Role of submesoscale circulations in vertical transport within and across the mixed-layer

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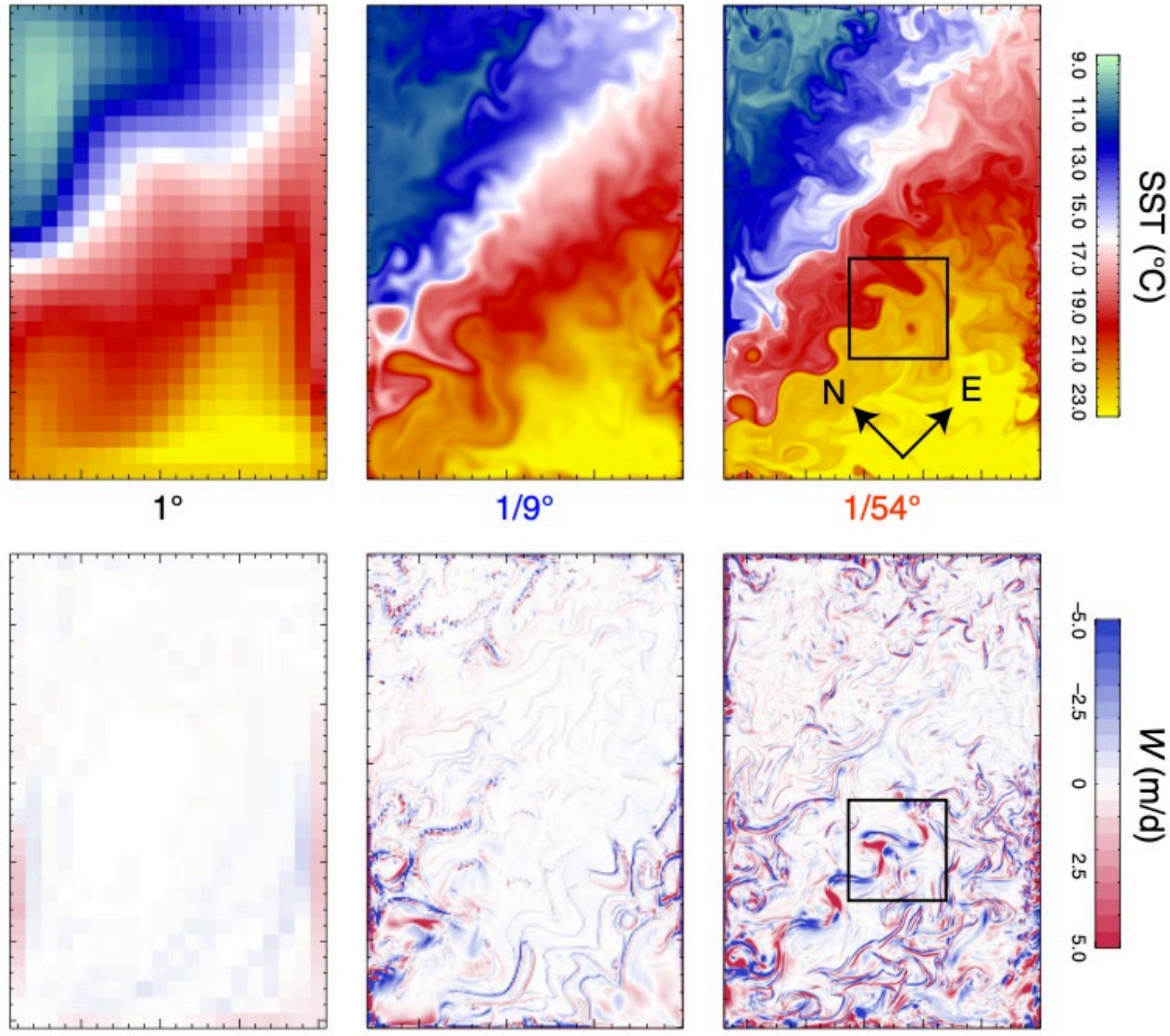
MOTIVATION

Mesoscale (10-100km) and submesoscale (0.1 to 10 km) regulate tracer distributions

The vertical velocity of submesoscale can be as large as 100 m/d, affecting greatly vertical transport of tracers

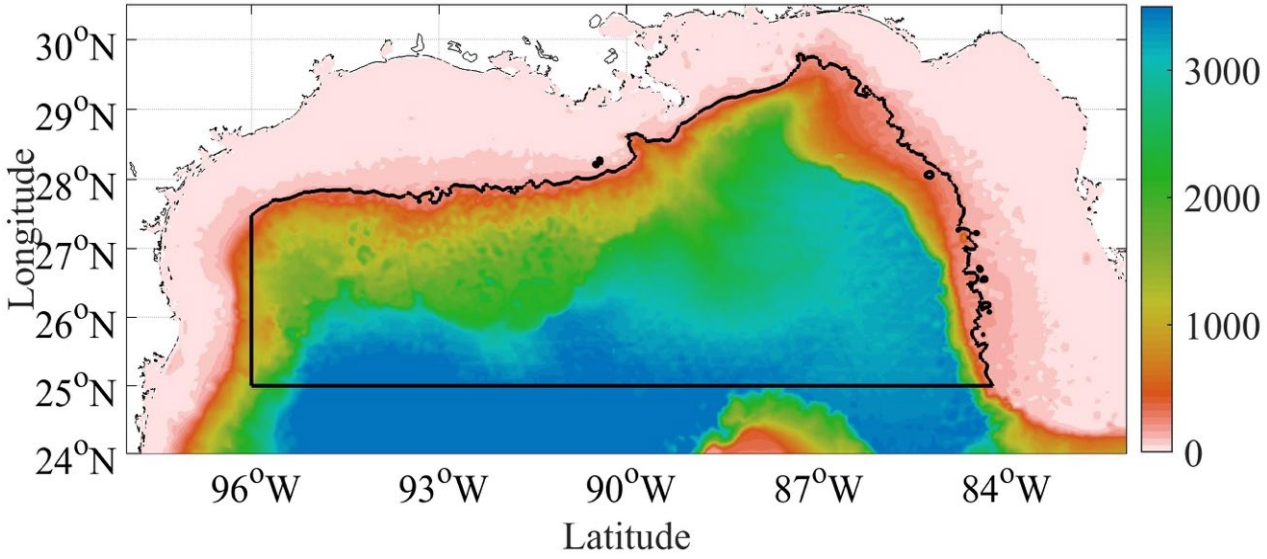
GOAL

Quantify submesoscale role in vertical fluxes across the mixed layer across seasons



Levy et al., 2018

DOMAIN

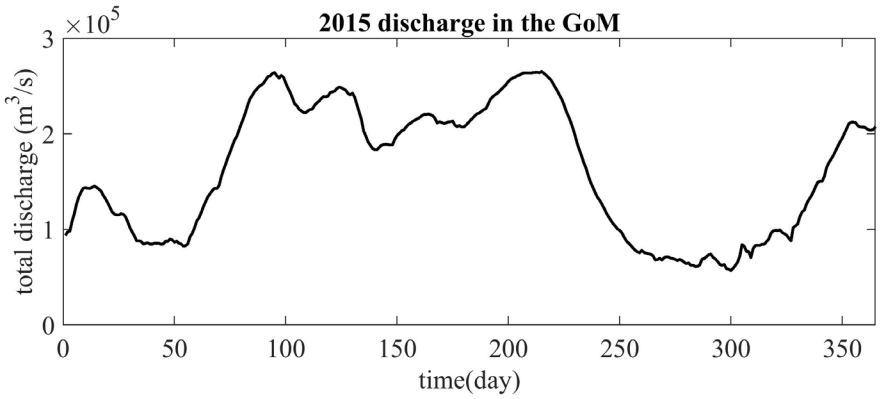


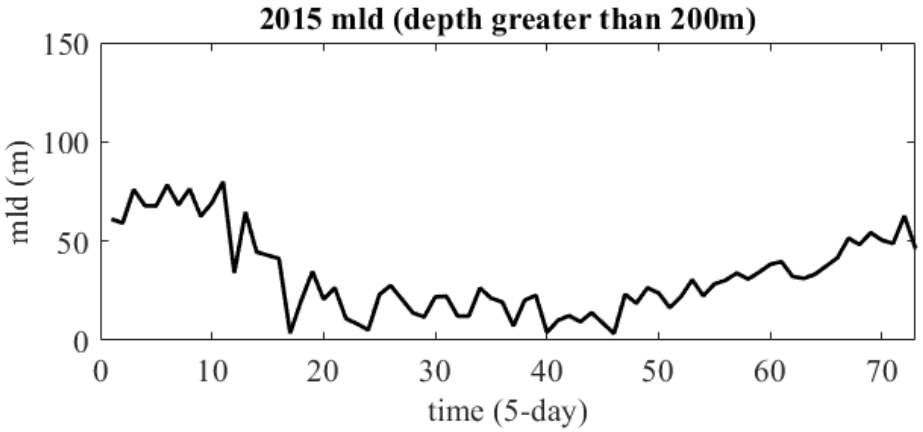
Bathymetry of the Gulf of Mexico, black curve highlights the region where passive Lagrangian particles are released. Integrations cover 2015 and 2016

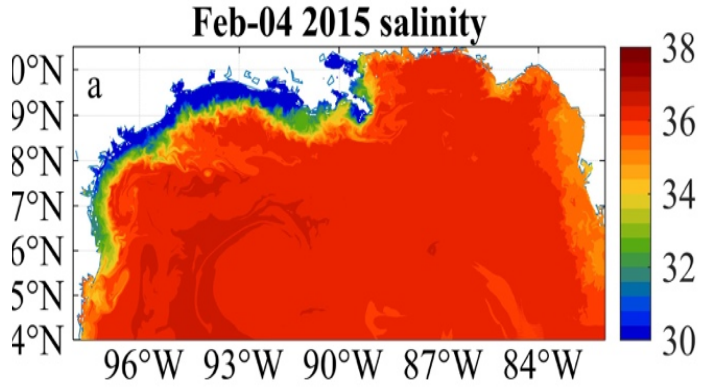
- ✓ The domain is 98-82W, 24-31N; 1km & 5km resolution
- ✓ Color shading shows the bathymetry of the Gulf of Mexico
- ✓ 21874 tracers are released for each case

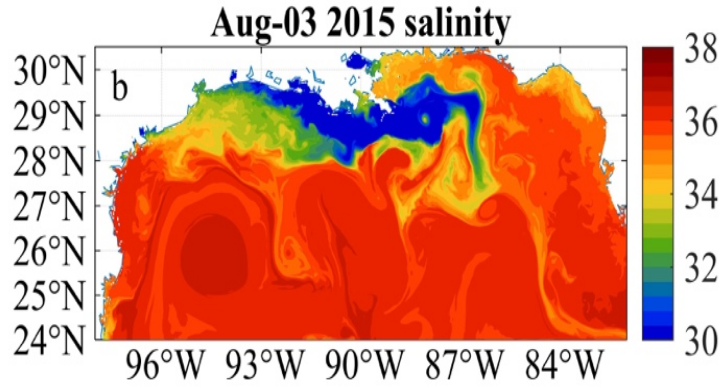
- ✓ HYCOM Gulf of Mexico 1/25° (GOMl0.04) as boundary conditions
- ✓ ERA-Interim 6-hourly reanalysis for momentum and heat fluxes
- ✓ Daily fresh water discharge from the United State Geological Survey for river discharge (USGS, http://waterdata.usgs.gov/nwis/rt).

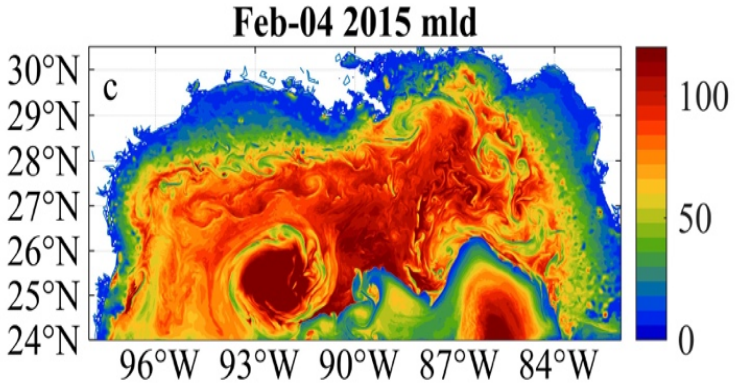
Mixed Layer Depth

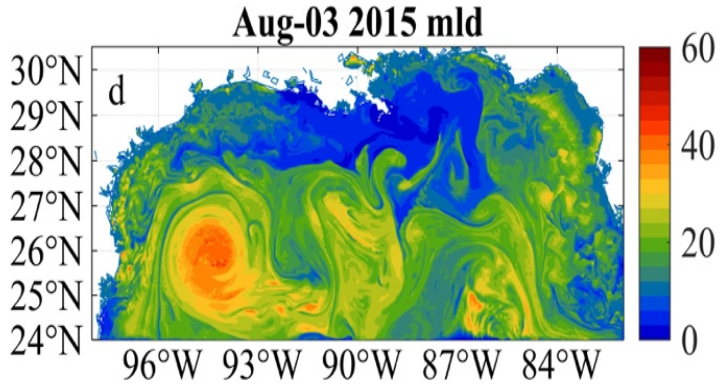






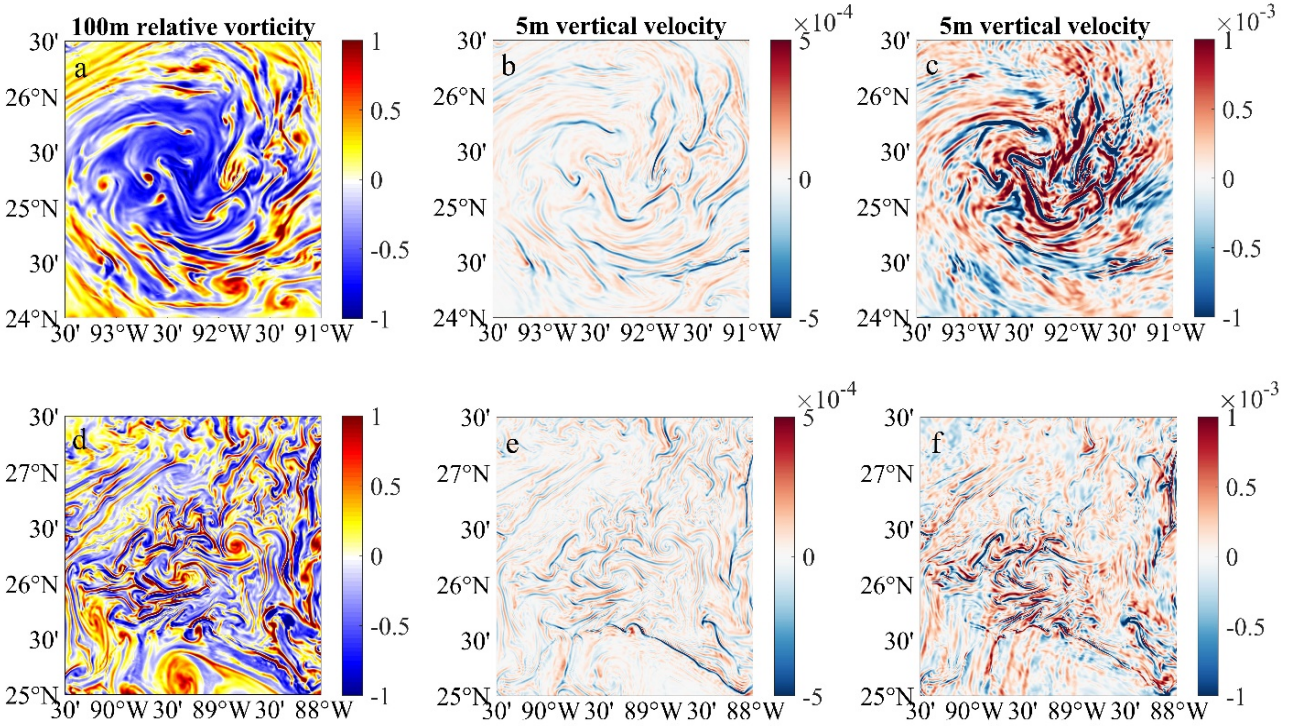




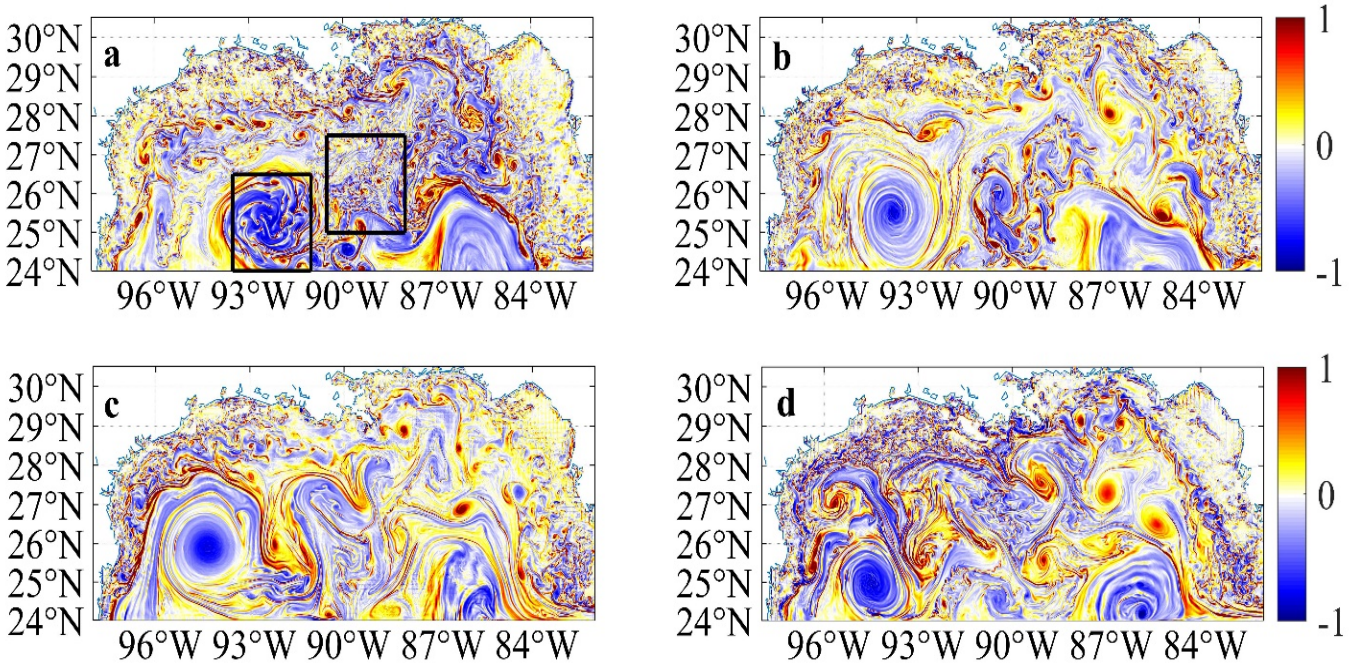


Salinity (top panel) and mixed layer depth (bottom panel)

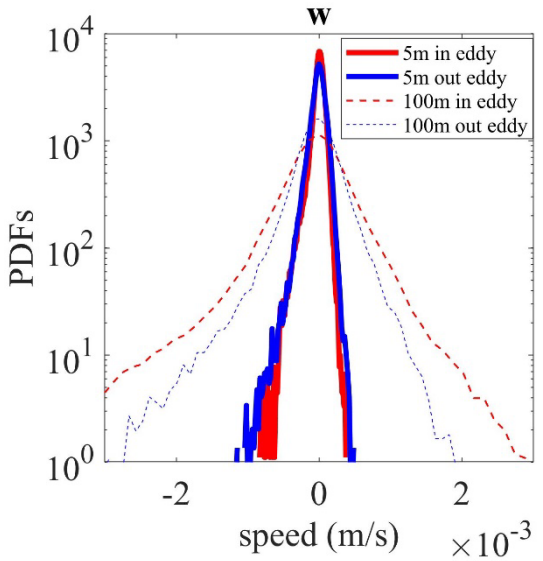
CURL and W at 5m and 100m



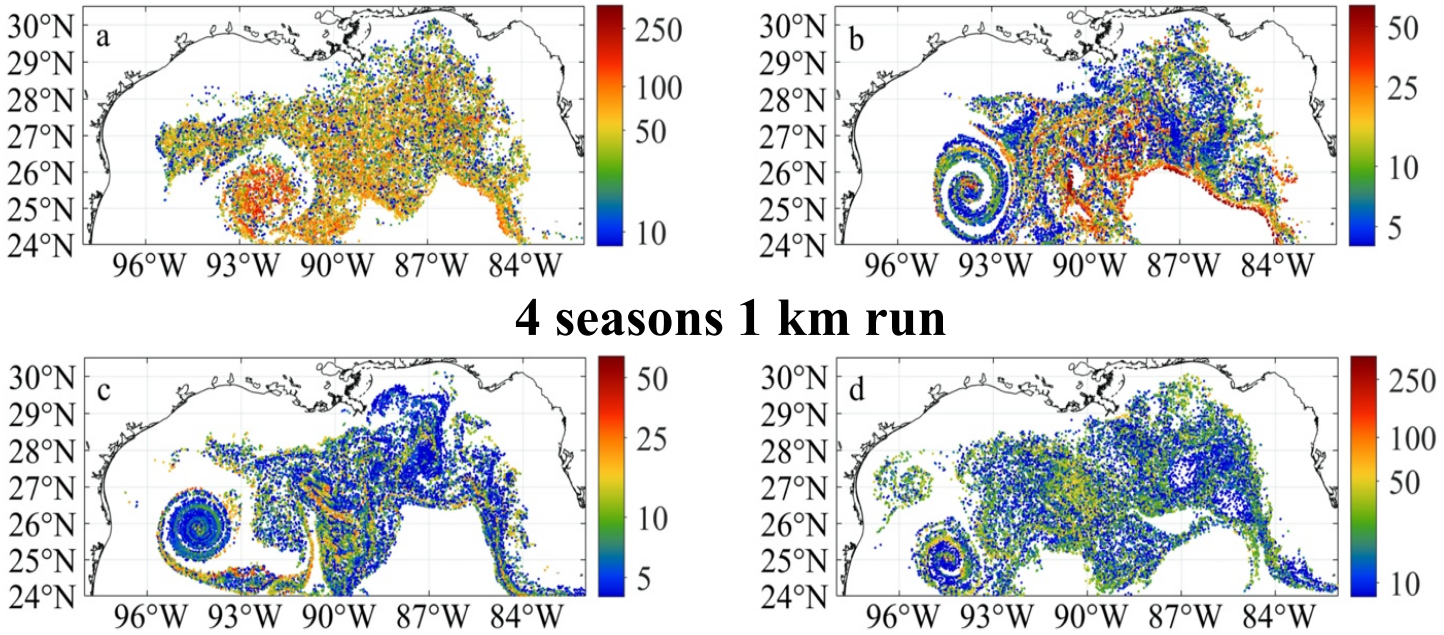
Surface vorticity / f



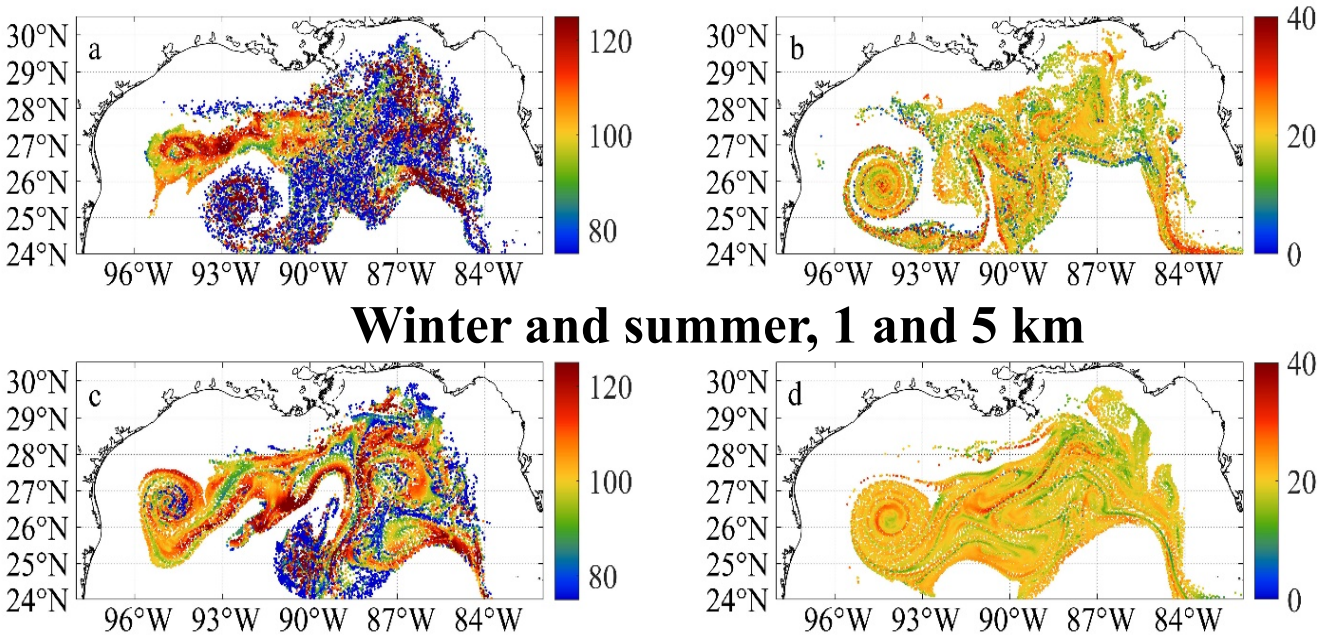
5m vorticity and 5m&100m w + w PDF



PARTICLES



4 seasons 1 km run



Winter and summer, 1 and 5 km

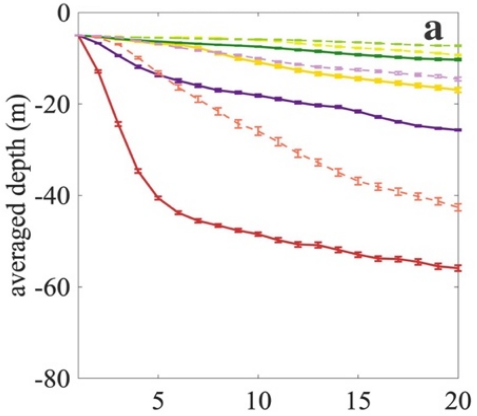
Near-surface case

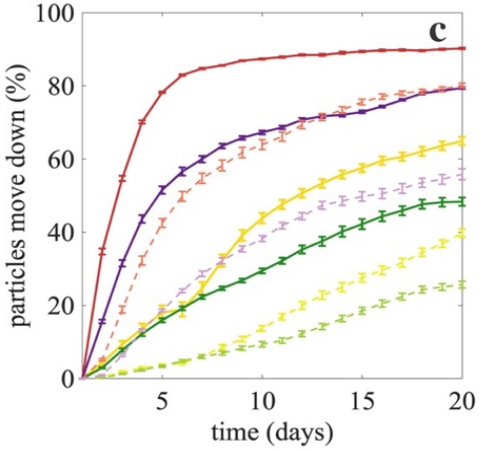
- ✓ Near-surface cases are tracers released at 5m
- ✓ Below-mixed layer cases are tracers released below the mixed layer, i.e., 100m in Feb, 20m in Aug, 50m in May and Nov

Below-mixed layer case for 1km (a, b) and 5km (c, d) winter and summer

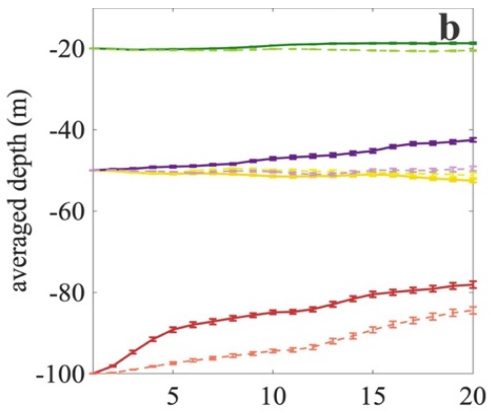
DISPERSION

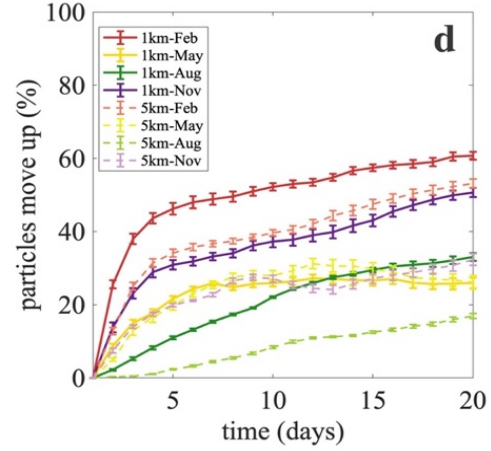
Near surface



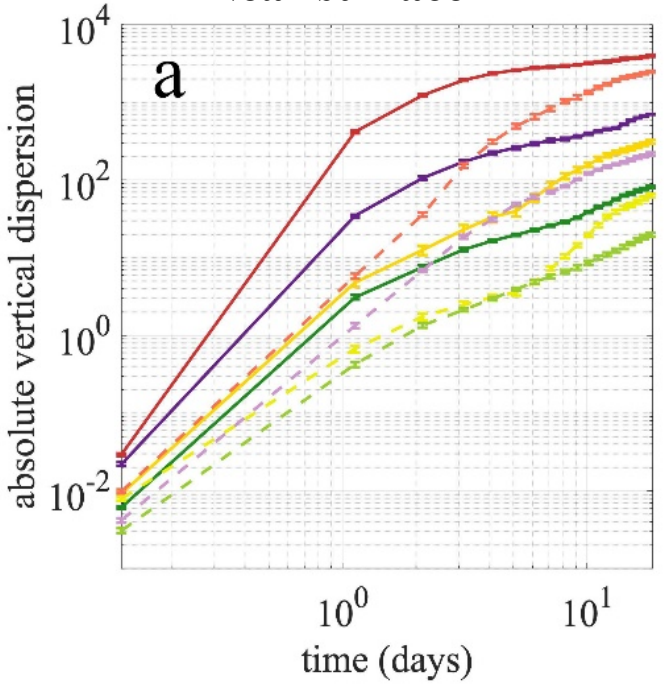


Below mixed layer

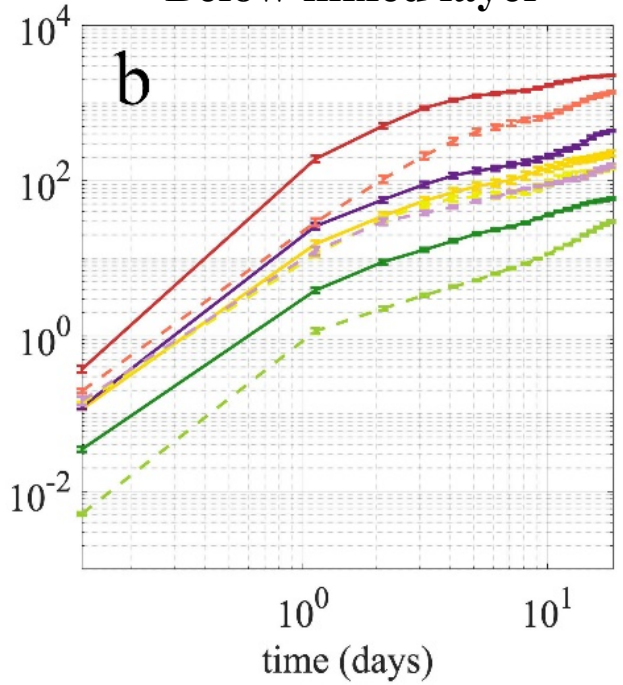




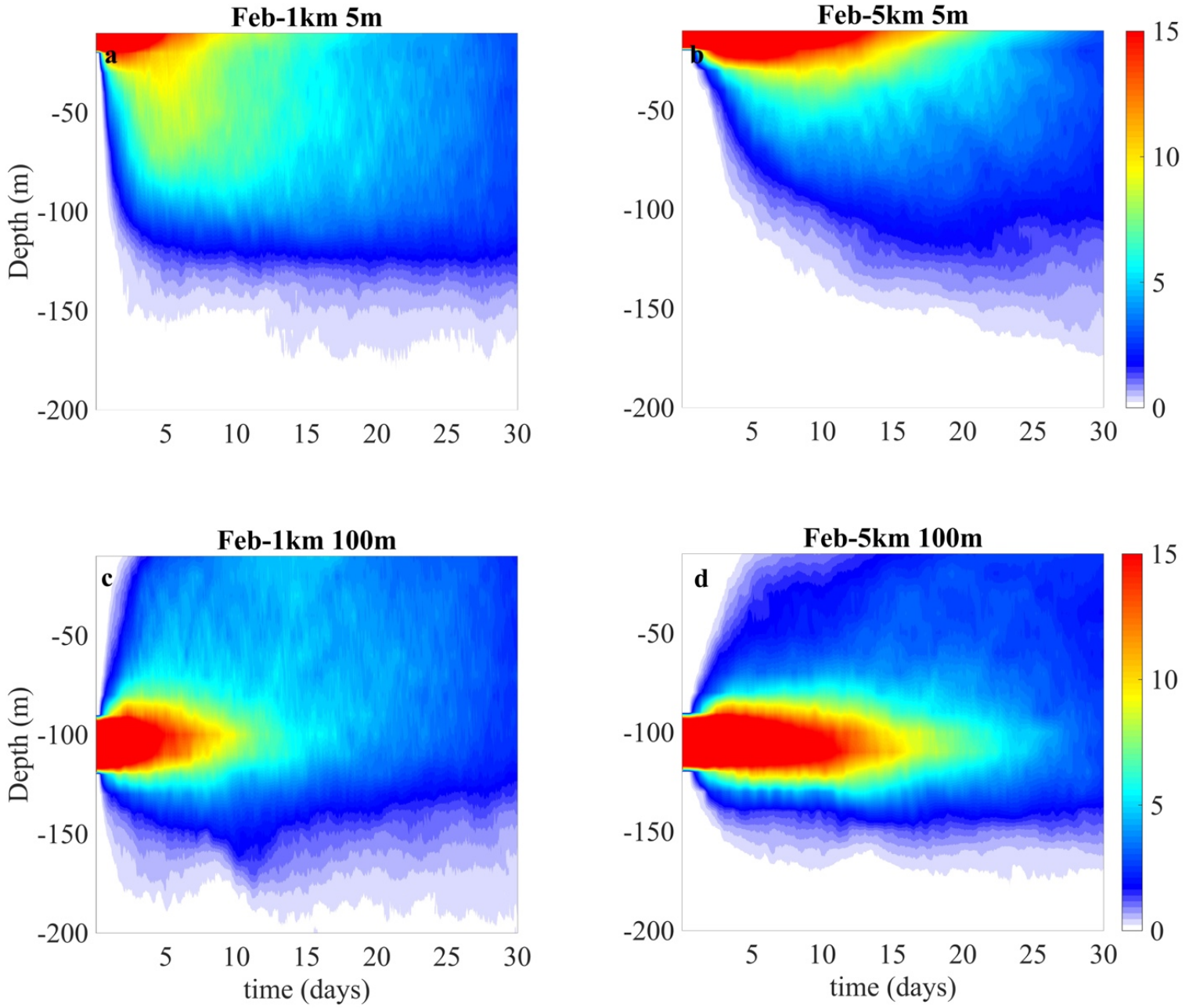
Near surface



Below mixed layer



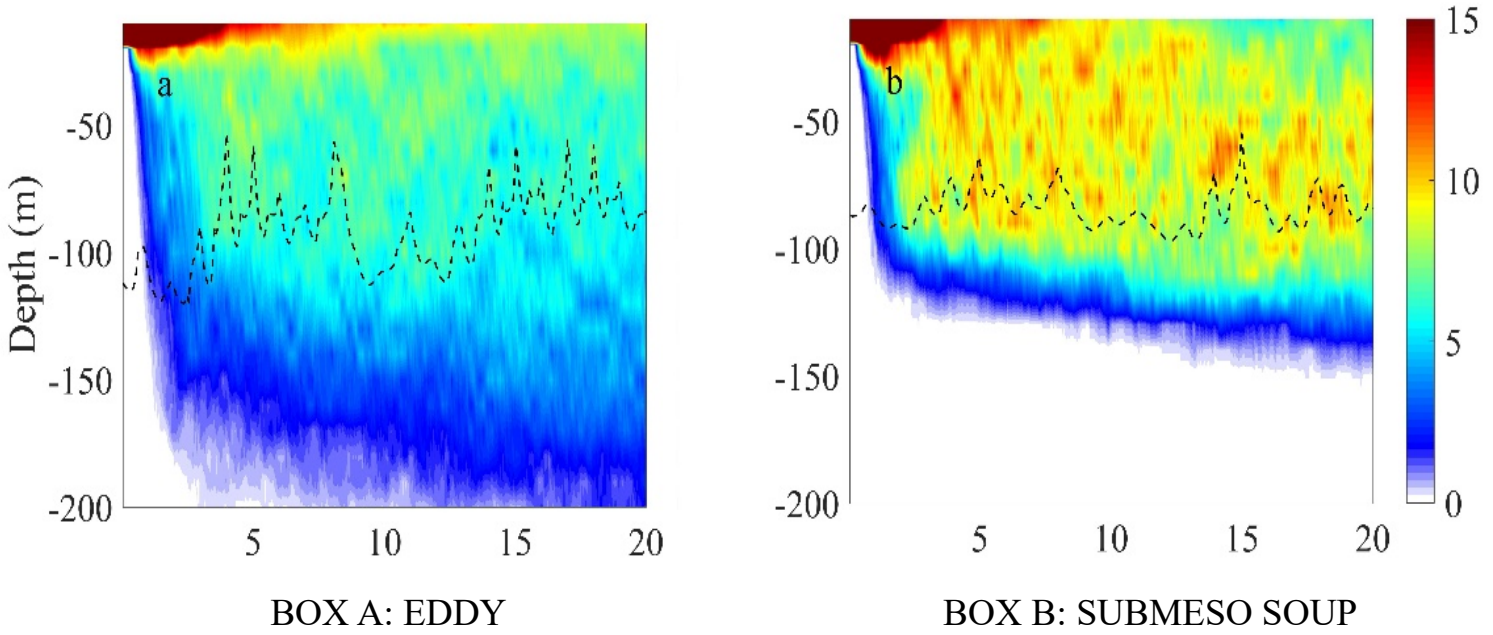
TRACER CONCENTRATION



TRACER CONCENTRATION

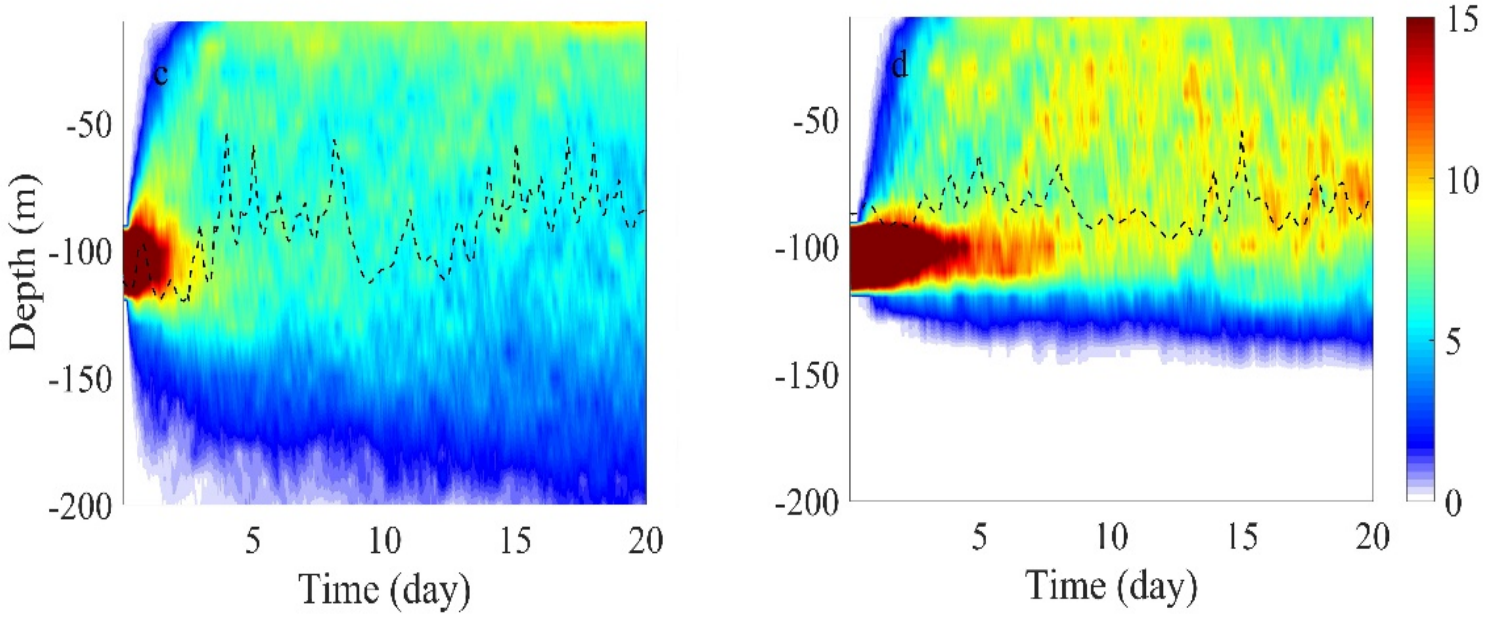
IN THE LOOP EDDY AND IN THE SUBMESOSCALE SOUP

1KM CASE



BOX A: EDDY

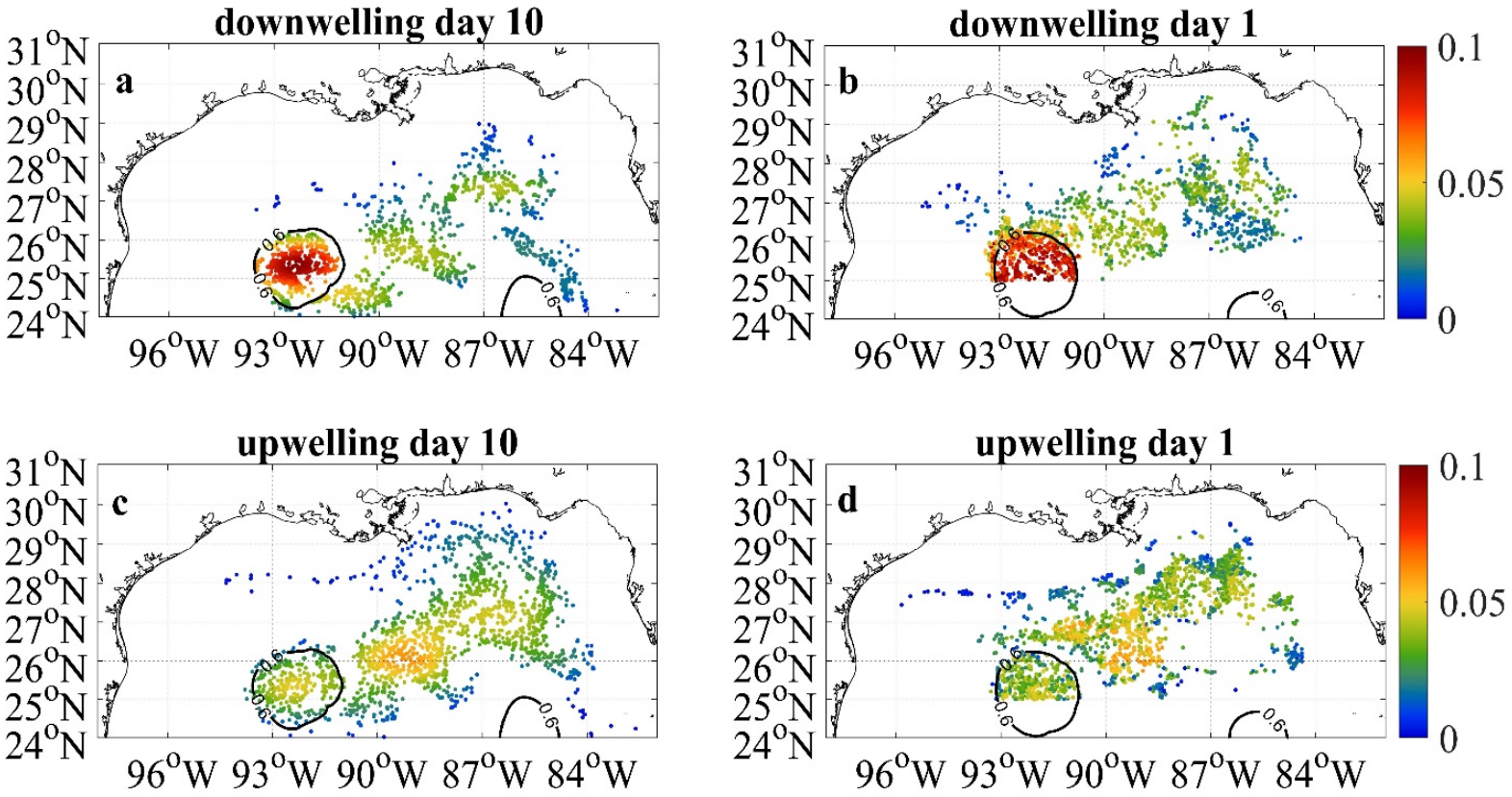
BOX B: SUBMESO SOUP

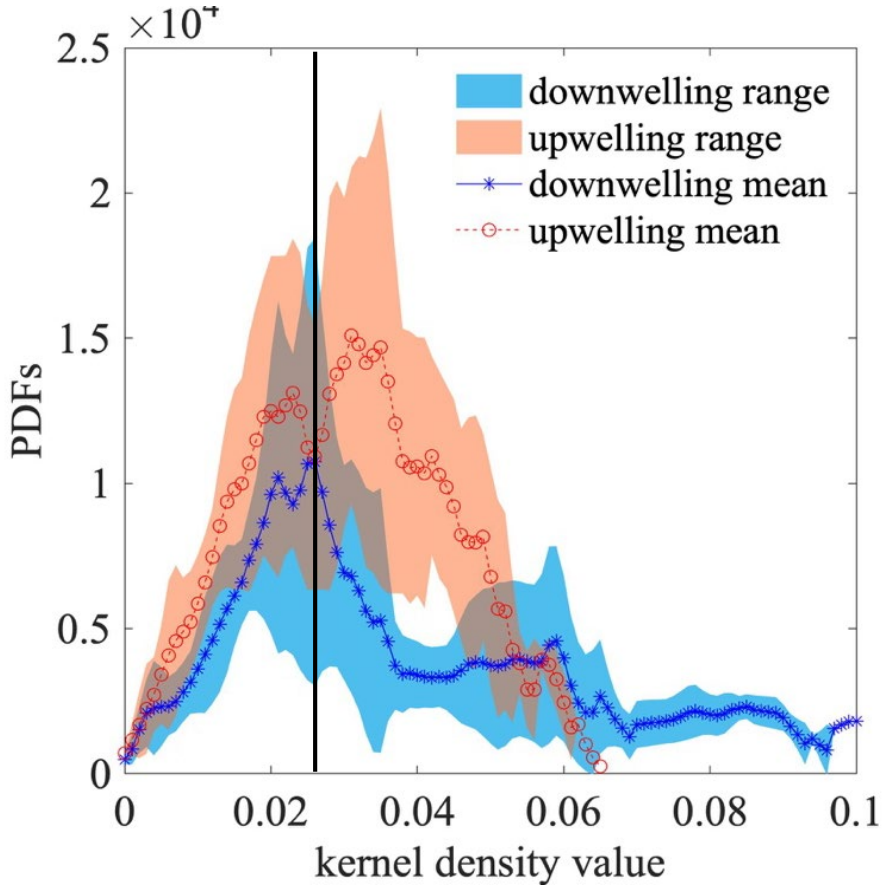


KERNEL DENSITY DISTRIBUTION

KDE = non-parametric way to estimate the PDF of a given variable. KDE is a way to find the PDF for a given dataset.

- ✓Downwelling: tracers released at 5m found below 100m on day 10
- ✓Upwelling: releases at 100m, found above 20m on day 10





Two-sample Kolmogorov-Smirnov test: different at 90% confidence level

CONCLUSIONS

- ✓ Largest vertical flux occur in winter; vertical exchange is least in summer when the mixed layer depth is less than 20 m deep (but comparable behavior)
- ✓ Submesoscale motions act to transport tracers vertically on scales relevant to the ecosystem and primary productivity. Important also for carbon and oxygen drawdown
- ✓ In winter active downwelling processes across the MLD are associated preferentially with submesoscale-soup regions and mesoscale structures (due to submesoscale instabilities inside the mesoscale eddies)
- ✓ Upwellings into the MLD is more uniformly distributed among intense submesoscale regions.

Thank you!