

PREPARATION AND OPERATIONS OF THE MISSION PERFORMANCE
CENTRE (MPC) FOR THE COPERNICUS SENTINEL-3 MISSION

S3-A Ocean Validation Cyclic Performance Report

Cycle No. 023

Start date: 30/09/2017

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1 Introduction

The purpose of this document is to report the major features of the data quality from the Sentinel-3A mission. The document is associated with data dissemination on a cycle per cycle basis. This document reports results from SRAL/Sentinel-3A Slow Time Critical (STC) Marine Level 2 products processed by the Marine Centre using the software IPF-SM-2. The objectives of this document are:

- ❖ To provide a data quality assessment.
- ❖ To report any change likely to impact data quality at any level, from instrument status to software configuration.
- ❖ To present the major useful results for cycle 23, from September-30-2017 to October-27-2017.

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2 Cycle Overview

The main metric that describes the data quality is the one derived from the analysis of sea surface variability at crossovers. For this cycle, the crossover standard deviation is **5.6 cm** rms using a selection to remove shallow waters (1000 m), areas of high ocean variability and high latitudes ($> |60|^\circ$): This first metric is in line with usual values that are obtained on altimetry mission. Cycle 23 spans from September-30-2017 to October-27-2017. Thus SRAL operates in SAR mode.

 The logo for the Sentinel-3 Mission Performance Centre. It features a stylized satellite icon at the top, followed by the text 'SENTINEL 3' in a small font. Below this, there are four small square images: a satellite, a sunset, a satellite view of Earth, and a person. To the right of these images, the text 'Mission Performance Centre' is written in a vertical stack. At the bottom right of the logo area is a small green square icon with a white symbol.	<p style="text-align: center;">Sentinel-3 MPC</p> <p style="text-align: center;">S3-A Ocean Validation Cyclic Performance Report</p> <p style="text-align: center;">Cycle No. 023</p>	<p>Ref.: S3MPC.CLS.PR.06-023</p> <p>Issue: 1.0</p> <p>Date: 06/11/2017</p> <p>Page: 3</p>
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3 Baseline Processing

The version of the S3-MPC software used to compute the altimeter parameters for this dataset is the IPF-SM-2, version 06.07.

4 Data coverage and edited measurements

This section presents results that illustrate data quality during cycle 23. These metrics allow long term monitoring of missing and edited measurements.

4.1 Missing measurements

Missing measurements relative to the Sentinel-3A nominal ground track are plotted on Figure 1. The map below illustrates the 1Hz missing measurements in the STC products. Very few measurements are missing over Ocean.

Figure 2 shows the daily monitoring of available measurements over Ocean during the cycle. The mean percentage is close to 100 %.

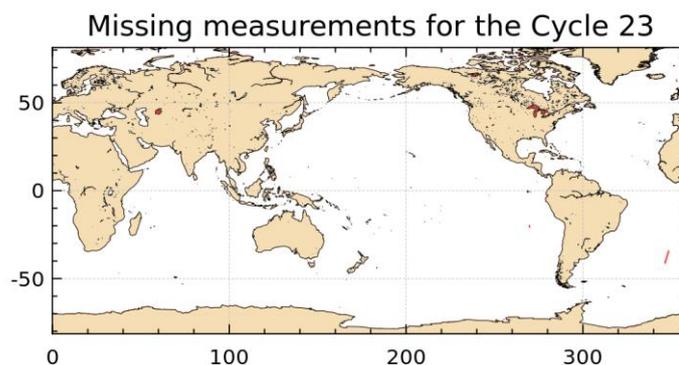


Figure 1: Map of missing measurements over ocean for cycle 23.



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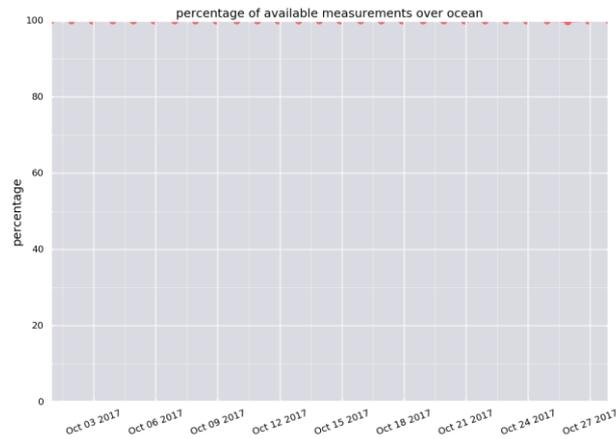


Figure 2: Monitoring of percentage of available measurements per day.

4.2 Edited Measurements

The editing criteria are defined as minimum and maximum thresholds for various parameters. These criteria for editing will be refined for Sentinel-3A mission. Measurements are edited if at least one parameter is found to be outside those thresholds. These thresholds are expected to remain constant throughout the Sentinel-3A mission, so monitoring the number of edited measurements allows a survey of the data quality. In the following, only measurements over ocean are kept.

The number and percentage of points removed by each criterion is given on the following table. Note that these statistics are obtained with measurements already edited by ice flag (**15.54 %** of points removed).

Sea surface height (Orbit - Range)	-130	100	m	717	0.06 %
Orbit - Range - MSS	-10	10	m	17275	1.34 %
Std. deviation of range	0	0.2	m	16489	1.28 %
Number of range	10	DV	count	861	0.07%
Dry tropospheric correction model (ECMWF Gauss)	-2.5	-1.9	m	0	0.00 %
Wet tropospheric correction	-0.5	-0.001	m	0	0.00 %



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model (ECMWF Gauss)					
Std. deviation of sigma0	0	0.7	db	33398	2.59 %
Ocean tide height model (GOT4V10)	-5	5	m	165	0.01 %
Solid earth tide height model (Cartwright and Tayler 1971)	-1	1	m	0	0.00 %
Pole tide height model (Wahr 1985)	-15	15	m	0	0.00 %
WTC derived from MWR	-0.5	-0.001	m	12919	1.00%
Global statistics of edited measurements by thresholds	–	–	–	49485	3.84 %

Table 1: Table of parameters used for editing

The measurements rejected during the editing process are shown in Figure 3. Equatorial wet zones or zones with sea ice appear in the plot as regions with less valid data, as it is also the case for other altimeters: measurements are corrupted by rain or sea ice. They were therefore removed by editing. Many isolated points are observed, they are related to MWR calibrations. For these measurements, the MWR wet tropospheric correction is set to Default Value and thus edited.

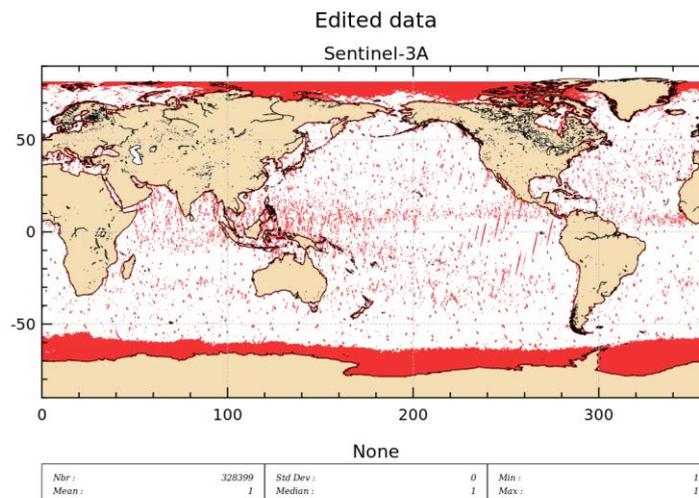


Figure 3: Edited measurements for cycle 23.



5 Instrumental and geophysical parameter analysis

The monitoring of instrumental and geophysical parameters is crucial to detect potential drifts or jumps in long-term time series. These verifications are produced operationally so that they allow systematic monitoring of the main relevant parameters.

5.1 Sentinel-3A Sensors

A detailed assessment of the Sentinel-3A sensors SRAL and MWR is made in separate bulletins:

- ❖ S3-A SRAL Cyclic Performance Report (S3MPC.PR.04-0023).
- ❖ S3-A MWR Cyclic Performance Report (S3MPC.PR.05-0023).

5.2 Significant wave height

Figure 4 shows along-track significant wave height derived from altimeter measurements. Wave height may reach several meters.

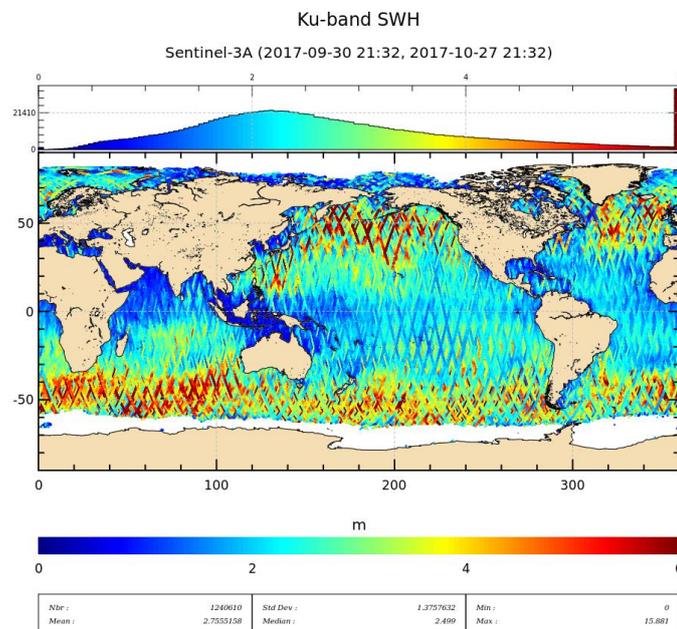


Figure 4: Significant wave height for cycle 23.



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The SAR parameters are compared to Pseudo Low Resolution Mode (PLRM) processing. The PLRM is an LRM like processing of the SAR observations. It provides a reliable reference to compare with. The daily average of Ku-band SWH for Sentinel-3A SARM and P-LRM is plotted as a function of time on Figure 5. They show similar features. A bias of 20 cm is observed between P-LRM and SARM SWH.

For more details concerning the SWH assessment, please refer to the:

- ❖ S3-A Winds and Waves Cyclic Performance Report (ref. S3MPC.ECM.PR.07-0023)

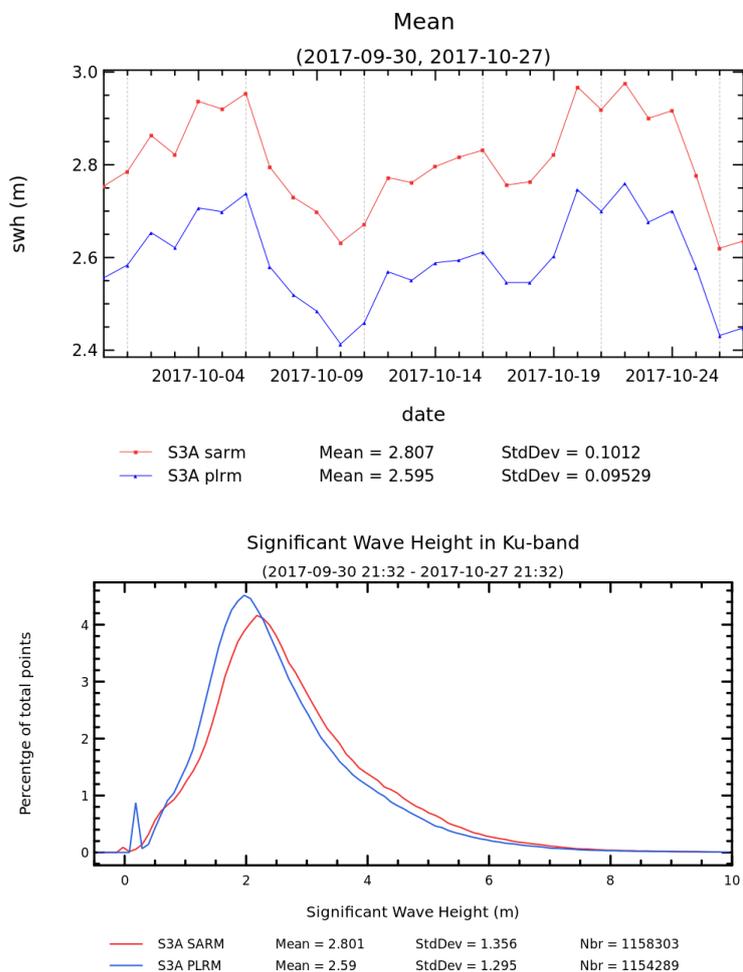


Figure 5: Daily monitoring of significant wave height for Sentinel-3A (Ku-band) on top and histogram for cycle 23 on bottom (limited to 66° latitude).

5.3 Backscattering coefficient

Figure 6 shows along-track backscatter coefficient derived from altimeter measurements.

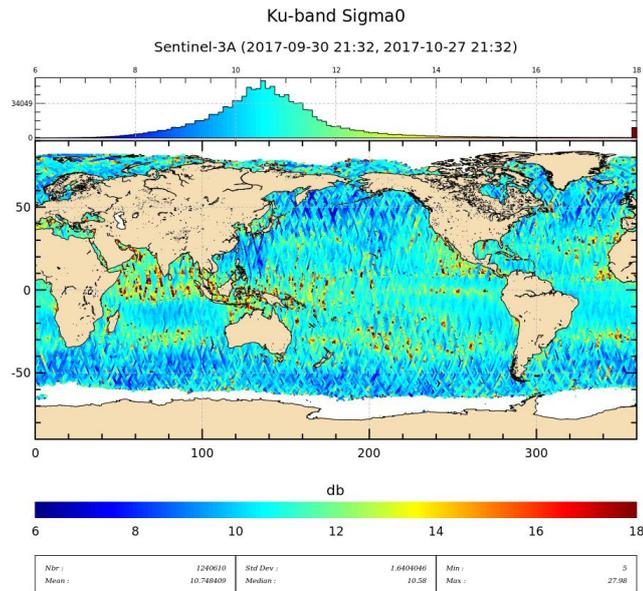


Figure 6: Backscattering coefficient for cycle 23.

The daily average of the backscattering coefficient for Sentinel-3A SARM and P-LRM (Ku-band) is plotted as a function of time on Figure 7. There is no bias observed between SARM and P-LRM backscattering coefficient.



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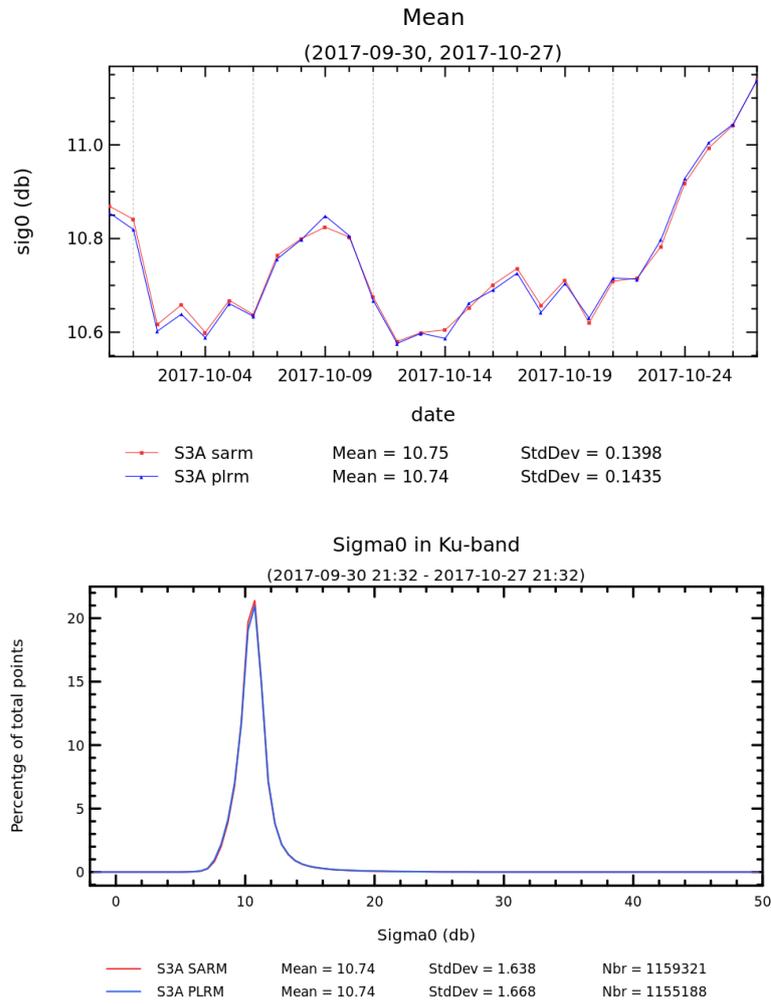


Figure 7: Daily monitoring of backscattering coefficient for Sentinel-3A on top and histogram for cycle 23 on bottom (limited to 66° latitude).

5.4 Altimeter wind Speed

Figure 8 shows wind speed estimations derived from along-track altimeter measurements. The wind speed is derived from the one parameter (backscatter coefficient) Saleh Abdalla's algorithm.

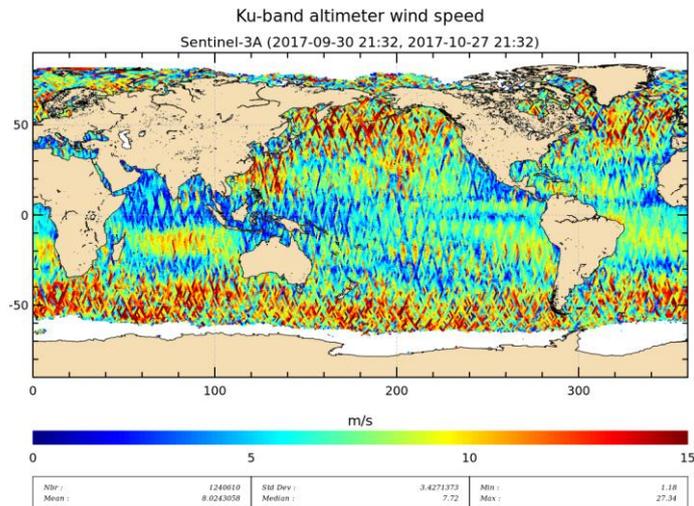


Figure 8: Altimeter wind speed for cycle 23.

The daily average of altimeter wind speed for Sentinel-3A SARM and P-LRM is plotted as a function of time on the top of Figure 9. SARM and P-PLRM wind speed are fully in line.

The histogram is shown on the bottom. A bias of only 0.04 m/s is observed. For more details concerning the wind speed assessment, please refer to the:

- ❖ S3-A Winds and Waves Cyclic Performance Report (ref. S3MPC.ECM.PR.07-0023)



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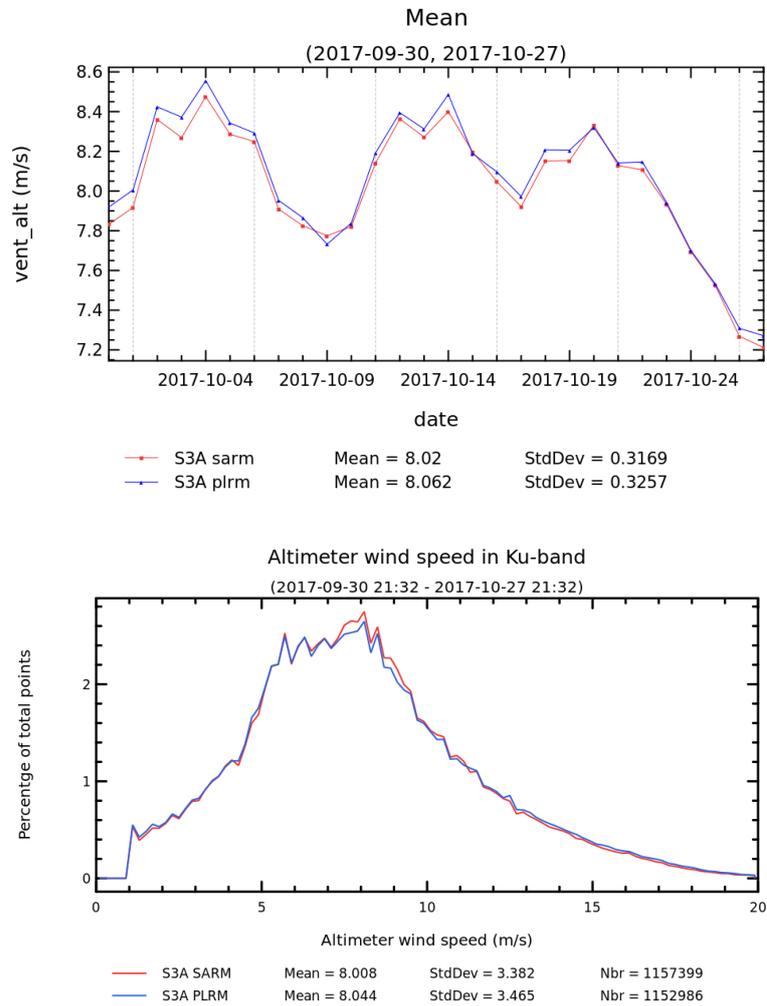


Figure 9: Daily monitoring of altimeter wind speed for Sentinel-3A on the left and histogram for cycle 23 on the right (limited to 66° latitude).

6 Crossover Analysis

6.1 Overview

SSH crossover differences are the SSH differences between ascending and descending passes where they cross each other. Crossover differences are systematically analyzed to estimate data quality and the Sea Surface Height (SSH) performances. SSH crossover differences are computed from the valid data set on a one cycle basis, with a maximum time lag of 10 days, in order to limit the effects of ocean variability which are a source of error in the performance estimation. The mean SSH crossover differences should ideally be close to zero and standard deviation should ideally be small. Nevertheless, SLA varies also within 10 days, especially in high variability areas. Furthermore, due to lower data availability (due to seasonal sea ice coverage), models of several geophysical corrections are less precise in high latitude. Therefore, an additional geographical selection - removing shallow waters, areas of high ocean variability and high latitudes ($> |60|^\circ$) - is applied for cyclic monitoring.

6.2 Maps of SSH crossover differences

The map of the mean differences at crossovers (4 by 4 degree bin) is plotted for cycle 23 on Figure 10. Mean and standard deviation statistics are computed over boxes. Although the result is a little bit noisy because of the short time period (27 days), it does not highlight strong anomalies. Large geographical patterns are observed, they will be investigated using a larger time period.

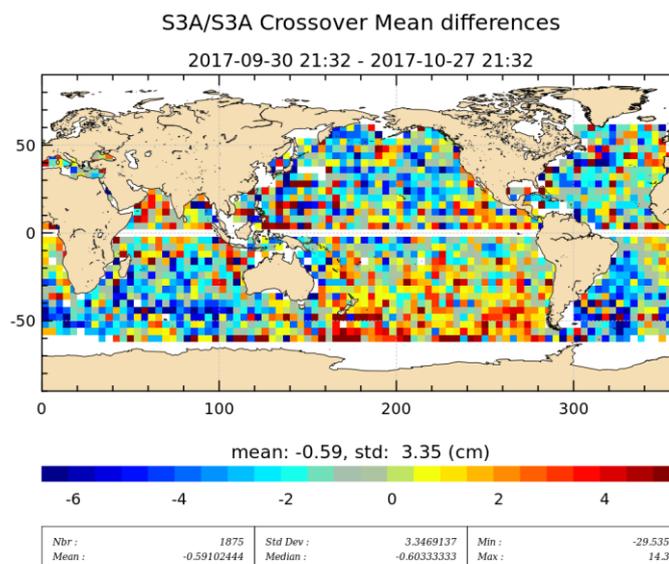


Figure 10: Cycle 23 Sea Surface Height differences at crossovers, after data editing, applying additional geographical selection (removing shallow waters, areas of high ocean variability and high latitudes ($> |60|^\circ$)).

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6.3 Cycle by cycle monitoring

The mean and standard deviation of SSH differences at crossovers are plotted for Sentinel-3A and compared with Jason-3 as a function of time on a one cycle per cycle basis on top of Figure 11. The statistics are computed after data editing and using the geographical selection criteria ($|\text{latitude}| < 60^\circ$, bathymetry $< -1000\text{m}$, ocean variability (computed over several years) $< 0.2\text{m}$).

Note that statistics are computed for each cycle (with a repeat period of approximately 27 days for Sentinel-3A and 10 days for Jason-3). Furthermore, figures are computed by averaging in boxes of 4° by 4° resolution. This is done in order to reduce weight of crossover points in high latitudes (there are much more crossover points in high and very high latitudes than in mean and low latitudes).

The mean difference is slightly negative (-0.21 cm in average) indicating that the bias between ascending and descending tracks is very small.

The standard deviation metric shows performances close to the Jason-3 ones. A part of the differences observed between Sentinel-3A and Jason-3 metrics could be explained by the mean time lag at crossovers. This parameter varies as function of the satellite orbit. For the Jason-3 mission it is around 3 days whereas it reaches more than 4 days for Sentinel-3A.

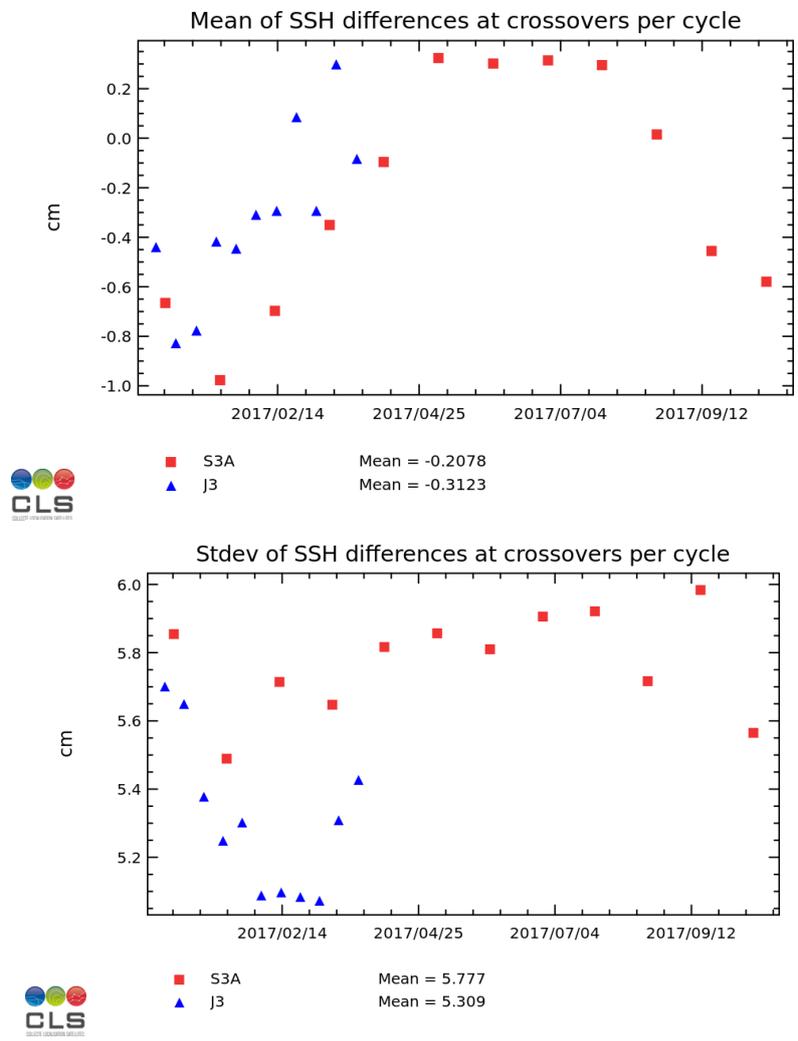


Figure 11: Mean and standard deviation of SSH differences at crossovers for Sentinel-3A and Jason-3 as a function of time.

6.4 Comparison of pseudo time tag bias

The pseudo time tag bias is found by computing at SSH crossovers a regression between SSH and orbital altitude rate (H), also called satellite radial velocity:

$$SSH = \alpha H$$

This method allows us to estimate the time tag bias but it absorbs also other errors correlated with H as for instance orbit errors. Therefore, it is called "pseudo" time tag bias.

Figure 12 shows the monitoring of the pseudo time tag bias for Sentinel-3A on a cyclic basis. A value of **72 microseconds** is found for this cycle using SARM data. The variability from one cycle to the other makes difficult the interpretation of this parameter. Dedicated studies are ongoing to characterize the time tag bias more precisely.

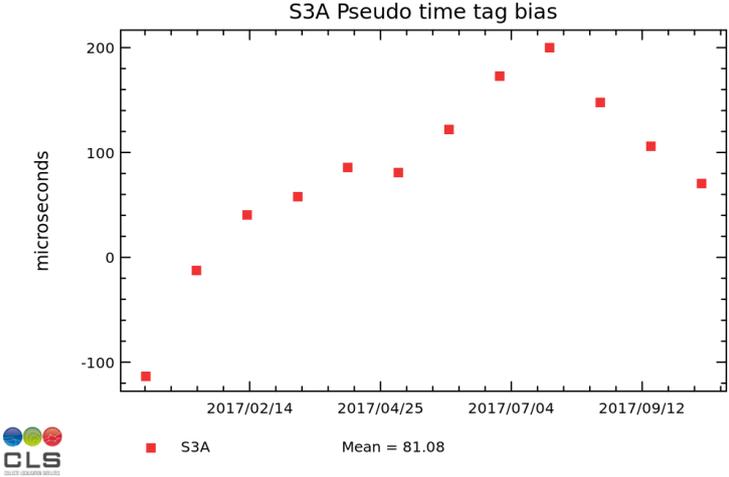


Figure 12: Cyclic monitoring of pseudo time tag bias for Sentinel-3A.



7 Along Track Analysis

7.1 Mean of along-track SLA

7.1.1 Temporal analysis

The monitoring of mean SLA and its standard deviation (Figure 13) is done in order to detect possible jumps or drifts.

We note a mean bias of 1.5 cm between SARM and PLRM Sea Level time series.

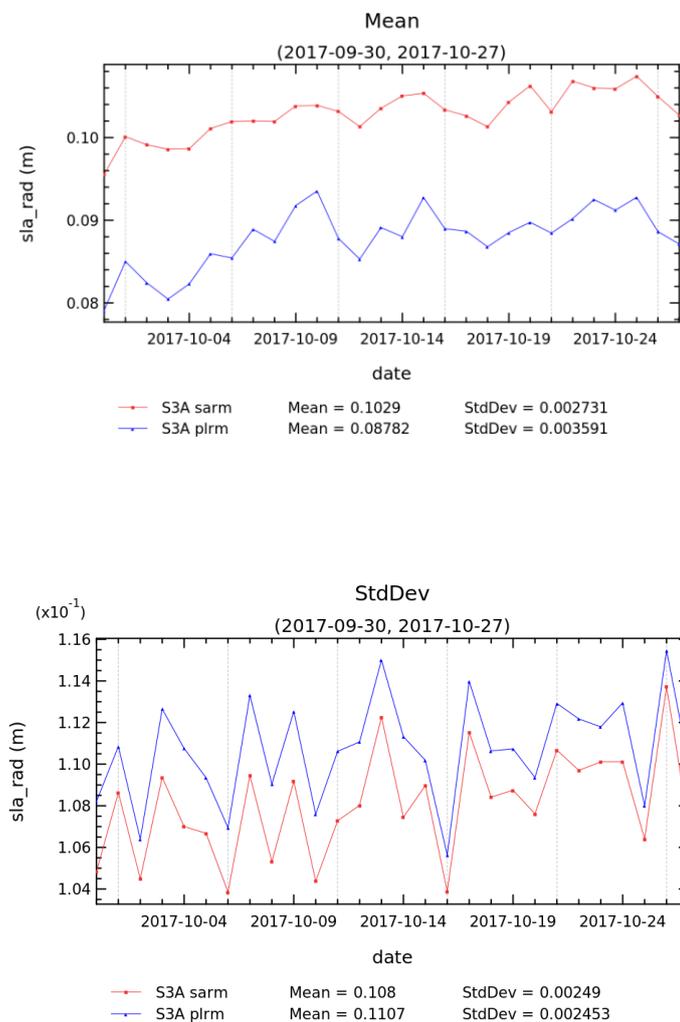


Figure 13: Daily monitoring of mean (top panel) and standard deviation (bottom panel) of Sentinel-3A SLA computed using the radiometer wet tropospheric correction (sla_rad).



7.1.2 Maps

Figure 14 respectively shows the map of Sentinel-3A and Jason-3 SLA relative to the Mean Sea Surface. Both maps highlight similar geophysical variation.

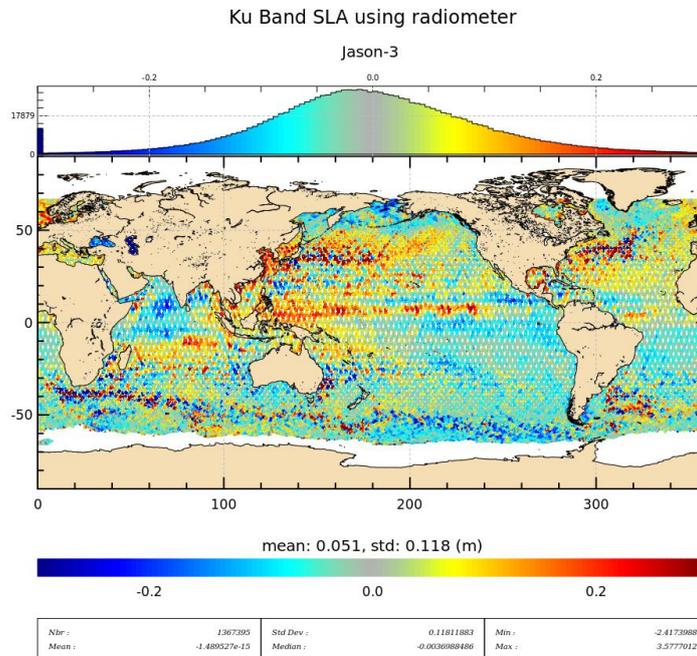
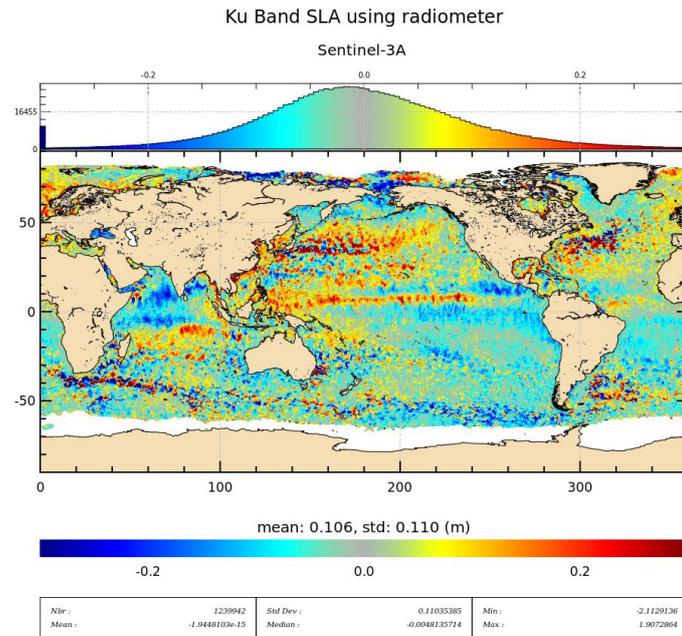


Figure 14: Along track map of Sentinel-3a Sea level anomaly relative to MSS for cycle 23 (top panel). Along track map of Jason-3 Sea level anomaly relative to MSS for Sentinel-3A cycle 23 (bottom panel). For both maps, an offset equal to the mean value has been applied.



8 Long term monitoring

8.1 Significant wave height monitoring

Figure 15 shows the daily average of Ku-band SWH for Sentinel-3A and Jason-3 IGDR products as a function of time since operational STC products are available. They show similar features and biases of ~9 cm between Sentinel-3A SARM and Jason-3 (-10 cm for PLRM with respect to Jason-3).

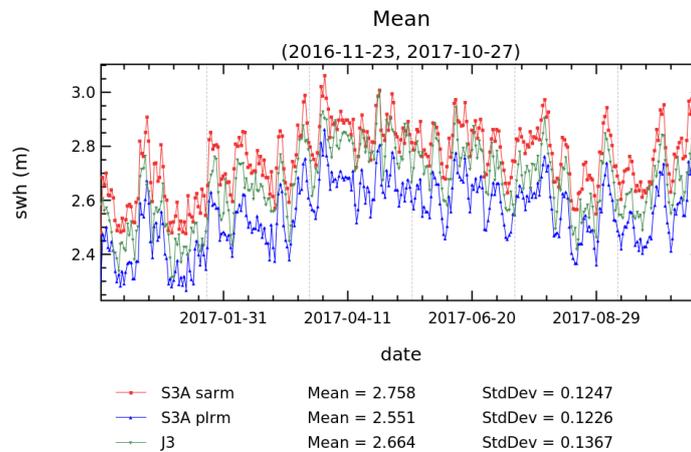


Figure 15: Daily monitoring of significant wave height for Sentinel-3A (Ku-band) and Jason-3 (Ku-band).

8.2 Backscattering coefficient monitoring

Figure 16 shows the daily average of the backscattering coefficient for Sentinel-3A and Jason-3 (Ku-band) as a function of time. Note that the atmospheric attenuation is available in the Sentinel-3A products but the backscatter coefficient is not corrected for it (whereas it is accounted for Jason-3 backscatter coefficient). A bias of ~3 dB is observed between Sentinel-3A and Jason-3. This is expected since Sentinel-3A has been aligned on Envisat mean value. The Sentinel-3A backscatter curves are flat, this traduces the stability of this parameter. The 27th of November, the L2 configuration ADF was updated to correct the mean bias between SARM and P-LRM backscatter coefficient.

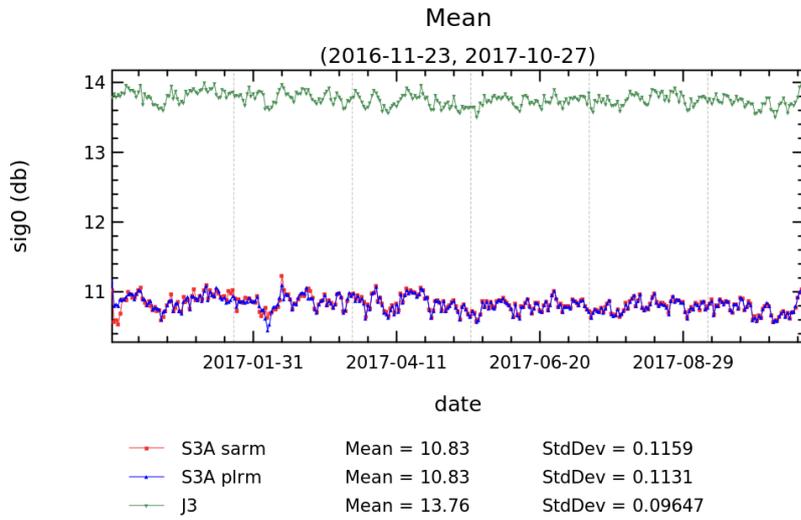


Figure 16: Daily monitoring of backscattering coefficient for Sentinel-3A and Jason-3.

8.3 Altimeter wind Speed monitoring

Figure 17 shows the daily average of altimeter wind speed for Sentinel-3A and Jason-3 as a function of time. The SARM and P-LRM wind speed features are in agreement with Jason-3 but exhibit a mean bias of ~0.5 m/s compared to Jason-3.

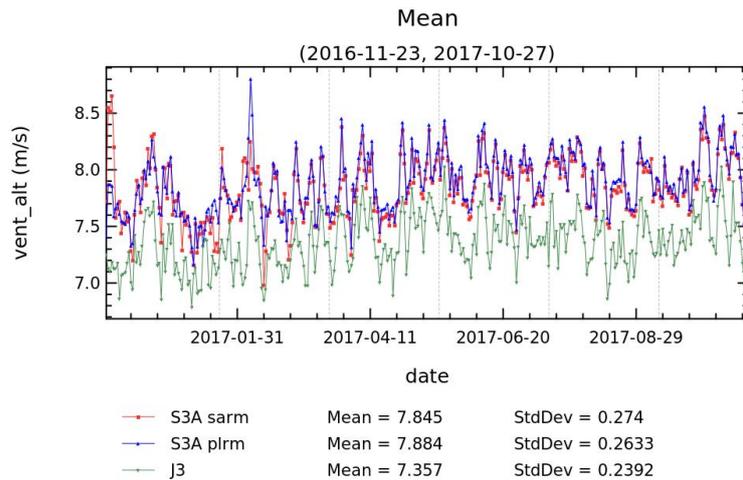


Figure 17: Daily monitoring of altimeter wind speed for Sentinel-3A and Jason-3.



8.4 Mean of along-track SLA monitoring

The comparison between mean SLA for Sentinel-3A and Jason-3 (Figure 18) is done in order to detect possible jumps or drifts. The sea level is computed using the radiometer wet tropospheric correction.

We note a mean bias of 1.4 cm between SARM and PLRM Sea Level time series. The Sentinel-3A sea level in SARM is centered around 9 cm in average (4.2 cm for Jason-3).

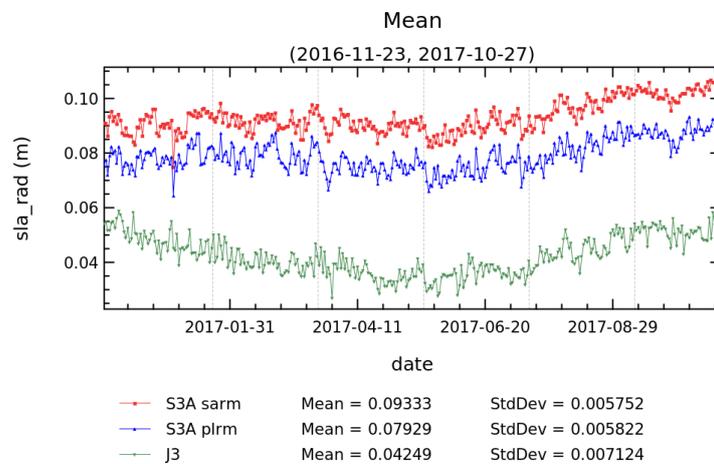


Figure 18: Daily monitoring of mean SLA for Sentinel-3A and Jason-3.

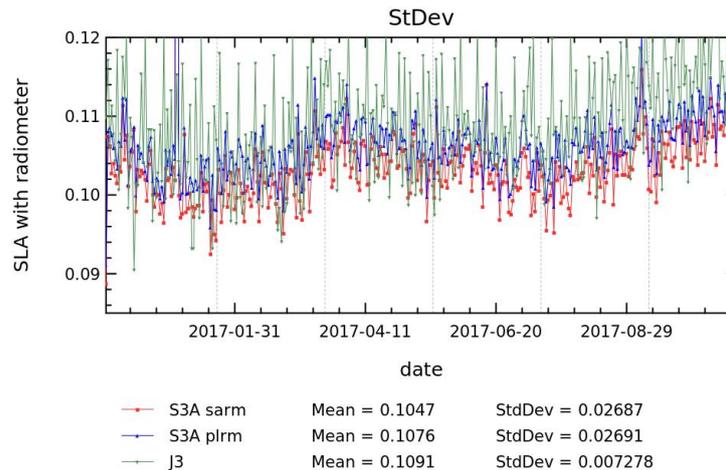


Figure 19: Daily monitoring of SLA standard deviation for Sentinel-3A and Jason-3.

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9 Conclusions

These results over cycle 23 highlight a good quality of the Sentinel-3A STC Marine products. The performances observed at crossovers over this cycle are close to the Jason-3 ones. The sea level and other parameters derived from the altimeter (backscatter coefficient, SWH, wind speed) show good metrics, close to Jason-3 performance.

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10 Appendix A

Other reports related to the STM mission are:

- ❖ S3-A SRAL Cyclic Performance Report, Cycle No. 023 (ref. S3MPC.ISR.PR.04-023)
- ❖ MWR Cyclic Performance Report, Cycle No. 023 (S3MPC.PR.05-023)
- ❖ S3-A Winds and Waves Cyclic Performance Report, Cycle No. 023 (ref. S3MPC.ECM.PR.07-023)
- ❖ S3-A Land and Sea Ice Cyclic Performance Report, Cycle No. 023 (ref. S3MPC.UCL.PR.08-023)

All Cyclic Performance Reports are available on MPC pages in Sentinel Online website, at:
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