

The paper applies wavenumber spectral analysis to compare SSH data from four altimetry missions—HY2B, Saral/AltiKa, Sentinel-3A, and SWOT. It evaluates their spectral characteristics and introduces a new method for global statistical analysis. A key focus is on SWOT's ability to resolve small-scale ocean variability, leveraging its finer spatial resolution. The study highlights the differences in spectral content among these missions and attempts to quantify global-scale variations using SWOT data by introducing a new parameter.

While the study presents a well-motivated analysis, the manuscript would benefit from clearer phrasing in several sections to improve readability and eliminate ambiguities. Additionally, certain methodological aspects require further justification, particularly regarding data preprocessing and resolution effects. I recommend that this manuscript be considered for publication, provided the authors address the following major concerns:

Major Comments

- The averaging method used to compute spectral slopes (Appendix A), which relies on a distance-weighted scheme, raises concerns about its statistical validity. A detailed justification of this approach, including examples and a discussion of the weight distributions, is necessary to ensure the robustness of the analysis. Additionally, A direct comparison with conventional approaches (e.g., standard averaging methods) is needed to show the advantages of its proposed methodology over standard spectral analysis techniques.
- The section "Global Analyses of Ocean Scale Changes" lacks clarity, primarily due to insufficient explanation of key methodological steps. The authors refer to Appendix B, which introduces spectral coherence methods without clearly linking them to the main analysis. The section does not explicitly explain how the proposed global-scale parameter (derived from mutual power spectra) captures ocean variability. The transition from Appendix B's coherence-based method to a global variability assessment is particularly vague.

Specific Comments

Introduction

I.28: "...sub-mesoscale activity can also reverse the cascade of energy from..."

I. 55: Xu et al. (2012) instead of Xu Y et al. (2012)

I. 71: "*Another altimeter*"

Which one?

I. 84: "*reciprocal power spectral analysis*"

The term “reciprocal power spectral density” isn't a standard term, better referring to cross spectral density.

Datasets and Methodology

I. 90-91: The explanation of how SWOT data is split into along-track components lacks details on the method used. Does this involve simple subsampling, or is interpolation applied?

I. 92: *From October to November 2023*

Does it mean October AND November?

I. 93-94: *“To compare [...] by SWOT’s KaRIn”*

The sentence structure could be improved to convey the intended meaning more effectively.

I. 103: “orbit data” rather than “orbit fix data”.

I. 104-108: There is some confusion in this section due to the repetition of sentences. Is the GDR corrected or uncorrected? What is the difference between a corrected and an uncorrected product? Additionally, is the SGDR corrected or uncorrected?

I. 116-119: The advantages of Ka-band in SARAL/AltiKa (lines 116–119) should be supported by relevant literature.

I. 118: There seems to be a repetition of the word “water”

A final period is missing between “data” and “The final...”.

Altair band: This seems to be a typo. It likely refers to the AltiKa Ka-band, which, if I'm not mistaken, operates exclusively in the Ka-band. Therefore, the phrase 'The final choice was...' may be unnecessary.

I. 119: Why were only cycles 175 and 176 selected for SARAL/AltiKa? Do these correspond to the October-November 2023 period?

I. 120: *“The Sentinel-3A (S3A) satellite carries the SRAL altimeter...”*

I would specify “...carries Synthetic Aperture Radar Altimeter (SRAL)...”

I. 127: As mentioned earlier, please specify why cycles 104 and 105 were selected.

I. 131: What are sub-stellar points?

I. 132: *“SWOT carries s Ka-band radar”*

Typo: 's' should be changed to 'a'.

I. 137: *“Selected data from SWOT’s ocean [...] are selected for this paper.”*

Remove the first “selected”

I. 140, 142, 144: replace “along-orbit” with “along-track”

I. 140-142: What kind of corrections are applied?? Clarifying this step is essential for reproducibility.

I. 149: “...*Fourier transforming it...*”

I would suggest to write instead: “performing a Fourier transform on it”

I.154: “*We calculated the SSH anomalous wavenumber power spectral density (PSD) for each mission...*”

This is unclear. Are the authors referring to the power spectrum of SSH anomalies?

I. 157: The phrase "departed from the previous method of averaging" is vague. What method did the authors adopt instead? The preprocessing steps for calculating the PSD in each $10^\circ \times 10^\circ$ box follow methods similar to Dufau et al. (2016).

However, instead of averaging all individual PSDs within a box (as done in previous methods), the authors suggest a different way to compute the average PSD for each box.

This section requires further clarification

I. 166: “... *is the 2 km sampling rate...*”

“resolution” instead of “rate”.

I. 169-170: “*For wavelengths below 25 km for the first three missions, the 1 Hz SSH error level was estimated by fitting a level to the spectrally flat noise levels present in the PSD maps (Figure 1).*”

This sentence is confusing. I assume Figure 1 presents the unbiased spectra (i.e., without the constant noise level), is that correct? If so, the sentence needs to be rephrased for clarity. I would also suggest adding the noise level to the plot, if possible, to visualize the intersection with the slope. Additionally, including references to Xu and Fu (2012) and Dufau et al. (2016) would be helpful.

I. 175: “...*by removing the estimated constant error level below ...*”

Remove “below”.

I. 176-178: “*Diverse methods for calculating the Power Spectral Density (PSD) [...] in the estimated PSD slope range*”

I agree but should not be here.

I. 179: “*Hence, for the first three conventional missions, we chose wavelengths in the range of 70-250 km*”.

Missing references: Dufau et al., 2016; Le Traon et al., 2008; Xu & Fu, 2011

I. 184-185: "Due to the presence of [...] etc (Boas et al., 2022)"

I believe this should not be a sentence on its own, but rather linked to the previous one for better coherence.

I. 185: "wavelength range" instead of "wavelength"

I. 186-188: The one-dimensional mesoscale resolution capability essentially represents the shortest wavelength detectable in along-track altimeter observations where the signal exceeds the noise, correct? Perhaps this sentence could be rephrased for clarity.

Global resolution capability of altimetry satellites

I. 207: "[...] theoretical predictions from SQG and GG theories."

Add a reference please.

I. 208-209: The authors should specify the figure number referenced in the cited paper.

I. 212: "[...] oblique pressure tide [...]"

Do the authors mean baroclinic instead of oblique?

I. 261: "satellite altimetry observes" instead of "satellites altimetry observed"

I. 226: "for one month" instead of "for the one month".

I. 227: "[...] results of previous studies."

Add references please.

I. 230: "northwest Pacific" instead of "Pacific northwest".

I. 239-241: "However, for the data from the period [...] potential error in one of the satellite's corrections"

Could the authors clarify this statement?

I. 243-244: How the authors explain the high-level noise pattern in the mid-north Atlantic for SWOT (Figure 3c)?

I. 256: Dufau et al. (216) instead of Dufau C et al. (2016)".

I. 269: "[...] where the peak slope occurs."

Would it be possible to include a plot to visually represent this statement?

I. 272: "Experiments have demonstrated..."

Add references

Global analyses of ocean-scale changes

I. 284: As I mentioned earlier, it would be better to refer to the cross-spectral density.

I. 288: Marks et al. (2016) instead of Marks K M et al (2016).

I. 290: Why 0.5? Add some details please.

I. 294: Western Boundary Currents

I. 297: northwest Indian Ocean current

I. 306: “*world’s ocean current regions*”

Remove “*world’s*”

Appendix B

I. 403-407: How are equations 5 and 6 linked? Is R the cross-correlation function and S the cross-spectral density (Fourier transform of the cross-correlation)? Also, in equation 6, is P equivalent to S? Please be careful with the notation. Additionally, could you define all the variables?

I. 408-409: “*The coherence function can judge the [...] cycle signals to infer resolution capability.*”

Already mentioned earlier, see I. 397-398.

Marks et al. (2016) instead of Marks K M et al (2016).

I. 417: Which kind of interpolation is performed? Linear?

Figures

Figure 1: The authors should specify whether these spectra are biased or unbiased.

Figures 2, 3 and 5c: The units are missing.

Figure A1: The legend mentions some orange points, but I cannot see them in the plot.

References

I. 481 and 499: The reference formatting is inconsistent.