Assessment of the observability of coastal currents in LRM and SAR altimetry observations: a north-western Mediterranean Sea case study

General comments:

The paper deals with an original method to evaluate the ability of altimetry to catch the main features of a coastal slope current having a space scale in the range of few ten kilometres. A validated numerical modelling is used to fill the gap in terms of space and time co-localisation between in situ measurement and altimetric tracks. The method is innovative and worthy.

Page 3, observability is defined as the condition that the observed processes have a sea level signature and spatial-temporal scales larger than the altimeter resolution. For the north-western Mediterranean Sea, the objective is therefore to check whether altimetry is capable of capturing the observed behaviour of the North Current (mean characteristics, trend, seasonal variability, higher frequency variability of the order of 2 to 15 days, etc.).

Unfortunately, the paper fails to reach this goal and suffer of weaknesses and is not suitable for pulication as is. It should be rejected or strongly revised before any publication.

1) The paper only considers the mean characteristics of the North Current (NC), and the variability is discussed only in terms of standard deviation without distinguishing between measurement noise and physical variability. Of course, the mesoscale perturbations of the NC remain out of the scope as the revisiting period of satellite is too coarse, but one expected at least a discussion about the observability of the seasonal variability. The figure 5.c suggest strongly a comparison with altimetric observations that is not achieved.

Reply: Thanks for this comment. In order to discuss this point we have added hovmöller diagrams at the end of the paper representing the currents after the optimal filtering we found thanks to the histograms. We have commented these figures in the text by focusing on the seasonal variability shown by the hovmöller diagrams but also on some strong events that occurred over the altimetry periods. For Jason 2 and SARAL we have discussed the similarity with the model reference but not for Sentinel-3 as the period is not the same. We have focused on the current amplitude, its width and the location of the NC core.

2) You use the MDT of Rio et al (2014) which reproduces the NC mean slope rather well. One would thus like to know the respective contribution of the SLA and of the MTD to the altimetry derived characteristics of the NC. That is, what is the benefit of adding an SLA to derive the mean characteristics over the concerned time period? Using the longest common available window between altimetric data and numerical modelling prevent any investigation in term of variability and lead only to global statistics.

Reply: We thank the reviewer for this comment. The Mediterranean Sea benefits from a

good quality MDT. However it is not the case elsewhere. Adding the SLA enables to investigate the variability, and/or the mean over another period than the one used to compute the MDT, along the tracks. The respective contribution of SLA and MDT is especially visible when deriving the currents as we represent the mean of individual along-track velocity profiles. To better indicate this contribution we have added the current derived from the MDT in black on Figure 6. We have also developed the text to answer this question by adding the following paragraph: “As we focus on the mean SSH over a long period the results are close to the MDT along the section. However the contribution of the SLA is given by the variability indicated by the error bars. The current obtained from the average of individual current profiles compared to the one derived from the MDT also shows the impact of focusing on the SLA.”

3) I don’t agree with your chapter 4.2 and associated figures 8,9,10 (maybe I don’t understand correctly your methodology?). I guess (it is not written explicitly) you filtered -spatially- only the SLAs before adding the MDT and then derive the current trough geostrophy using your relation (1). Using a low-pass filter with a cut-off wavelength of 60, 50 or even 30 km will remove almost all traces of the Northern Current since it has a horizontal cross-sectional scale of about 20 km. Consequently, the figures 8,9,10 mainly show the distribution of the current derived from the MDT signal appearing when removing progressively the part of NC in the SLA signal. The MDT is more or less in aggreement with the numerical modelling.

Reply: The reviewer is right. We have filtered the SLAs before adding the MDT and then derived the current. We have added this explicitly in the text in section 2.1.c: “Before adding the MDT and computing current estimates, the SLA may be filtered in the along track direction in order to remove the remaining altimetry noise”. We have also rewritten the methodology used in section 4.2 in order to clarify it and better explain our objectives.

The histograms represent the variability of the current obtained after the filtering of the data. The current derived from the MDT only does not reproduce the model distribution. Please find below the histogram of the model velocities along the Jason 2 track with the MDT velocities superimposed. To compare both products we repeated these values as many times as the satellite passed over the track.

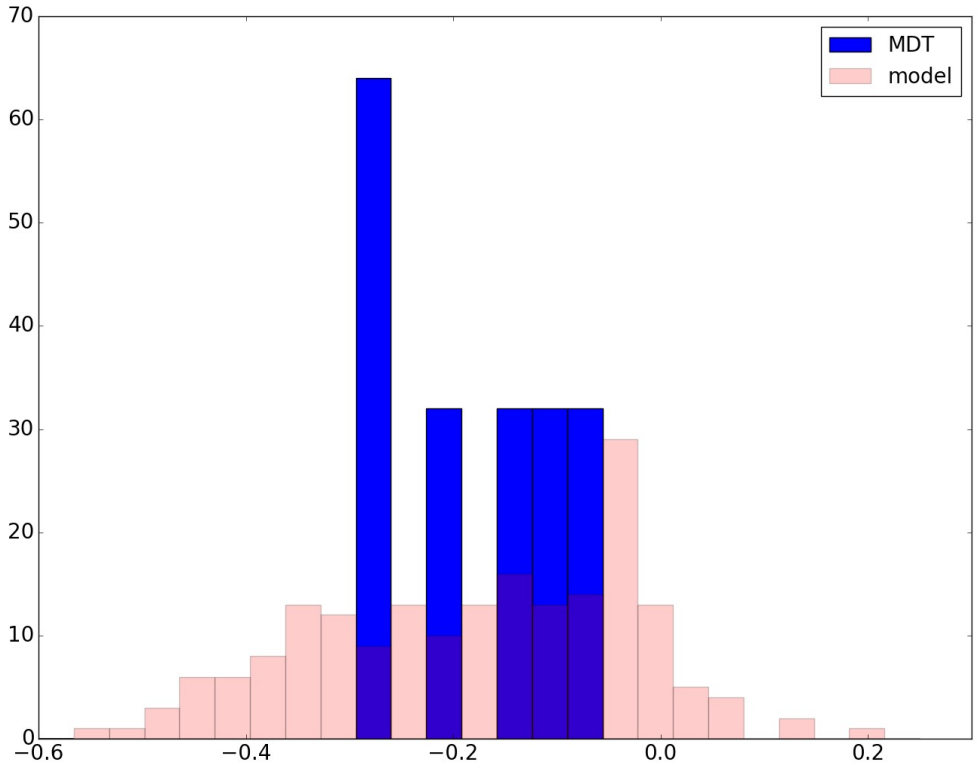

Figure 1: Distribution of the current values along the Jason 2 track 222 over the first 60 km to the coast for the model (in pink) and the current derived from the MDT (in blue)

The currents derived from the MDT show a peak of strong values at about -0.3 m/s. This is not the case for the model as it shows the current variability with some values going until -0.6 m/s. To support the assumption that the histograms represent the variability of the Northern Current we have plotted the results obtained for winter and summer months. You can find these figures below. We do not add these results in the paper however we comment on the variability shown by the histograms in the text.

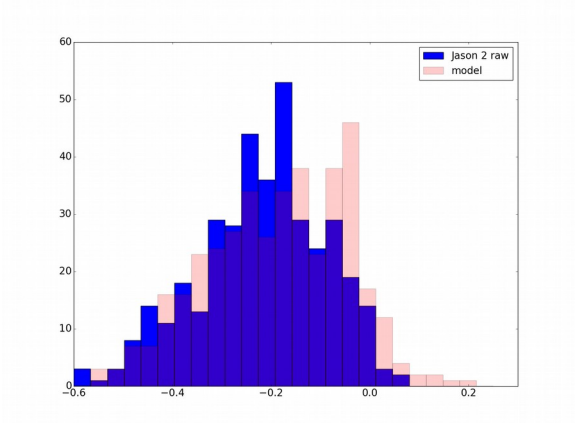

Figure 2: Distribution of the current values along the Jason 2 track 222 over the first 60 km to the coast for low-passed filtered altimetry data with a cutoff frequency of 60 km (in blue) and the model (in pink) for the winter months (January, February, March)

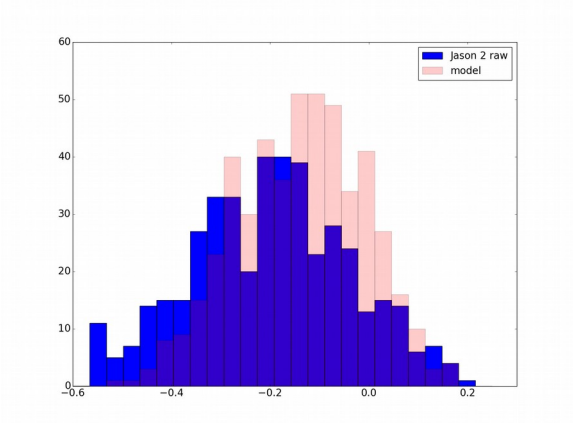

Figure 3: Distribution of the current values along the Jason 2 track 222 over the first 60 km to the coast for low-passed filtered altimetry data with a cutoff frequency of 60 km (in blue) and the model (in pink) for the summer months (July, August, September)

The methodology used reduces the ambition of the study. The benefit of the different altimetric signal (Jason,Saral,Sentinel) is not fully demonstrated as we don't know the SLA's own contribution to the current mean and as the physical variability is mixed with the noise. May I suggest to do at least seasonal means in order to investigate if the SLA is able to catch the seasonal variation of the NC. It seems possible on longer series.

Reply: We hope that the addition of the figures and text previously described allow to answer this comment. We have discussed the SLA's contribution in section 4.1 and added a paragraph in section 4.2 to investigate the current variability with the hovmöller diagrams. These hovmöller diagrams also enable to visualize to which extent the NC is captured: almost entirely for Sentinel-3 whereas it is not completely resolved for Jason 2. SARAL current is also less noisy compared to the other missions.

Detailed comments:

Lines 122-128: You refer to the variability of the NC without indicating a time scale or length. It might be useful for the reader to have this information in relation to the frequency of the model outputs and the satellite repetition. In the literatures, two periods dominate 10-20 days and 2-6 days.

Reply: Thanks for this suggestion. We have added in the text the time scales in that paragraph.

Line 210: You should explain why you are or are not applying filtering.

Reply: We have added "To investigate the data noise issue, both unfiltered and filtered SLA have been considered for the computation of geostrophic velocities in sections 4.1 and 4.2 respectively"

Line 250: amplitude is perhaps not the exact terms as it refers here to the mean value of the NC core velocity.

Reply: We have changed the term “maximum NC amplitude” to “mean NC core velocity”

Figure 3: A suggestion, a white centred palette would be more appropriate to illustrate the velocity differences.

Reply: it has been done

Line 280: “They are associated with a misplaced current in the model rather than with incorrect current values“. ? You mean probably “incorrect current intensity” or more precisely “incorrect current maximum”.

Reply: We have changed “incorrect current values” to “incorrect current maxima”

Line 290: “The irregular temporal sampling of the gliders also contributes to these larger model-data differences, compared to the HF radars results. Indeed, a deeper analysis shows that the same features may occur in the simulation and in the observations, but shifted by one or two days (not shown).” I don’t understand why time lags in signal induce more differences for irregular sampling than for regular one. Figure 3c exhibits also strong difference for radar comparison with the HF.

Reply: Here we wanted to highlight that a regular and high frequency sampling as the one of the HF radars (every day) enables to find the same signal but with an offset of 2-3 days for example. The structures are just lagged in time in the Hövmoller diagrams which explain the differences between the model and the radars in Figure 3c while qualitatively the diagrams seem really close. However as there are gaps in the gliders sampling, if a structure is offset it will not appear in the model. To be clearer in the text we have reformulated into “The irregular temporal sampling of the gliders also contributes to these larger qualitative model-data differences, compared to the HF radars results. Indeed, a deeper analysis shows that the same features may occur in the simulation and in the observations, but shifted by one or two days (not shown). Thus they are represented in the HF radars Hovmöller diagram but may correspond to gaps in the glider diagram.”

Figure 4: In my opinion, figure 4 is not really useful for your demonstration and the associated paragraph (line 286-314) is confusing.

Reply: We have removed Figure 4 and the associated paragraph.

Figure 5: To support the corresponding text, dx, |u|max, |u|max/2 must be quoted in figures 5a and b, otherwise these figures are not helpful.

Reply: Thanks for this suggestion, we have included dx, |u|max, |u|max/2 in the figure.

Line 466: The increase in noise due to spatial filtering does not seem to be addressed in section 4.1.

Reply: The sentence was confusing. It has been changed to “In practice, users systematically apply a spatial filter to altimetry SLA data before geostrophic current derivation in order to remove the measurement noise observed in section 4.1”

Typo:

Line 97: the3 -> the

Reply: It has been corrected

The name of the journal is missing for several references.
Reply: It has been corrected