

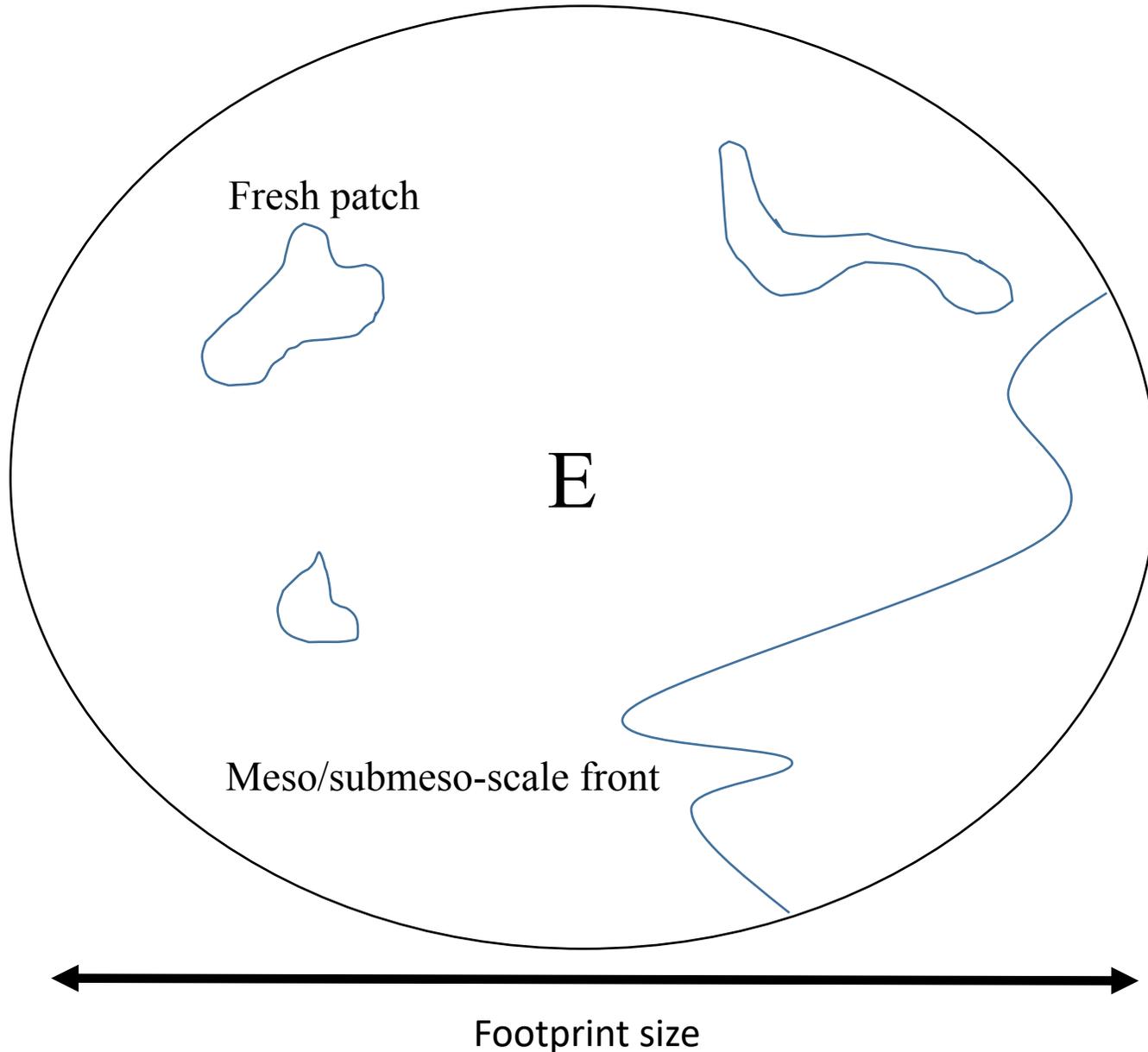
Model Derived Sea Surface Salinity Subfootprint Variability in the North Arabian Sea and Western Pacific

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Motivation & Objectives

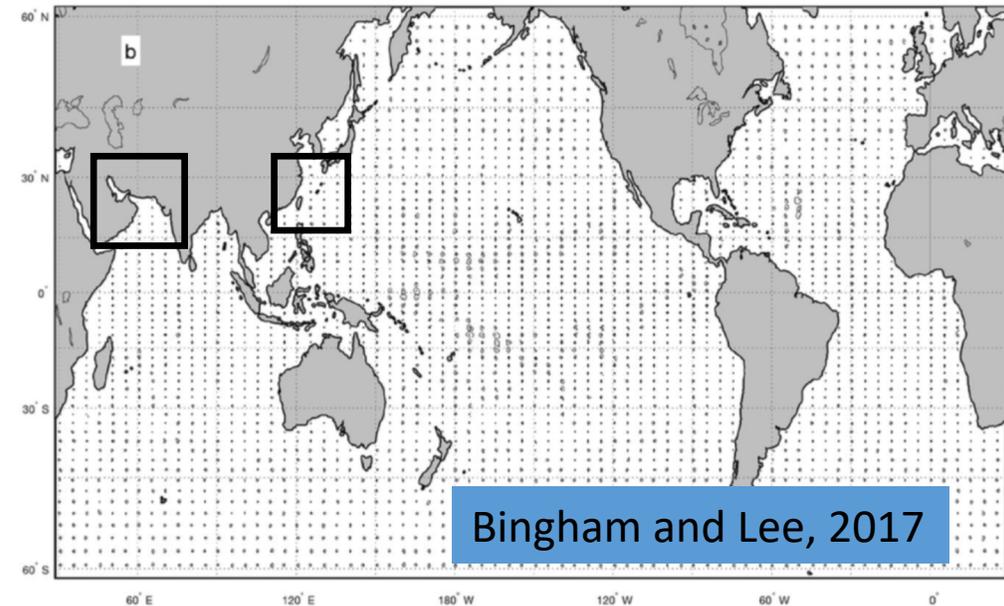


How well does satellite measurement of SSS capture the real variability?

What variability is hidden within the footprint and inaccessible to the satellite?

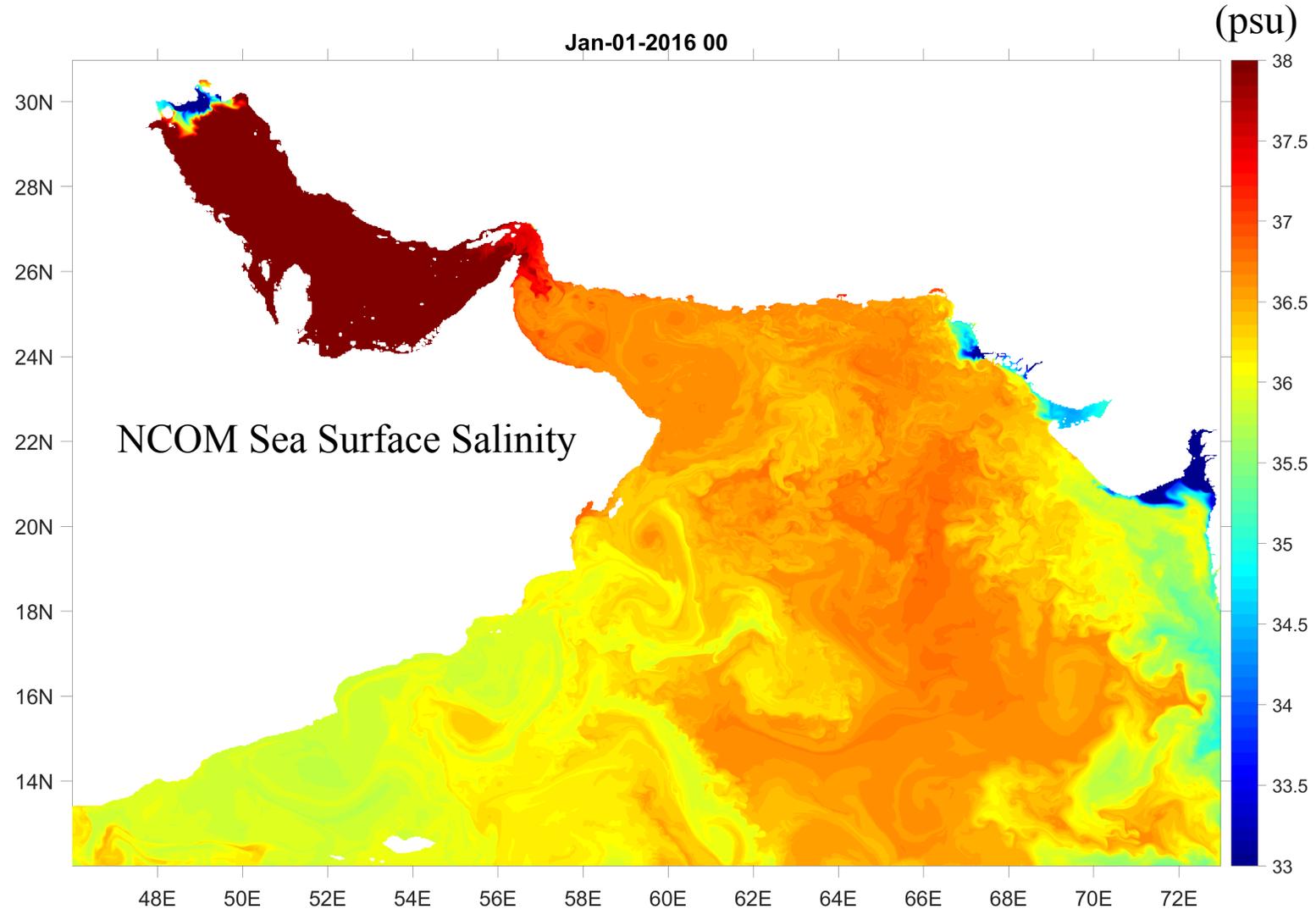
At what scales does SSS vary?

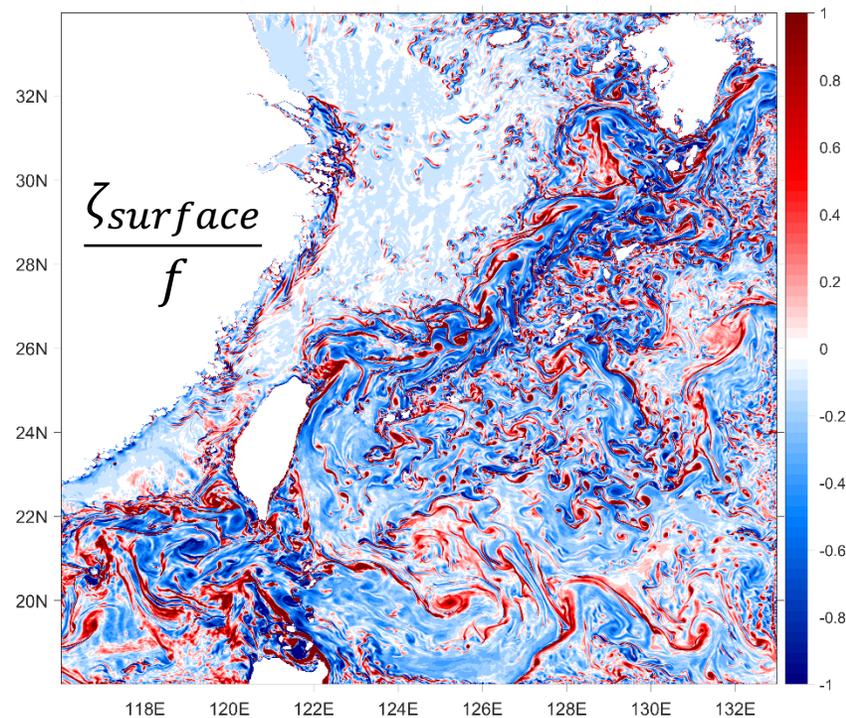
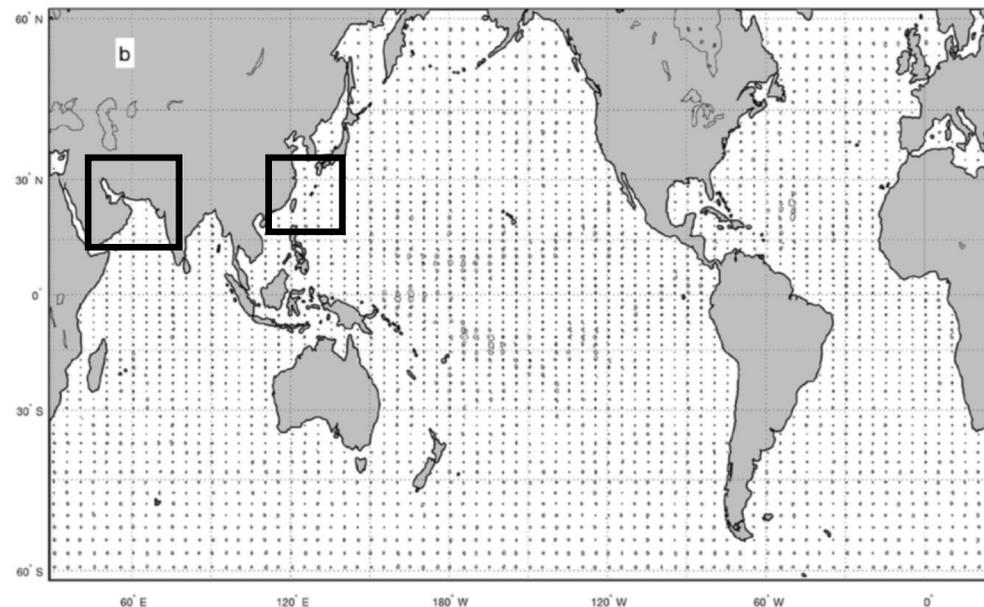
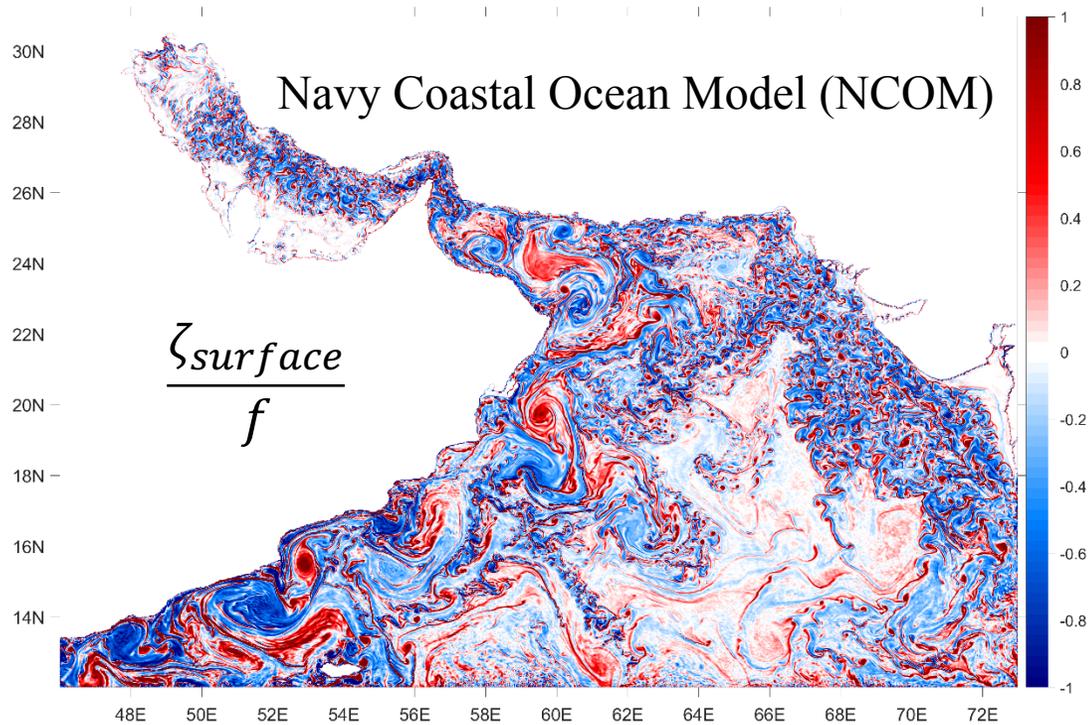
Decorrelation scales



Motivation & Objectives

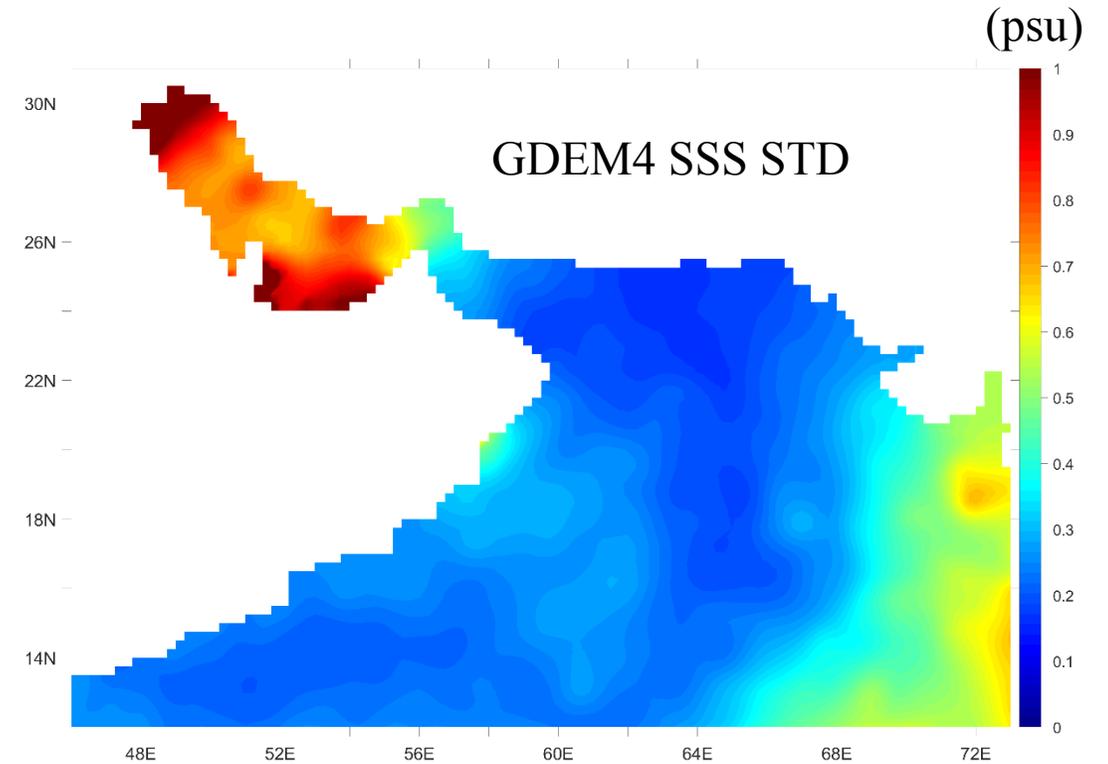
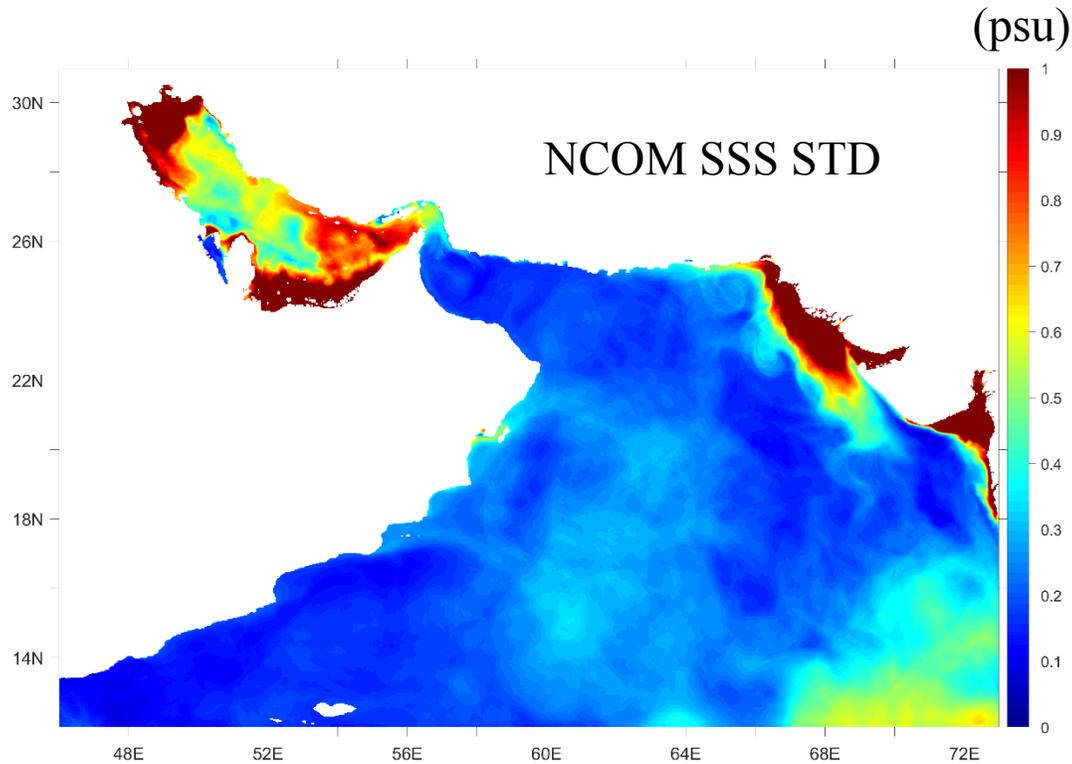
- *In situ* measurements provide highly accurate descriptions of the ocean state.
- But, their temporal and spatial coverage can be lacking due to real world constraints.
- Numerical GCMs provide the opportunity to produce reasonable approximations of the real ocean with much greater spatial and temporal coverage.
- Here we use the Navy Coastal Ocean Model (NCOM) run at very high resolution (1 km) to estimate SSS subfootprint variability (SFV) at a variety of footprint sizes.





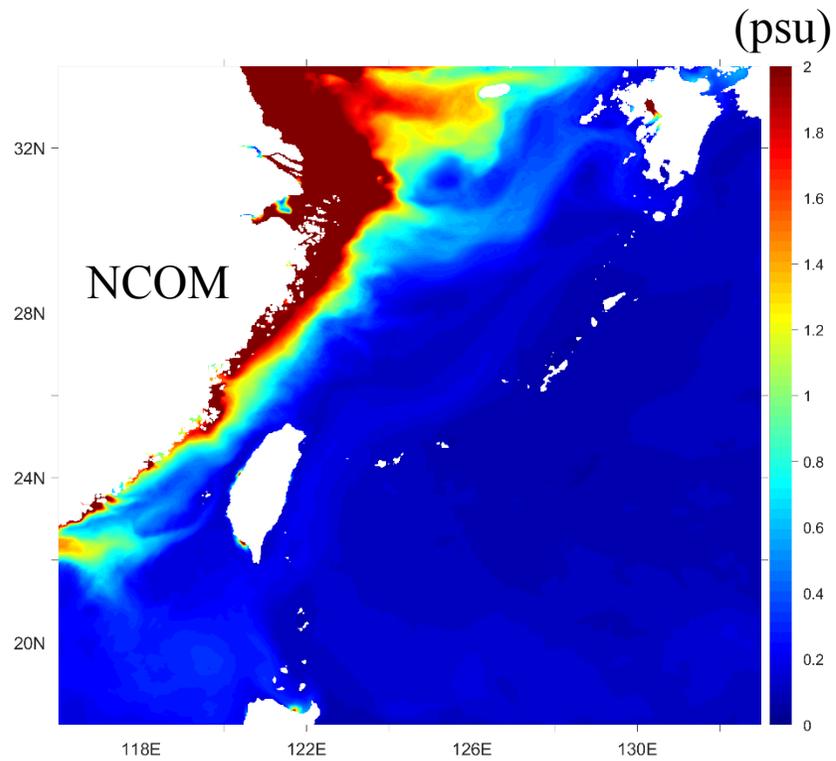
- Non-assimilative 1 km simulations of both the Arabian Sea and western Pacific.
- 3 hour output fields for the entirety of 2016 are available for analysis.
- Total grid points:
 - Arabian Sea: 2110 x 2791 (lon/lat)
 - western Pacific: 1684 x 1777 (lon/lat)

Model 'Validation' – Arabian Sea

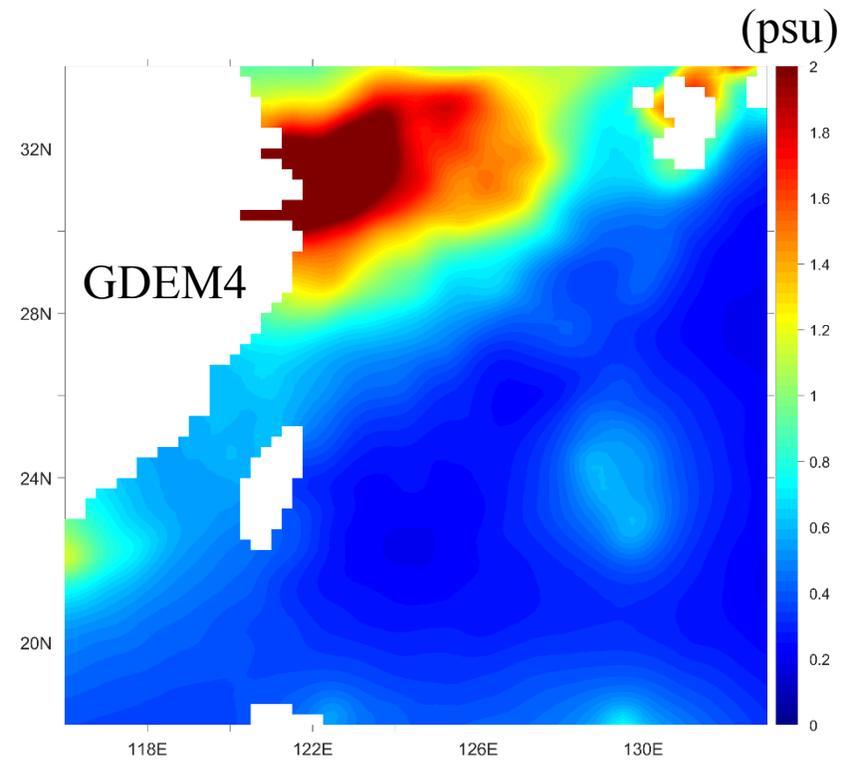


- Annual SSS standard deviation for NCOM 2016 and GDEM4 climatology.
- GDEM4 is an observation-based climatology.
- The model is an imperfect instantaneous representation of the real ocean, but the annual statistics of the data set are highly comparable to the climatology of the real ocean.

Model 'Validation' – western Pacific



SSS STD



SSS STD

SFV Methodology

Find the weighted standard deviation at a particular place in space and time over a circle with diameter $2d_0$:

$$\sigma = \sqrt{\frac{\sum_C w_i (S - \bar{S})^2}{\sum_C w_i}}$$

where

$$w_i = e^{-(d_i/d_0)^2}$$

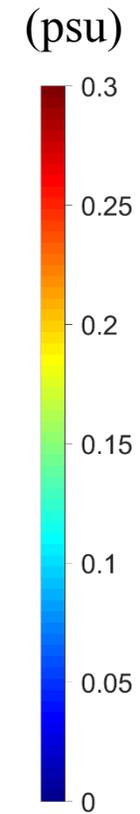
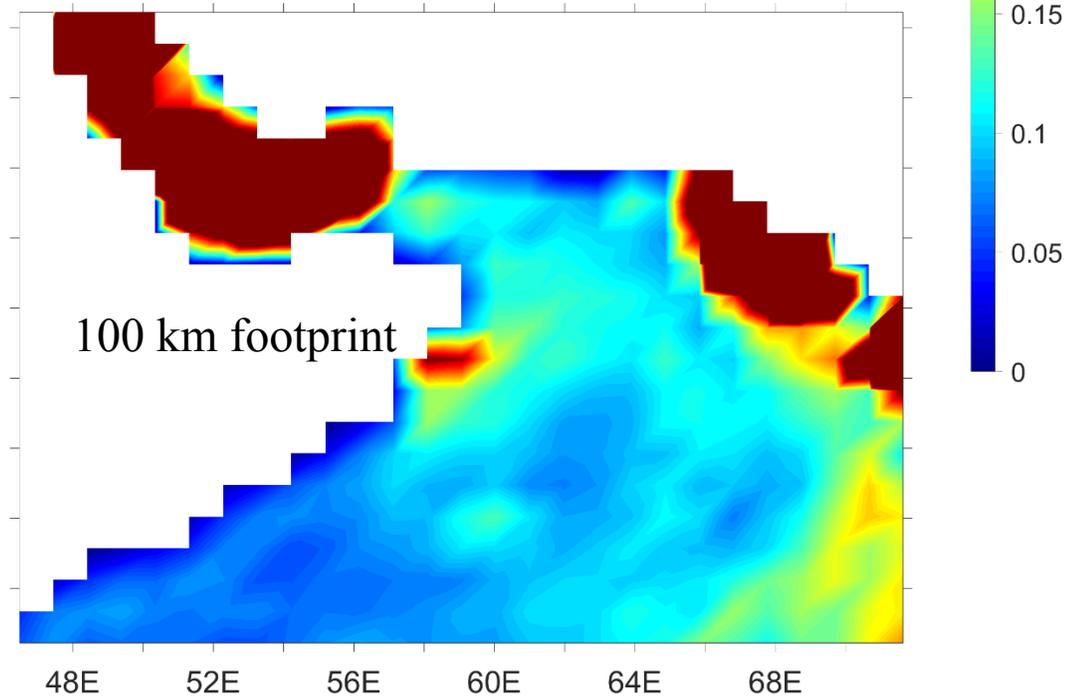
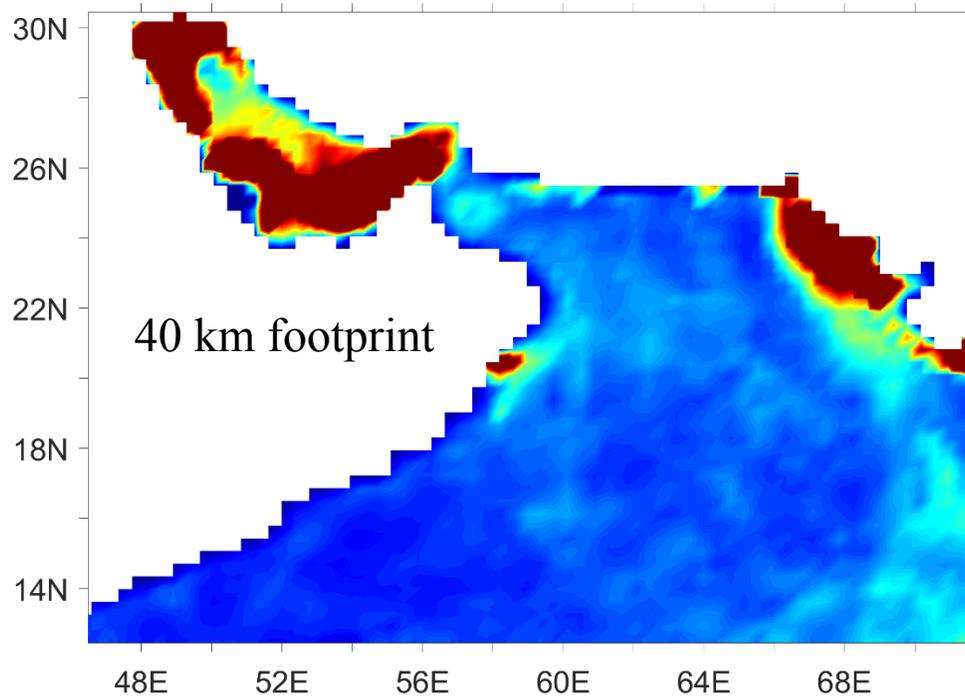
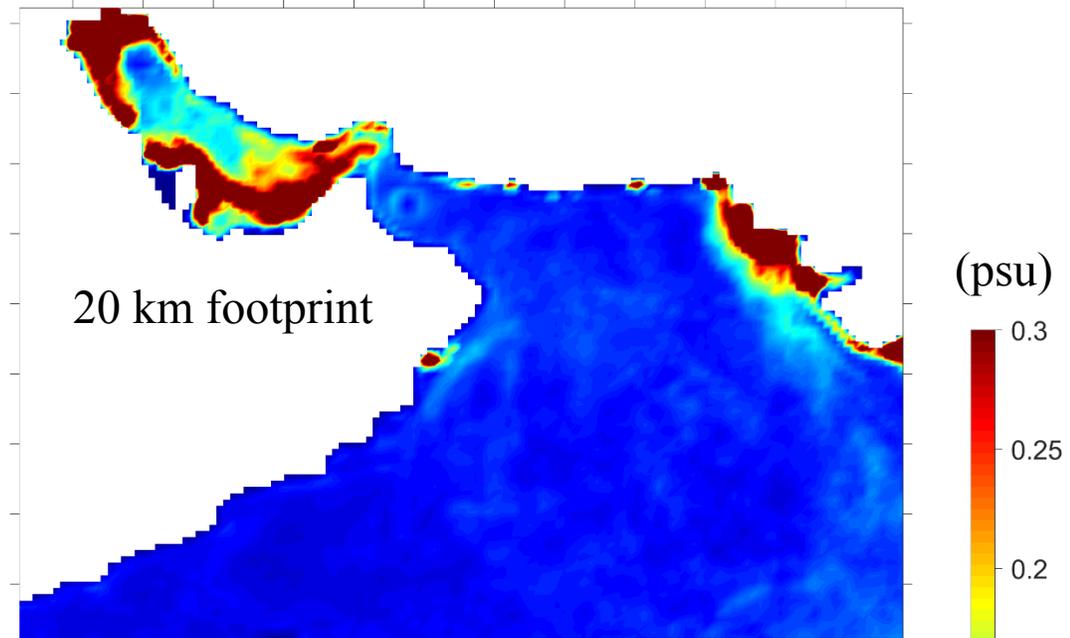
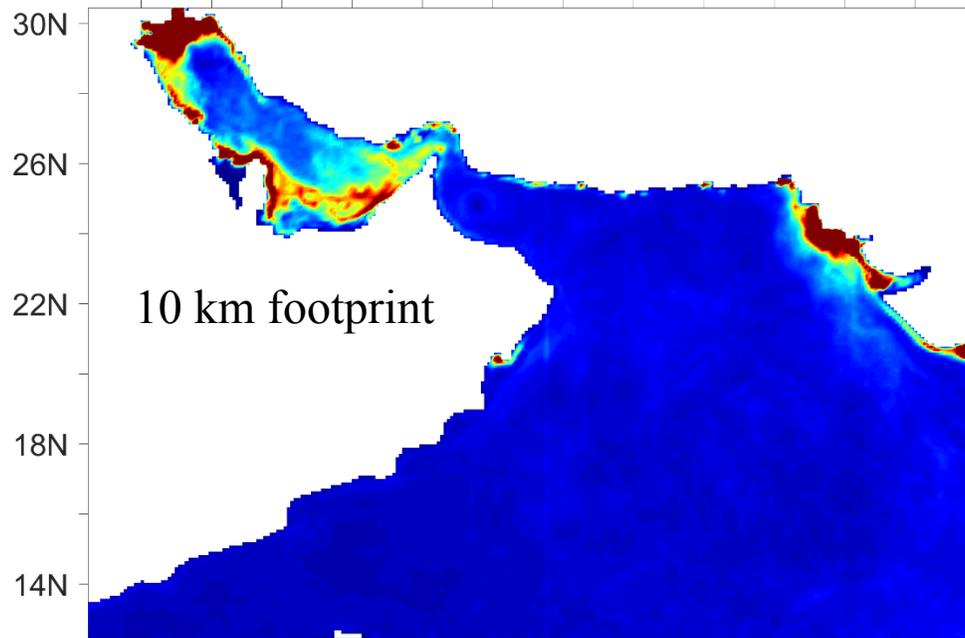
$$2d_0 = 10 \text{ km} \parallel 20 \text{ km} \parallel 40 \text{ km} \parallel 100 \text{ km}$$

d_i = distance to grid point

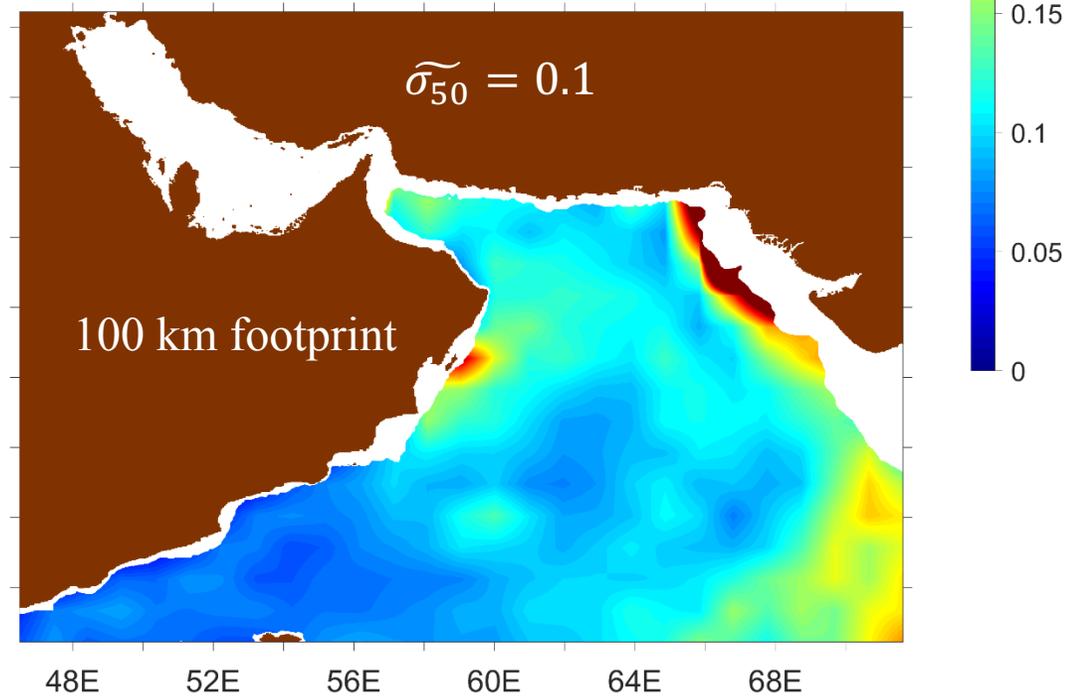
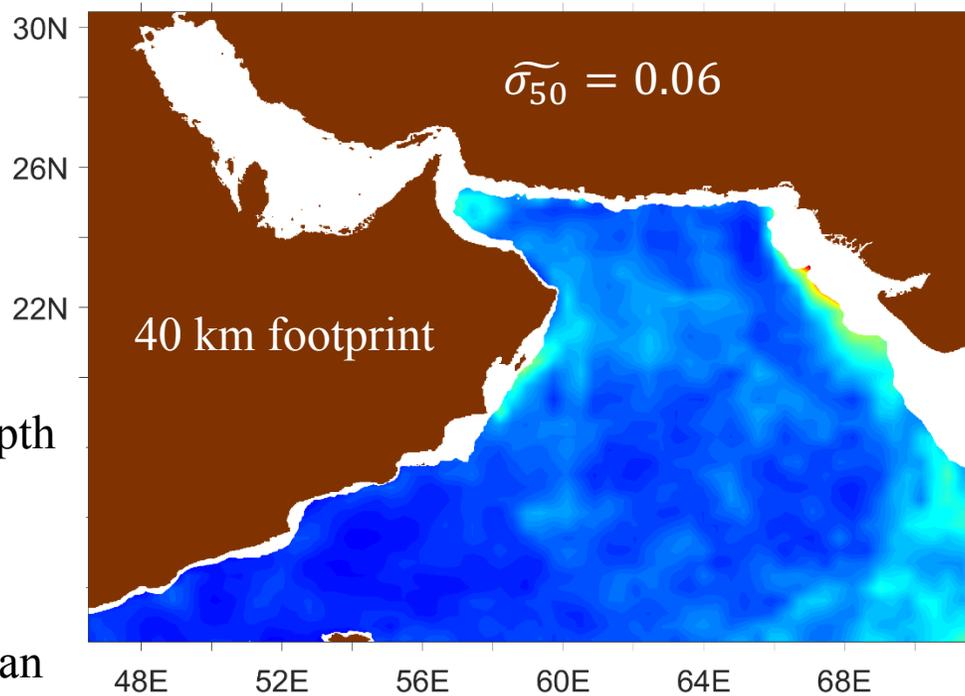
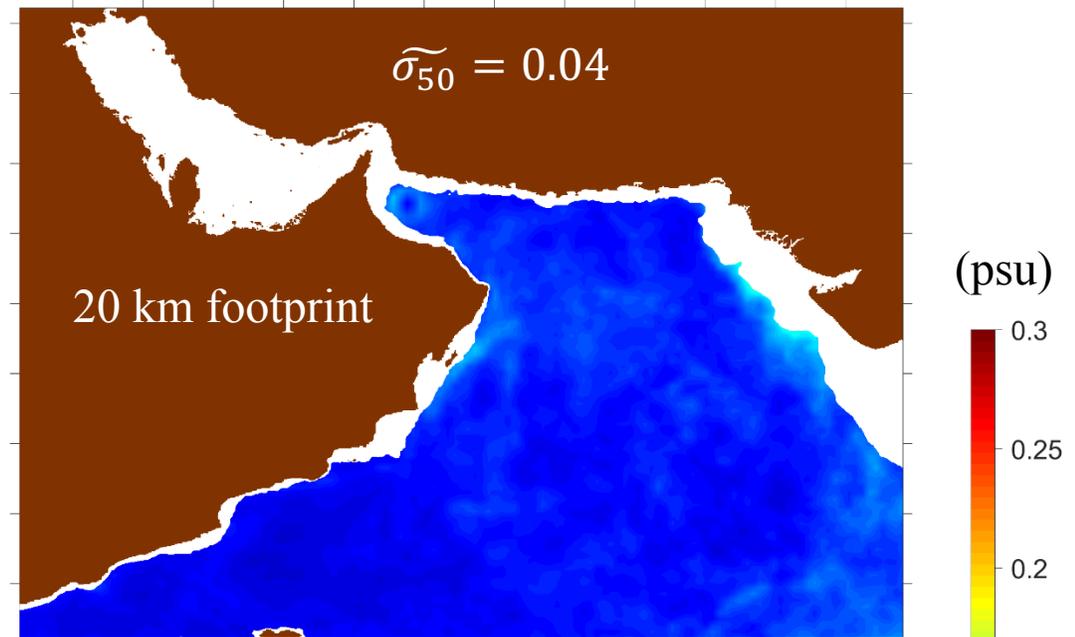
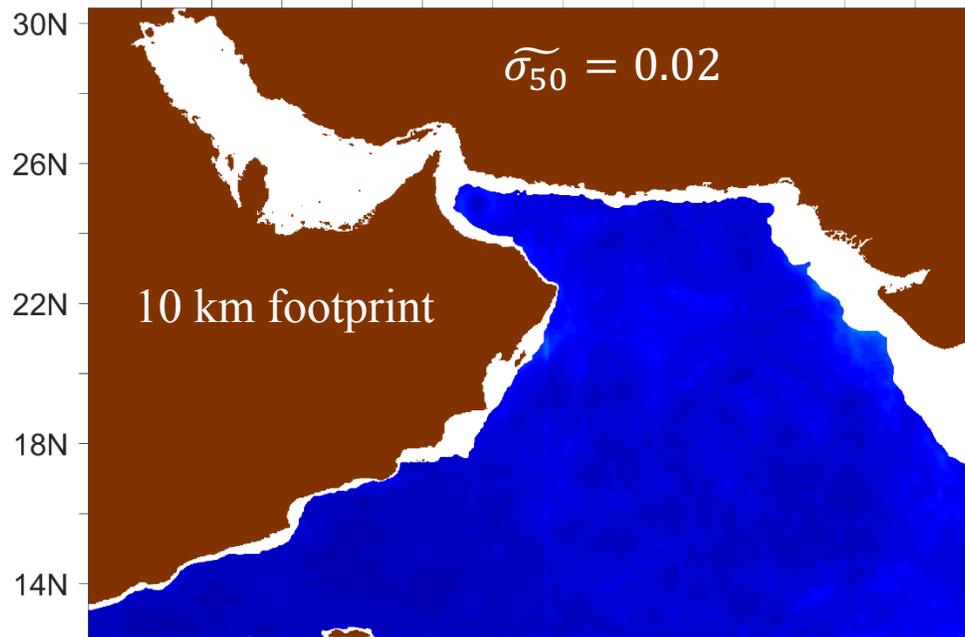
$$N = 2,928 \text{ time steps}$$

After σ is derived at all grid points and all times, the following parameters are calculated:

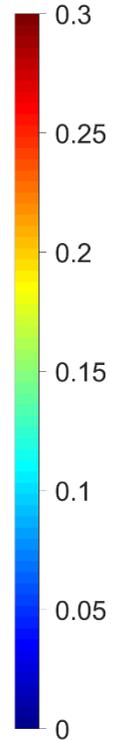
1. σ_{50} is the median σ through time at that point
2. σ_{95} is the σ larger than 95% of others through time at that point (Boutin et al., 2016)



σ_{50}



(psu)



σ_{50}

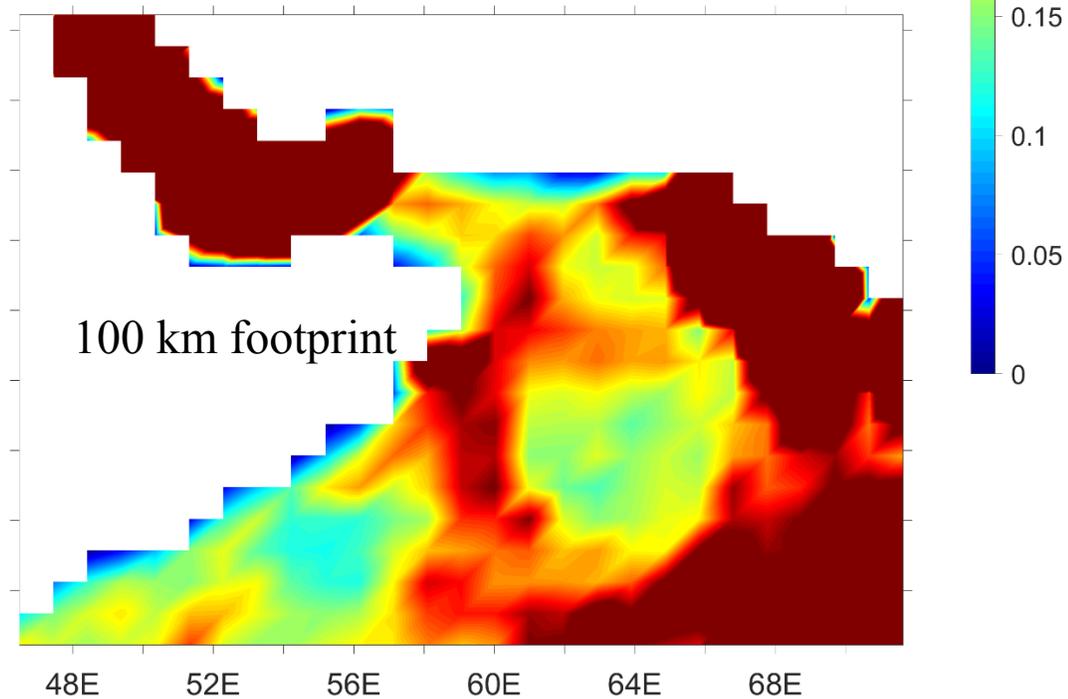
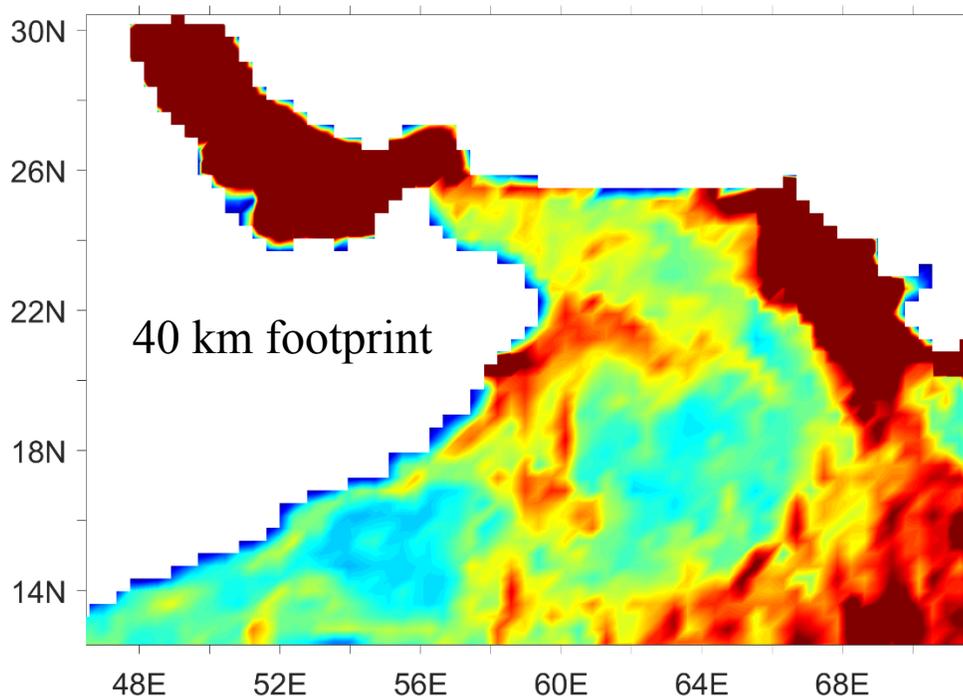
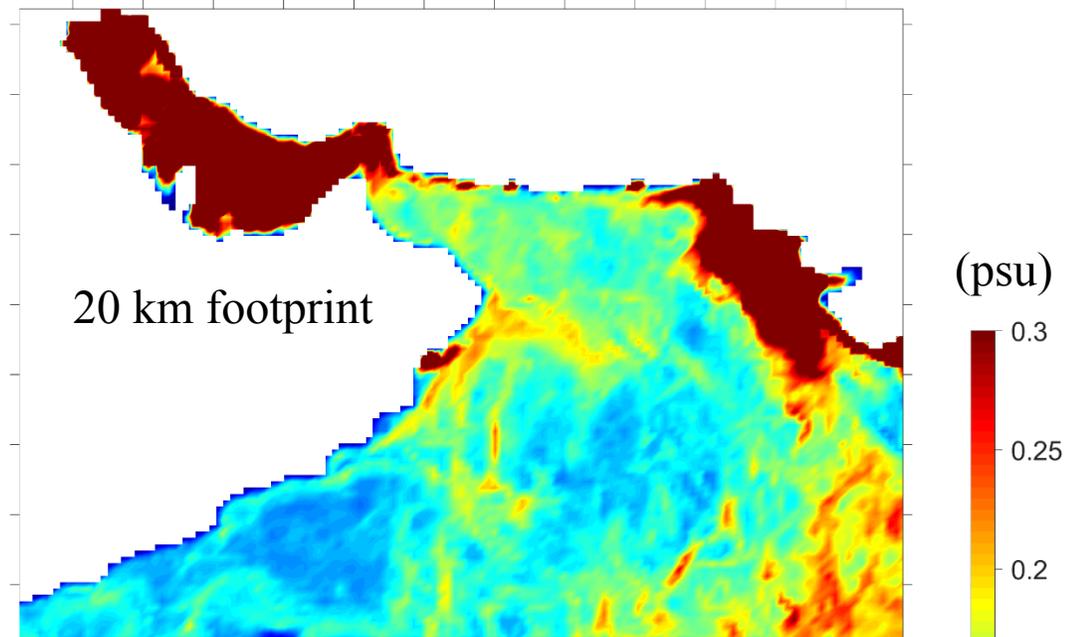
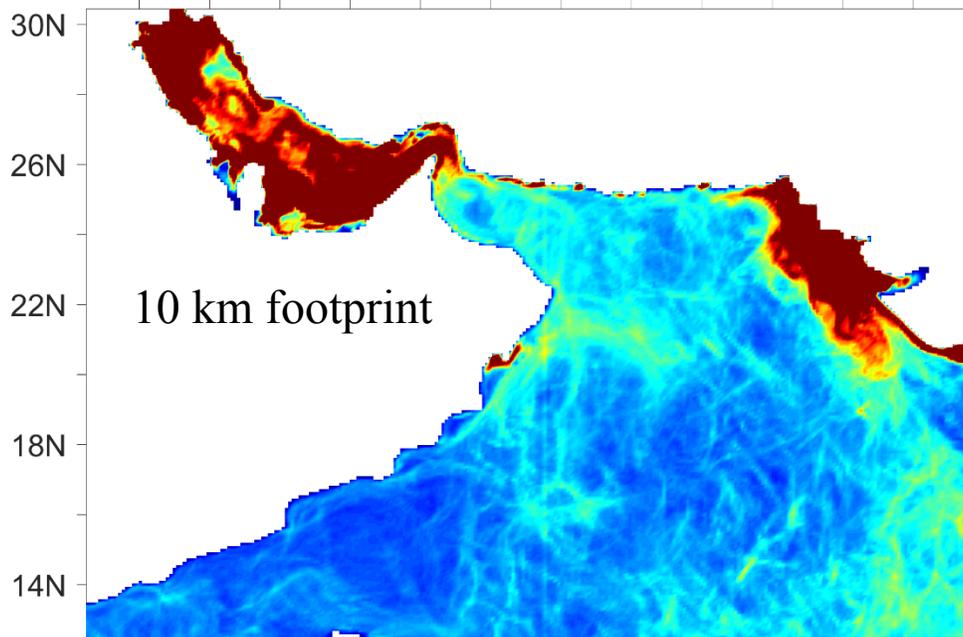
< 500 m water depth
removed from
analysis

$\widetilde{\sigma}_{50}$ = spatial median

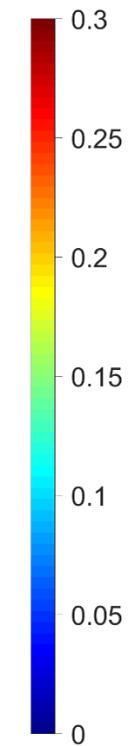
48E 52E 56E 60E 64E 68E

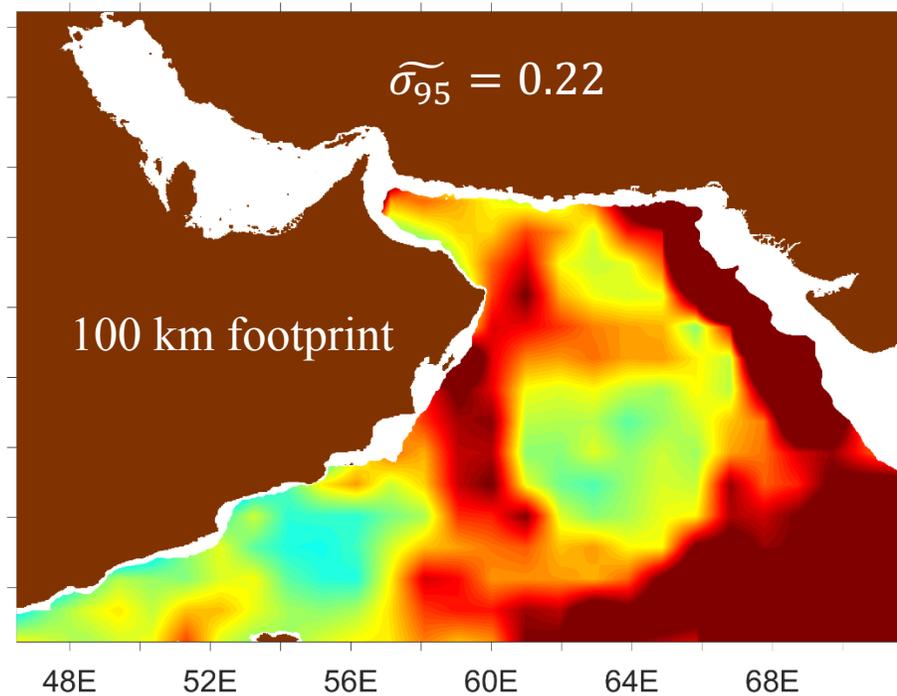
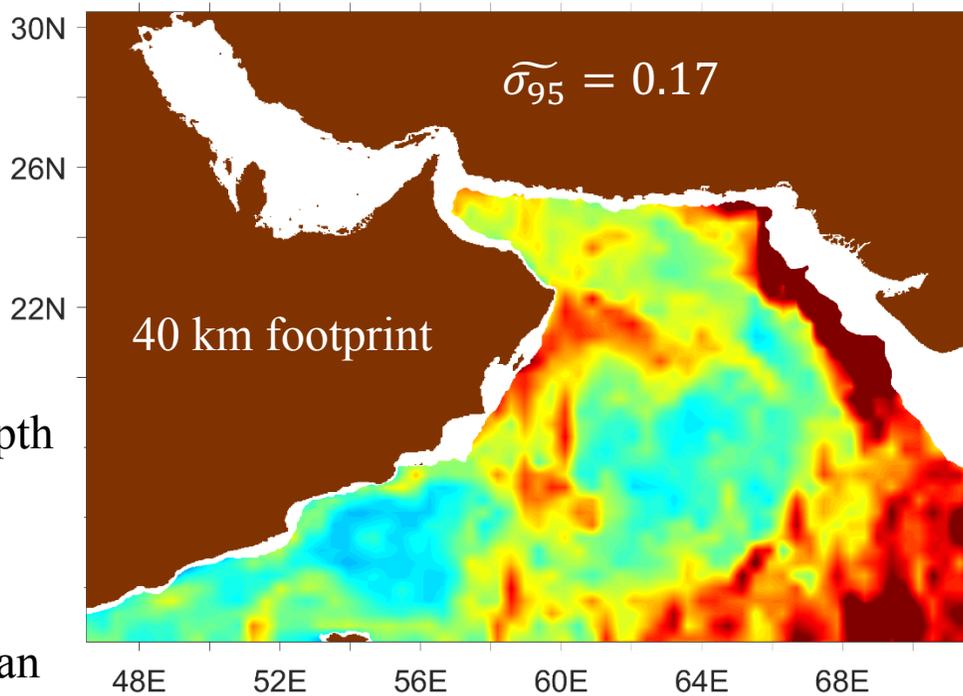
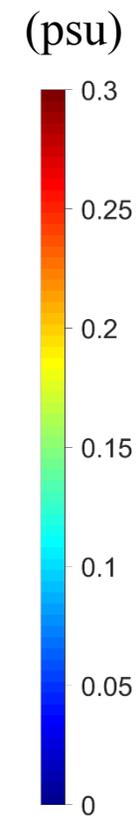
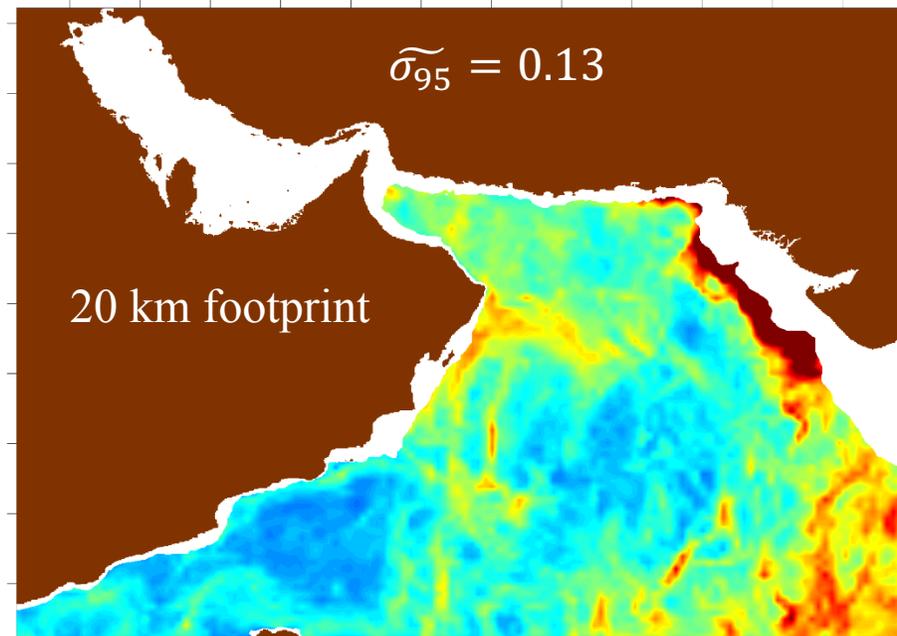
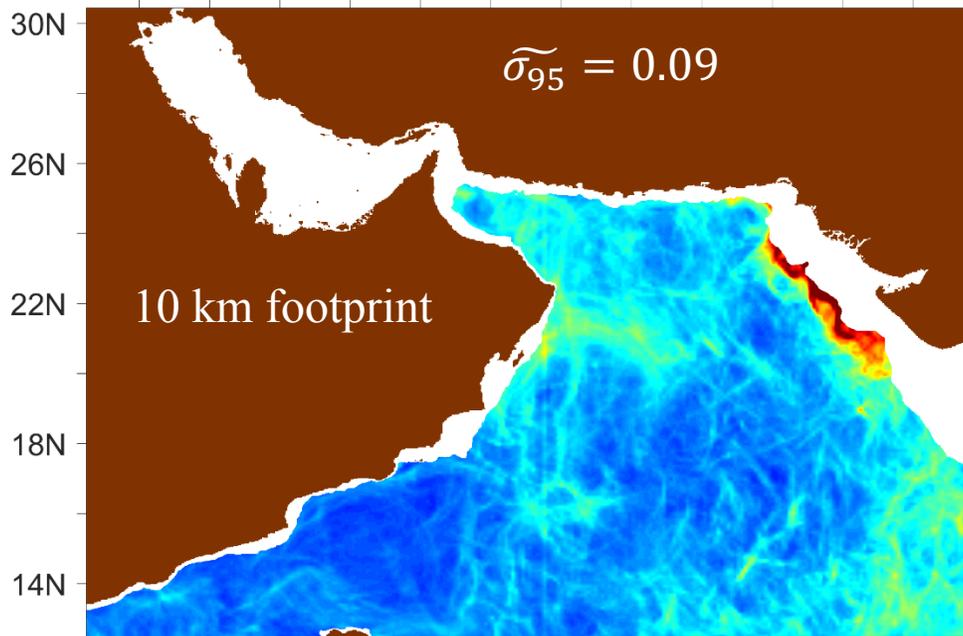
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σ_{95}



(psu)





σ_{95}

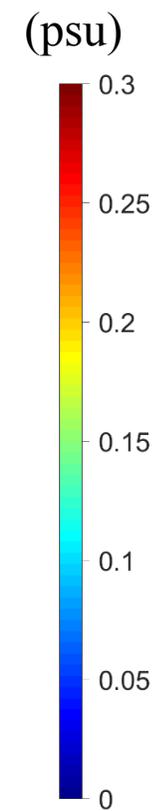
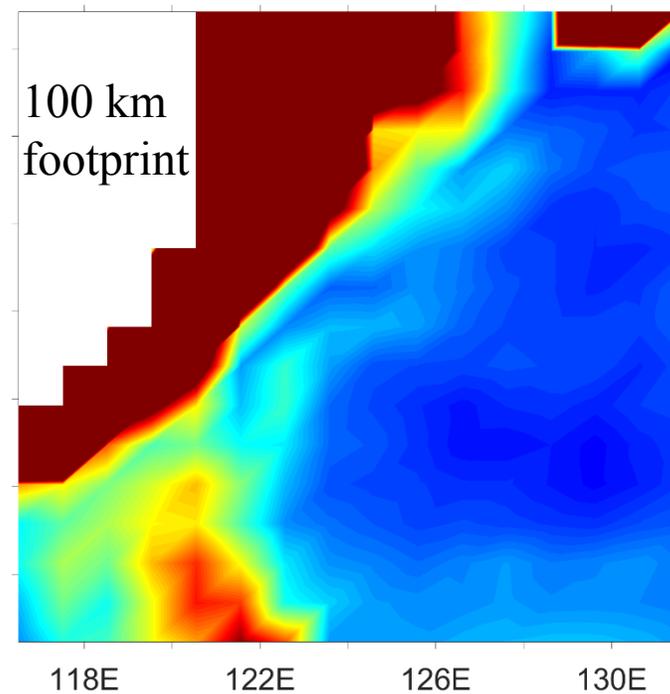
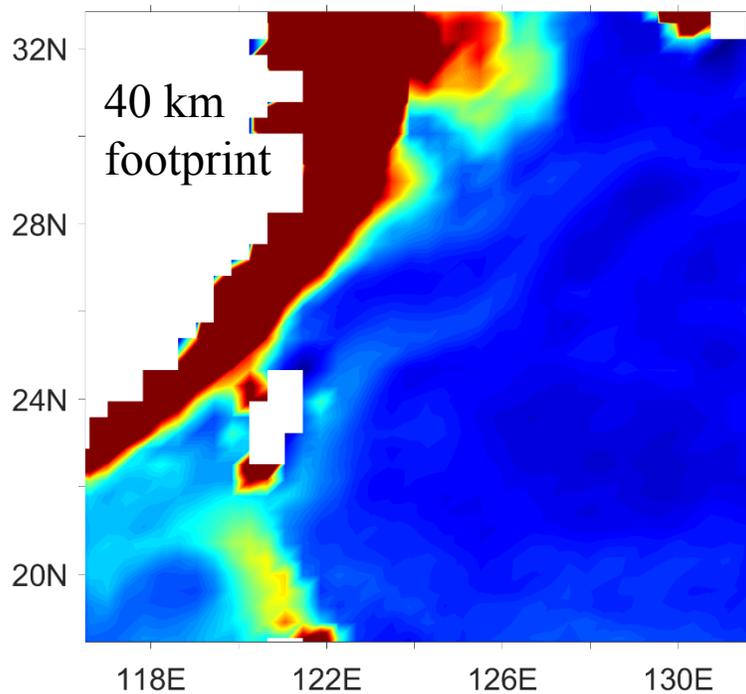
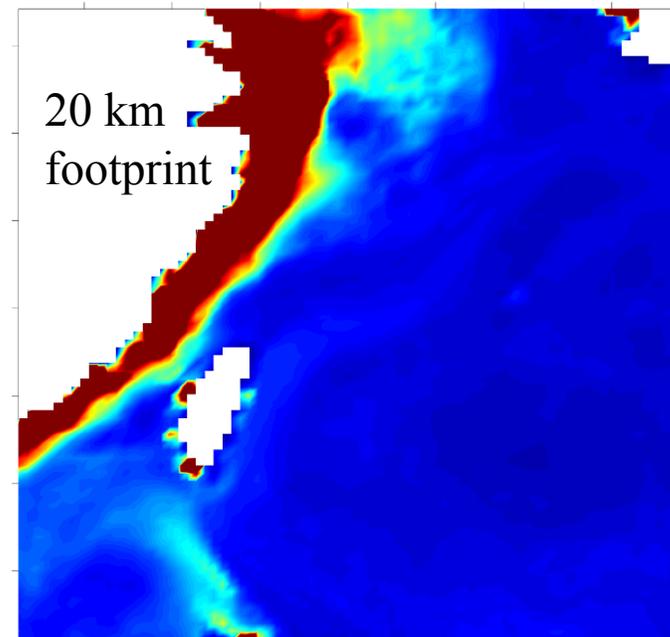
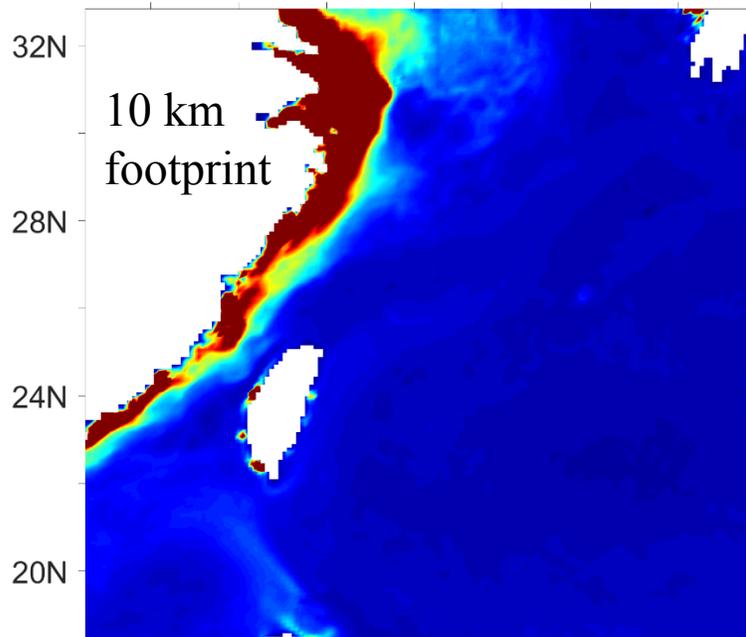
< 500 m water depth
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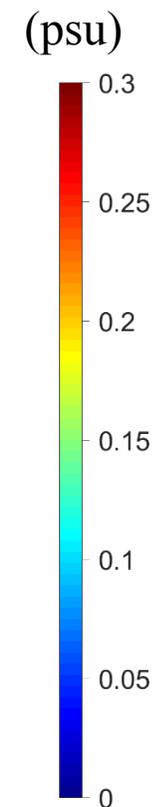
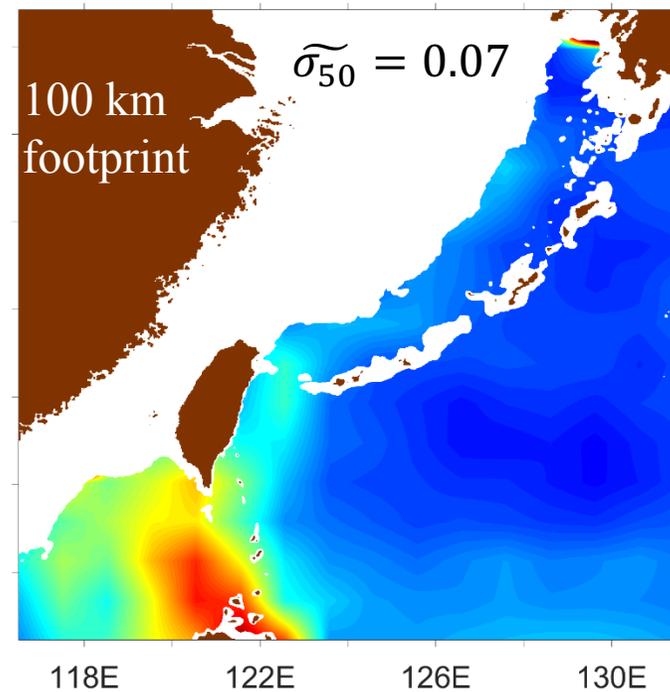
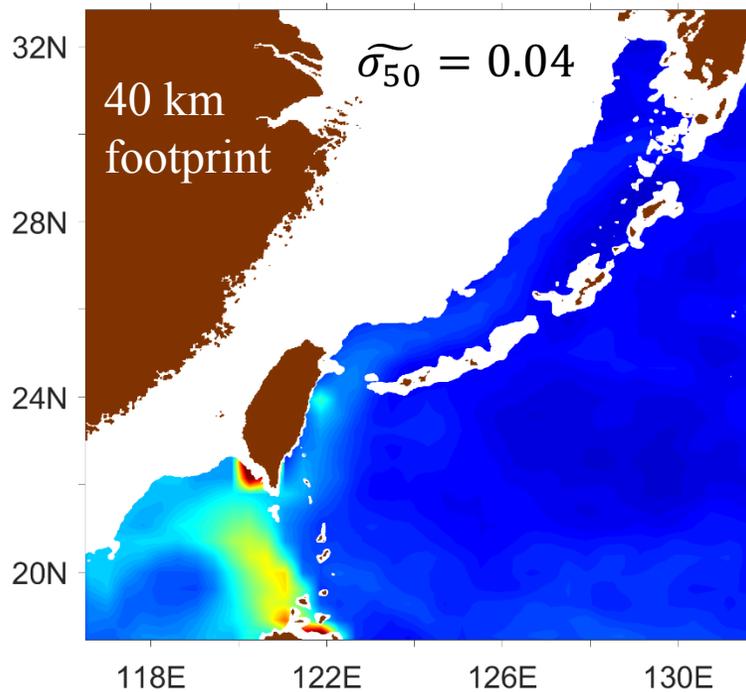
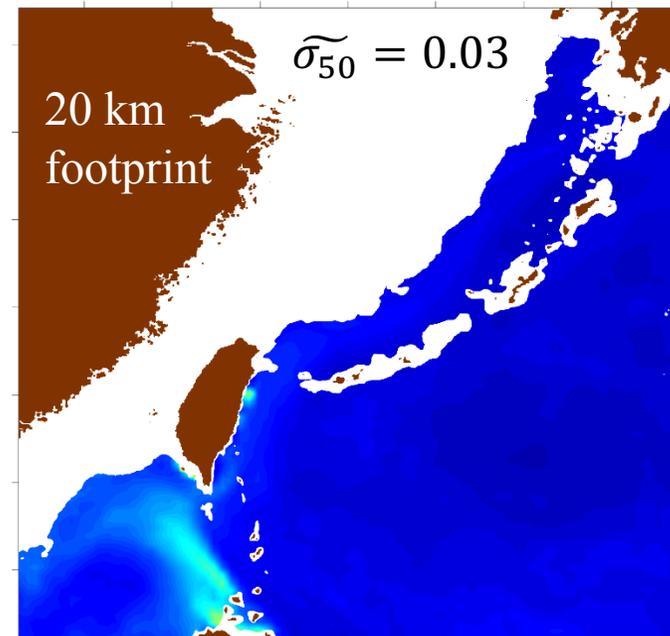
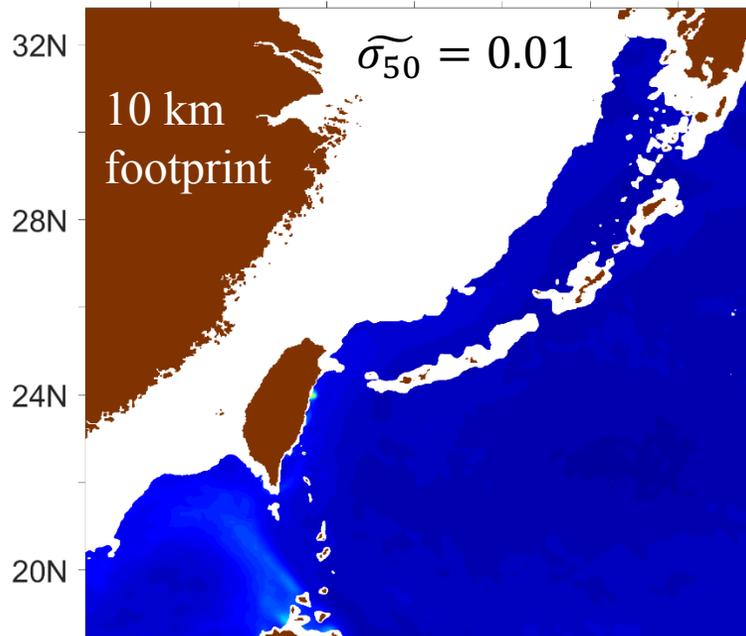
$\widetilde{\sigma}_{95}$ = spatial median

48E 52E 56E 60E 64E 68E

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σ_{50}



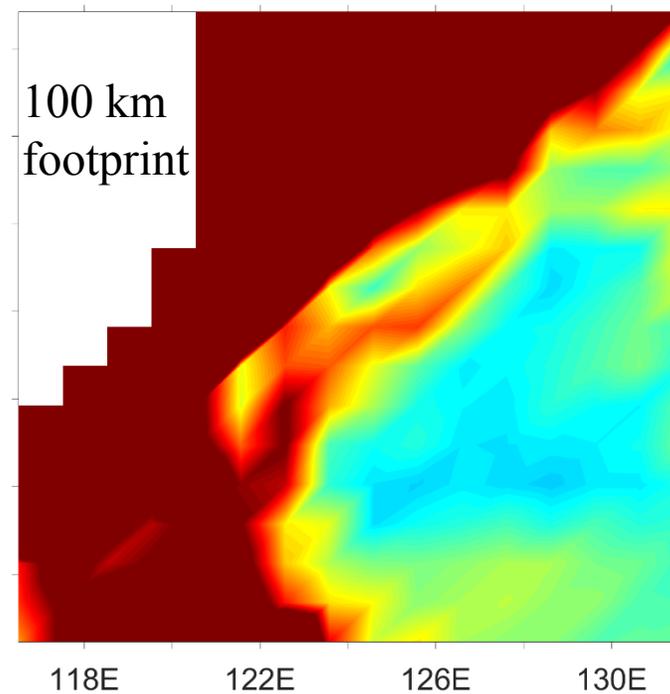
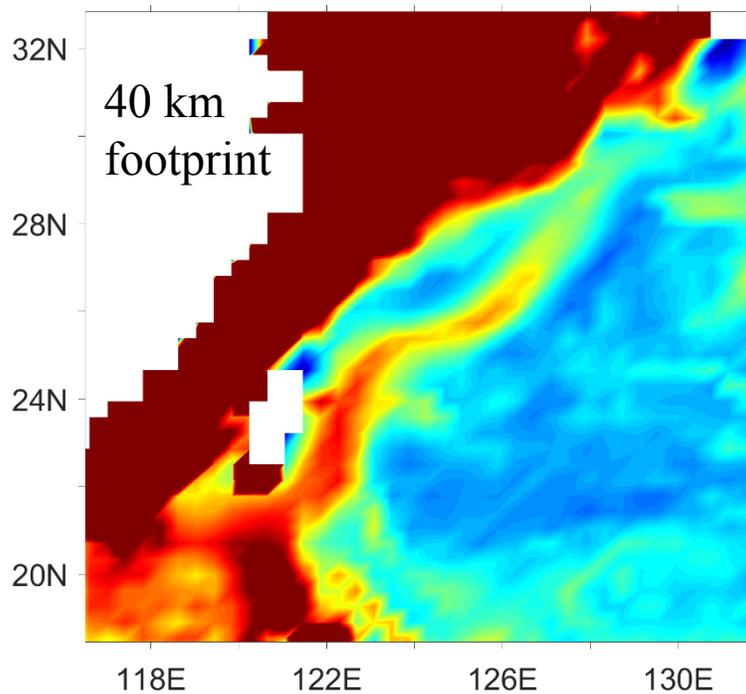
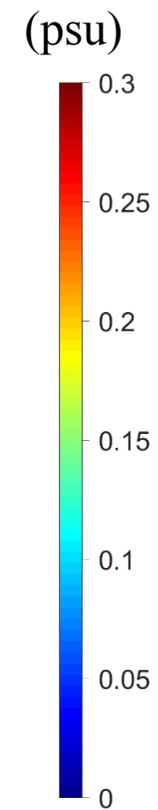
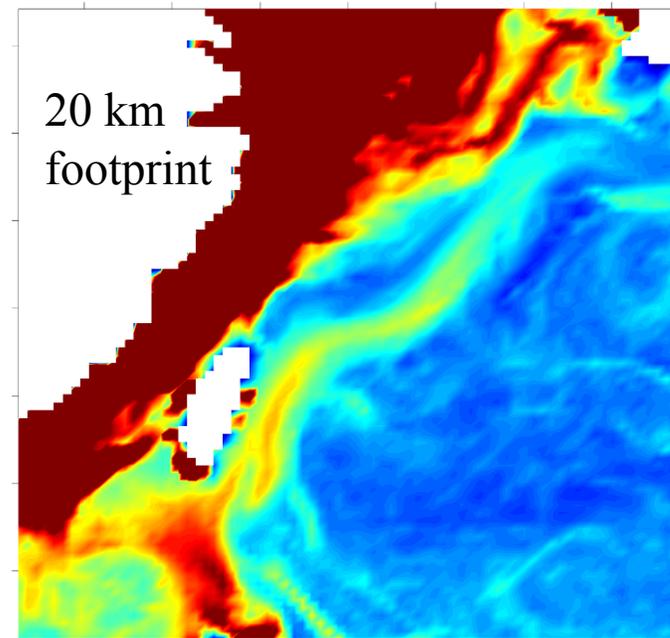
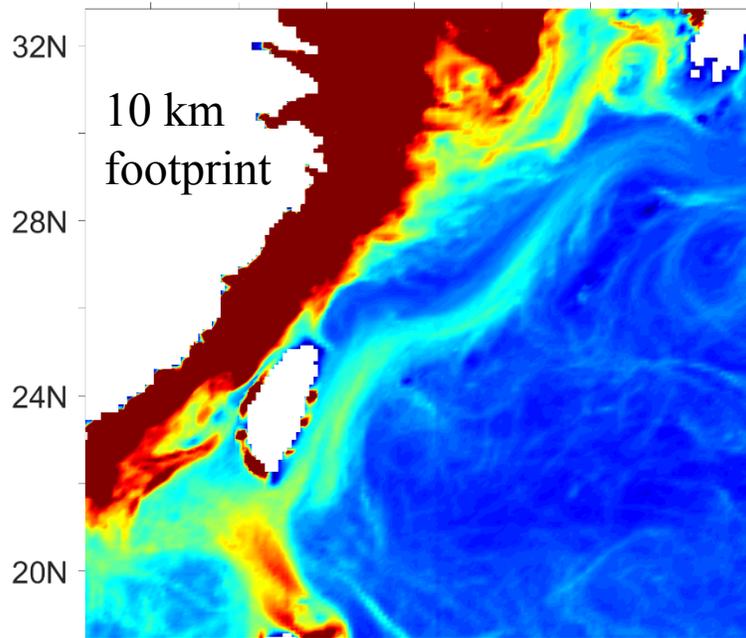


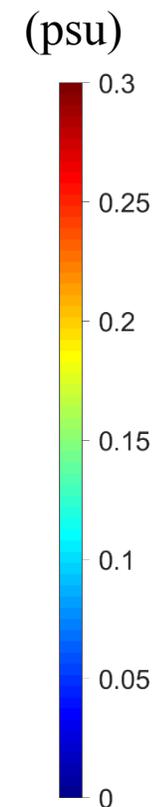
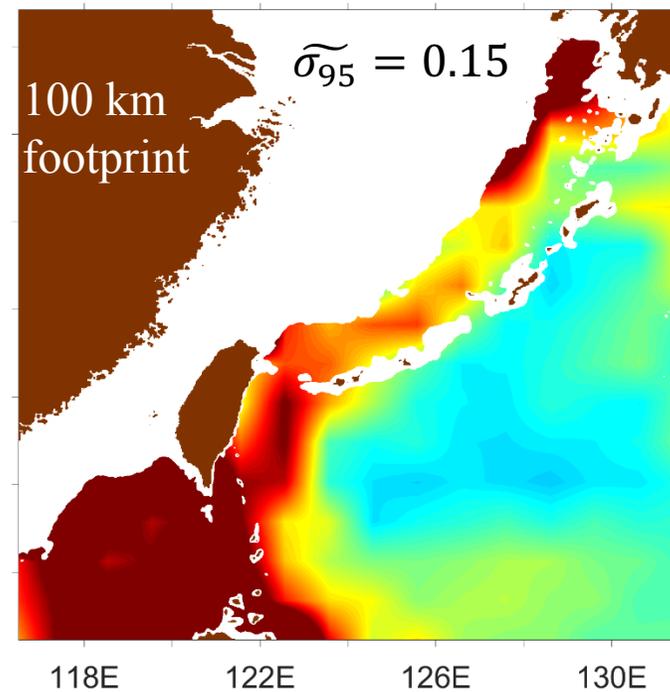
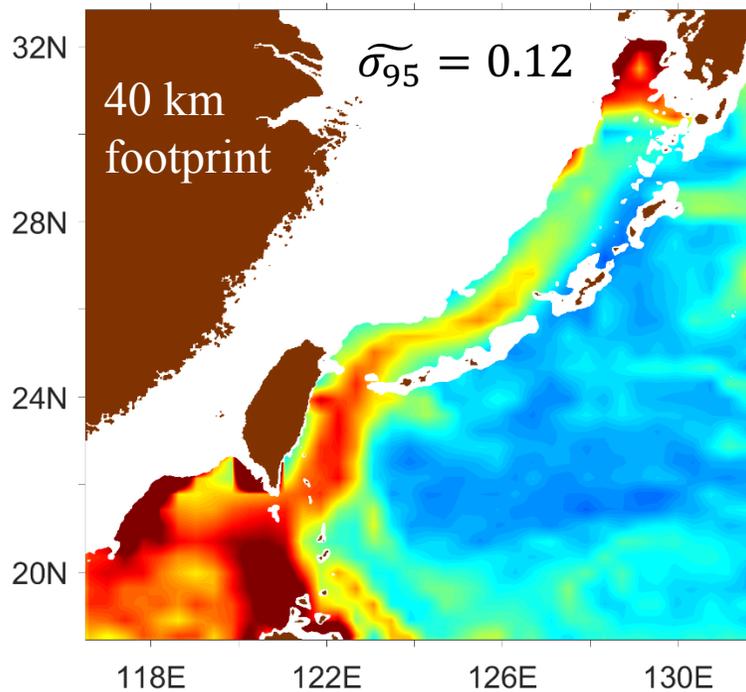
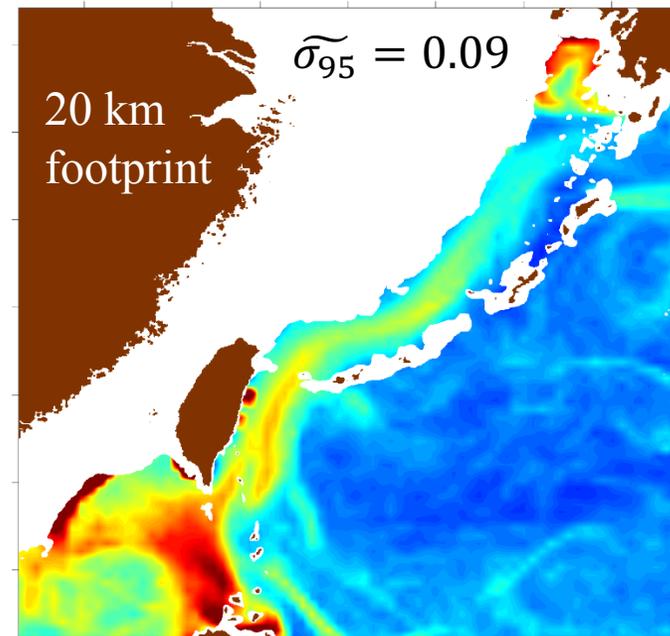
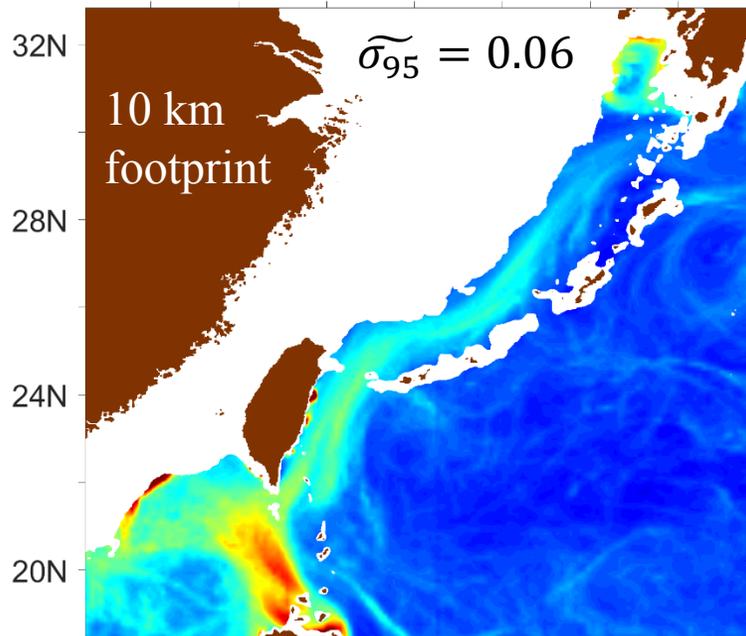
σ_{50}

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$\widetilde{\sigma}_{50}$ = spatial median

σ_{95}



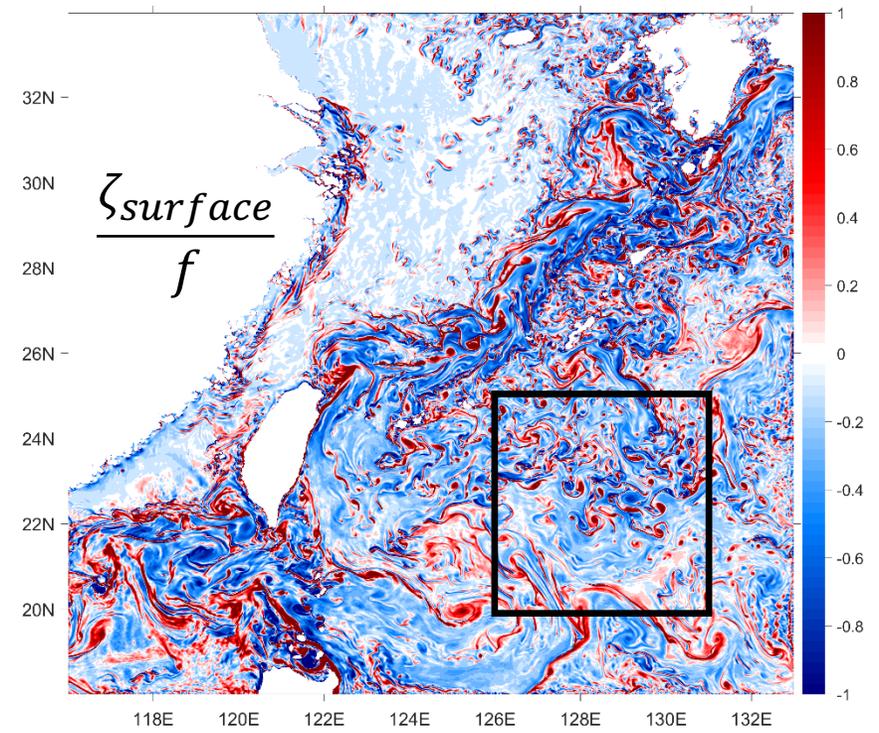
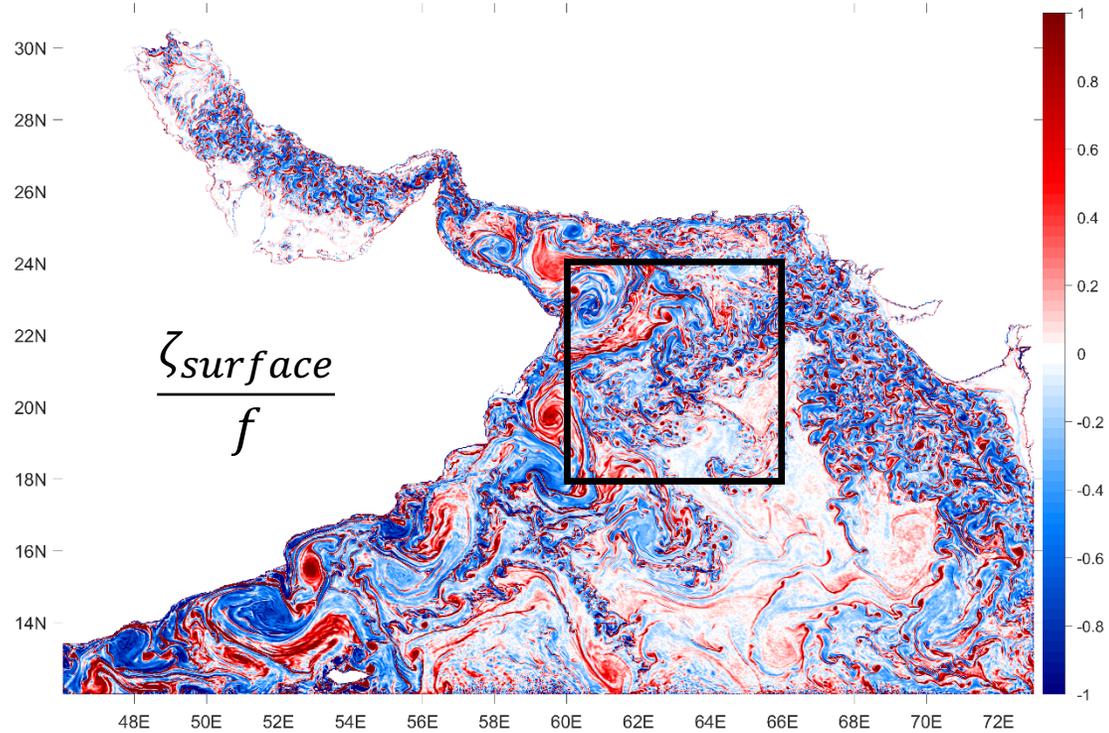


σ_{95}

< 500 m water depth removed from analysis

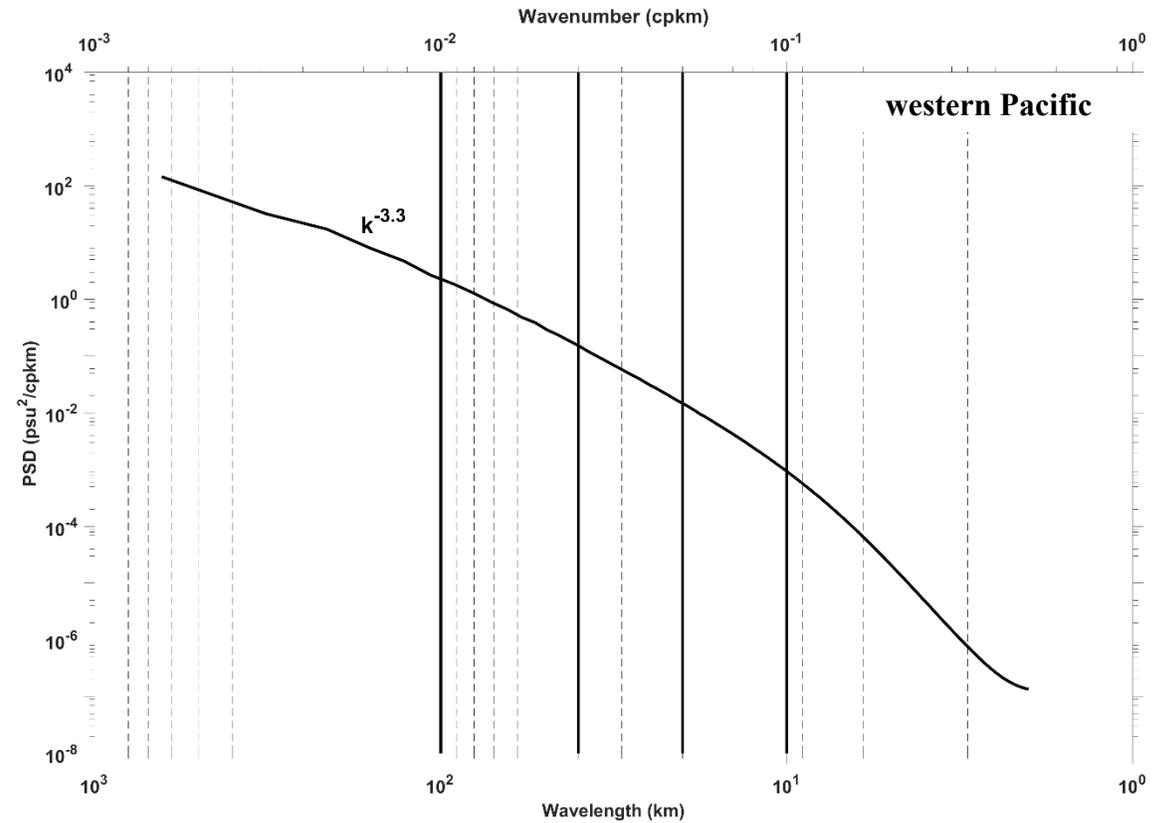
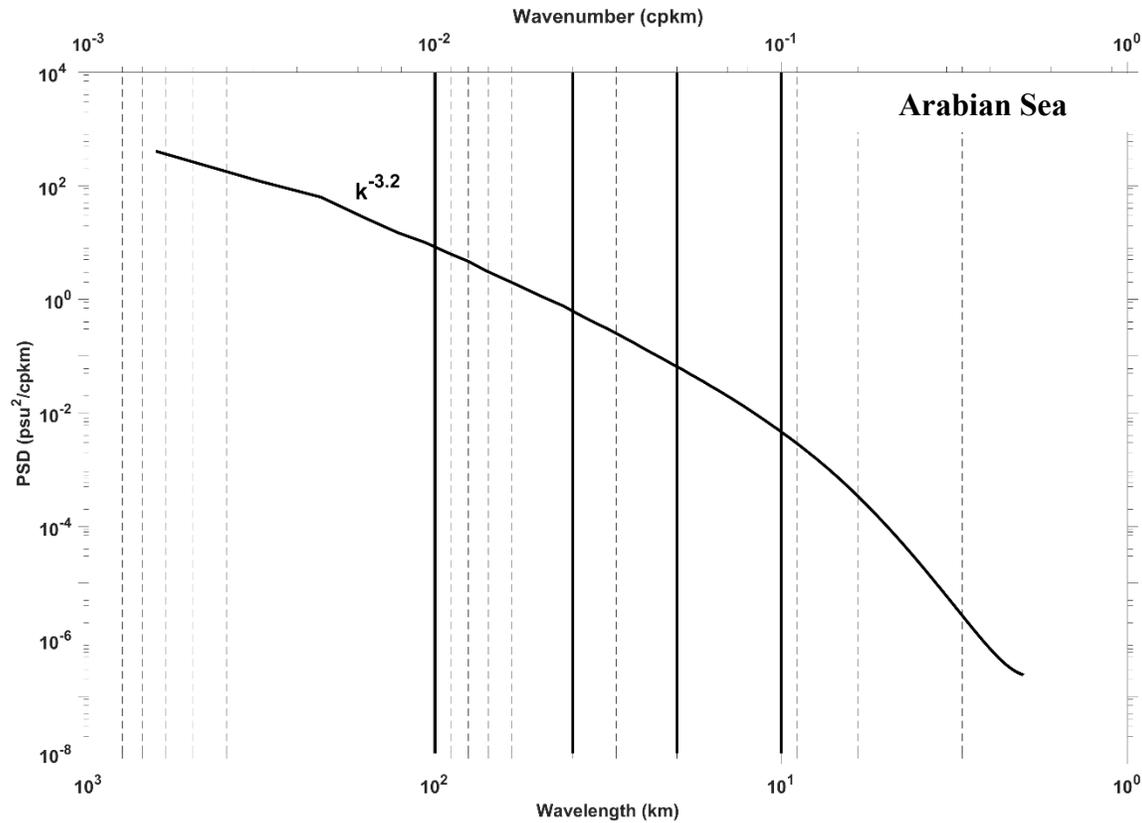
$\widetilde{\sigma}_{95}$ = spatial median

SSS Wavenumber Spectra



- 2 dimensional power spectral density (PSD) of SSS was calculated for every time step in 2016 (N = 2928) and averaged into a one dimensional spectrum for each subdomain.

SSS Wavenumber Spectra

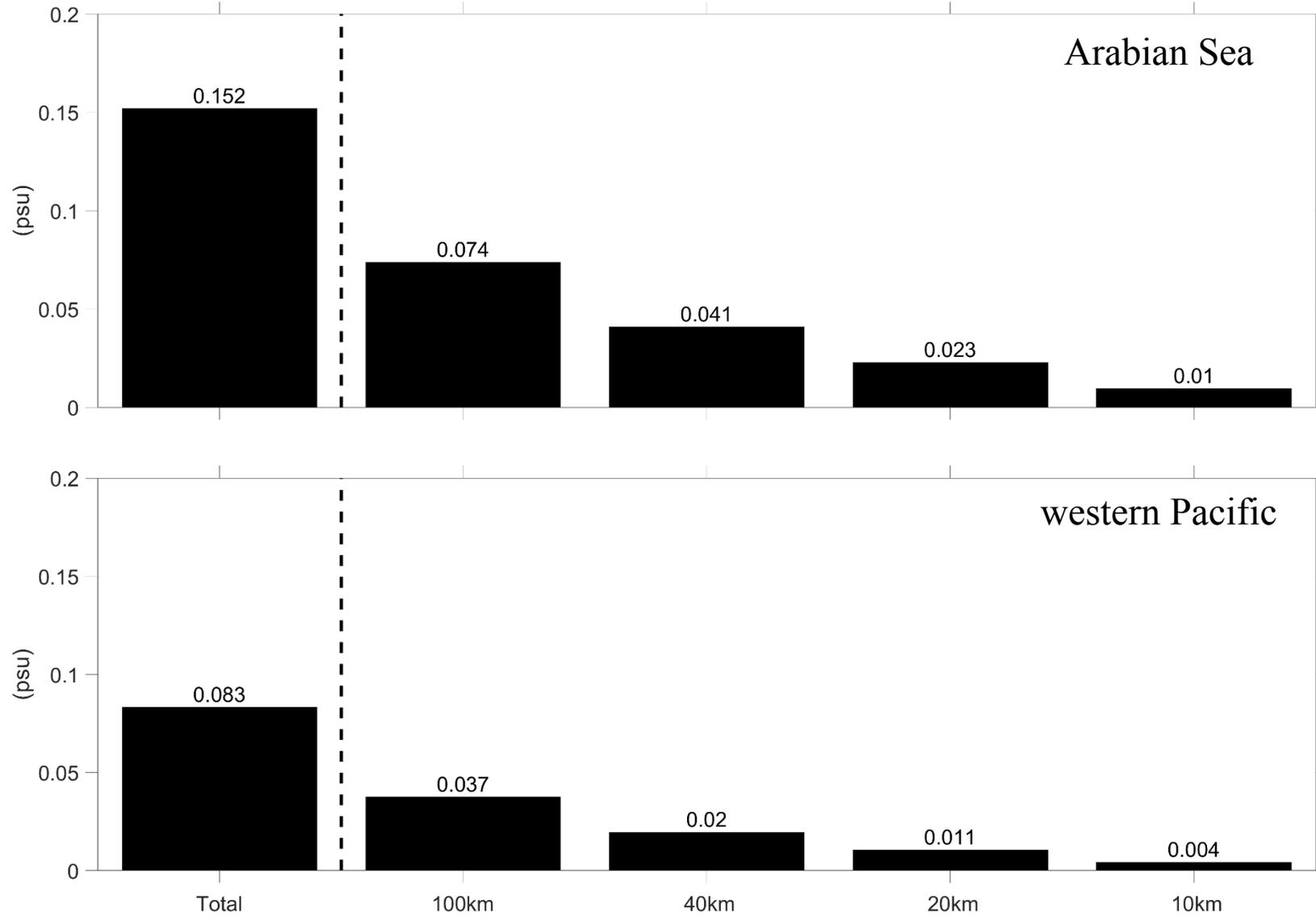


- 2 dimensional power spectral density (PSD) of SSS was calculated for every time step in 2016 (N = 2928) and averaged into a one dimensional spectrum for each subdomain.
- Spectral slopes were derived between 200 km and 10 km.

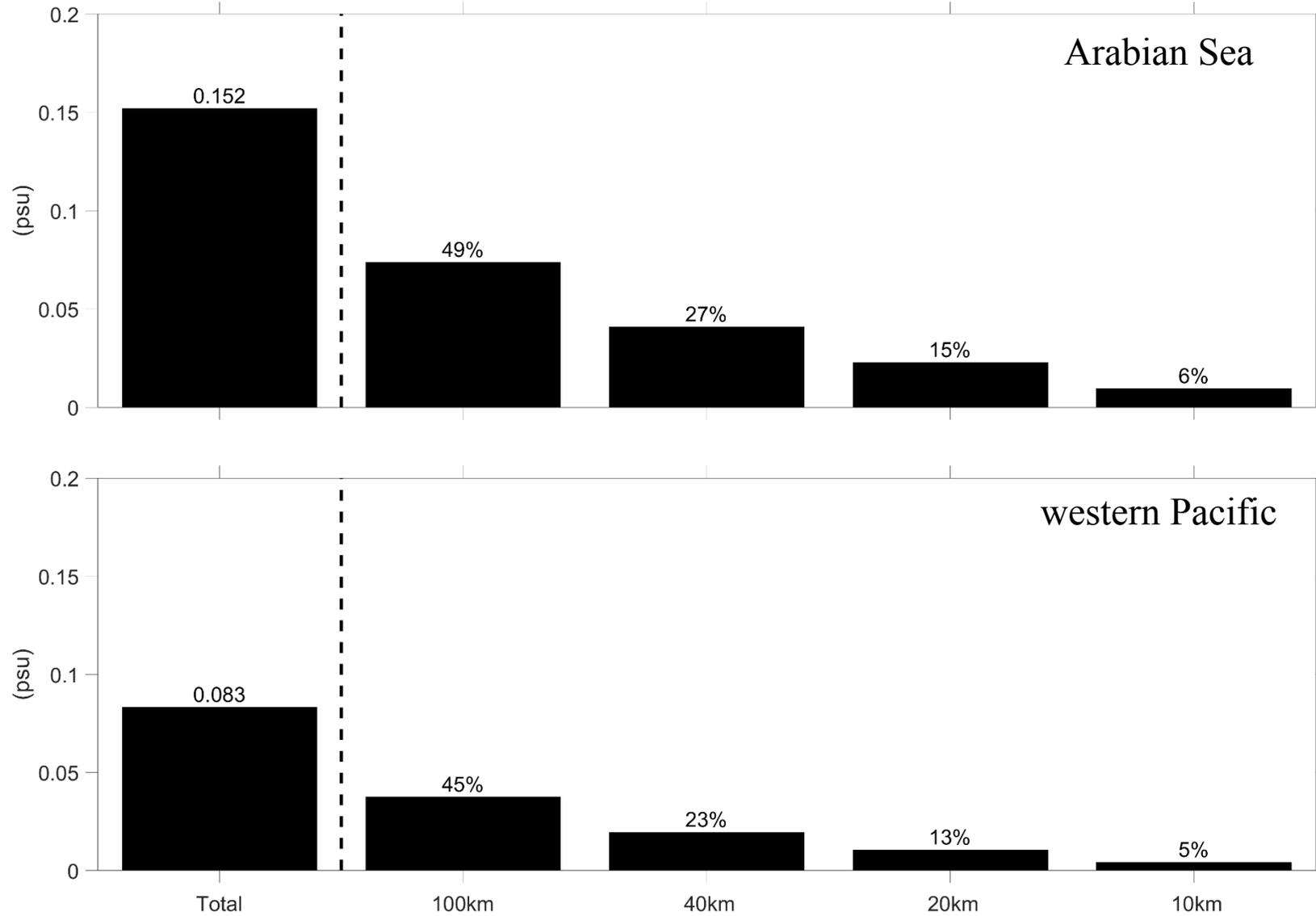
- Integrating over wavenumber bands gives an estimate of the spatial variance in SSS:

$$\sigma_k = \sqrt{\iint PSD(k_x, k_y) dk_x dk_y}$$

$$\sigma_k = \sqrt{\iint PSD(k_x, k_y) dk_x dk_y}$$



$$\sigma_k = \sqrt{\iint PSD(k_x, k_y) dk_x dk_y}$$



Methodology Comparison

Arabian Sea

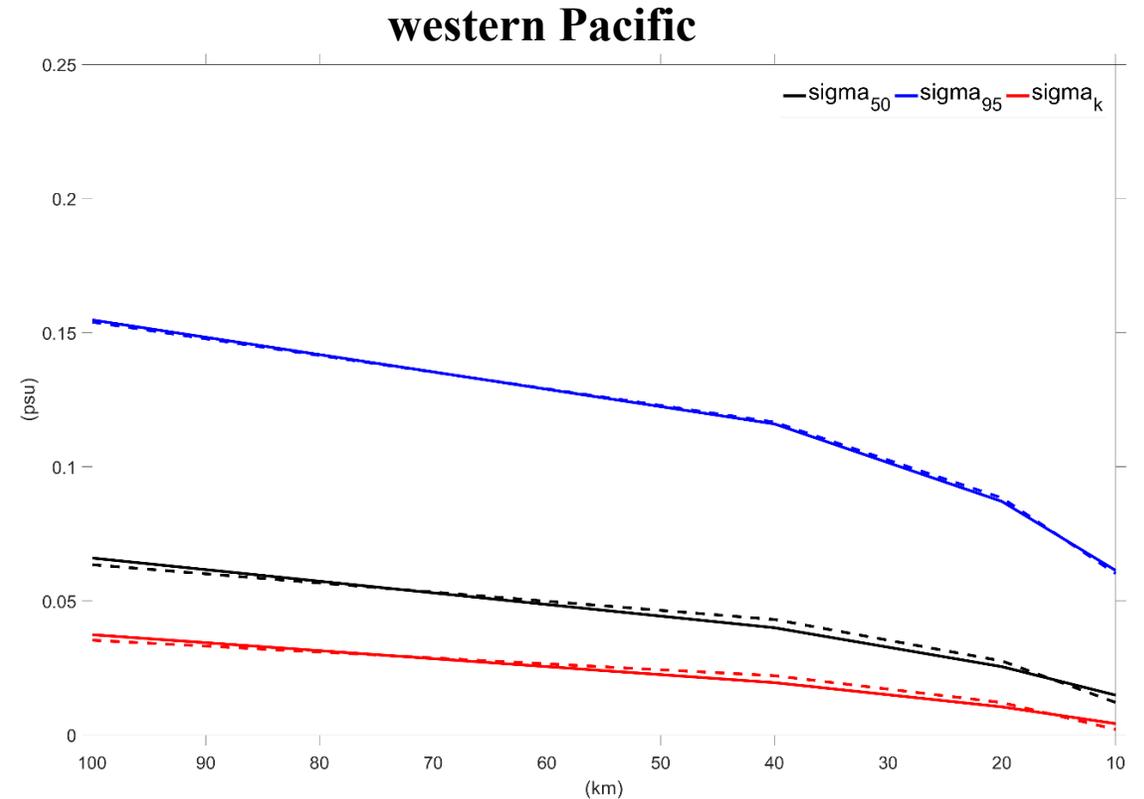
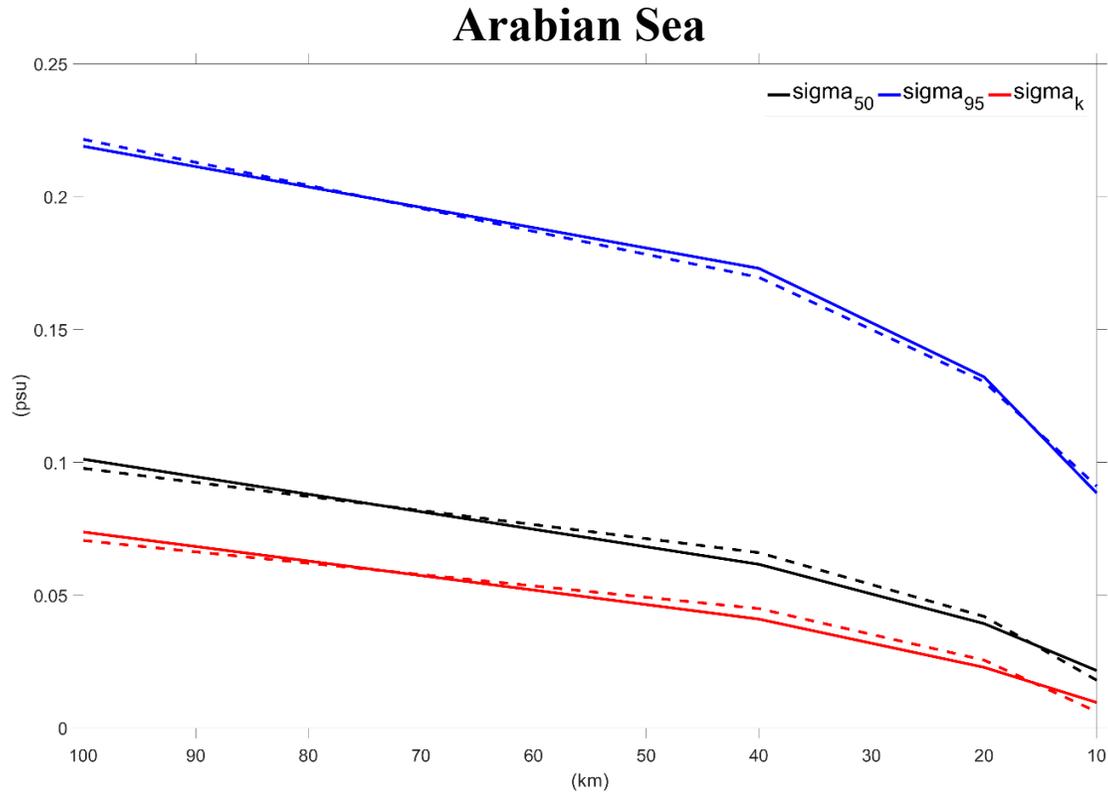
	$\tilde{\sigma}_{50}$	$\tilde{\sigma}_{95}$	σ_k
100 km	0.1 psu	0.22 psu	0.07 psu
40 km	0.06 psu	0.17 psu	0.04 psu
20 km	0.04 psu	0.13 psu	0.02 psu
10 km	0.02 psu	0.09 psu	0.01 psu

western Pacific

	$\tilde{\sigma}_{50}$	$\tilde{\sigma}_{95}$	σ_k
100 km	0.07 psu	0.15 psu	0.04 psu
40 km	0.04 psu	0.12 psu	0.02 psu
20 km	0.03 psu	0.09 psu	0.01 psu
10 km	0.01 psu	0.06 psu	0.004 psu

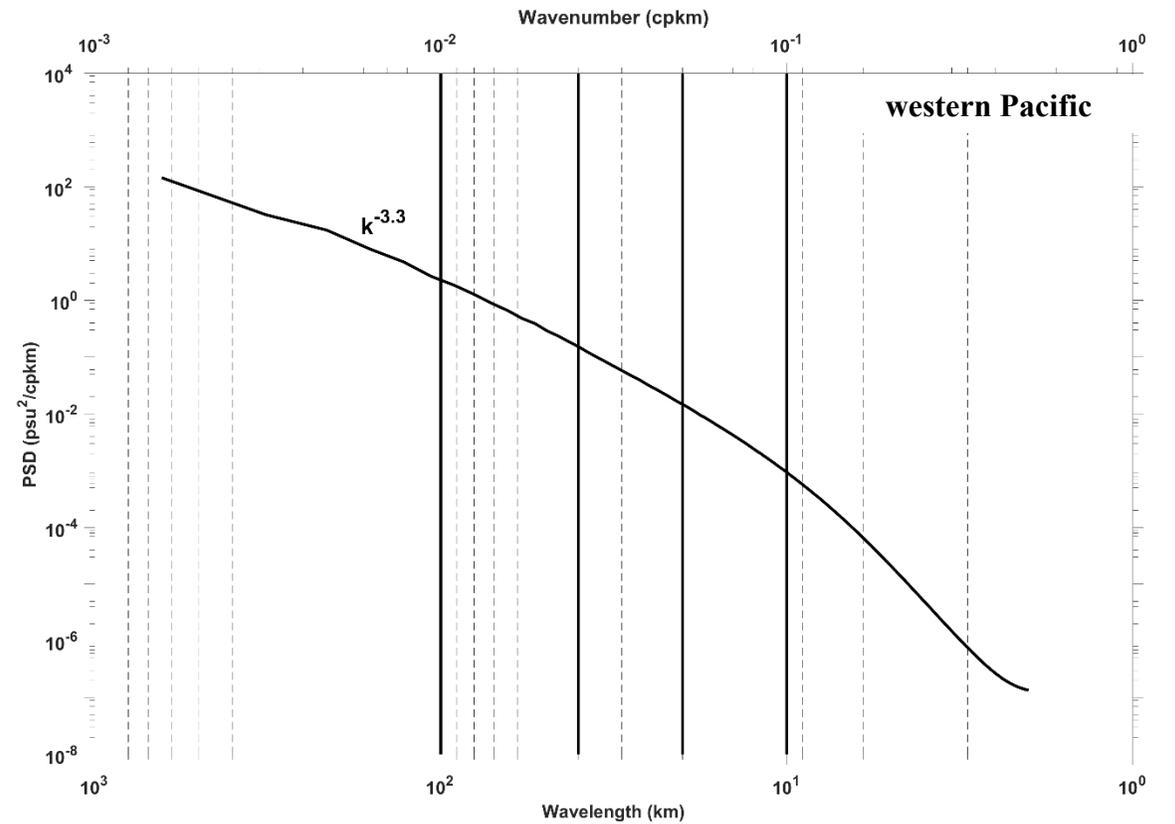
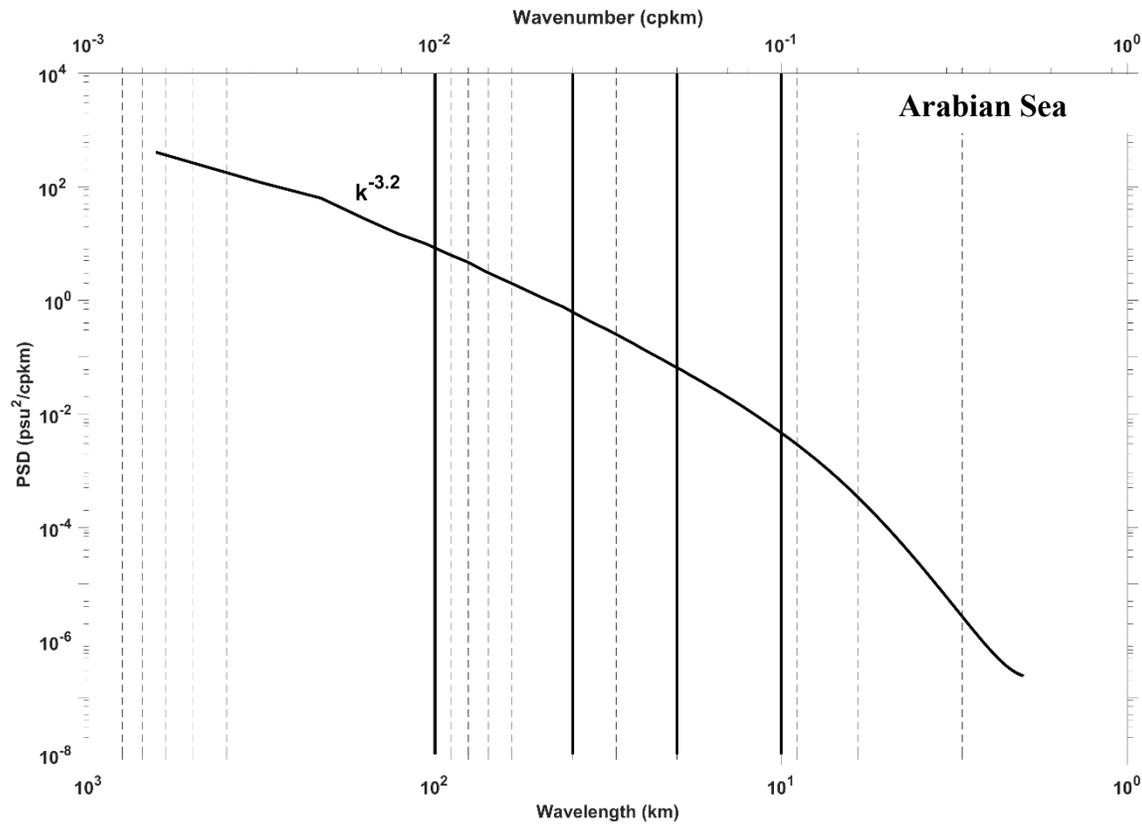
- The three methodologies provide a set of SSS SFV estimates.
- $\tilde{\sigma}_{95} > \tilde{\sigma}_{50} > \sigma_k$
- **Is there a linear decay of variance as a function of footprint diameter?**

Methodology Comparison



- Each line is best fit by a logarithmic function.
- **These results suggest a logarithmic decay in SSS variance with decreasing footprint diameter.**

Summary



- The wavenumber spectra help visualize the decay in variance with decreasing footprint diameter. A 40 km footprint actually captures much of the total variance, because SSS variability is concentrated at long wavelengths (synoptic & mesoscale). **These results suggest that the current footprint size obscures important physics, but does not necessarily neglect the majority of the SSS spatial variance.**