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

S3-A MWR Cyclic Performance Report

Cycle No. 016

Start date: 25/03/2017

End date: 21/04/2017



Mission
Performance
Centre

SENTINEL 3



Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Contract: 4000111836/14/I-LG

Customer:	ESA	Document Ref.:	S3MPC.CLS.PR.05-016
Contract No.:	4000111836/14/I-LG	Date:	29/04/2017
		Issue:	1.0

Project:	PREPARATION AND OPERATIONS OF THE MISSION PERFORMANCE CENTRE (MPC) FOR THE COPERNICUS SENTINEL-3 MISSION		PERFORMANCE CENTRE (MPC)
•			
Title:	S3-A MWR Cyclic Performa	nce Report	
Author(s):	MWR ESLs		
Approved by:	G. Quartly, STM ESL Coordinator	Authorized by	Sylvie Labroue, STM Technical Performance Manager
Distribution:	ESA, EUMETSAT, S3MPC consortium		
Accepted by ESA	P. Féménias, MPC TO		
Filename	S3MPC.CLS.PR.05-016 - i1r0 - MWR Cyclic Report 016.docx		

Disclaimer

The work performed in the frame of this contract is carried out with funding by the European Union. The views expressed herein can in no way be taken to reflect the official opinion of either the European Union or the European Space Agency.









S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: iii

Changes Log

Version	Date	Changes
1.0	29/04/2017	First Version

List of Changes

Version	Section	Answers to RID	Changes



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: iv

Table of content

1	INT	RODUCTION
2	OVE	RVIEW OF CYCLE 016
	2.1	STATUS5
	2.2	IPF processing chain status
	2.2.	1 IPF version5
	2.2.	2 Auxiliary Data files5
3	MW	R MONITORING OVER CYCLE 016
	3.1	OPERATING MODES
	3.2	CALIBRATION PARAMETERS
	2.2	1 Gain5
	3.2.	1 Gain
	3.2.	2 Noise Injection Temperature5
	3.3	Brightness Temperatures
	2.4	GEOPHYSICAL PRODUCTS MONITORING
	3.4	GEOPHYSICAL PRODUCTS MONITORING
	3.4.	1 Wet Tropospheric Correction5
	3.4.	2 Atmospheric Attenuation5
4	100	IG-TERM MONITORING
4		
	4.1	INTERNAL CALIBRATION PARAMETERS
	4.1.	1 Gain5
	4.1.	2 Noise Injection temperature5
	4.2	VICARIOUS CALIBRATION
	4.2.	1 Coldest ocean temperatures5
	4.2.	2 Amazon forest
	4.2.	3 References
	4.3	GEOPHYSICAL PRODUCTS
	4.3.	1 Monitoring of geophysical products
	4.3.	2 Comparison to insitu measurements
5	SPE	CIFIC INVESTIGATIONS

Mission Performance Centre

Sentinel-3 MPC

S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: v

6	EVENTS	5
7	APPENDIX A	5



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: vi

List of Figures

Figure 1 : Distribution of operating mode5
Figure 2 : Map of measurements with DNB processing for 36.5GHz channel (red) and safety mode for both channels over KREMS (blue)5
Figure 3: monitoring of receiver gain for both channels: 23.8GHz (left) and 36.5GHz (right)5
Figure 4: Monitoring of Noise Injection temperature for both channels: 23.8GHz (left) and 36.5GHz (right)5
Figure 5: Map of Brightness temperatures of channel 23.8GHz for ascending (right) and descending (left) passes 5
Figure 6: Map of Brightness temperatures of channel 36.5GHz for ascending (right) and descending (left) passes5
Figure 7: Histograms of MWR-ECMWF difference of wet tropospheric correction for SARAL/MWR , Jason2/AMR and Sentinel-3A/MWR SAR and PLRM 5
Figure 8: MWR-ECMWF difference of wet tropospheric correction: using SAR (left) and PLRM altimeter backscatter (right)5
Figure 9 : Jason2/AMR MWR-ECMWF difference of wet tropospheric correction 5
Figure 10: Ku band Atmospheric attenuation of the Sigma0 Left: Histograms for Sentinel-3A/MWR, Jason2/AMR; Right: Map of difference of MWR-model atmospheric attenuation for Sentinel-3A5
Figure 11: Daily mean of the gain for both channels: 23.8GHz (left) and 36.5GHz (right)5
Figure 12: Daily statistics of the noise injection temperature for channel 23.8GHz (left) and 36.5GHz (right): mean (bold line), min/max (thin line), standard deviation (shade)5
Figure 13: Coldest temperature over ocean at 23.8GHz for Sentinel-3A, SARAL/AltiKa, Jason2, and Metop-A/AMSU-A5
Figure 14: Coldest temperature over ocean for the liquid water channel Sentinel-3A, SARAL/AltiKa, Jason2, and Metop-A/AMSU-A5
Figure 15 : Average temperature over Amazon forest at 23.8GHz channel for Sentinel-3A, SARAL/AltiKa, Jason2, and Metop-A/AMSU-A5
Figure 16: Average temperature over Amazon forest at 36.5GHz channel for Sentinel-3A, SARAL/AltiKa, Jason2, and Metop-A/AMSU-A5
Figure 17: Monitoring of difference MWR-ECMWF correction: daily average (left) and standard deviation (right)5



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: vii

Figure 18: Monitoring of difference MWR-ECMWF atmospheric attenuation: daily average (left) and standard deviation (right)5
Figure 19: Monitoring of difference MWR-ECMWF water vapour content: daily average (left) and standard deviation (right)5
Figure 20 : Monitoring of difference MWR-ECMWF cloud liquid water content : daily average (left) and standard deviation (right)5
List of Tables
Table 1 : General overview of the MWR quality assessment5



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 1

1 Introduction

This document aims at providing a synthetic report on the behaviour of the radiometer in terms of instrumental characteristics and product performances as well as on the main events which occurred during cycle 16.

This document is split in the following sections:

- Section 2 gives an overview on the status of the current cycle
- Section 3 addresses the monitoring of the MWR of the current cycle. This section covers the short term monitoring of internal calibration, brightness temperatures and geophysical parameters.
- Section 4 addresses the long term monitoring from the beginning of the mission. It provides a view of the internal calibration monitoring as well as two subsections covering the monitoring of vicarious calibration targets and geophysical parameters.



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 2

2 Overview of Cycle 016

2.1 Status

The Table 1 gives a summary of the instrument behavior during this period.

Parameter	Status	Comments
Instrument		Nominal
Internal Calibration		Nominal
Geophysical products		Nominal
		Nominal
Long-term monitoring		Nominal

Table 1 : General overview of the MWR quality assessment

Color legend:





S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 3

2.2 IPF processing chain status

2.2.1 IPF version

This section gives the version of the IPF processing chain used to process the data of the current cycle.

If a change of IPF version occurs during the cycle, the table gives the date of last processing with the first version and the date of first processing with the second version:

: first date of processing

: last date of processing

MWR L1B CAL

	NRT from Svalbard
06.03	
00.03	-

MWR L1B

IPF version	STC (LN3)	NRT (SVL)
06.03	-	-
00.03	-	-

SRAL/MWR Level 2

	STC from Marine Center
06.06	
	2017-04-12 09 :33 :59
06.07	2017-04-12 14 :36 :59
00.07	

SENTINEL 3 Mission Performance Centre

Sentinel-3 MPC

S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 4

2.2.2 Auxiliary Data files

This section gives the version of the auxiliary data files used to process the data of the current cycle.

Side Lobe Correction file (Svalbard Core Ground Station)

Filename	Date
S3A_MW_1_SLC_AX_20000101T000000_20991231T235959_2016 0603T120000 MPC O AL 002.SEN3	
00031120000NIFC_O_AL_002.3EN3	

MWR CCDB

Filename	
S3A_MWCHDNAX_20160216T000000_20991231T235959_201	
61014T120000MPC_O_AL_002.SEN3	

L2 Configuration file (Marine Center- STC)

Filename	
S3SR_2_CON_AX_20160216T000000_20991231T235959_20170 201T120000MPC_O_AL_007.SEN3	-
	2017-04-12 09 :33 :59
S3SR_2_CON_AX_20160216T000000_20991231T235959_20170	2017-04-12 14 :36 :59
322T120000MPC_O_AL_008.SEN3	



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 5

3 MWR Monitoring over Cycle 016

This section is dedicated to the functional verification of the MWR sensor behaviour during cycle 16 (25 March 2017 – 21 April 2017). The main relevant of the parameters, monitored daily by the MPC team, are presented here.

3.1 Operating modes

The radiometer has several operating modes listed hereafter:

- Mode 0 : Intermonitoring (Earth observation)
- Mode 1 : Monitoring
- Mode 2 : Noise Injection calibration
- Mode 3 : Dicke Non-Balanced calibration (100% injection hot point)
- ♦ Mode 4 : Dicke Non-Balanced calibration (50% injection cold point)

Figure 1 gives the distribution of the different modes in the data.

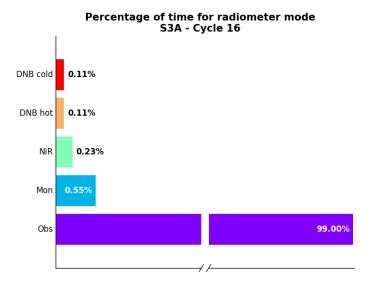


Figure 1: Distribution of operating mode

For measurements in the Intermonitoring mode, two kind of processing can be used according to the measured brightness temperature. If this temperature is smaller than the reference load inside the instrument, the NIR processing is used; if the temperature is greater, the DNB processing is used. The transition from one processing to the other will occur more or less close to the coast depending on the



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 6

internal temperature of the MWR. The internal temperature of the MWR is such that only a small percentage of measurements required a DNB processing in this cycle as shown by Figure 2.

This figure shows also the passage over the US KREMS radar facility in the Kwajalein atoll (9°23′47″ N - 167°28′50″ E) in the Pacific. For safety reasons, the MWR is switched to a specific mode about 50 km before the facility location and back to nominal mode 50km after.

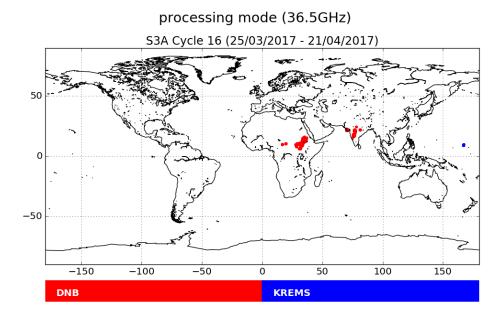


Figure 2 : Map of measurements with DNB processing for 36.5GHz channel (red) and safety mode for both channels over KREMS (blue)

3.2 Calibration parameters

To monitor the instrument behavior during its lifetime, the relevant parameters of the MWR internal inflight calibration procedure are presented in the following subsections. These parameters are:

- the gain: this parameter is estimated using the two types of Dicke Non-Balanced calibration measurements (100% and 50% of injection). The DNB processing of the Earth measurements uses this parameter.
- the noise injection temperature: this parameter is measured during the Noise Injection calibration measurements. The NIR processing of the Earth measurements uses this parameter.

3.2.1 Gain

Figure 3 shows the monitoring of the receiver gain for the current cycle. The mean value over the cycle is 4.757mv/K and 4.549mV/K for channel 23.8GHz and 36.5GHz respectively. These values are close to values estimated on-ground during characterization of the instrument (4.793mV/K and 4.665mV/K for



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 7

channels 23.8GHz and 36.5GHz respectively). The gain for both channels show a slight increase. Nominal behavior is observed since only 1 cycle of data is considered in this section. The gap observed between pass 400 and 500 is due to data not received by the MPC.

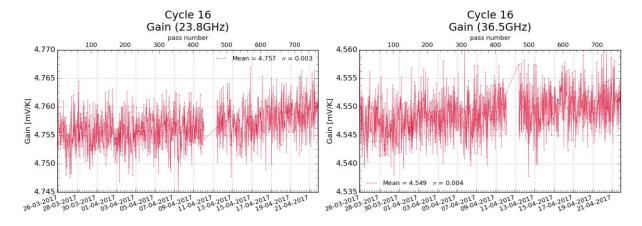


Figure 3: monitoring of receiver gain for both channels: 23.8GHz (left) and 36.5GHz (right)

3.2.2 Noise Injection Temperature

Figure 4 shows the monitoring of the noise injection temperature for the current cycle. The noise injection temperature for the 23.8GHz channel is constant over the cycle close to 314K. For the 36.5GHz channel, the diode shows a slow increase along the cycle of less than 0.2K. Nominal behavior is observed since only 1 cycle of data is considered in this section. The monitoring will be pursued and data checked for any impact. The gap observed between pass 400 and 500 is due to data not received by the MPC.

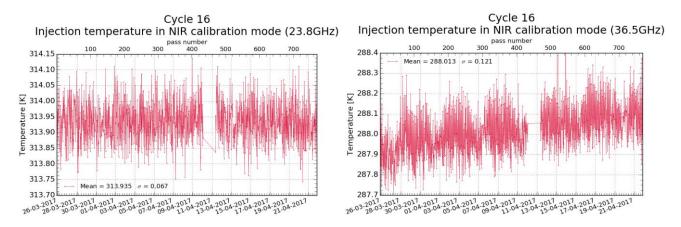


Figure 4: Monitoring of Noise Injection temperature for both channels: 23.8GHz (left) and 36.5GHz (right)



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 8

3.3 Brightness Temperatures

The two following figures show maps of brightness temperatures for both channels split by ascending (right part) and descending (left part) passes. The Figure 5 and Figure 6 concern the channels 23.8GHz and 36.5GHz respectively. These maps show a good contrast between ocean and land for both channels. No issue has to be reported from these figures.

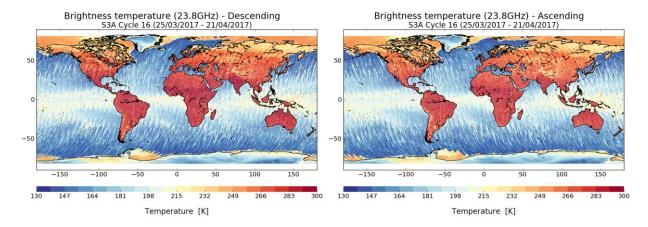


Figure 5: Map of Brightness temperatures of channel 23.8GHz for ascending (right) and descending (left) passes

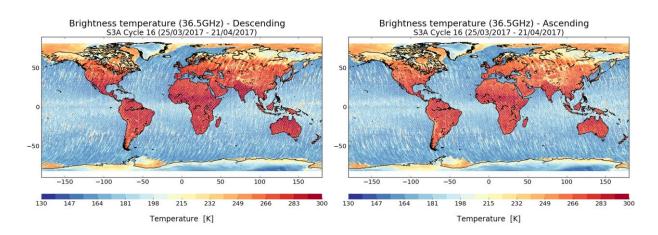


Figure 6: Map of Brightness temperatures of channel 36.5GHz for ascending (right) and descending (left) passes



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 9

3.4 Geophysical products monitoring

The inversion algorithms allow to retrieve the geophysical products from the measurements of the radiometer (brightness temperatures measured at two different frequencies) and the altimeter (backscattering coefficient ie sigma0). Four geophysical products are issued from the retrieval algorithms: the wet tropospheric correction, the atmospheric attenuation of the Sigma0, the water vapor content, the cloud liquid water content. This section provides an assessment of two of these retrievals used by the SRAL/MWR L2 processing: the wet tropospheric correction and the atmospheric attenuation of the Sigma0. The wet tropospheric correction is analysed through the MWR-ECMWF difference of this correction.

3.4.1 Wet Tropospheric Correction

Figure 7 presents the histograms of the MWR-ECMWF differences of wet tropospheric correction (Δ WTC) for cycle 16. In this figure, Sentinel-3A/MWR correction is compared to the correction retrieved by Jason2/AMR (IGDR) and SARAL/MWR (IGDR) over the same period.

The standard deviation of the difference MWR-ECMWF corrections for S-3A is about 1.38cm for both SAR and PLRM corrections while it is 1.51cm for SARAL and 1.12cm for Jason-2. First Jason-2 benefits from its three channels radiometer (18.7GHz, 23.8GHz, 34GHz), providing a correction with a smaller deviation with respect to the model. SARAL/MWR is closer to S-3A/MWR in this context with its two channels (23.8GHz and 37GHz for SARAL, 23.8 and 36.5GHz for S-3A). Then the standard deviation for SARAL is the closest reference, even though the Sigma0 in Ka band raises some questions. With the use of STC products for S-3A, the Δ WTC for the three instruments are directly comparable since all use ECMWF analyses for the computation of the model correction. The standard deviation of Δ WTC for S-3A is smaller than for SARAL meaning that we have a better estimation of the correction for S-3A according to these metrics. Jason-2 gives the best performances with the smallest deviation. Moreover, one can notice that both SAR and PLMR corrections have very similar performances: mean(std) of Δ WTC being close to -0.01cm(1.39cm) and 0.01cm(1.37cm) for SAR and PLRM respectively.

Figure 8 presents a map of the Δ WTC for Sentinel-3A only for SAR correction on the left and PLRM correction on the right. For this cycle, the maps show geographical patterns expected for this parameter. Note that the color scale is centered to the mean value. The comparison with Jason2 map of Δ WTC (Figure 9) shows similarities although Sentinel-3A Δ WTC is larger than Jason2 because of their different instrument configuration.

S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 10

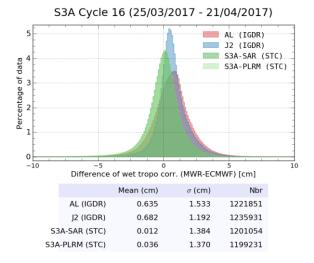


Figure 7: Histograms of MWR-ECMWF difference of wet tropospheric correction for SARAL/MWR , Jason2/AMR and Sentinel-3A/MWR SAR and PLRM

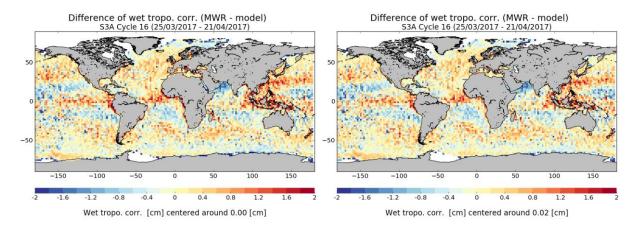


Figure 8 : MWR-ECMWF difference of wet tropospheric correction : using SAR (left) and PLRM altimeter backscatter (right)

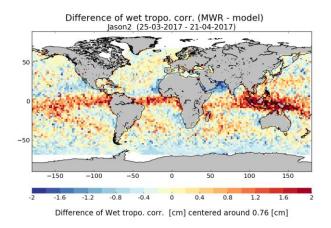


Figure 9: Jason2/AMR MWR-ECMWF difference of wet tropospheric correction



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 11

3.4.2 Atmospheric Attenuation

The left part of Figure 10 presents the histograms of the Ku band atmospheric attenuation of the SigmaO. In this figure, Sentinel-3A attenuation is compared to the attenuation retrieved for Jason2/AMR. The results of S-3A are very similar to Jason-2 results with an average attenuation close to 0.21dB for S-3A and 0.17dB for Jason2. Mean value for Jason2 has slightly changed since last cycle (0.2dB for cycle 15 of S-3A). The right part of Figure 10 shows a map of the difference of MWR attenuation and model attenuation computed from ECMWF analyses for Sentinel-3A. Globally a bias of 0.02 dB between MWR and model attenuation can be guess from this plot.

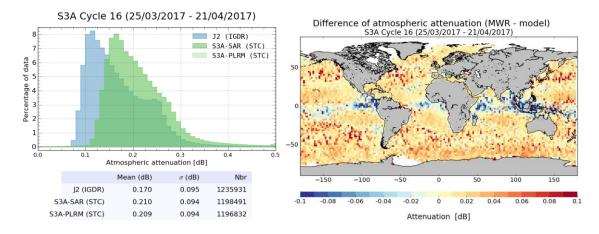


Figure 10 : Ku band Atmospheric attenuation of the Sigma0

Left : Histograms for Sentinel-3A/MWR, Jason2/AMR; Right: Map of difference of MWR-model atmospheric attenuation for Sentinel-3A



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 12

4 Long-term monitoring

In this section, a long-term monitoring of the MWR behaviour is presented.

4.1 Internal Calibration parameters

This section presents a long term monitoring of internal calibration parameters. Data used for the diagnosis presented here are:

- Reprocessed data (using IPF v6.5) from cycle 1 to cycle 9
- MWR L1B data generated by PDGS at Svalbard core ground station are used from 26/10/2016

4.1.1 Gain

Figure 11 shows the daily mean of the receiver gain for both channels. This calibration parameter is used in the DNB processing of the measurements. As seen previously in section 3.1, only a small part of the measurements are processed in DNB mode. The first part of the monitoring of the calibration parameters is performed using NTC product generated during the first reprocessing (IPF v6.5), the second part using NRT products from the day of the IPF update on the Svalbard ground station forward. The gap between the two datasets comes from the delay between the end of the reprocessed period and the implementation of the IPF on the station. This gap will be covered by a future reprocessing.

From the two panels of Figure 11, one can see that the receiver gain has a different behaviour for each channel. The gain for the 23.8GHz is slowly increasing since the beginning of the mission showing two slopes and an inflexion point during cycle 7. The gain has increased of +0.03mv/K since the beginning of the mission. For the 36.5GHz channel, the gain is inscreasing from cycle 1 and then starts to decrease at the beginning of cycle 4. Since cycle 15, it started to increase again. Due to the small number of data processed using this parameter, it will be difficult to assess if this decrease has an impact on data quality. The monitoring will be pursued and data checked for any impact.

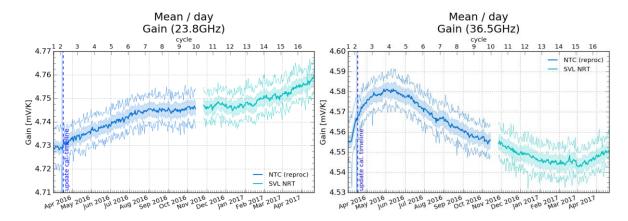


Figure 11: Daily mean of the gain for both channels: 23.8GHz (left) and 36.5GHz (right)



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 13

4.1.2 Noise Injection temperature

Figure 12 shows the daily mean of the noise injection temperature for both channels. This calibration parameter is used in the NIR processing of the measurements. As seen previously in section 3.1, the main part of the measurements are processed in NIR mode. Moreover the first part of the monitoring of the calibration parameters is performed using NTC product generated during the first reprocessing (IPF v6.5), the second part using NRT products from the day of the IPF update on the ground station. The gap between the two datasets comes from the delay between the end of the reprocessed period and the implementation of the IPF on the station. This gap will be covered by a future reprocessing.

From the two panels of Figure 12, one can see that the noise injection parameter has a different behaviour for each channel. For the 23.8GHz channel, the noise injection temperature has decreased of 0.5K during the first 2 cycles, after what there has been no significant change of behaviour until cycle 13. During this cycle, the noise injection temperature seems to start a slow decrease. For the channel 36.5GHz, one can see that the diode is not stabilized: the injection temperature has increased from cycle 1 to 5 followed by a stabilization period from beginning of June (cycle 5) to mid-July (end of cycle 6) when the noise injection temperature for the 36.5GHz channel starts to decrease, then increase during cycle 14. The monitoring will be pursued and data checked for any impact.

Some peak values are noticeable at the end of cycle 4 (mainly channel 23.8GHz), at the end of cycle 6, during cycle 9, 10, 12,16. Some of these peaks concerns both channels at the same time, while a small part of them only one of them. The investigations performed in the cycle 6 report has shown that these measurements are localized around a band of latitude that may change along the time series. The source is not yet clearly identified but a intrusion of the Moon in the sky horn is suspected.

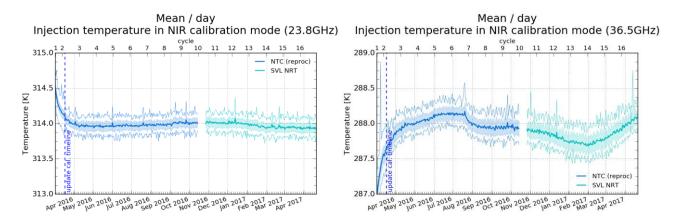


Figure 12 : Daily statistics of the noise injection temperature for channel 23.8GHz (left) and 36.5GHz (right): mean (bold line), min/max (thin line), standard deviation (shade)



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 14

4.2 Vicarious calibration

The assessment of the brightness temperatures quality and stability is performed by the use of vicarious calibrations. Two specific areas are selected. Sentinel-3A data used in this section are:

- coldest ocean temperature analysis use Level 2 data
 - data from the recent processing (using IPF v6.5) (STC) from 06 April to 06 May,
 - data from the recent processing (using IPF v6.5) (NTC) from 15 June to 30 September.
 - STC data since December 2016
- Amazon forest analysis use Level 1B data:
 - o data from the recent processing using IPF v6.5 (L1B NTC data from mid-March to October).
 - STC data from LN3 processing center

4.2.1 Coldest ocean temperatures

The first area is the ocean and more precisely the coldest temperature over ocean. Following the method proposed by Ruf [RD 1], updated by Eymar [RD 3] and implemented in [RD 7], the coldest ocean temperatures is computed by a statistic selection. Ruf has demonstrated how a statistical selection of the coldest BT over ocean allows detecting and monitoring drifts. It is also commonly used for long-term monitoring or cross-calibration [RD 4] [RD 5] [RD 6].

The Figure 13 presents the coldest ocean temperature computed following method previously described at 23.8GHz channel for Sentinel-3A/WMR and three other microwave radiometers: AltiKa/MWR, Jason2/AMR and Metop-A/AMSU-A. For AMSU-A, the two pixels of smallest incidence (closest to nadir) are averaged. The Figure 14 presents the same results for the liquid water channel of the same four instruments: 36.5GHz for Sentinel-3A, 37GHz for AltiKa, 34GHz for Jason2 and 31.4GHz for Metop-A.

Concerning the 23.8GHz channel presented on Figure 12, one can see the impact of the calibration of the MWR with the increase of the coldest ocean brightness temperature: around 135K before and 140K after the update of the characterisation file and LTM files for the STC on the fly products (green line). The temperature of the coldest ocean points is now closer to the other sun-synchroneous missions (Metop-A, SARAL/AltiKa). The orange and brown lines are for the reprocessed data, respectively in STC and NTC timeliness.

The analysis for the liquid water channel (Figure 14) is more complicated due to the different frequency used by these instruments for this channel: 36.5GHz for Sentinel-3A, 37GHz for AltiKa, 34GHz for Jason2 and 31.4Ghz for AMSU-A. But the coldest temperature can be used relatively one with another. For instance, one can see that the difference between AltiKa and Jason-2 is about 6K which is in line with the theoretical value estimated by Brown between the channel 34 GHz of JMR and the channel 37 GHz



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 15

of TMR (-5.61 K \pm 0.23 K) [RD 8]. Then we can expect that Sentinel3 should be closer to AltiKa than Jason2 due to the measurement frequency. The STC and NTC products reprocessed using the new MWR characterisation file (light green curves) show hottest temperatures similar to AltiKa. For the on-the-fly STC products, a jump in the temperatures occurs with the update of MWR characterisation file.

The period is too short to allow a drift analysis but it is reassuring to see that Sentinel-3A/MWR has the same behaviour than the other radiometer.

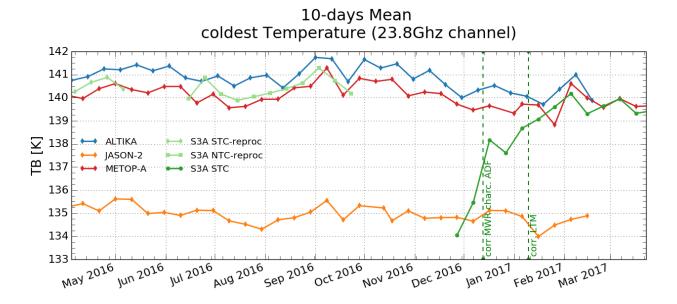


Figure 13 : Coldest temperature over ocean at 23.8GHz for Sentinel-3A, SARAL/AltiKa, Jason2, and Metop-A/AMSU-A

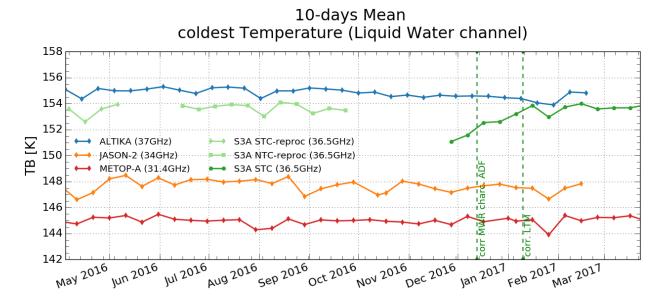


Figure 14 : Coldest temperature over ocean for the liquid water channel Sentinel-3A, SARAL/AltiKa, Jason2, and Metop-A/AMSU-A



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 16

4.2.2 Amazon forest

The second area is the Amazon forest which is the natural body the closest to a black body for microwave radiometry. Thus it is commonly used to assess the calibration of microwave radiometers [RD 2][RD 3]. The method proposed in these papers have been used as a baseline to propose a new method implemented in [RD 7]. In this new approach, a mask is derived from the evergreen forest class of GlobCover classification over Amazon. The average temperature is computed here over a period of 10 days except for Jason2 for which a period of one month is required. Due to the orbit of Jason2, a longer period is required to reach a significant number of measurements falling within the mask.

The averaged temperature over the Amazon forest is shown on Figure 15 and Figure 16 for water vapor channel (23.8GHz) and liquid water channel respectively. These two figures show the very good consistency of Sentinel-3A with the three other radiometers on the hottest temperatures: around 286K for the first channel, and 284K for the second channel. The mean value as well as the annual cycle is well respected. These results show the correct calibration for the hottest temperatures and the small impact of the MWR calibration for the hottest temperatures when comparing the NTC (updated calibration) and the NRT . As for the coldest ocean temperatures, the period is too short to allow a drift analysis.

SENTINEL 3 Mission Performance Contre

Sentinel-3 MPC

S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 17

Mean of Brightness Temperature (23.8GHz) over Amazon forest

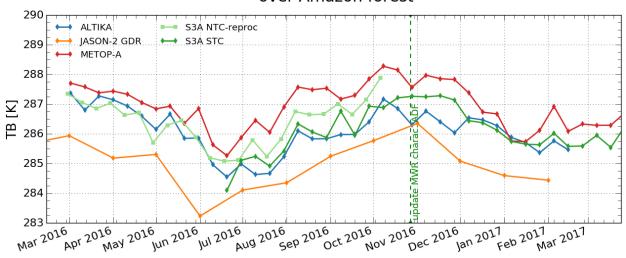


Figure 15 : Average temperature over Amazon forest at 23.8GHz channel for Sentinel-3A, SARAL/AltiKa, Jason2, and Metop-A/AMSU-A

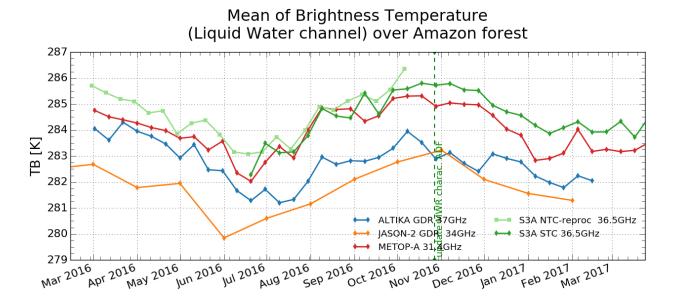


Figure 16 : Average temperature over Amazon forest at 36.5GHz channel for Sentinel-3A, SARAL/AltiKa, Jason2, and Metop-A/AMSU-A



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 18

4.2.3 References

- **RD 1** C. Ruf, 2000: Detection of Calibration Drifts in spaceborne Microwave Radiometers using a Vicarious cold references, **IEEE Trans. Geosci. Remote Sens., 38, 44-52**
- RD 2 S. Brown, C. Ruf, 2005: Determination of an Amazon Hot Reference Target for the on-orbit calibration of Microwave radiometers, Journal of Atmos. Ocean. Techno., 22, 1340-1352
- RD 3 L. Eymard, E. Obligis, N. Tran, F. Karbou, M. Dedieu, 2005: Long term stability of ERS-2 and TOPEX microwave radiometer in-flight calibration, IEEE Trans. Geosci. Remote Sens., 43, 1144-1158
- RD 4 C. Ruf, 2002: Characterization and correction of a drift in calibration of the TOPEX microwave radiometer, IEEE Trans. Geosci. Remote Sens., 40, 209-511
- RD 5 R. Scharoo, J. Lillibridge, W. Smith, 2004: Cross-calibration and long-term monitoring of the microwave radiometers of ERS, TOPEX, GFO, Jason and Envisat, Marine Geodesy, 27, 279-297
- RD 6 R. Kroodsma, D. McKague, C. Ruf, 2012: Cross-calibration and long-term monitoring of the microwave radiometers of ERS, TOPEX, GFO, Jason and Envisat, Applied Earth Obs. and Remote Sensing, 5, 1939-1404
- **RD 7** Estimation des dérives et des incertitudes associées pour les radiomètres micro-ondes. Revue des méthodes existantes, **SALP-NT-MM-EE-22288**,
- **RD 8** Brown, S., C. Ruf, S. Keihm, and A. Kitiyakara, "Jason Microwave Radiometer Performance and On-Orbit Calibration," Mar. Geod., vol. 27, no. 1–2, pp. 199–220, 2004.

4.3 Geophysical products

4.3.1 Monitoring of geophysical products

In this section, comparisons of MWR-ECMWF fields are performed for several instruments. The selected instruments are Jason-2/AMR and SARAL/ALtiKa. For a long term monitoring perspective, GDR products are used to compute the difference with respect to ECMWF fields. GDR products for each mission have its own latency due to cycle curation and mission constraints such as the cold-sky calibration for Jason-2 mission. Indeed, AltiKa GDR is available with delay of ~35 days, while for Jason2 this delay is up to 60 days.

4.3.1.1 Wet tropospheric correction

Figure 17 shows the monitoring of the MWR-ECMWF differences of wet tropospheric correction (Δ WTC) using Level2 STC products from the Marine Center. Sentinel-3A correction is compared to Jason2/AMR and SARAL/MWR corrections. For SARAL (annoted AL in Figure 17) and Jason2 (J2), IGDR products were selected. The daily average of Δ WTC for Sentinel-3A is close to 0cm since 10th of January while it is around 0.6cm for SARAL and Jason2. This difference is small and results partialy from the inversion algorithm.



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 19

The more relevant parameter to assess the performance of a correction is the standard deviation of Δ WTC. First Jason-2 benefits from its three channels radiometer (18.7GHz, 23.8GHz, 34GHz), providing a correction with a smaller deviation with respect to the model. SARAL/MWR is closer to S-3A/MWR in this context with its two channels (23.8GHz, 37GHz). Then the standard deviation for SARAL is the closest reference, even though the Sigma0 in Ka band raises some questions. With the use of STC products for S-3A, the Δ WTC for the three instruments are directly comparable since all missions use ECMWF analyses for the computation of the model correction. The standard deviation of Δ WTC for S-3A is smaller than for SARAL meaning that we have a better estimation of the correction for S-3A according to these metrics. Jason-2 gives the best performances with the smallest deviation. Moreover, one can notice that both SAR and PLMR corrections have very similar performances. The peak value in the standard deviation observed during cycle 14 for both SAR and PLRM Δ WTC comes from the model correction provided by the products. During this day, one ECMWF analyse over the four required for a good estimation all along the day was missing.

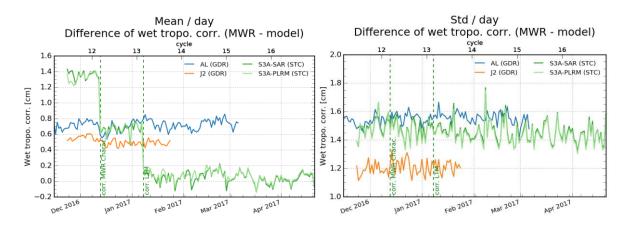


Figure 17: Monitoring of difference MWR-ECMWF correction: daily average (left) and standard deviation (right)

4.3.1.2 Atmospheric attenuation

Figure 18 shows the monitoring of the MWR-ECMWF differences of atmopsheric attenuation (Δ ATM_ATT) using Level2 STC products from the Marine Center. Sentinel-3A correction in Ku band is compared to Jason2/AMR. SARAL/AltiKa is not shown here because the altimeter uses the Ka band. Figure 18 shows that the several evolutions affected mainly the average value of Δ ATM_ATT: the daily average show steps when the configuration of the IPF is updated, while the standard deviation is stable over the whole period. The mean of Δ ATM_ATT for Jason2 is around 0.005dB , a little larger for S-3A: around 0.015dB since mid-January, more stable around 0.01dB since mid-february. A finer tuning of the retrieval algorithm is expected to correct for this small difference.



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 20

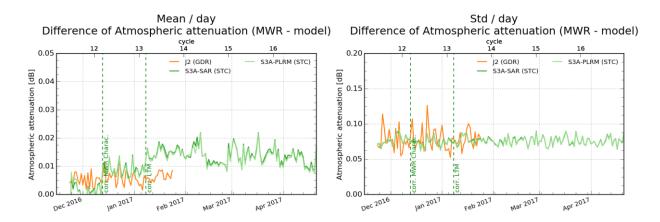


Figure 18 : Monitoring of difference MWR-ECMWF atmospheric attenuation : daily average (left) and standard deviation (right)

4.3.1.3 Water vapor content

Figure 19 shows the monitoring of the MWR-ECMWF differences of atmopsheric attenuation (Δ WV) using Level2 STC products from the Marine Center. Sentinel-3A correction in Ku band is compared to Jason2/AMR. SARAL/AltiKa is not shown here because the altimeter uses the Ka band. Figure 19 Figure 18shows that the several evolutions affected mainly the average value of Δ WV: the daily average show steps when the configuration of the IPF is updated, while the standard deviation is stable over the whole period. The mean of Δ WV for Jason2 is between -1.0kg/m2 and -0.5kg/m2 , very close to AltiKa results of -0.5kg/m2, and a little larger for Sentinel-3A: around 0.5kg/m2 since mid-January. The standard deviation of Δ WV is very similar between AltiKa and S-3A between 2 and 2.5kg/m2, and a little smaller for Jason2 around 2kg/m2. A finer tuning of the retrieval algorithm is expected to correct for the small difference of the daily average.

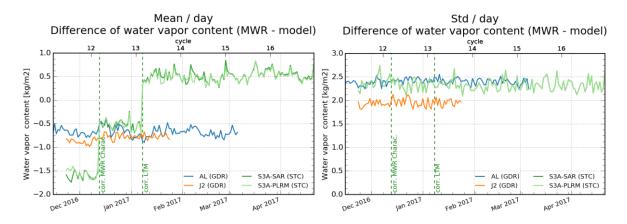


Figure 19 : Monitoring of difference MWR-ECMWF water vapour content : daily average (left) and standard deviation (right)



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 21

4.3.1.4 Cloud liquid water content

Figure 20 shows the monitoring of the MWR-ECMWF differences of cloud liquid water content (Δ WC) using Level2 STC products from the Marine Center. Sentinel-3A fields is compared to Jason2/AMR and SARAL/AltiKa. Figure 20 Figure 18shows that the several evolutions affected mainly the average value of Δ WC: the daily average show steps when the configuration of the IPF is updated but with a smaller effect than for the other geophysical parameters, while the standard deviation is stable over the whole period. The mean of Δ WC is close to 0.04kg/m2 for the three missions. The standard deviation of Sentinel-3A is little higher than for the two other missions: ~0.3kg/m2 for S-3A, 0.2 kg/m2. This point needs to be analyzed.

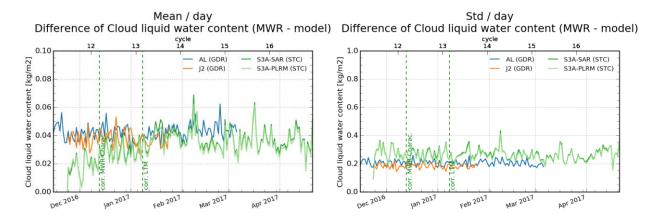


Figure 20 : Monitoring of difference MWR-ECMWF cloud liquid water content : daily average (left) and standard deviation (right)

4.3.2 Comparison to insitu measurements

The comparison of wet tropospheric correction to Radiosonde measurements will be addressed with 2 years of data.



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 22

5 Specific investigations

None.



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 23

6 Events

Add here the list of all MWR events happened during the cycle.



S3-A MWR Cyclic Performance Report

Cycle No. 016

Ref.: S3MPC.CLS.PR.05-016

Issue: 1.0

Date: 29/04/2017

Page: 24

7 Appendix A

Other reports related to the STM mission are:

- S3-A SRAL Cyclic Performance Report, Cycle No. 016 (ref. S3MPC.ISR.PR.04-016)
- S3-A Ocean Validation Cyclic Performance Report, Cycle No. 016 (ref. S3MPC.CLS.PR.06-016)
- S3-A Winds and Waves Cyclic Performance Report, Cycle No. 016 (ref. S3MPC.ECM.PR.07-016)
- S3-A Land and Sea Ice Cyclic Performance Report, Cycle No. 016 (ref. S3MPC.UCL.PR.08-016)

All Cyclic Performance Reports are available on MPC pages in Sentinel Online website, at: https://sentinel.esa.int

End of document