

Review of Napolitano et al. “Thermohaline gradients and frontal regimes in the northwestern Tropical Atlantic”

General comments:

The manuscript provides a thorough assessment of submesoscale frontal characteristics in the northwestern Tropical Atlantic, where the North Brazil Current interacts with the Amazon River freshwater plume.

Using surface observations from four saildrones, the authors compute horizontal velocity and buoyancy gradients within and outside the Amazon plume and assess the relative contributions of temperature and salinity in setting the strength of the density gradients. Density gradients are stronger at small scales and are dominated by salinity gradients within the plume region.

The saildrone observations are complemented by a high-resolution model, revealing the spatiotemporal variability of submesoscale fronts both within the plume region, driven by variability in the NBC and Amazon outflow, as well as outside the plume region driven by the seasonal mixed-layer cycle.

Overall, the manuscript is detailed and well-written. The combination of observations and a high-resolution model provides confidence in the model representation of surface fronts in this region, while also providing insights into the spatial and seasonal variability of submesoscale fronts that are difficult to obtain from observations alone. It makes a valuable contribution to our understanding of submesoscale variability in general, as well as the specific dynamics in the region.

The manuscript is of high quality and should be accepted following some very minor technical corrections. Most of the comments below are just suggestions or questions to consider.

Reviewer: Maya Jakes, University of Southampton

Specific comments:

1. You show the seasonal variability of submesoscale fronts very clearly in the model. What was the basis behind the choice of 2008 and 2009? Is this due to the availability of the model output? I am wondering how often the NBC and Amazon plume configuration match that of EUREC4A-OA? Did you consider doing an EOF analysis to assess the dominant configurations of the NBC and Amazon Plume (using model/satellite data)? Is it dominated by seasonal variability or is there also strong interannual/decadal variability?
2. Did you look at the depth extent of the submesoscale fronts in the model?
3. You compute the mean gradients across the four saildrone tracks. How much difference does it make if you use this approach compared to if you had along-track gradients from only one saildrone?

4. Do the assigned errors account for the angle at which the saildrones cross the fronts?
5. In the model analysis of 1D gradients, you use density differences along zonal transects. What difference does it make if you use meridional transects instead? Or 2D gradients?
6. What determines the location of the “submesoscale soup”? There is a large region between the plume edge and the “submesoscale soup” in Fig 8b with little to no small-scale fronts – why do you not get the same seasonal intensification of fronts here?

Technical corrections:

L2 – clarify *horizontal* scales

L5 – I found this sentence a bit confusing, maybe rephrase as something like "density gradients are reinforced or partially compensated by temperature-salinity variability."

L10 – clarify *seasonal* mixed-layer cycle

L12 – clarify *density-compensated* fronts

L18 – include more references in addition to Muller-Karger et al. 1998

L19 – Coles et al. 2013 as well as Flagg et al., 1986?

L39 – “we revisit density gradients observed at fine scales” Maybe another word for revisit? E.g. analyze / investigate

L46 – “hit the road” is a bit ambiguous. Maybe replace with “travel”?

L94 – “saildrone observations” rather than “saildrones observations”

L94 – “intensify” rather than “soar”?

L95 – Instead of “where more and more sharp fronts originate”, what about “where buoyancy frontal sharpness is greater” or “where more sharp buoyancy fronts are present”?

L100 – “latter” rather than “later”

L109 – “loss of synopticity” wording here is a bit confusing. Maybe delete and rephrase as “...interpreted with caution, since the effects...”?

L118 – “reinforce or partially cancel each other effect on density” rephrase as “partially compensate or reinforce the density gradients”?

L134 – “. And” – continuation of the previous sentence. Change to “... and ...”?

L145 – where does the buoyancy error = 7×10^{-6} value come from?

L150 – use italicized / math font for “f”. Also in equation 7.

Figure 3 caption – “driven by salinity (**blue**) or temperature (**red**)”

L184 – “probability density functions (pdfs)”

L203 – “intensify” rather than “soar”?

L208 - Sometimes plume is capitalised after 'Amazon', sometimes just P is capitalised and sometimes none of the letters are.

Figure 6 caption – “clockwise **from** $-\frac{\pi}{2}$ for frontogenesis...”

L288 – “mesoscale and submesoscale **motions**”

L296 – maybe quote the Tu values after “uncompensated front”

Figure 8b – The wavelike structures along the southeast part of the plume edge are interesting.

L315 – delete space before comma

Figure 10c caption – “compensation (orange) and reinforcement (green)”

L407 – text quotes 0.02, but caption quotes 0.01

410 – “appears”

414 – “**With** the region...”

419 – “budgets **of**”?

432 – “associated **with**”