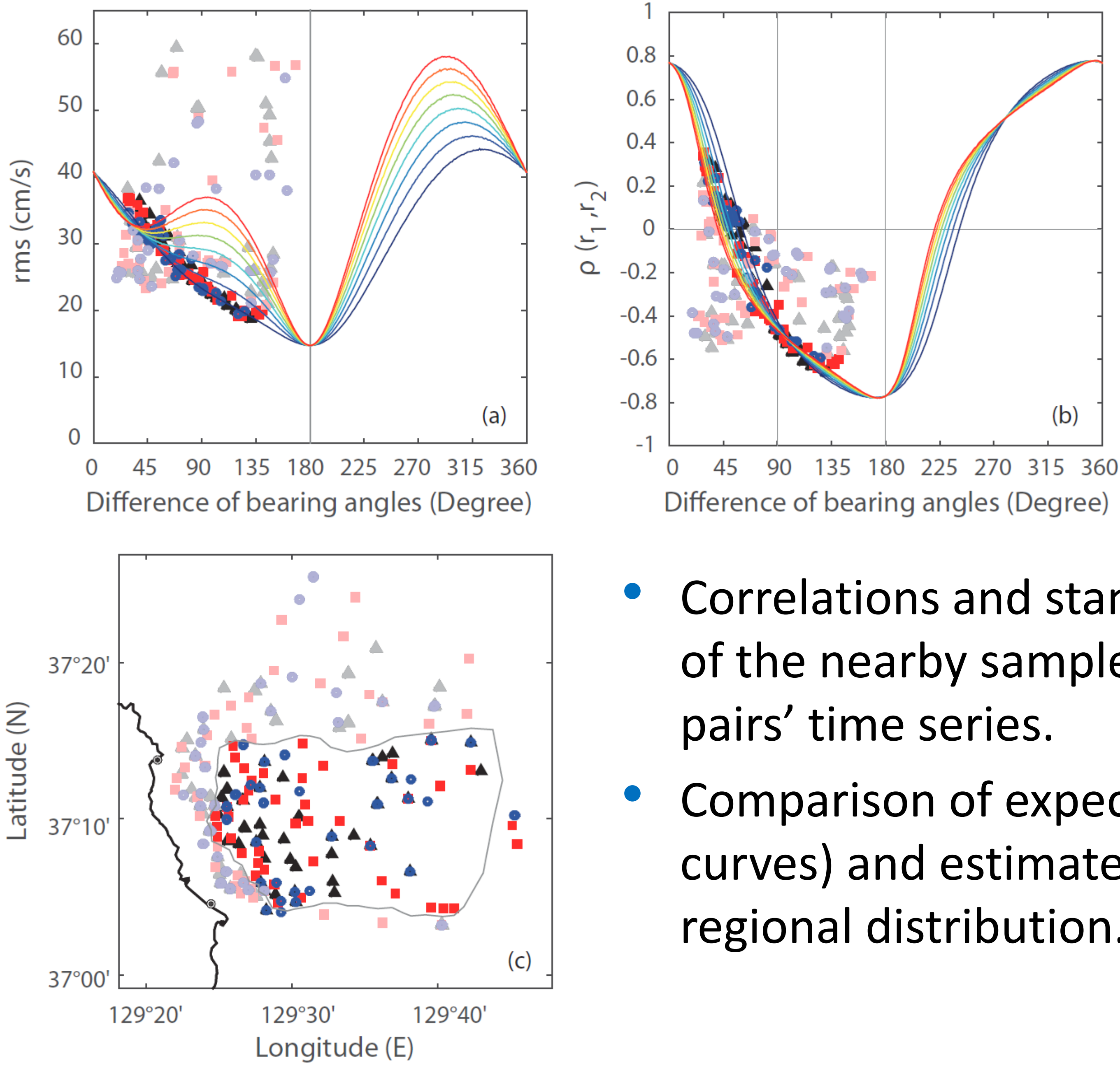
SNR $\chi = \frac{\sigma^2}{\gamma^2} = \frac{\rho}{\cos\delta - \rho}$

rms of the sum of paired radials



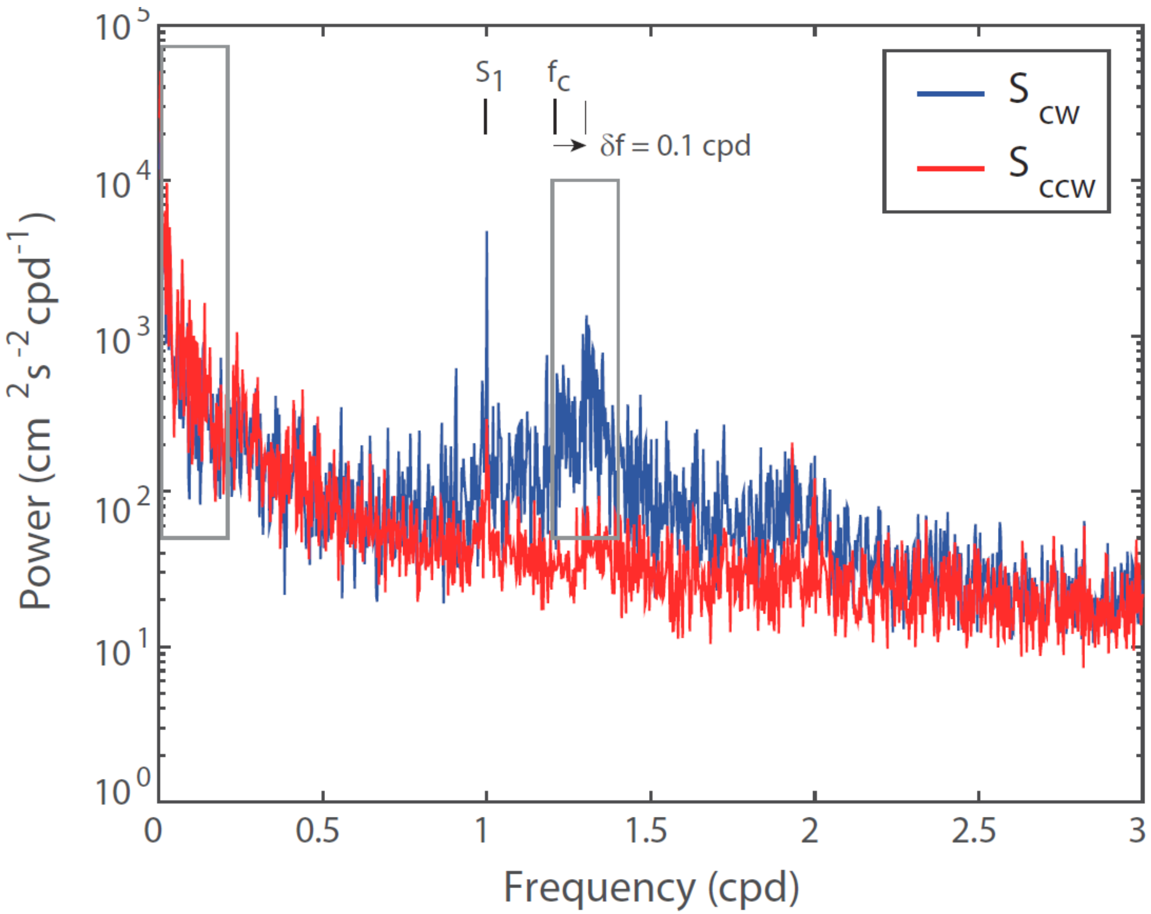


QAQC of radial velocities



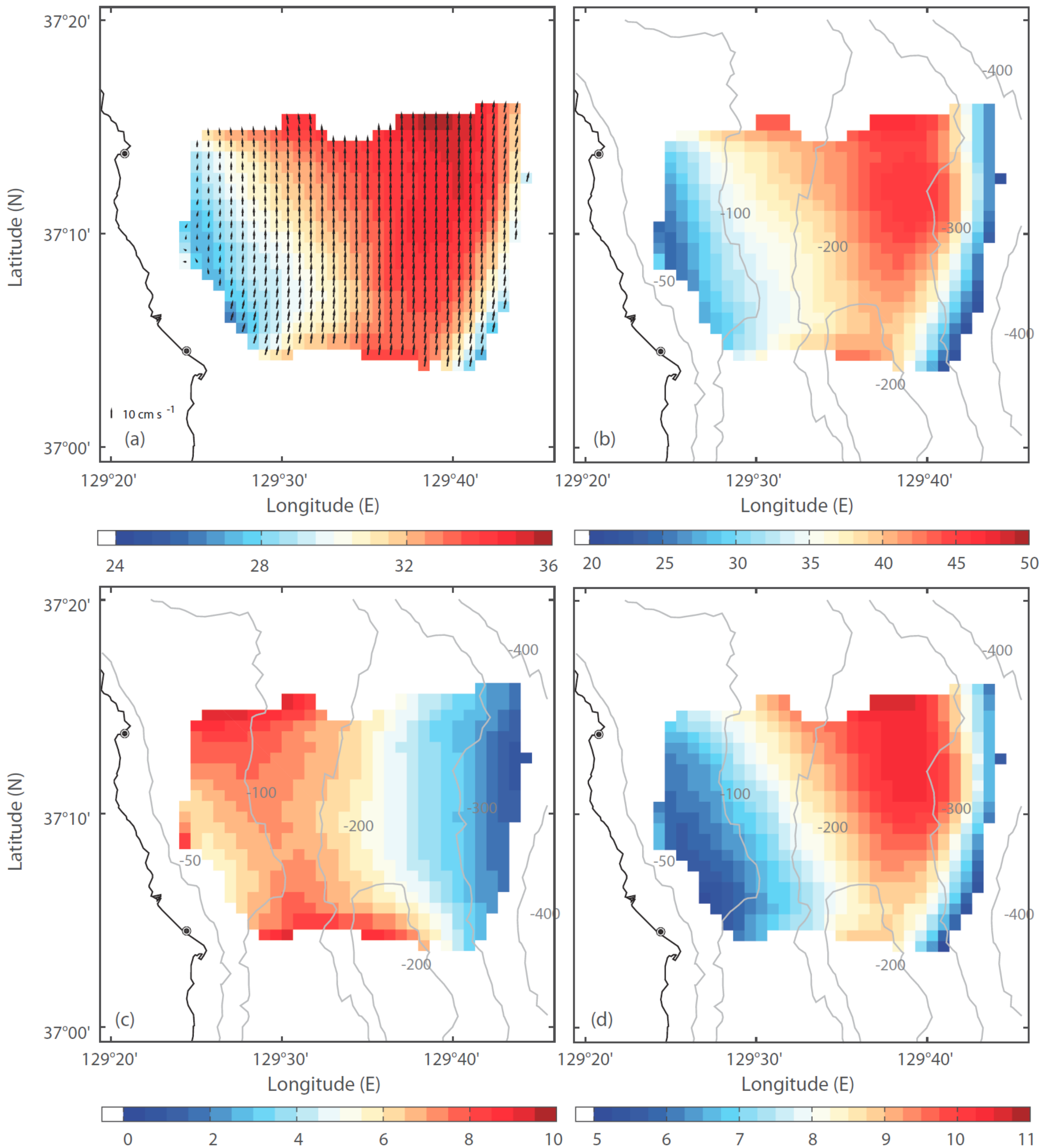
- Correlations and standard deviations of the nearby sampled radial velocity pairs' time series.
- Comparison of expectations (colored curves) and estimates (dots) and their regional distribution.

Rotary energy spectra of surface currents



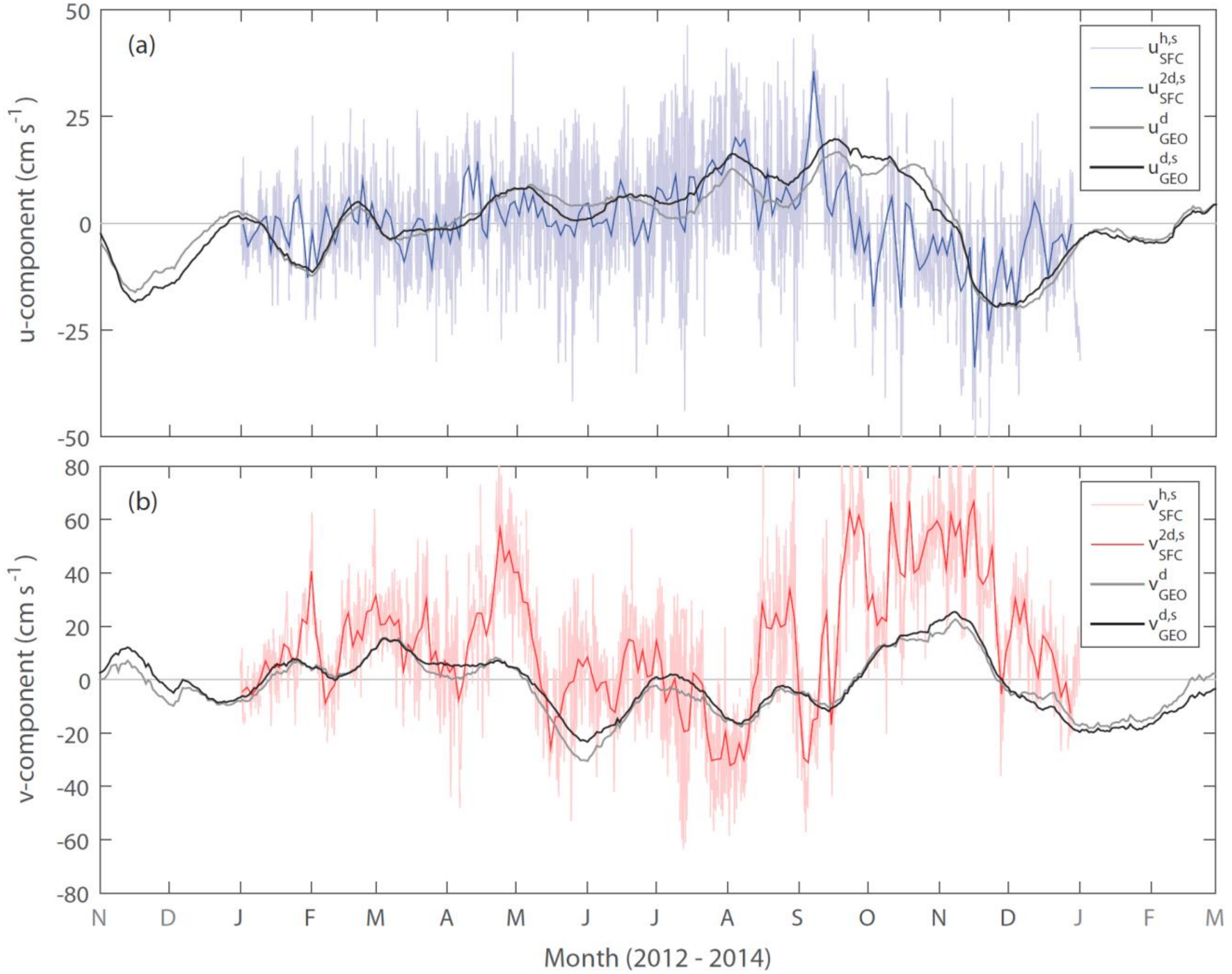
- Primary variance in the low, diurnal, and near-inertial (super-inertially shifted) frequency band(s)
- Propagating NI motions from the generation sites

Maps of variability in frequency band(s)



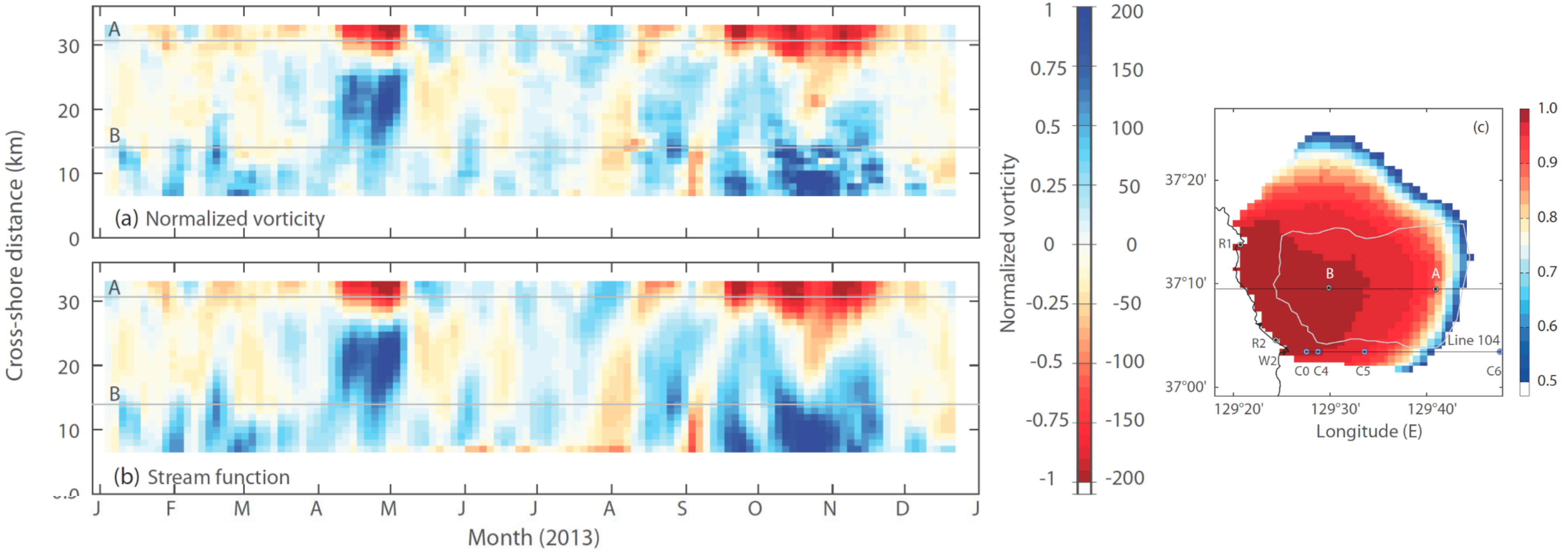
- Mostly northward mean surface currents.
- Influence of coastal boundaries.
- Potential reasons of diurnal surface currents - marine boundary layer development associated with land/sea breezes.

Low-frequency surface currents and geostrophic currents



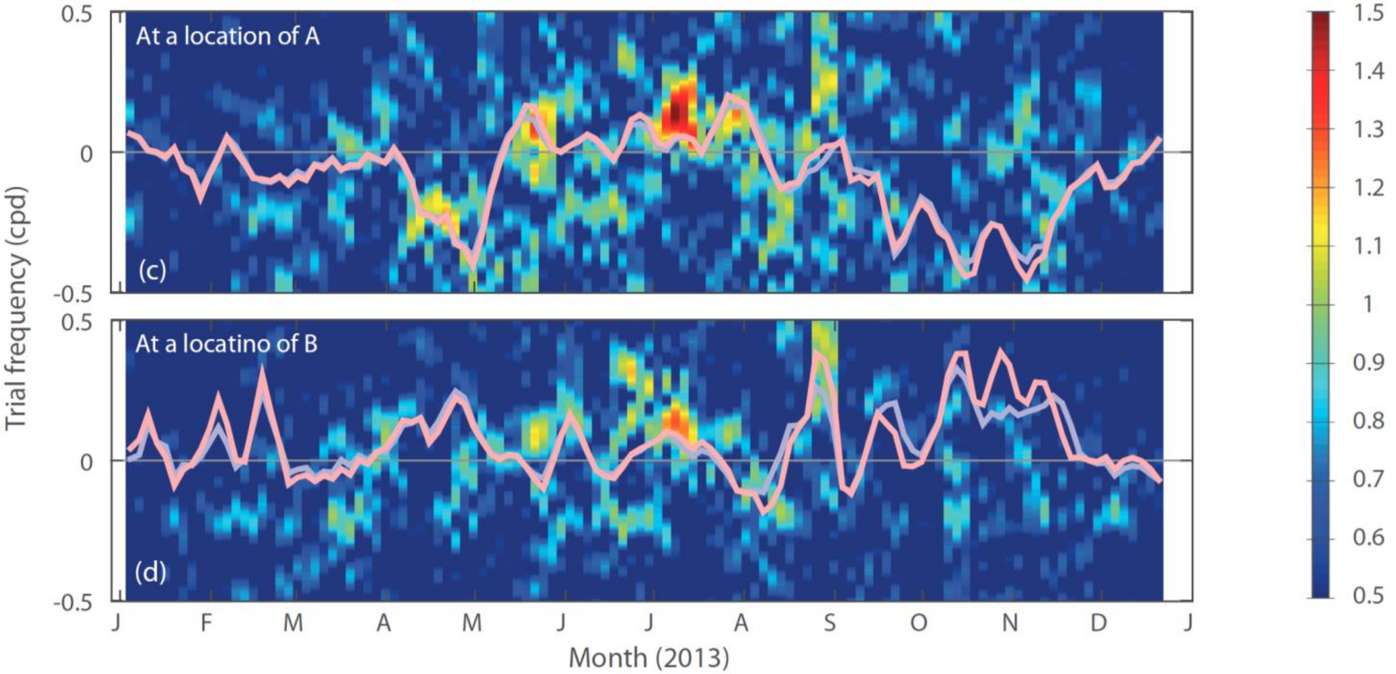
- Locally averaged surface currents vs. geostrophic currents
- Summer reversal – density gradient

Normalized vorticity and stream functions

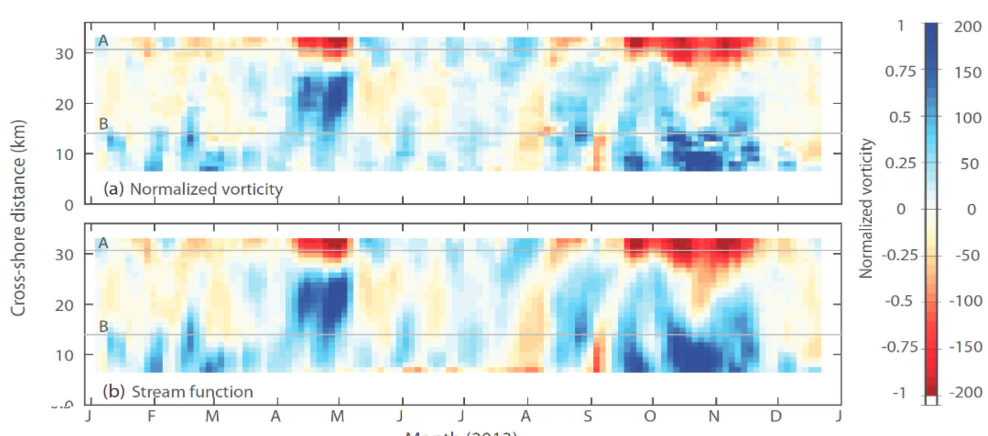


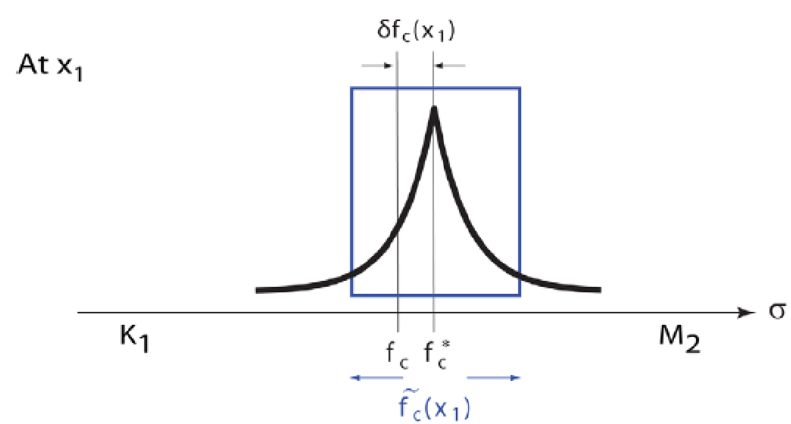
- Normalized vorticity and stream function along a cross-shore line (clockwise – red; counter-clockwise – blue); coherent
- Cross-shore migration (offshore) of vortical features

Clockwise near-inertial surface currents

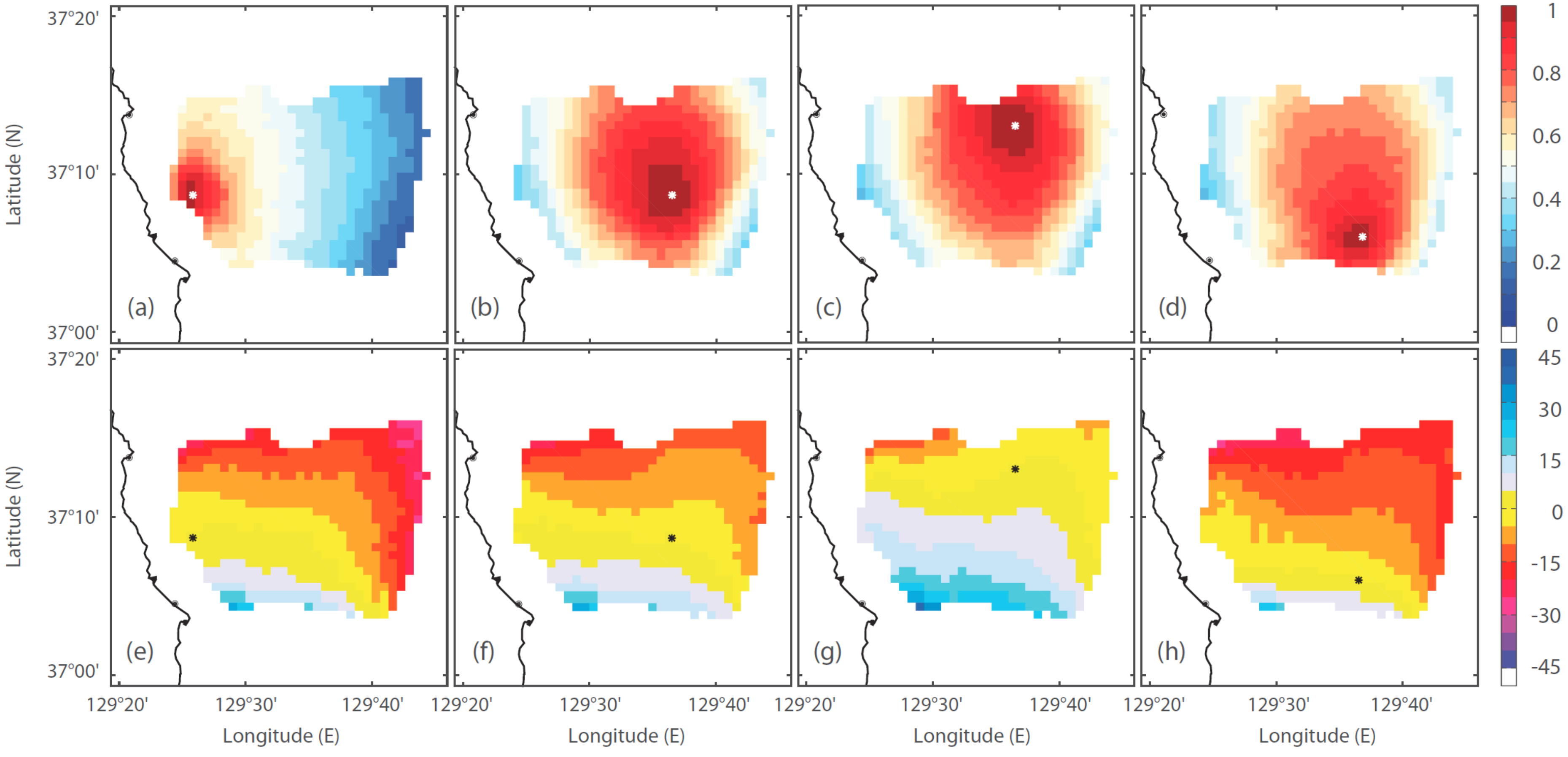


- Peak of NI variance can be shifted with background vorticity
- Variance at a single trial frequency overlaid with normalized vorticity and stream function





Coherence in the NI frequency band



- Spatial structure of NI surface currents
- Decreasing tendency of decorrelation length scales onshore
- Onshore phase propagation

Summary

- HFR (WERA)-derived surface currents off the East Coast of Korea contain dominant variance in low-frequency, diurnal, and clockwise near-inertial frequency band(s).
- Consistent with geostrophic currents with summer reversal
- Effective Coriolis frequency can be explained with an interaction between near-inertial surface currents and background flows/vorticity.