

The variability of the surface current in the Gulf of Tonkin derived from HF radar observation and the relation of surface transport with Chl-a concentration by Lagrangian analysis

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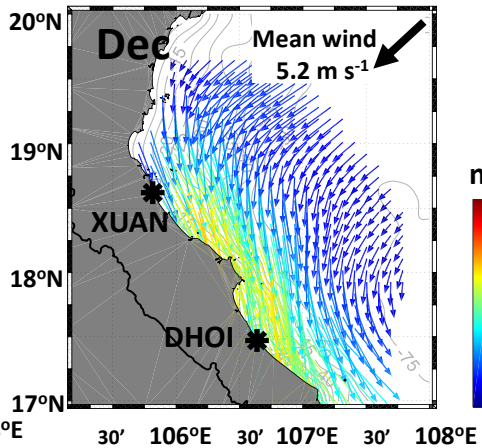
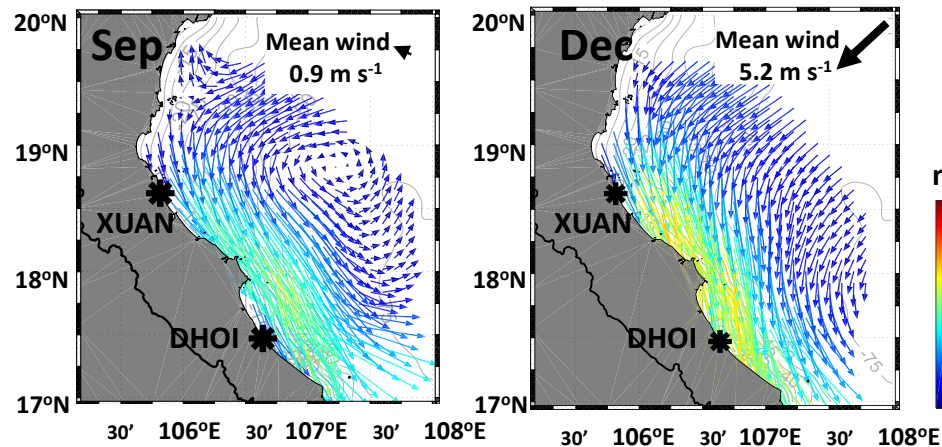
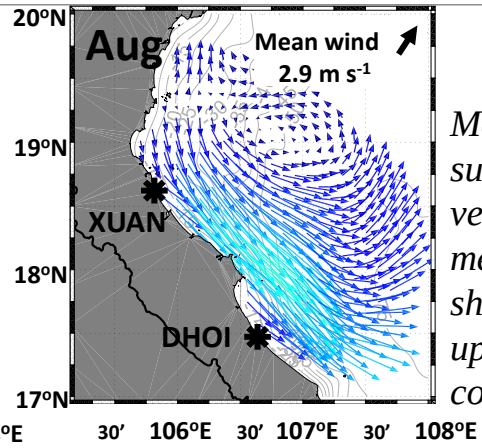
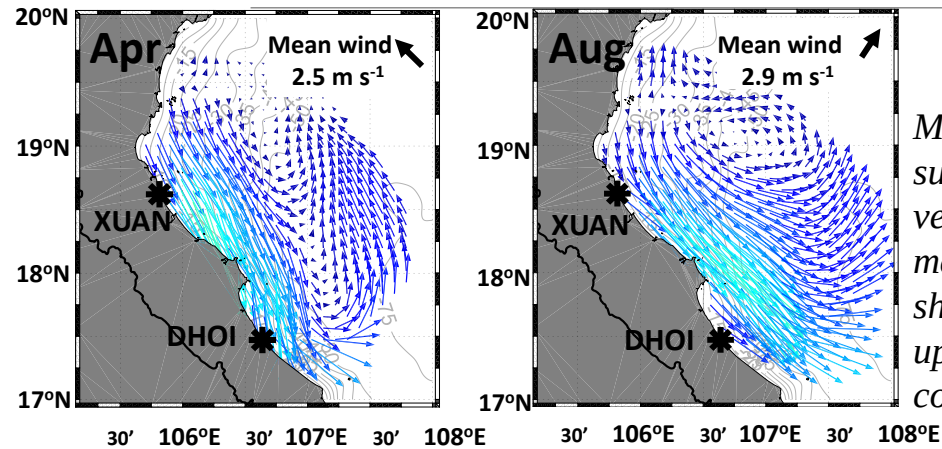
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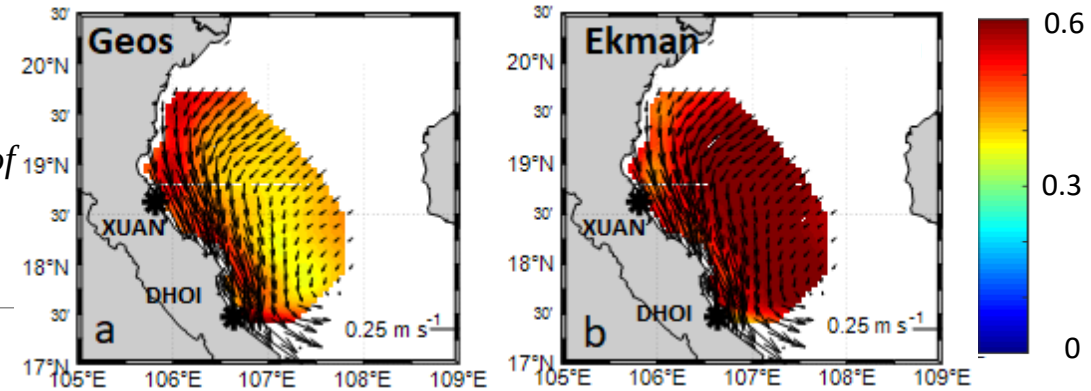
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The variability of surface current velocities



Monthly mean surface current velocities. The mean wind is shown in the upper right corner

Relative contribution of the geostrophic and Ekman components to the total currents. The vectors show the mean currents



Major characteristics of the surface currents in the study region:

- Tidal motions account for approximately 60% of surface current variability in the GoT while the remaining's (monsoon wind, density-driven) account for about 40% in the total variability.
- Large contribution of the Ekman component to the surface currents
- The geostrophic flow component is large in the coastal region where the density-driven currents are induced by the southward advected river plume with the strong coastal current (often exceed 1 m/s during the year) (Published in *Ocean Dynamics*, 2021:

“Multi-scale variability of circulation in the Gulf of Tonkin from remote sensing of surface currents by high-frequency radars”)

Data used:

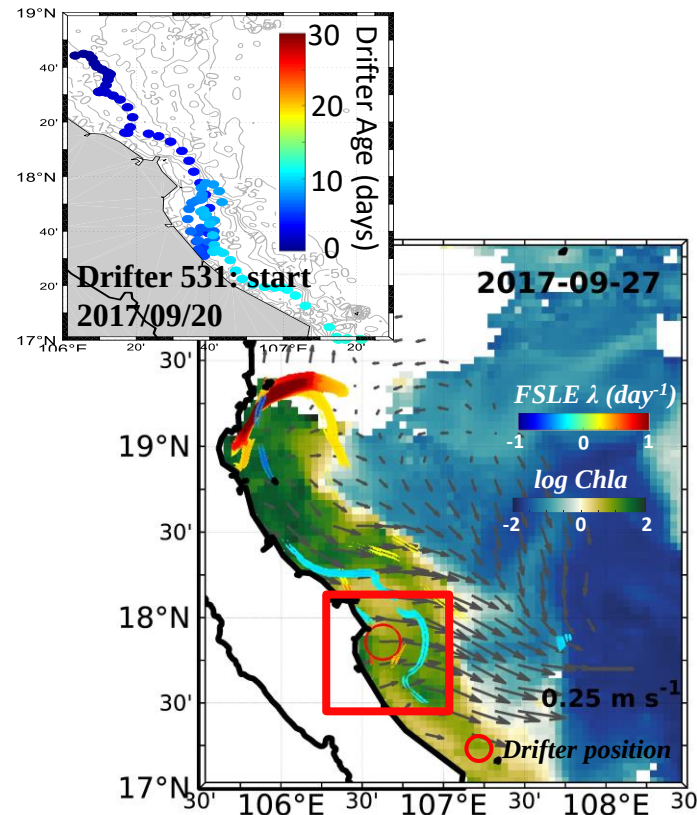
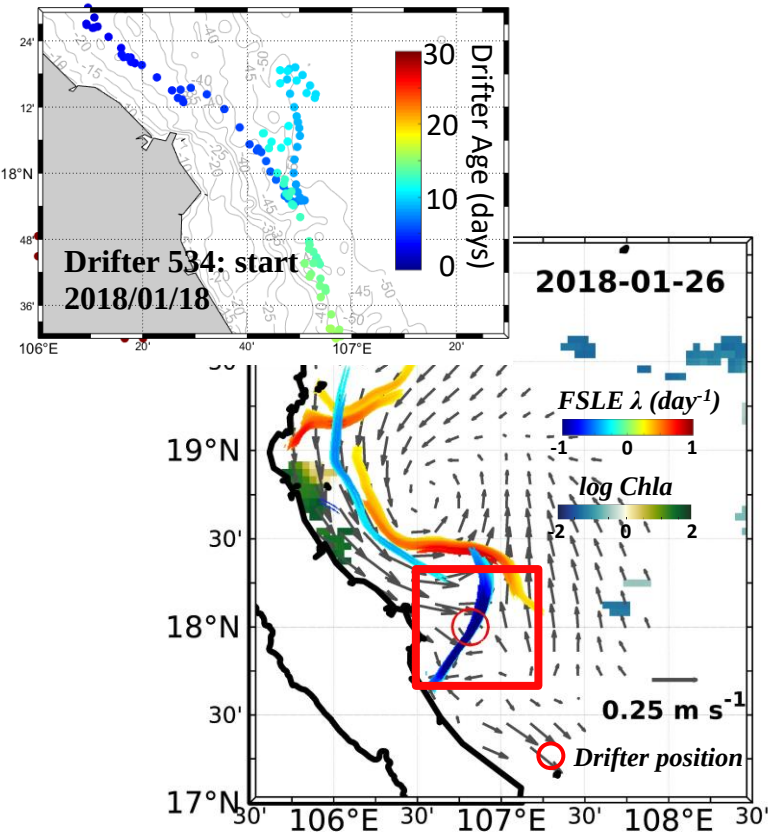
HFR-derived surface velocities in the southern Gulf of Tonkin: April 2014 – January 2018

Drifters;

Daily 4km Chla-OC5 from MODIS/Aqua:

<https://hermes.acri.fr/index.php?class=archive>

Meso/submesoscale variability of current velocities revealed by HFR measurements and drifter tracking

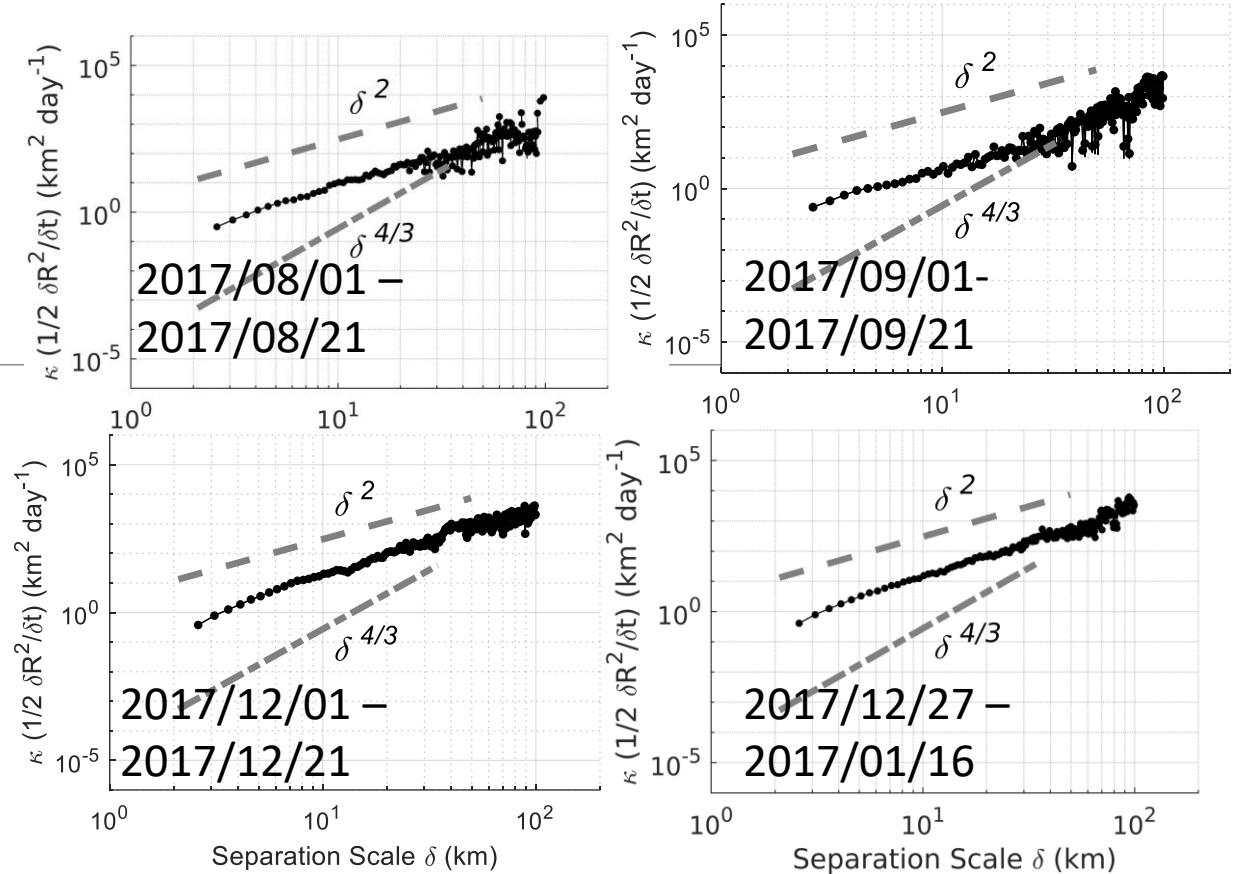
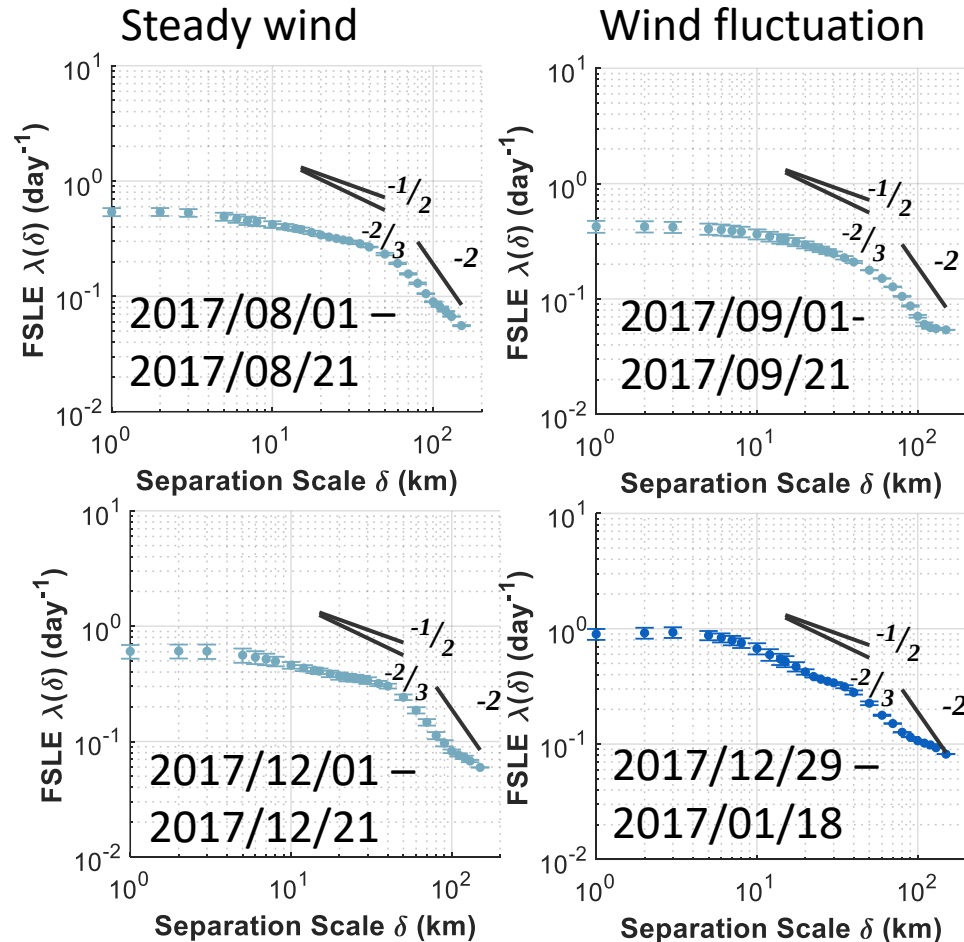


- Frontogenesis caused by the instability of the coastal currents
- Cyclonic eddy arises from the instability of the geostrophic balance and influence of episodic forcing (such as: storms) during summer to early winter

Motivation of the study:

Characterize the turbulent mixing and flow regimes (horizontal dispersion, diffusivity, scaling properties of turb mixing, and scales of turbulent motions) on the basis of velocity observations by HF radars in the Gulf of Tonkin

Characterization of mixing: tracking of virtual particles & Lagrangian diagnostics



Methods

Particles were initialized in triplet on a regular grid with initial separation ~ 2 km. About 3000 pairs were used in calculation. Only original pairs were used.

Dispersion rate at a fixed length scale

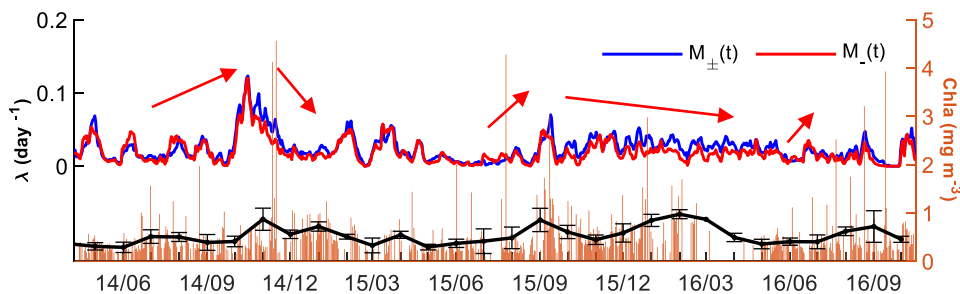
Richardson Superdiffusion regime ($\delta^{-2/3}$);

Balistic regime (δ^{-1}): low turbulence, transport by the mean flow;

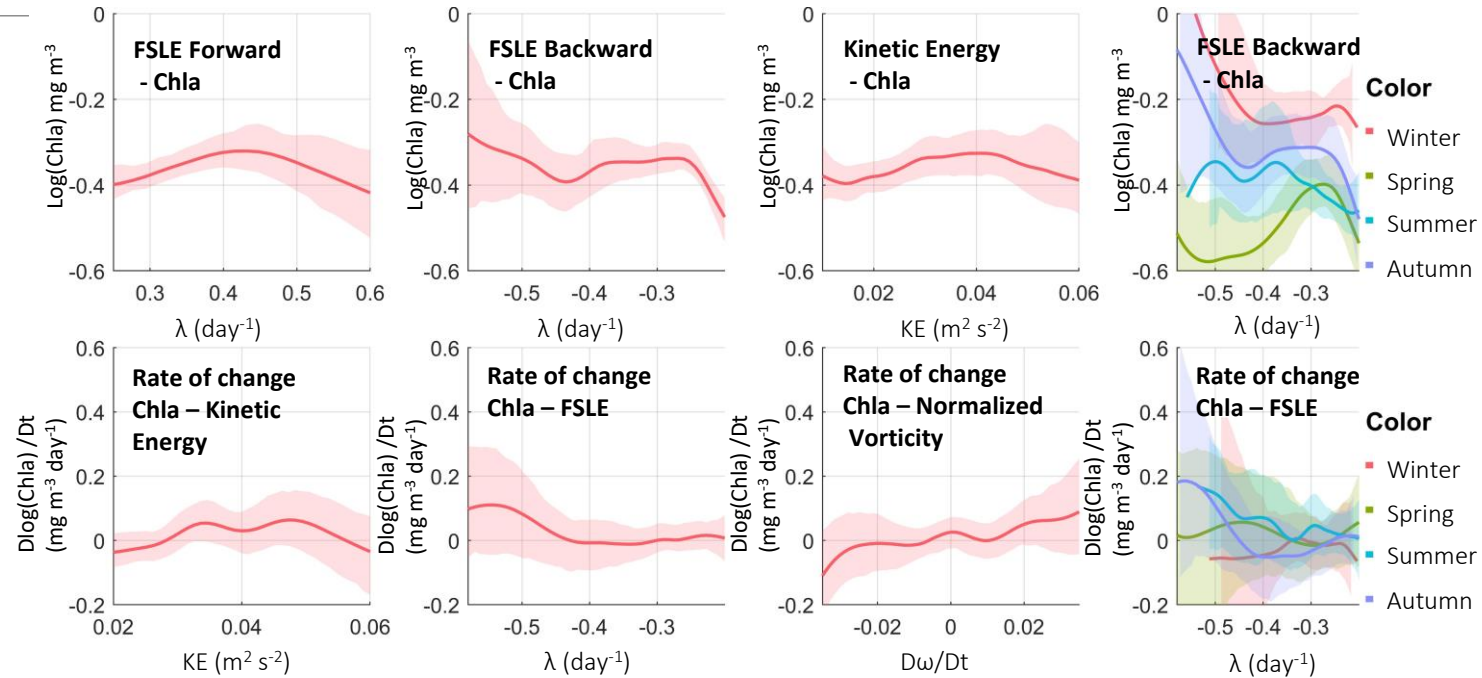
Diffusive regime (δ^{-2}): at scales $>$ largest eddy scale Ro (~ 50 km)

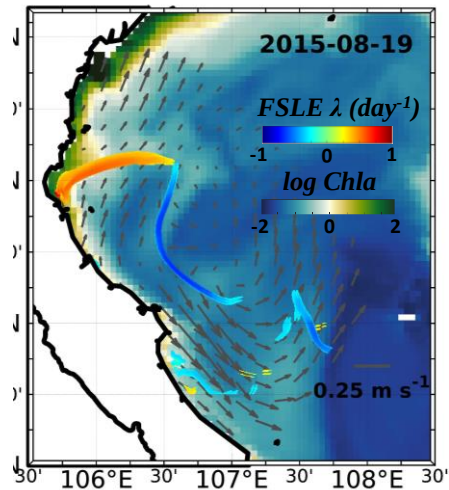
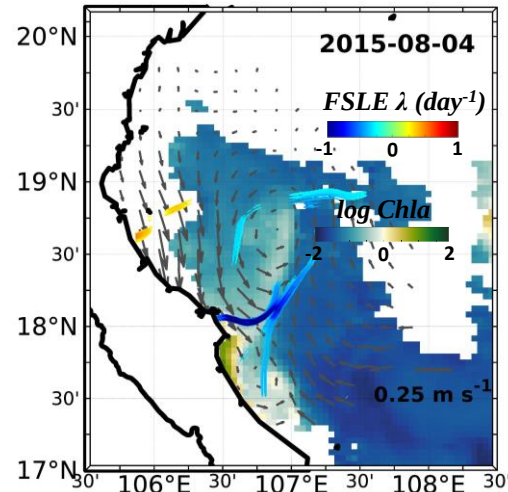
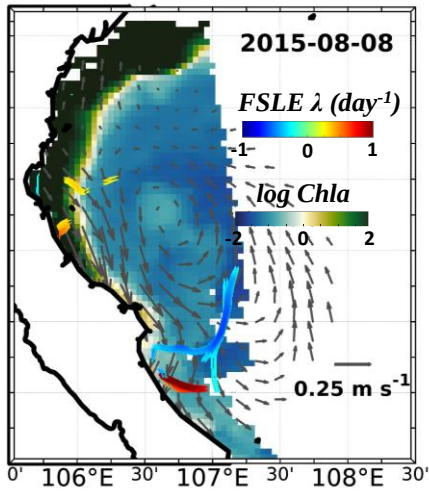
Impact of the lateral stirring on the Chla distribution in the GoT

- Continuous HFR data from 04/2014 – 10/2016 were used in the calculation
- Attracting small-scale fronts, unveiled by backwards Lagrangian Coherent Structures, are matched areas and periods with large Chl-a concentrations.



Temporal evolution of mixing measures ($M_{\pm} = \sqrt{\lambda_{+}\lambda_{-}}$), backward FSLE ($M_{-} = |\lambda_{-}|$) and daily Chla concentration (orange) overlaid by the monthly average (black line)





Discussion and Conclusion

- The dynamical feature of the surface current is representing by the Lagrangian approach
- Large mixing occurs near the coast and during the late summer to early spring as well as the increase in the Chla distribution
- Although the bloom of Chla depends mostly on the seasonal occasion, the frontogenesis and the ageostrophic eddy play a role in the uplift of the Chla

References:

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5. Tran, M. C., Sentchev, A., & Nguyen, K. C. (2021). Multi-scale variability of circulation in the Gulf of Tonkin from remote sensing of surface currents by high-frequency radars. *Ocean Dynamics*, 71(2), 175–194. <https://doi.org/10.1007/s10236-020-01440-x>