Ocean small-scale fronts in the Northwestern Tropical Atlantic:

Assessment from the EUREC4A-OA/ATOMIC field experiment

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INTRODUCTION

Upper ocean fronts

Unveiled by very high-resolution models simulations & remotely sensed data. They are be suspected to be ubiquitous in the surface ocean

Provide a dynamical conduit which links the upper ocean with the interior[2] and the different interfaces: the MIZ and the MABL

Modify the ML charactericties through the vertical exchanges of buoyancy, heat, gases, nutrients…

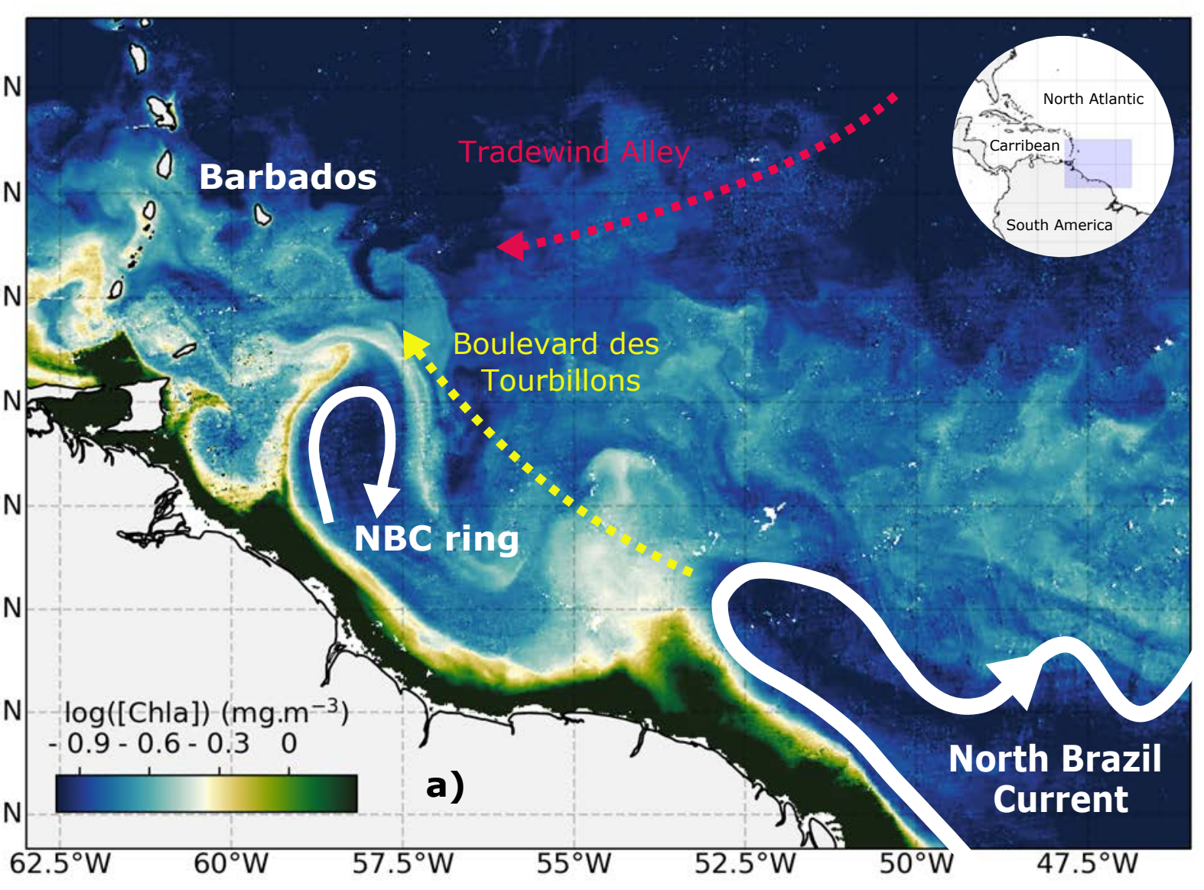
Small dimensions: sub (1 – 10 km) to mesoscale (10 – 100s km)[1]

Short duration (hours to months)

Their magnitude and distribution remain poorly documented

CONTEXT

Jan – Feb 2020: the EUREC4A-OA/ATOMIC campaign



features from different scales interacting

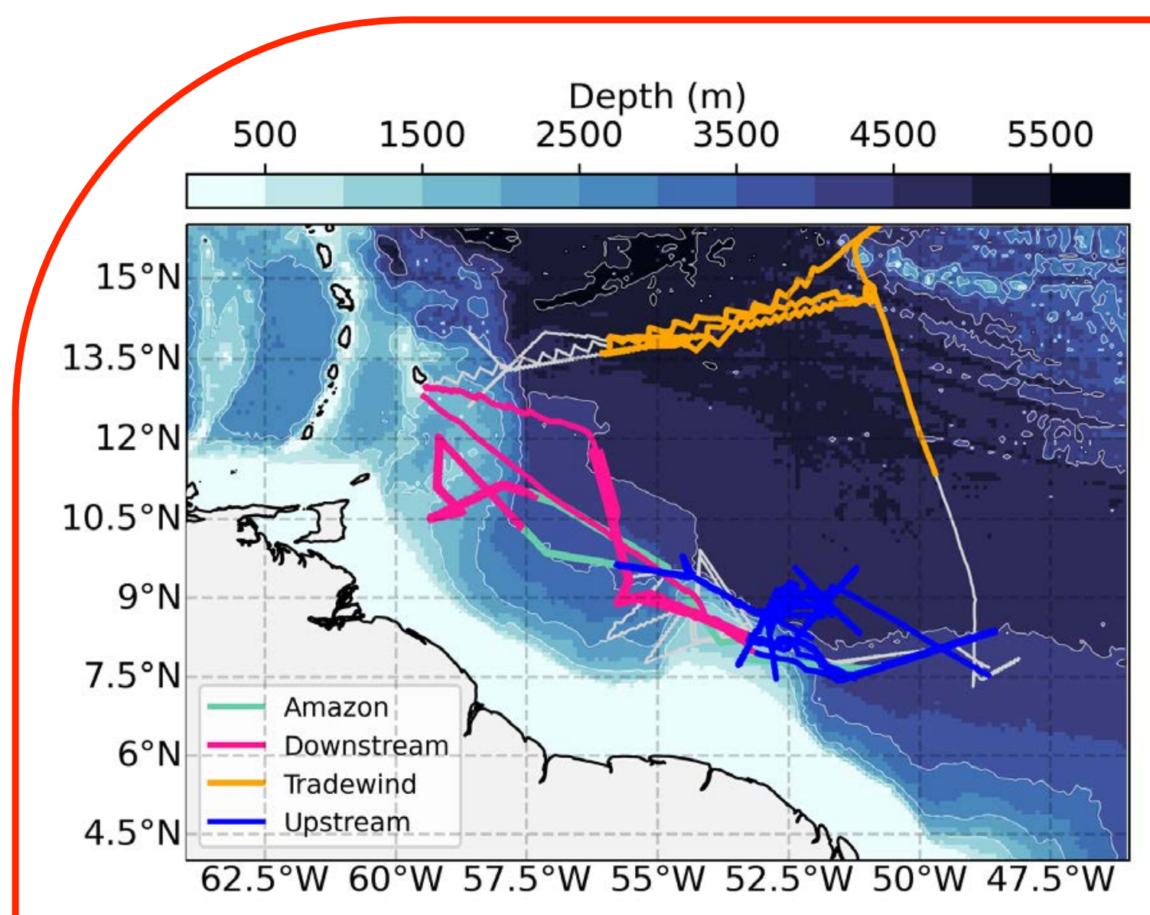
The Amazon plume

Mesoscale eddies (North Brazil Current rings)

Chla satellite map of 1st of February over the region of the EUREC4A-OA/ATOMIC campaign

- 120-km-wide freshwater plume advected northwestard with an extend of 100,000 km^2 after 14 days
- 2 NBC rings – named A1 and A2 - shed by the North Brazil Current (NBC) respectively in early February 2020 and late December 2019
- Fronts and filaments resulting from the stirring of the shelf waters and the plume by NBC rings

DATA



- 5 Saildrones (uncrewed wind-propelled platforms instrumented to measure the air-sea interface) were deployed
- 1-min frequency sampling resulting in a mean spatial resolution of 80 m
- SST and SSS measured at 0.5 m
- Trajectories divided in 4 regions: Amazon, Downstream, Tradewind, Upstream

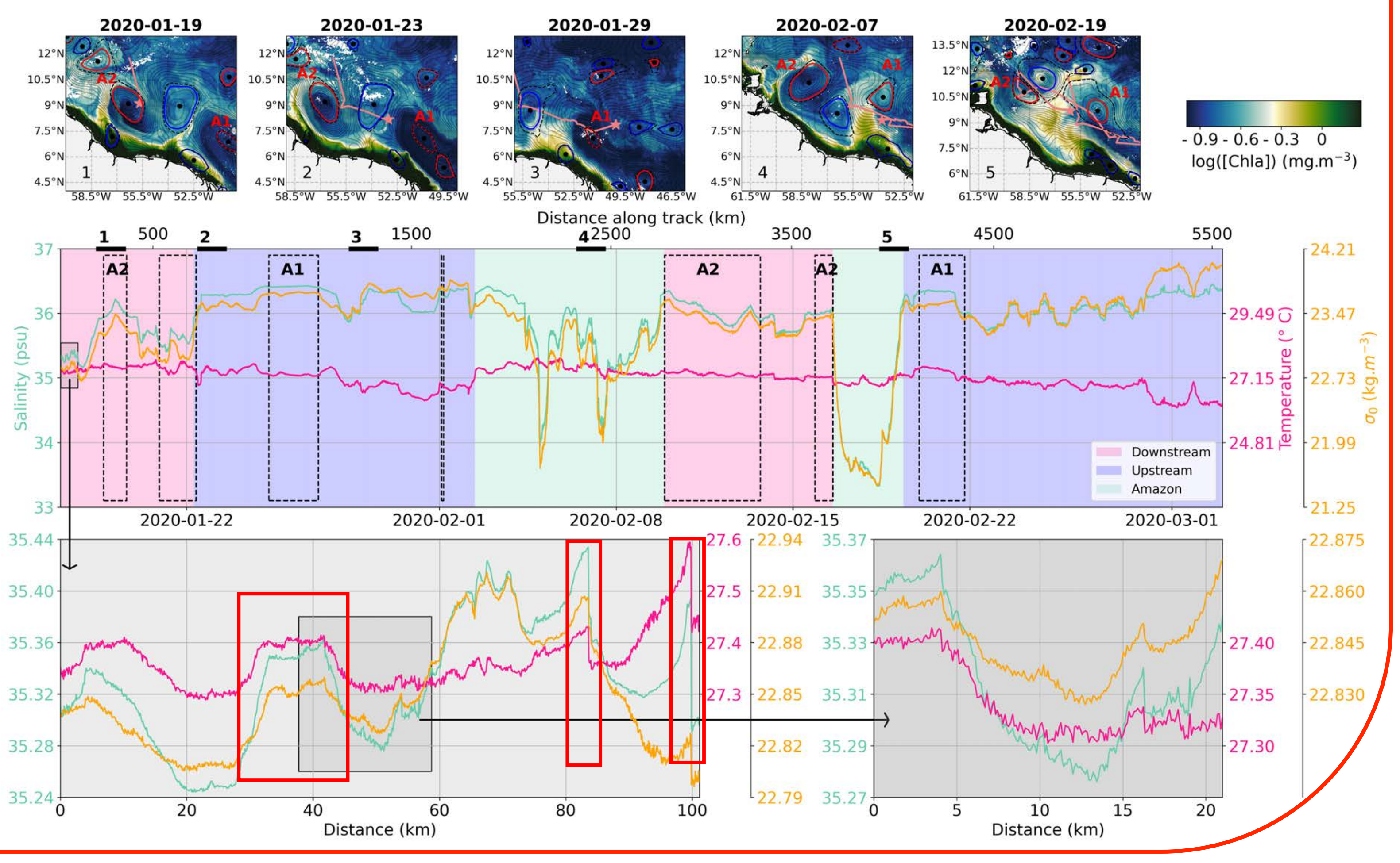
SST, SSS and density time series from one Saildrone

Strong thermohaline gradients occur at all scales

density is salinity driven at large scale

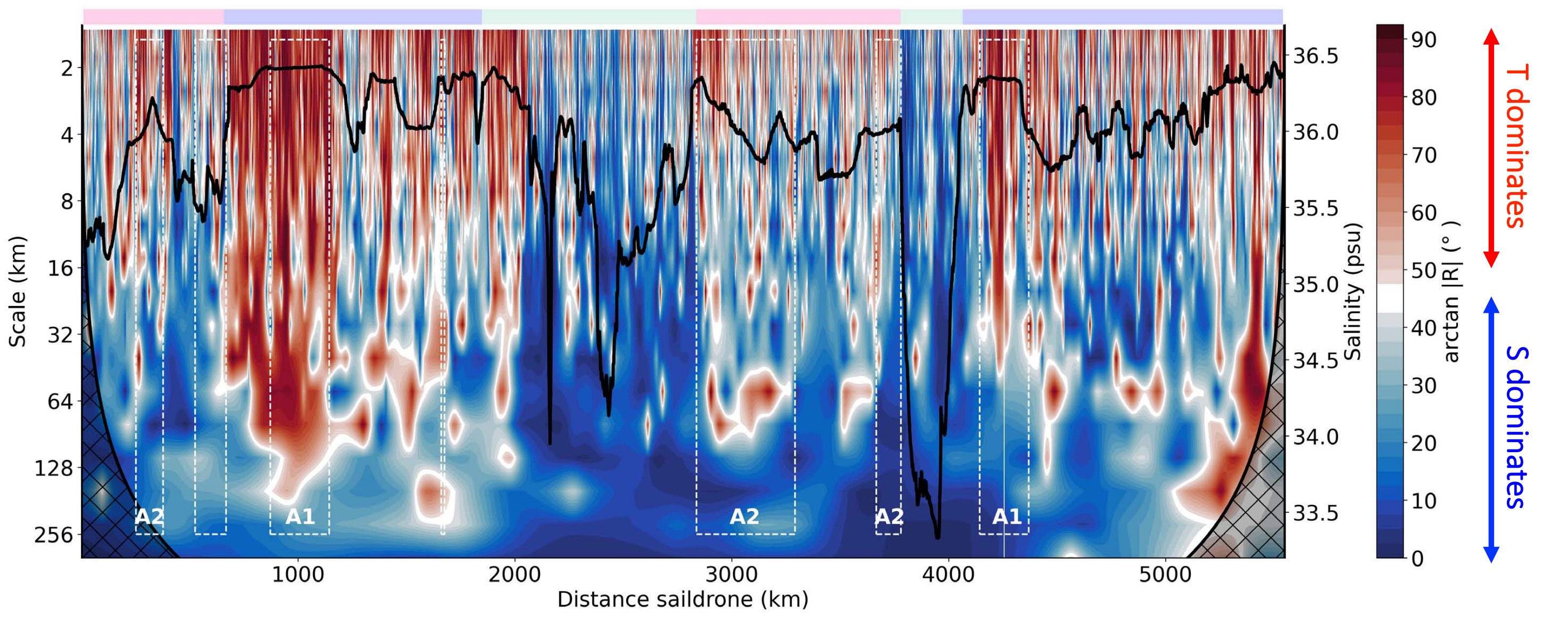
But temperature tend to compensate salinity at small-scale

Salinity & Temperature are density-scaled



FRONTS COMPENSATION[4,5]

Computation of the density ratio using wavelet coefficients :

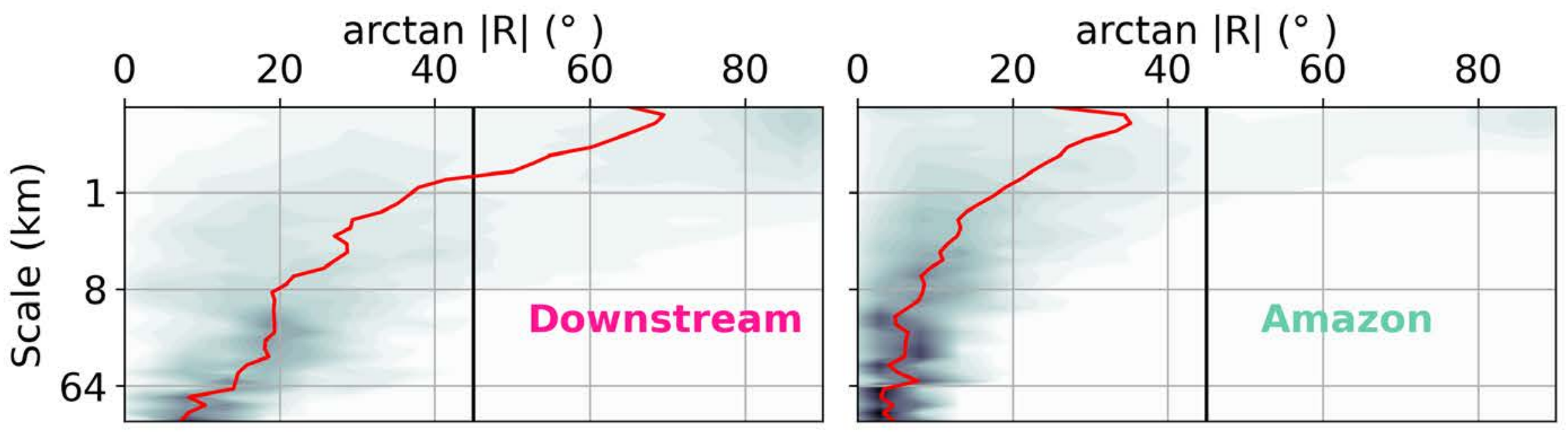


Wavelet location

Wavelet coefficient

$$R(x_n, k) = \frac{\alpha(x_n)\Delta T(x_n, k)}{\beta(x_n)\Delta S(x_n, k)}$$

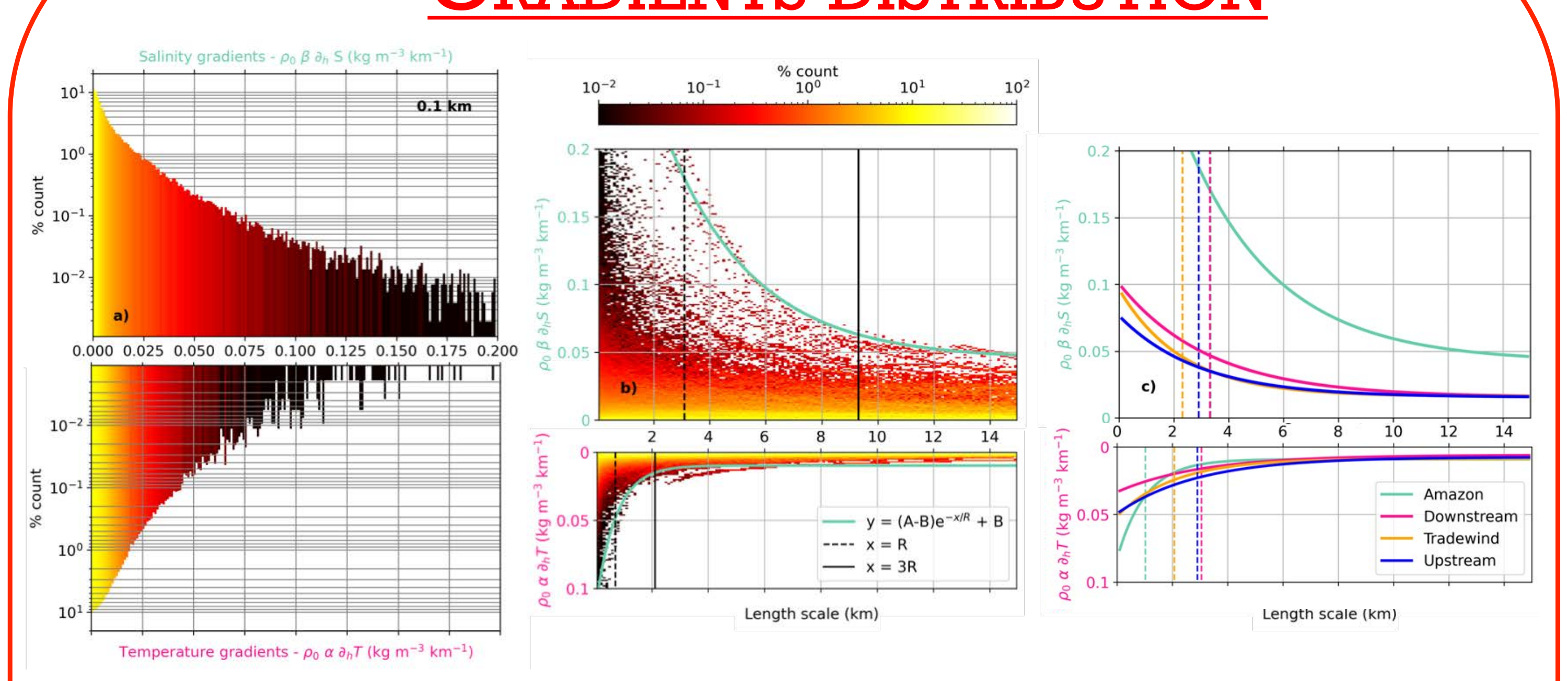
Wavelet scale



Bivariant histogram of arctan |R| for length scales from 0.16 to 140 km computed from the 20 % highest scaled coefficients

- Increasing T compensation at the submesoscale
- Strong salinity gradients remain uncompensated at small scales while weaker ones can result in any value of R, T and S being poorly correlated

GRADIENTS DISTRIBUTION[3]



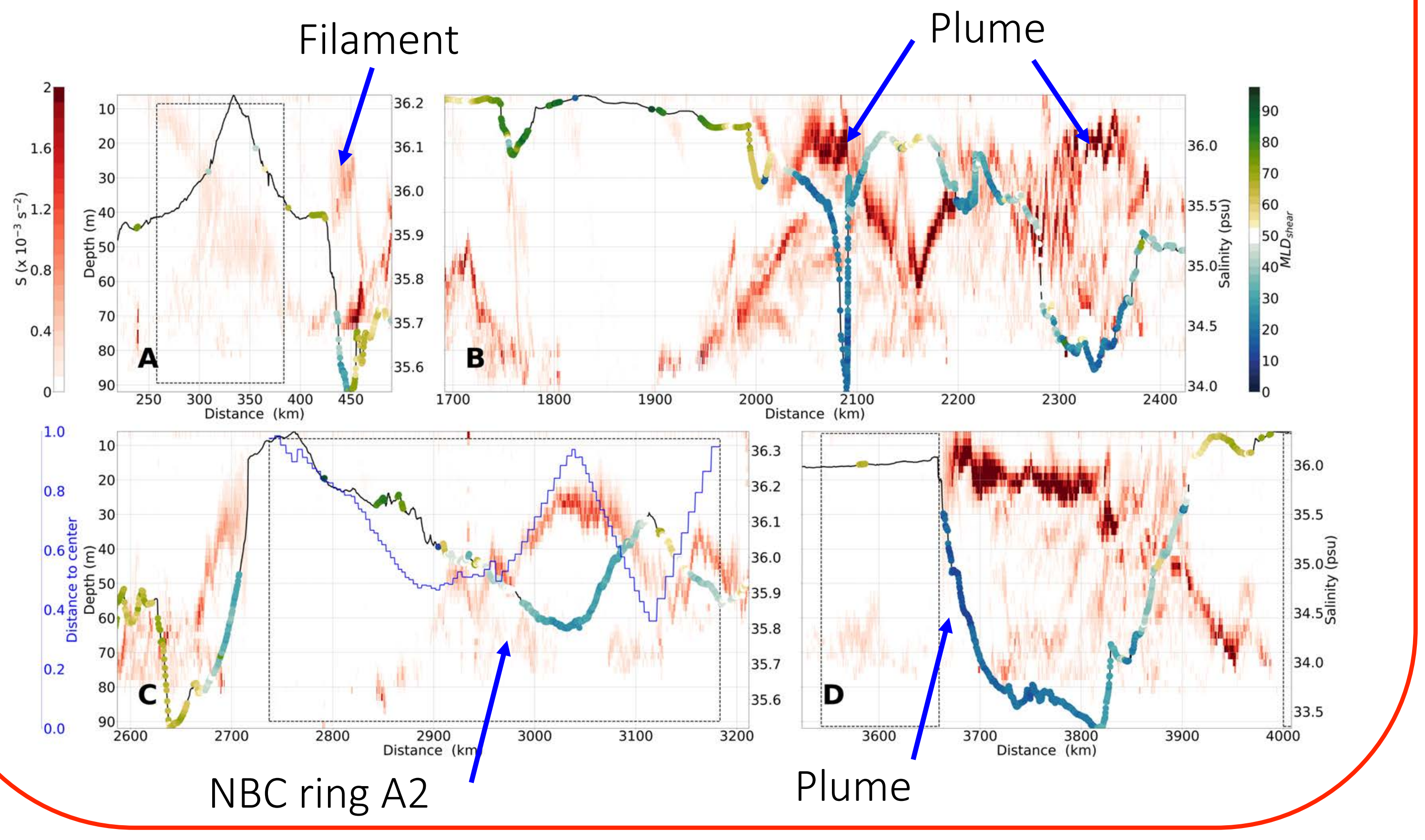
(a) S and T gradients histograms at 0.1 km, (b) S and T bivariant histograms for length scales from 0.1 to 15 km, (c) 99.9 – envelopes of the S and T bivariant histograms for the 4 regions

- Increasing gradients with decreasing length scale, reaching up to 1.41 kg m^{-3} km^{-1} for density at the smallest scale resolved
- The Amazon region stands out by strong salinity gradients at all scales.

VERTICAL SIGNATURE

Depth of maximum vertical shear as an estimate of the MLD

Fronts associated to the fresh water signal are coincident with a sharp increase of the maximum vertical shear level, related to a shallow MLD



CONCLUSION AND PERSPECTIVE

- Saildrones sampled a great diversity of scales, revealing very strong density gradients at the smallest scale resolved, in particular within the freshwater plume area
- If density is salinity-driven at large scale, we observe increasing T compensation at the submesoscale
- Strong salinity fronts are associated with the rise of the maximum vertical shear level, which indicates a shallower MLD
- How these fronts modify air-sea fluxes ?
- What types of instabilities drive the cascade of the freshwater content to smaller scales ?

REFERENCES

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