Lagrangian reconstruction of sea surface salinity to extract small-scale variability from SMAP

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Motivation

- Small-scale density fronts are often associated with strong vertical velocities of the order of 100 m/day and they have a key role on the vertical exchange of properties and tracers (e.g. Siegelman et al., 2020).
- Temperature and salinity observations are necessary to evaluate their combined contribution on the generation of density fronts (Drushka et al., 2019).
- The current satellite salinity observations do not have enough resolution to observe these scales.
- Sea surface salinity (SSS) from the SMAP satellite has an effective resolution of ~70 km.

Lagrangian advection of salinity using satellite-derived currents

- To obtain small-scale salinity variability from SMAP SSS observations, we apply a Lagrangian reconstruction technique that consists on the advection of particles with altimetry currents (e.g. Dencausse et al., 2014).
- These particles have a salinity content associated at the initial time from SMAP observations, and they are advected following the currents during an optimal time of 7 days.
- The salinity field after the Lagrangian advection is the reconstructed SSS field, which has higher resolution than the original SMAP SSS field (Fig. 2).

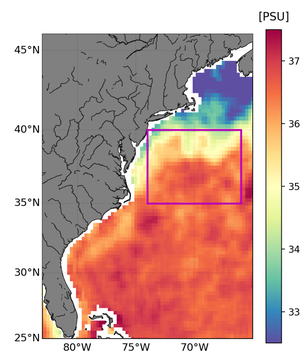


Fig. 1: SMAP SSS field on 2017-02-12 at the Northwest Atlantic Ocean and the simulation domain.

Comparison with ~140 transects of high-resolution SSS observations from the Oleander project

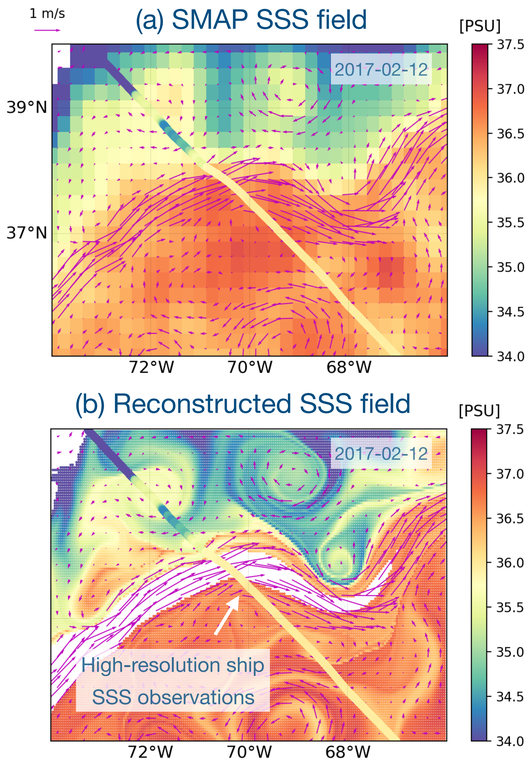


Fig. 2: (a) SMAP and (b) reconstructed SSS fields on 2017-02-12. Dots represent the SSS from ship observations.

- Reconstructed fields show realistic variability in the region with higher in situ variability.

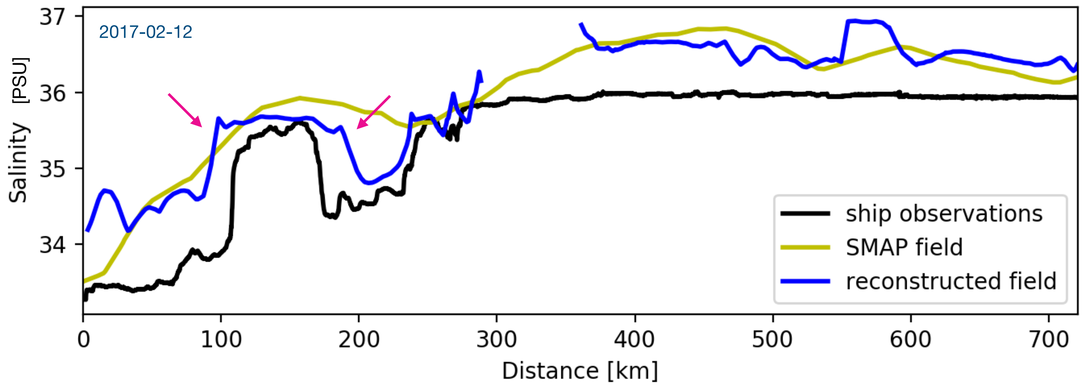


Fig. 3: In situ, SMAP and reconstructed SSS fields on 2017-02-12. SMAP and reconstructed fields are interpolated onto the ship position.

- Location and intensity of salinity fronts are similar in the reconstructed and ship SSS fields.

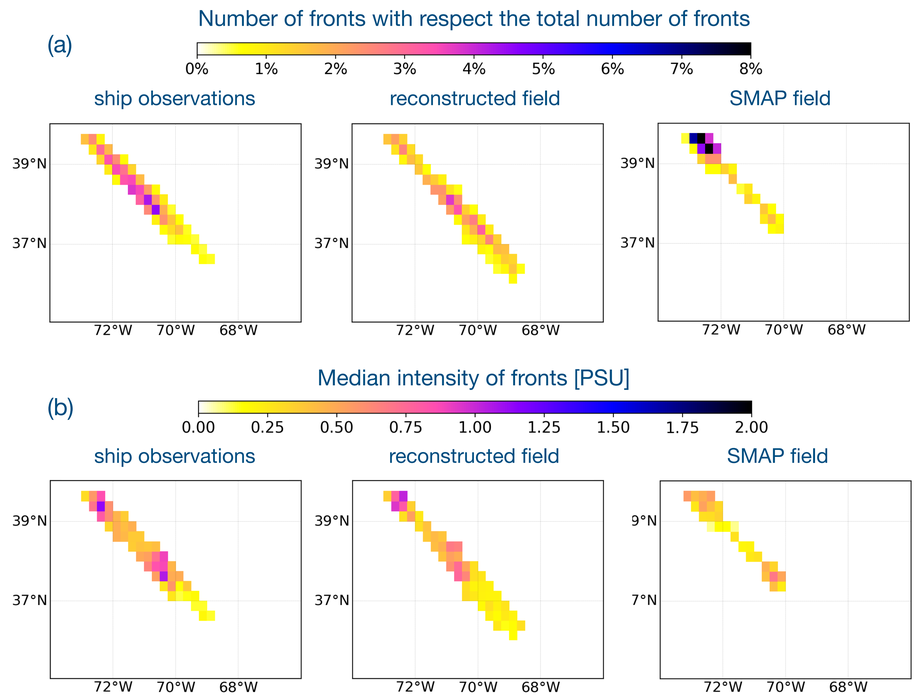
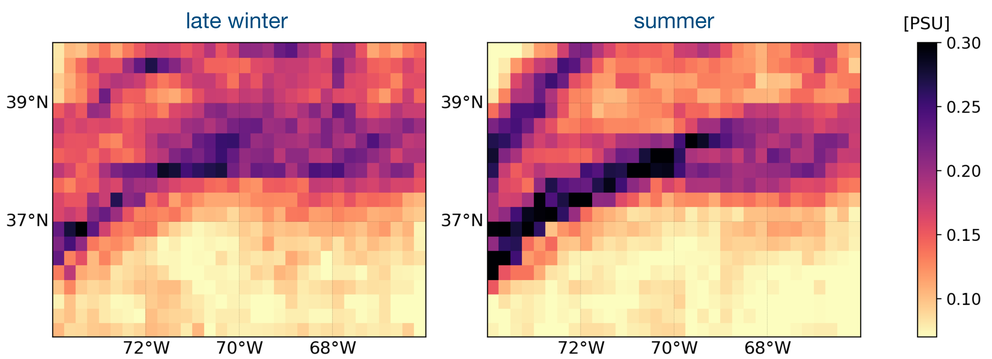


Fig. 4: (a) Number of fronts detected for each field along all the available transects of ship observations within bins of 0.25° x 0.25°. The number of fronts is normalized by the total number of fronts detected in each field. (b) Median of the intensity of the fronts detected in each bin.

Small-scale salinity variability enhanced in summer

- Lagrangian reconstruction applied to weekly SMAP observations to evaluate the small-scale salinity variability in the region analyzed.
- We infer the horizontal standard deviation within bins of different sizes, being the standard deviation representative of the salinity variability at scales shorter than the bin size.



- In summer, the northern part of the domain has higher small-scale salinity variability.
- This variability is enhanced due to higher gradients of SMAP SSS driven by an inflow of coastal fresher water from the Gulf of Maine (Geyer et al., 2004).

Fig. 5: Horizontal standard deviation of the reconstructed SSS field inferred within bins of 0.25° x 0.25° and averaged for late winter (FMA) and summer (JJA).

References

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Drushka et al., Global Patterns of Submesoscale Surface Salinity Variability, J. of Physical Oceanogr. (2019) DOI 10.1175/JPO-D-19-0018.1

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