PASS-SWIO

Portagauge And Satellite Sea level monitoring system for the Southwest Indian Ocean

Technical Note on the Analysis of Sentinel-3 Altimeter data at the coast of Madagascar

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December 2023

ESA Contract 4000136883/21/I-DT-Ir
Issue:1.1

Issue	Date	Comments
1.0	13/12/2023	
1.1	31/01/2024	Minor Updates following ESA review

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1 Introduction

This short technical note reports on an analysis of Sentinel-3 SAR altimeter data close to the coast of Madagascar. Data from the “standard” ESA / EUMETSAT L2 products are compared to a data set processed through the SARvatore for Sentinel-3 service with settings specific for coastal processing. The purpose is to assess if the specific coastal processing provides any improvements in performance over the standard product.

2 Data Sets

In this technical note we compare Sentinel-3A and 3-B SRAL SAR altimeter data processed in two different ways. The source data set is along-track Sentinel-3A and Sentinel-3B SRAL SAR altimeter data from orbits 362 and 041 in the vicinity of Toamasina, on the NE coast of Madagascar (Figure 1), for the years 2020 and 2021.

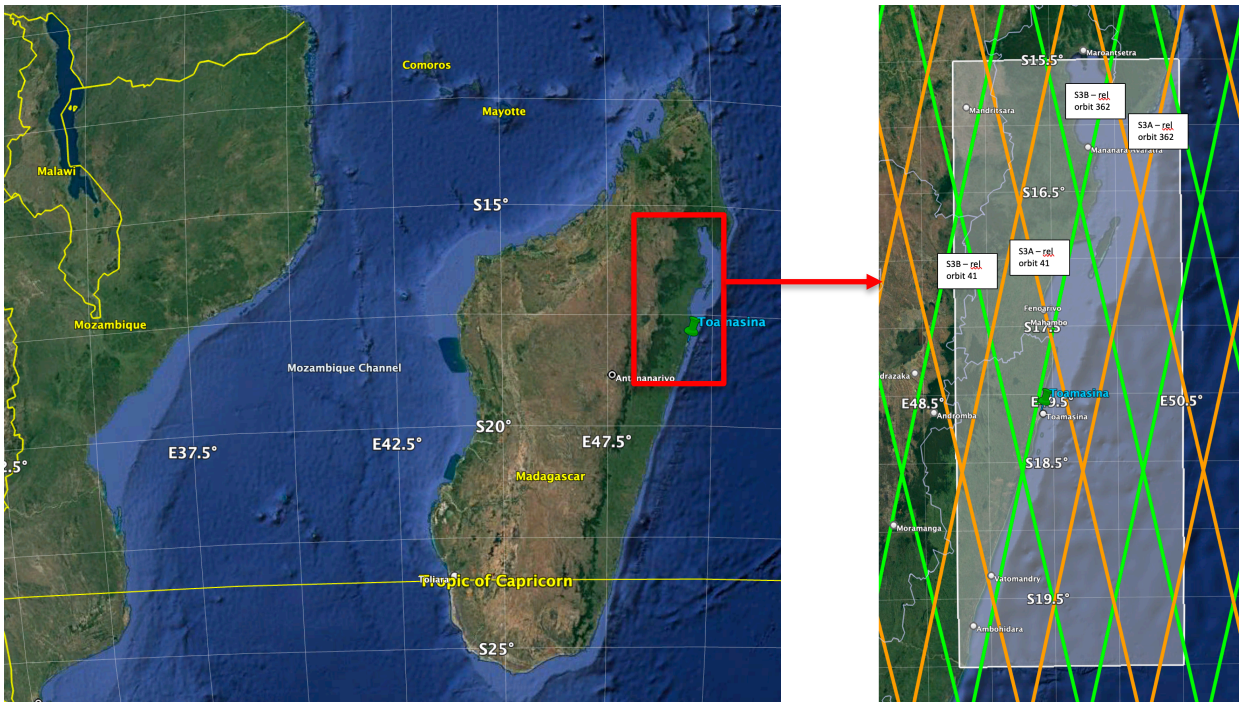

Figure 1 Madagascar (left) and close up (right) of coastline near Toamasina with Sentinel-3A (orange) and Sentinel-3B (green) tracks overlaid.

The first data set is the “standard” EUMETSAT / ESA Level 2 marine product available through the EUMETSAT EO portal and data store (version BC005).

The second data set is based on the same source data, but processed with specific coastal settings (including the SAMOSA+ retracker) using the SARvatore for Sentinel-3 service on the ESA Altimetry Virtual Laboratory, on EarthConsole ((https://earthconsole.eu/altimetry-virtual- lab/) with funding provided by ESA Network of Resources Sponsorship.

3 Analysis

3.1 Valid Data Retrievals

Both data sets were filtered to identify valid data, as follows:

For the AVL specialised coastal processor:

Misfit[1]>3 data were removed;

"Flag_OceanLike" and a

"A landmask" was applied from GSHHS.

For EUMETSAT L2 Standard Product

"Range flag"

"Landmask",

MSS_CNES flag

TWLE >2 m observations were removed.

The percentage and number of “good” observations for the four tracks of the two data sets are shown in Figure 2.

Again, we see very similar performance more than 5km from the coast, but that the specialised coastal processor is able to retrieve a high proportion (greater than 60%) of valid data to within 1km of the coast.

This confirms our expectation that the SAMOSA2 retracker is appropriate for open ocean waveforms, and that the specialised coastal retracker, SAMOSA+ is better for coastal, calmer, seas, which produce peakier waveforms.

[1] Note that the “misfit” in AVL products is equivalent to the “mqe” (mean quadratic error of the fitting) in EUMETSAT products. Ideally we would have used this element in the filtering of the EUMETSAT data.

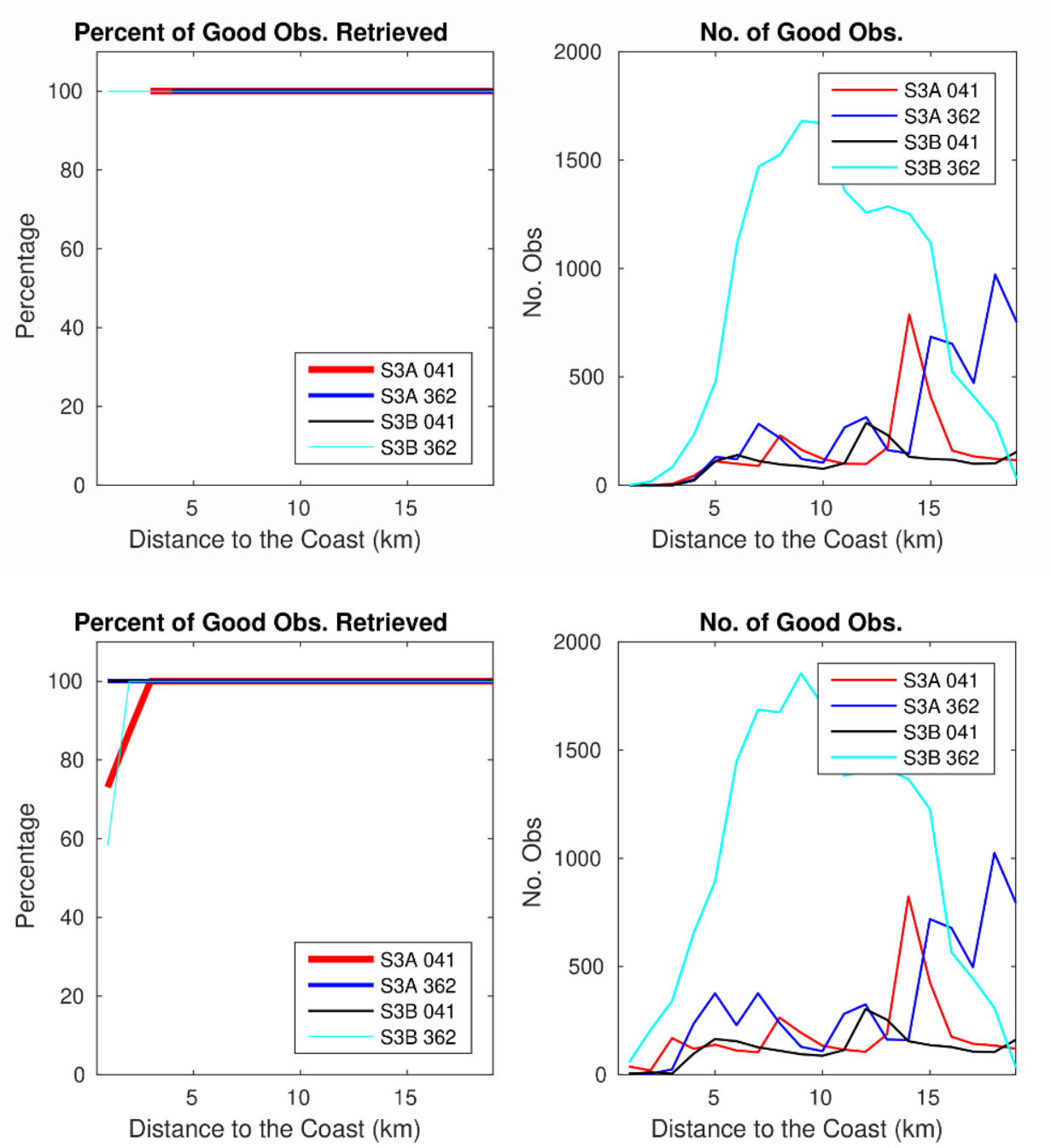

Figure 2. Percentage of "good observations" (left) and total number of "good observations" (right) retrieved from (top) the standard EUMETSAT/ESA L2 product, and (bottom) the specialist coastal processor.

3.2 Time Stamp Offset

The first analysis directly compared the two data sets, in order to check the data in the two data sets were being correctly read, geo-located and time stamped. This analysis identified that there was a 37 second offset between the two data sets (Figure 3). It is thought this difference might be related to the "Leap Second" variable that is included in the EUMETSAT/ ESA L2 data set, but not the coastal processor data set, although its value is 36 seconds, and not 37.

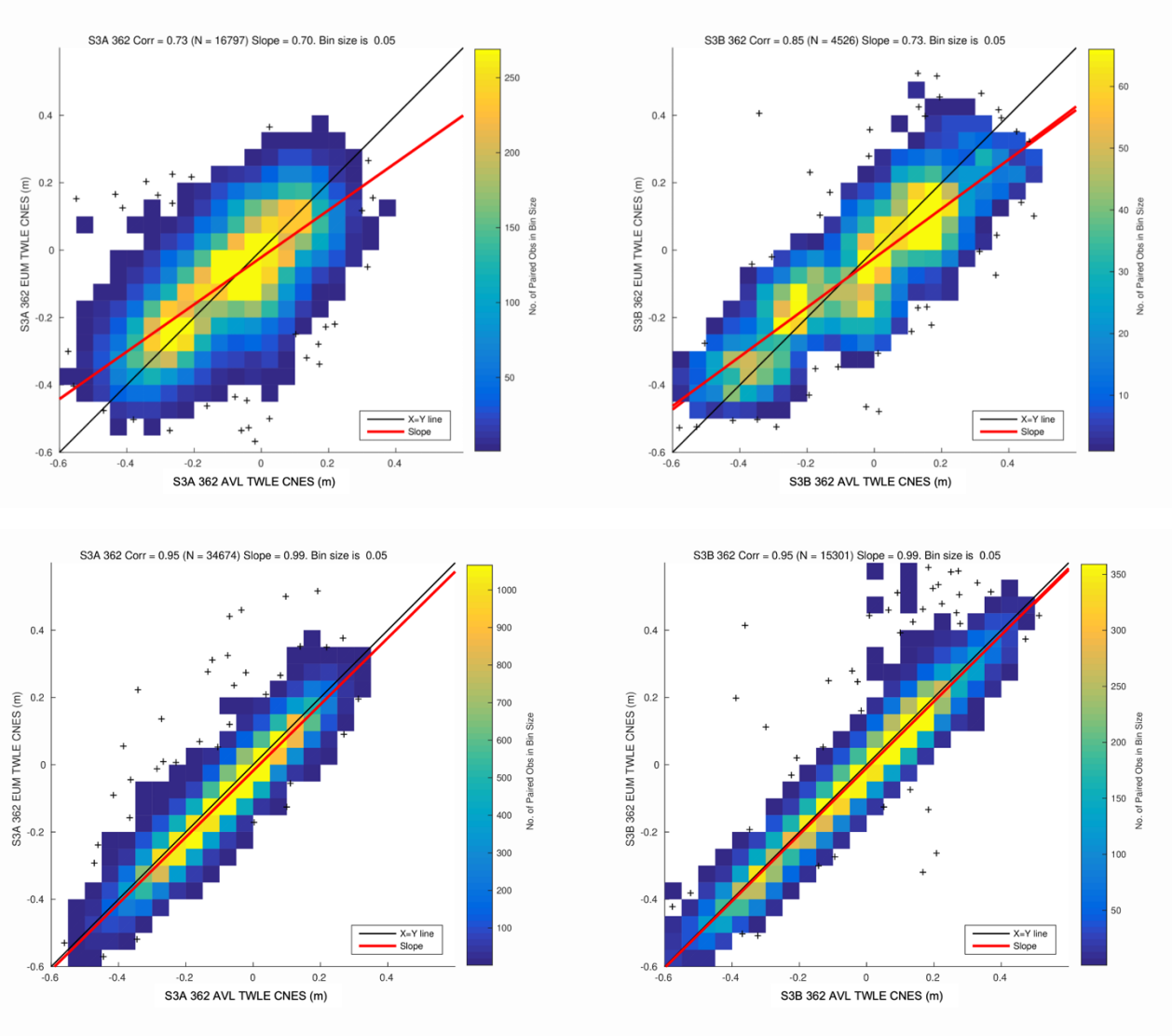

Figure 3 Total Water Level Envelope from EUMETSAT L2 Marine product (Y-axis – labelled "EUM") against Total Water Level Envelope from the specialised coastal processor (X-axis - labelled "AVL"). Left for Sentinel 3A track 362, Right for Sentinel 3B track 362. Top row, without correcting the timestamp offset, bottom row, after removing 37 seconds from the "AVL" dataset time stamp.

3.3 **Along Track "Noise"**

An accepted approach to assess the performance of an altimeter processor is to calculate the along-track "noise", i.e. the difference between consecutive measurements of uncorrected sea surface height. A lower noise indicates a more accurate product. Figure 4 compares the along track noise from 4 tracks.

This analysis indicates that the noise levels from the two processors is similar at 5 -10km from the coast (at approximately 5 cm). Within 5km of the coast, the coastal processor provides measurements within 5km of the coast, whereas the standard product does not. However, the along-track noise does increase, particularly for S3A track 362. This is expected as the echo

footprint includes coastal land, which will produce contamination of the waveform. Following recent work in the HYDROCOASTAL project, it is expected that the way misfit is calculated can be improved so that more data can be recovered.

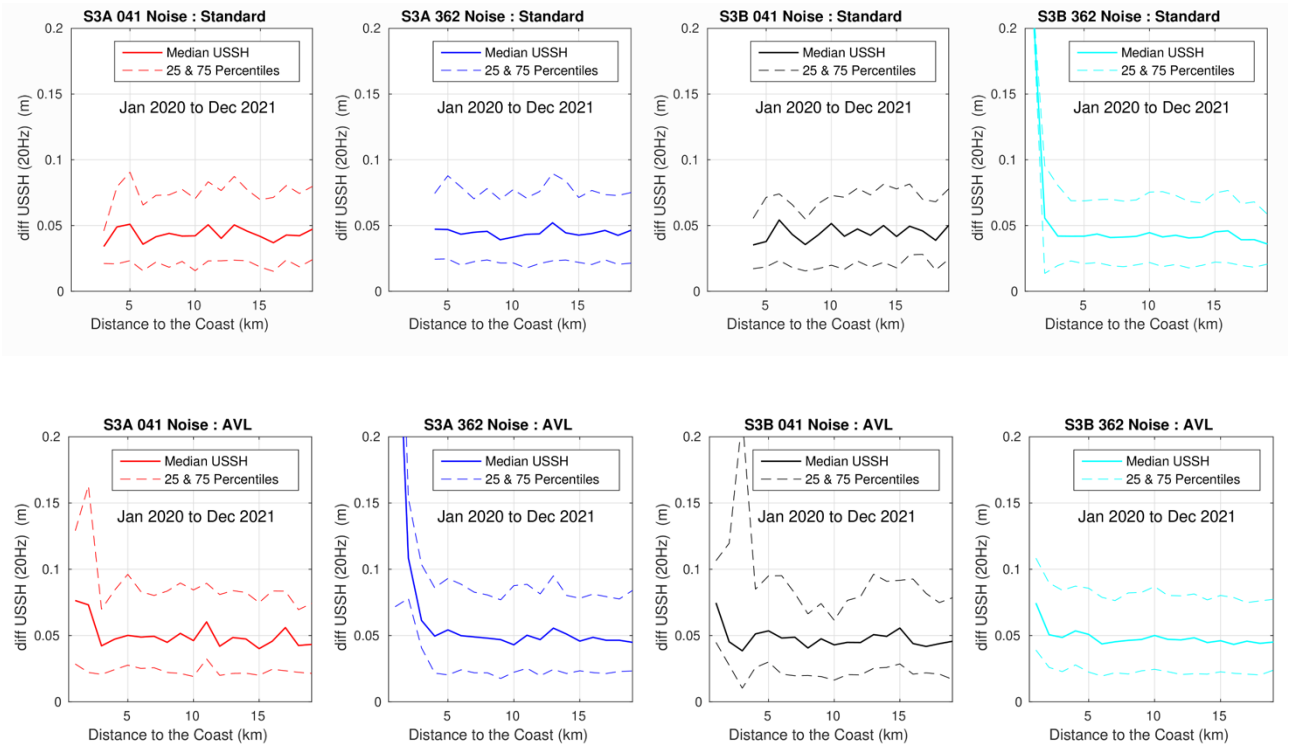

Figure 4. Along-track "noise" in sea-surface height, calculated as the difference between consecutive measurements of uncorrected sea surface height (USSH). Top – Map of Madagascar with the Sentinel 3A and 3B tracks indicated. Centre row – along track noise in USSH against distance to the coast, from the standard EUMETSAT/ESA L2 product for tracks S3A 041, S3A 362, S3B 041 and S3B 362. Bottom row along track noise in USSH against distance to the coast, from the specialised coastal processor ("AVL"). The colours of the lines in each plot correspond to the colour of the relevant track in the map.

3.4 Comparison against Toamasina Tide Gauge Data

Finally, Total Water Level Envelope data from the two processing approaches were compared to Total Water Level from the Toamasina Tide Gauge (Figure 5), this for data from April to July 2020. Note that this limited period of 4 months, means that only data from a maximum of 4 different

passes are included for each track. A longer data set would be preferred to provide more data for a more reliable analysis.

The analysis shows very similar correlations for the standard product and specialised coastal product for the tracks S3A 041, S3A 362 and S3B 362. The results for track S3B track 041 are very noisy, possibly a consequence of the limited data set. It is interesting to note the correlation does not decrease significantly with distance to the coast, and also that the correlation is high for all four tracks. This suggests that the water level variability is coherent along the coast near Toamasina.

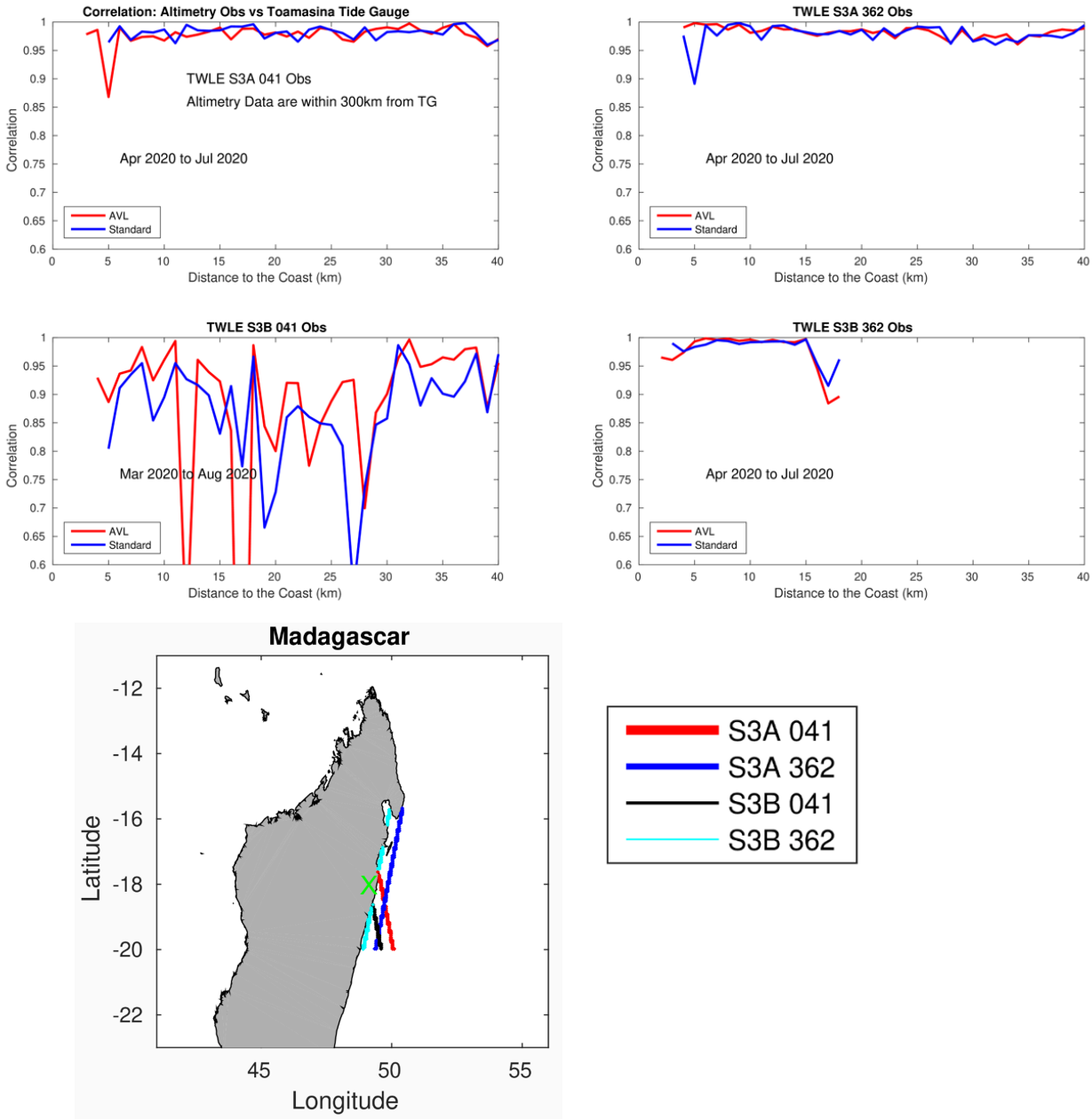

Figure 5. Correlation between the total water level from the satellite altimeter data and the Toamasina tide gauge against distance from the coast. S3A track 041 (top left), S3A track 362 (top right), S3B track 041(bottom left), S3B 362 (bottom right). The blue lines indicate the correlation between the tide gauge and "Standard" altimeter product, the red line indicates correlation with the specialist coastal product. The map and the caption indicate the location of the different tracks. The green "X" marks the location of Toamasina.

4 Conclusions

Data from the specialist coastal processor (SAMOSA+) were not found to provide more accurate sea surface height data than those from the standard L2 EUMETSAT/ESA product (SAMOSA2 retracker) in the range 5-10km from the coast. However, the specialised processing does provide data in near coastal locations (within 5km of the coast) where the standard product does not.