

Ocean Sci. Discuss., referee comment RC1  
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## Comment on os-2022-8

Anonymous Referee #1

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Referee comment on "Assessing the capability of three different altimetry satellite missions to observe the Northern Current by using a high-resolution model" by Alice Carret et al., Ocean Sci. Discuss., <https://doi.org/10.5194/os-2022-8-RC1>, 2022

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### General Comments

The manuscript evaluates the ability of three altimeter missions (i.e. JASON2, SARAL/AltiKa, Sentinel-3A) data to capture the Northern Current sea level signature (in terms of SSH drop, NC width and distance to the coast) in the coastal ocean, using the high-regional model SYMPHONIE as a reference. Authors have previously assessed the model against High-Frequency (HF) radar and glider data. Findings show the importance of applying spatial filters to altimeter data before computing the geostrophic currents in order to obtain a better agreement with the model. Authors also conclude that the combined effects of instrumental improvements (that reduce the noise and the loss of coastal data), the long-term time series and the higher temporal resolution are essential to enhance coastal features observability.

The manuscript could be better structured in general terms to faithfully reflect quality research, making it more readable, cohesive and concise. On the one hand, I did regret the lack of detail in the section describing the methodology and the lack of a specific section with results and discussion. On the other hand, I felt that there was some unnecessary repetition of the three NC signature diagnostics (e.g. mean NC core location; width and distance to the coast) and of the recent progress made on both altimetry technologies and processing techniques.

Since the ability of each altimeter mission to observe the coastal features (e.g. Northern Current) was expected to be also investigated, I would recommend to include a detailed discussion on how the latest advances in sensors (e.g. in terms of spatial resolution, data accuracy, ionosphere effects, data noise, etc.) and data processing have contributed to improve it.

In addition, considering that the High Frequency Radars (HFR) are emerging as a valuable

asset of coastal observing systems, being able to monitor surface currents at unprecedented spatio-temporal scales over wide coastal areas, I think it will be worth it to highlight the benefits of using high-resolution models (instead of HFRs measurements) as a reference (i.e. ground truth) to assess the altimeter data in coastal areas.

It is obvious that substantial effort has been put in this research and I am convinced that this study could help the coastal altimetry community to gain a better understanding of the current performance, limitations and further steps to extend the capabilities of current altimeters closer to the coastal zone.

Therefore, I would strongly encourage authors to resubmit their manuscript after carefully considering all comments below:

### **Specific comments**

- **Title:** Authors are invited to consider revising it to clearly reflect the content, with as many significant terms as possible: i) including the use of the high-resolution model as a reference for assessing the altimetry data, in order to highlight the novelty of the methodological study and; ii) specifically mentioning the particular coastal circulation feature analyzed in the study, the so-called Northern Current.
  - Suggestion 1: "Assessment of the Northern Current sea level signature observed by three altimetry satellite missions using a high-resolution model as a reference"
  - Suggestion 2: "Comparison of JASON-2, SARAL/AltiKa and Sentinel-3 data with a high-resolution model to assess their capability to observe the Northern Current"
  - Suggestion 3: "Assessing the capability three different altimetry satellite missions to observe the Northern Current by using a high-resolution model"
- **Abstract:** could describe in a more concise way the motive and objective of the research, the methodology used, the main findings and the conclusions.
  - The main objective of the study should be clarified (particularly from L18-L19)
  - Avoid the use of acronyms (e.g. HF, LRM, SAR), unless they are previously defined.
  - Avoid unnecessary details of the methodology in the abstract (L26)
  - Please, double check all values (L28-L42) since some inconsistencies have been found along the manuscript (e.g. 50-, 30- and 40-km cutoff wavelengths would probably be 60-, 30- and 40/50-km, as concluded in section 4;  $18 \pm 4$  km would probably be  $18 \pm 9$  km, etc.)
- **Introduction:**
  - Provides an overview of the current efforts that have been made to extend the capability of the altimeters closer to the coastal zone. However, it is recommended the addition of further details about the emerging altimetry technologies, sensors and data processing techniques aiming to address this challenge for satellite altimetry observations.
  - Provides a complete description of the main characteristics and seasonal variability of the Northern Current. Authors are encouraged to highlight the limitations of prior research studies addressing the contribution of along-track satellite altimetry to study the NC variability to help lay a foundation for understanding the research problem investigated by the authors.
- **The datasets and the methodology** are partially outlined. Further details about data

processing, data availability and data quality procedures are required. Additionally, the methodology used to validate the altimetry data vs. the model is missing in this section, being partially detailed in section 3 (L321-336) and in sections 1 (L383-410) and 4.2 (L466-483) for both spatial unfiltered and filtered data comparison, respectively. Authors should consider to:

- Replace the section 2 title with "Data and methods"
  - Add a completed description of the section 2, including a paragraph explaining that: "The different observing platforms (i.e. HFR, gliders and altimeter missions) and the high-resolution model are described in sections 2.1 and 2.2, respectively, while the model assessment methodology versus HF radar and glider data is detailed in section 2.3". The description of the methodology to validate the altimetry data by using the model as a reference could perhaps be included in this section too.
  - Clearly specify the post-processing steps applied to be able to compare the HFR velocities with altimeter geostrophic velocities in section 2.1a (e.g. filter out high frequency signals; temporal average; interpolation; etc.). HFR data quality control procedures and data availability (e.g. URL, DOI) should be included.
  - Go into detail on how the improvements in altimeters (section 2.1c) results in more accurate measurements, leading to a better characterization of coastal processes. Authors are requested to provide further information in terms of better vertical resolution (due to the enhancement of the bandwidth); improvement of the spatial resolution (thanks to the Ka-band smaller footprint); less affection of the ionosphere (lower for Ka-band); impact of track angles orientation; etc.
  - Include and cite prior SYMPHONIE model assessment studies and error estimations of surface currents to further demonstrate its ability to reproduce the main characteristics of the circulation in the study area and its variability (e.g. based on the results obtained by Estournel et al., 2003) to reinforce its role as ground truth (e.g. reference).
  - Please, add an additional Table showing the quantitative assessment based on statistics (e.g. average and standard deviations) of the different NC signature diagnostics (i.e. NC maximum amplitude, NC core location, NC width) provided by HF radars and glider Nice-Calvi transect and compared to the SYMPHONIE model, similar to Table 2.
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- **Signature of the NC on sea level.**
    - Authors are encouraged to provide further information or reference(s) for the selected criteria used to define the width of the NC (i.e. length of the section around the NC core).
    - It might be worth considering the description of the extraordinary event in August 2013, which led to the blocking of the NC flow (as mentioned in L359-365), in order to prove the model reliability for describing both, average and extraordinary NC events.
  - **Observability of the NC in altimetry data**
    - I would suggest a slight rewording of the section 4 for clarity: 'In this section a quantitative assessment of the NC sea level signature (in terms of SSH drop, NC width and distance to the coast) is performed for the three altimeter missions and the reference model. We consider both unfiltered and filtered 1 Hz SLA data for the computation of geostrophic velocities in sections 4.1 and 4.2, respectively, to analyze the importance of applying spatial filters to altimeter data in order to obtain a better agreement with the model'.
  - **Summary and Conclusion**
    - Results do not sufficient support the interpretations and conclusions included in this section.
    - A previous detailed discussion on how the latest advances in sensors (e.g. in terms

of spatial resolution, data accuracy, ionosphere effects, data noise, etc.) and data processing have contributed to improve the observability of the coastal features is required to be able to include the sentence between L536-L537 in this section.

▪ **References**

- Review the reference list; some of the references included (e.g. Borrione) are missing in the text.
- Please, wrap the text between L685-L750

▪ **Tables and Figures:**

- As a general comment for the entire section: Please, clearly specify the variable which is being shown in the figures (e.g. geostrophic velocity, surface current velocity, eastward -zonal- or northward -meridional- component of the current) as well as the time period used to calculate the average values.
- Table 1: Please, include the sampled used (as mentioned in section 4) and the global SSH RMS for each mission (as included in section 3).
- Table 2: add a 4<sup>th</sup> column including the dates of the analyzed period for each mission (as included in section 4).
- Table 2 – caption: include “Northern Current SSH signature based on averaged SSH drop, width and distance to the coast computed for...”
- Table 3: Please, add further details for every datasets in the first column (e.g. raw or unfiltered altimetry data; X-km cutoff wavelength for altimetry data), add the units in the column header instead of in every row.
- Fig. 1: Please, add an inset map of the NWMed (similar domain as in Fig 2. e) to provide a regional reference and indicate by a black square the extent of the main map (i.e. the one currently shown). Please, include basic geographic features mentioned in the manuscript (e.g. Toulon, Nice, Calvi, Gulf of Lion, Ligurian Sea, Balearic Islands, Mediterranean Sea, France, Spain, etc.) for helping readers to locate the area discussed in the text.
- Fig. 1 – caption: “Map of the NW Mediterranean study area, with inset map showing the location of the main map (outlined by a black box). ...Both maps contain labels to geographic features mentioned in the text...”. Please, describe the acronyms (e.g. NC=Northern Current; BC=Balearic Current, etc.)
- Fig. 2: a) Please, zoom in the map to allow the visualization of the current vectors and add the location of the HFR antennas and Toulon; b), c), d) draw altimetry tracks with dashed lines, with the exception of the track used in the study (to be highlighted in bold).
- Fig. 2- caption: Please, remove blank spaces before the semi-colons. Consider to: replace “Amplitude and vectors of mean surface currents” with “Mean surface current velocity map”; add the period of the HFR temporal average; replace “HF radars region” with “HF radars coverage area”; add “Nice-Calvi glider transect”; replace “Mean surface currents from the SYMPHONIE” with “Mean surface current intensity from the SYMPHONIE”, since the map only shows the current speed.
- Fig. 3: a & b) Please, set the same maximum and minimum values in both OY axes. c & d) Please, use the same colorbar limits for all the Hovmöller diagrams. Please, consider to replace the jet colormap in the bottom panels with a blue-white-red colormap such that zero is always color-coded in white to better highlight the differences between the model and the HFR or the glider data. Please, include the number of the month for each year (or the name of the seasons) in the OX axis to better identify the seasonal variability.
- Fig. 3- caption: Please add the meaning of the green bars (i.e. standard deviation for the satellite data) and replace “Time space diagrams” with “Hovmöller diagrams”. Please remove “The distance is referenced to the coast”, since any distance is provided in the figure.
- Fig. 4: Please, remove a & b panels (for the whole region) and keep c & d in the figure. Altimetry data over the HFR footprint area should be highlighted, e.g. increasing the size of the dots. If the authors decide to keep a & b panels, please, use the same colorbar limits in all panels.

- Fig. 5: a) It is not clear which is the difference with Fig. 3a. Is the mean zonal current velocity? Please, clarify it. C-bottom panel) Please, include the gridlines in the time series and include the number of the month for each year (or the name of the seasons).
- Fig. 5-caption: Please, include the meaning of the vertical dashed lines, horizontal grid lines and arrows shown in the a & b panels, as mentioned in L339-L341.
- Fig. 6 – caption. Please, replace “The blue envelope and green bars represent the standard deviation at each point” with “The blue envelope and green bars represent the standard deviation at each point for the model and the satellite data, respectively” .
- Fig. 7 – caption. Please, replace “Time space diagrams” with “Hovmöller diagrams”
- Fig 8 – 10. Please, consider to plot the altimetry distributions bars with light blue color for improving the visualization in the overlapping area.

### **Minor corrections/suggestions**

These minor revisions, listed below, will hopefully improve the quality of the manuscript before consideration of publication.

- Paper needs work in unifying the text (e.g. HF radars, radars; NC characteristics, diagnostics). As different types of radar technologies are mentioned in the manuscript, please, clearly specify if radars are HF, SAR, etc.
- L14. Add ‘surface’ before ‘ocean circulation’.
- L19. Add ‘surface’ before ‘coastal circulation’
- L20-L27. I would suggest a slight rewording for clarity ‘In this methodological study we assess the ability of three altimeter missions (i.e. JASON2, SARAL/AltiKa, Sentinel-3A) data to capture the Northern Current sea level signature in the coastal ocean, using a previously validated high-regional model as a reference. The impact of the recent progress made on both altimetry sensors and data processing on the observation of the NC is also analyzed’. Or something like that.
- L47. Remove “...” before the parenthesis.
- L55. Add ‘LRM (low-resolution mode)’ after ‘the Ka-band’.
- L90-L99. Rewrite the paragraph to make the main aim of the study and the successive steps given to apply the methodology clearer.
- L102. Remove ‘again’.
- L107. Include a reference describing the MOOSE. Tintoré et al., 2019 could perhaps be included.
- L116. Please double check the transport values. A maximal transport of 1.6 Sv in December is mentioned by Alberola et al., (1995).
- L120. Please, double check the NC width information. Following the reference given, the NC width is > 30 km with a well-defined episode of narrowing (< 20 km) from late January to mid-March.
- L135. Please, consider to include also in the ‘area south of Toulon’ (i.e. HF radar coverage area).
- L155. Add ‘HF’ before ‘radars’.
- L156. Add ‘to get rid of high-frequency processes not compatible with the hypothesis of geostrophy’ after ‘oscillations’.
- L179. Remove ‘(Synthetic Aperture Radar)’ after ‘SAR’ since it has already been mentioned above.

- L193. Replace 'X-TRACK' with 'X-TRACK, Along track Sea Level Anomalies (Version 1.02 - 2017 - DOI: 10.6096/CTOH\_X-TRACK\_2017\_02).
- L202. Replace '(MDT, Rio et al., 2014)' with 'SMDT-MED-2014, developed by Rio et al., 2014' and further explain that the sum of the MDT and the SLA produces the absolute dynamic topography (ADT), from which the absolute geostrophic velocity is derived using the geostrophic equation (Eq. 1).
- L207-210. I would suggest a slight rewording for clarity 'Both, unfiltered and filtered 1Hz SLA data have been considered for the computation of geostrophic velocities in sections 4.1 and 4.2, respectively'
- L219. Replace ';it is described' with ', as described'
- L228. Citation to the model ECMWF (European Centre for Medium-Range Weather Forecasts) is missing. Please, add the corresponding reference.
- L234. Replace 'Simulation validation' with 'SYMPHONIE model assessment'.
- L238-239. I would suggest a light rewording for clarity 'The model performance to represent the NC signal in the velocity field is assessed quantitatively (i.e. time-average and standard deviation) and the NC variability is evaluated qualitatively (Hovmöller diagrams)'
- L251. Add 'HF' before 'radars'.
- L252. Remove blank space before 'NC core'.
- L260. Replace 'time space diagrams' with 'Hovmöller diagrams'
- L273. Replace 'more differences' with 'higher differences'
- L273. Add 'HF' before 'radars'.
- L279. Replace 'time space diagrams' with 'Hovmöller diagrams'
- L280-L281. Please, double check. This consideration ('...misplaced current in the model...') seems to be inconsistent with the sentence above (L277: 'The NC is thus well located in the simulation...')
- L294-L297. Rearrange the paragraph considering the suggested changes in Fig. 4 (above)
- L308. Replace 'weaker' with 'lower'.
- L310. Replace 'don't' with 'do not'
- L321. Please, consider to include also in the 'area south of Toulon' (i.e. HF radar coverage area)
- L333. Please, include reference(s) for the selected criteria used to define the width of the NC
- L335. Replace 'defining' with 'considered as'
- L339-L341. Move this information to the caption of the Fig.5, as requested above.
- L355. Add some references after 'Previous studies', as Alberola et al., 1995.
- L366. Replace 'rms' with 'RMS'
- L369-370. Rewrite this paragraph, please.
- L389. Replace 'using the geostrophic equation' with 'using Eq. 1'
- L395-L401. I would suggest a light rewording for clarity 'For Jason-2 and SARAL missions, periods were selected based on the joint availability of both, observations and model outcomes (see in Table 2). For Sentinel-3, the matching period was very short, so thus the full data availability periods for observations and model were considered.'
- L410. Please include '(see Table 1)' if the previous suggestions for Table 1 have been considered by the authors.
- L424-426. Please, notice that this result (i.e. lower current variability in the model near the coast) is similar to the one for section 2.3 (L255-257), when the model was compared vs. HF radar.
- L461. Replace 'Note also that the NC is better (almost entirely) resolved in Sentinel-3, compared to Jason-2 and SARAL' with 'Note that Sentinel-3 data better matches the model outcomes in two (i.e. NC width and core location) of the three analyzed diagnostics, while SARAL is closer to the model estimation of the SSH drop'
- L466. Remove 'an operation that strongly...'
- L471. Replace 'time space diagrams' with 'Hovmöller diagrams'
- L473. Please, specify the reason for clarity.

- L485. Remove blank space before 'the model current...'
- L511. Unit split across lines.
- L533. Add 'glider' after (in situ)
- L540. Please, double check the values (same comment as in the abstract).
- L542. This sentence ('In winter...NV width also tends to diminish') is not consistent with the results found in this work (see L355)
- L543-L545 and L565-L569. please move these paragraphs to the respective sections where the results are shown and discussed.
- L546. 'Larger or lower' the temporal resolution?
- L550. Please, double check the values. As mentioned in section 4.1, Jason 2 and SARAL 1 Hz-data stop at 8 and 16 km to the coast, respectively.
- L553. Replace 'too high' with 'overestimated'
- L561. Please, double check this conclusion. As mentioned in section 4.1, Sentinel-3 seems to be the mission that captures the NC almost entirely (L447).