S3-A MWR Cyclic Performance Report

Cycle No. 011

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End date: 07/12/2016

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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.
### Changes Log

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### List of Changes

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</tbody>
</table>

# Table of content

1 INTRODUCTION ............................................................................................................. 1

2 OVERVIEW OF CYCLE 011 ............................................................................................. 2
   2.1 STATUS ................................................................................................................... 2
   2.2 IPF PROCESSING CHAIN STATUS ......................................................................... 3
       2.2.1 IPF version ...................................................................................................... 3
       2.2.2 Auxiliary Data files ......................................................................................... 4

3 MWR MONITORING OVER CYCLE 011 ..................................................................... 5
   3.1 OPERATING MODES ............................................................................................... 5
   3.2 CALIBRATION PARAMETERS .................................................................................. 6
       3.2.1 Gain ................................................................................................................ 6
       3.2.2 Noise Injection Temperature ........................................................................... 7
   3.3 BRIGHTNESS TEMPERATURES .............................................................................. 7
   3.4 GEOPHYSICAL PRODUCTS MONITORING ............................................................... 8
       3.4.1 Wet Tropospheric Correction ......................................................................... 9
       3.4.2 Atmospheric Attenuation .............................................................................. 10

4 LONG-TERM MONITORING ............................................................................................ 12
   4.1 INTERNAL CALIBRATION PARAMETERS ................................................................. 12
       4.1.1 Gain ................................................................................................................ 12
       4.1.2 Noise Injection temperature .......................................................................... 13
   4.2 VICARIOUS CALIBRATION ...................................................................................... 14
       4.2.1 Coldest ocean temperatures ......................................................................... 14
       4.2.2 Amazon forest ............................................................................................... 16
       4.2.3 References ...................................................................................................... 17
   4.3 GEOPHYSICAL PRODUCTS ....................................................................................... 18
       4.3.1 Monitoring of geophysical products ............................................................... 18
       4.3.2 Comparison to in situ measurements ............................................................. 18

5 SPECIFIC INVESTIGATIONS ............................................................................................ 19
<table>
<thead>
<tr>
<th>Events</th>
<th>Pages</th>
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</thead>
<tbody>
<tr>
<td>EVENTS</td>
<td>20</td>
</tr>
<tr>
<td>APPENDIX A</td>
<td>21</td>
</tr>
</tbody>
</table>
List of Figures

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

Table 1: General overview of the MWR quality assessment ---------------------------------------------- 2
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 11.

This report covers the short term monitoring of internal calibration and brightness temperatures based on NRT products generated at Svalbard (SVL) core ground station and monitoring of geophysical products based on NRT (Near Real Time) products for cycle 11 (10 November 2016 to 7 December 2016). The long term monitoring section provides a view of the internal calibration monitoring as well as two subsections covering the monitoring of vicarious calibration targets and geophysical parameters.

The long term internal calibration monitoring covers the period from cycle 1 to cycle 11. To this aim, the data from the recent reprocessing (using IPF v6.5) are used to cover the period from cycle 1 to cycle 9, the NRT product are used only from 26/10/2016 allowing an homogeneous time serie. The vicarious calibration monitoring is presented using reprocessing data and on-line data, again for homogeneity. The geophysical long term monitoring will be completed as soon as the amount of data will be sufficient.

This document is splitted 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
- Section 4 addresses the long term monitoring from the beginning of the mission
2 Overview of Cycle 011

2.1 Status

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

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*Table 1: General overview of the MWR quality assessment*

Color legend:

- OK
- Warning
- NOK
- Not available
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

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### MWR L1B

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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.

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3 MWR Monitoring over Cycle 011

This section is dedicated to the functional verification of the MWR sensor behaviour during the cycle 11 (10 November 2016 – 7 December 2016). The main relevant of the parameters, monitored daily by the MPC team, are presented here.

3.1 Operating modes

The radiometer have 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)

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

![Figure 1: Distribution of operating mode](chart)

For measurements in the Intermonitoring mode, two kind of processings 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 pending on the
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 50 km after.

![Map of measurements with DNB processing for 36.5GHz channel (red) and safety mode for both channels over KREMS (blue)](image)

**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 in-flight 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). This parameter is used by the DNB processing of the Earth measurements.
- **the noise injection temperature**: this parameter is measured during the Noise Injection calibration measurements. This parameter is used by the NIR processing of the Earth measurements.

#### 3.2.1 Gain

The Figure 3 shows the monitoring of the receiver gain for the current cycle. For both channels, the estimated gain is close to values estimated on-ground during characterization of the instrument:
4.793mV/K and 4.665mV/K for channels 23.8GHz and 36.5GHz respectively. The gain of 23.8GHz channel is constant over the cycle while the 36.5GHz channel gain shows a slight decrease. Nominal behavior is observed since only 1 cycle of data is considered in this section.

**3.2.2 Noise Injection Temperature**

The Figure 4 shows the monitoring of the noise injection temperature for the current cycle. The noise injection temperature for the 23.8GHz channels is constant over the cycle around 314K. For the 36.5GHz channel, the diode shows a slow decrease along the cycle of less than 0.1K. 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.

**3.3 Brightness Temperatures**

The two following figures show maps of brightness temperatures for both channels 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](image1)

![Figure 6: Map of Brightness temperatures of channel 36.5GHz for ascending (right) and descending (left) passes](image2)

### 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 i.e. 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

The left part of Figure 7 presents the histograms of the MWR-ECMWF differences of wet tropospheric correction ($\Delta$WTC) for the cycle 11. In this figure, Sentinel-3A/MWR correction is compared to the correction retrieved by Jason2/AMR and SARAL/MWR over the same period. For SARAL and Jason2, IGDR data have been selected because the GDR data were not available at the time of writing this report. The standard deviation of the difference MWR-ECMWF corrections is greater for S-3A than for the two radiometers: 1.9cm for S-3A while it is only 1.57cm for SARAL and 1.16cm for Jason-2. 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 rises some questions.

The mean value of S-3A $\Delta$WTC is larger than expected taking into account the update of the MWR characterisation file and the Level 2 configuration file which parameterize the inversion algorithms. An issue has been found with the Marine Center processing which did not use the correct MWR characterisation file (SIIIMPC-1276). The standard deviation is expected to be larger than for SARAL Std_\$\Delta$WTC due to the data used to compute the ECMWF correction (forecast for NRT S3-A products, analyses for Jason-3 and SARAL ECMWF correction).

The right part of Figure 7 presents a map of the $\Delta$WTC for Sentinel-3A only. For this cycle, the map shows geographical patterns expected for this parameter. Note that the color scale is centered to the mean value. The comparison with Jason2 map of $\Delta$WTC Figure 8 shows similarities although Sentinel-3A $\Delta$WTC is larger than Jason2 because of their different instrument configuration, and the issue of processing stated before.

![Figure 7: MWR-ECMWF difference of wet tropospheric correction using SAR altimeter backscatter](image)

**Left:** Histograms of differences for Sentinel-3A/MWR, Jason2/AMR and SARAL/MWR

**Right:** Map of $\Delta$WTC for Sentinel-3A
Concerning the correction computed using the PLRM backscatter coefficient (Figure 9), the standard deviation of the difference MWR-model of the correction is similar to the one using the SAR Sigma0. More refined analysis will be performed using a correct value of the model correction.

3.4.2 Atmospheric Attenuation

The left part of Figure 10 presents the histograms of the Ku band atmospheric attenuation of the Sigma0 for the cycle 11. 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 of 0.2dB. The right part of Figure 10 shows a map of attenuation of Sentinel-3A.

**Figure 10**: Ku band Atmospheric attenuation of the Sigma0

Left: Histograms for Sentinel-3A/MWR, Jason2/AMR; Right: Map of atmospheric attenuation for Sentinel-3A
4 Long-term monitoring

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

4.1 Internal Calibration parameters

In this section, data from the recent reprocessing (using IPF v6.5) are used to cover the period from cycle 1 to cycle 9, MWR L1B data generated by PDGS at Svalbard core ground station are used from 26/10/2016 allowing an homogeneous time serie. The period covered by the monitoring will start at cycle 1 until cycle 11.

4.1.1 Gain

The 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. Moreover the first part of the monitoring of the calibration parameters is performed using NTC product generated during the recent 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 11, one can see that the receiver gain has a different behaviour for each channel. The gain for the 23.8GHz is slowly increasing continously (+0.01mv/K) until cycle 7 and stabilized since then. For the 36.5GHz channel, the gain is increasing from cycle 1 and then starts to decrease at the beginning of cycle 4. The decreasing rate is almost constant since cycle 7. 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)](image-url)
4.1.2 Noise Injection temperature

The 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 recent 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 diode, the noise injection temperature has decrease of 0.5K during the first 2 cycles, since then the evolution has been constant. During cycle 8, a small increase (0.05K) of the noise injection temperature appears. The evolution is constant since cycle 8. For the channel 36.5GHz, one can see that the diode is not yet 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. The decreasing rate is increasing since cycle 9. 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 and 10 for the channel 36.5GHz. The investigations performed in the cycle 6 report has shown that these measurements are localized around a band of latitude, a different one for the three cases observed until now. The source is not yet clearly identified but a intrusion in the sky horn is suspected.

Figure 12: Daily mean of the noise injection temperature for both channels: 23.8GHz (left) and 36.5GHz (right)
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.

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/AMSUA. 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 MetopA. For Sentinel-3A, the results are shown NRT data from June to December and also for data from the recent processing (using IPF v6.5): L2 STC data from 06 April to 06 May, L2 NTC data from 15 June to 30 September.

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 136K with NRT products, around 140K for the STC and NTC products. It is expected that the NRT show a jump of the brightness temperature at the end of November when the IPF was updated in the Marine processing center. With the results of Figure 12, we can see that there is no jump of the temperature. An SPR has been raised by the MWR ESL (SIIIMPC-1276), the issue in the processing has been identified and corrected.

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 of TMR (-5.61 K ± 0.23 K) [RD 8]. Then we can expect that Sentinel3 should be closer to AltiKa than Jason2 due to the measurement frequency. This is observed for the STC and NTC products processed with the new MWR characterisation file. The NRT products shall show a jump at the end of November with the update of IPF but there is no change in the results (SIIIMPC-1276).

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 MetopA/AMSUA

Figure 14 Coldest temperature over ocean for the liquid water channel Sentinel-3A, SARAL/AltiKa, Jason2, and MetopA/AMSUA
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 temperature, the period is too short to allow a drift analysis.

![Mean of Brightness Temperature (23.8GHz) over Amazon forest](image)

*Figure 15 Average temperature over Amazon forest at 23.8GHz channel for Sentinel-3A, SARAL/AltiKa, Jason2, and MetopA/AMSUA*
Sentinel-3 MPC
S3-A MWR Cyclic Performance Report
Cycle No. 011

Mean of Brightness Temperature
(Liquid Water channel) over Amazon forest

Figure 16 Average temperature over Amazon forest at 36.5GHz channel for Sentinel-3A, SARAL/AltikKa, Jason2, and MetopA/AMSUA

4.2.3 References


RD 7 Estimation des dérives et des incertitudes associées pour les radiomètres micro-ondes. Revue des méthodes existantes, SALP-NT-MM-EE-22288,

4.3 Geophysical products

4.3.1 Monitoring of geophysical products

The monitoring of the geophysical products (wet tropospheric correction, atmospheric attenuation) have a long term perspective then required several months of data.

4.3.2 Comparison to insitu measurements

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

None.
6 Events

Add here the list of all MWR events happened during the cycle.
Other reports related to the STM mission are:

- S3-A SRAL Cyclic Performance Report (ref. S3MPC.ISR.PR.04-011)
- S3-A Ocean Validation Cyclic Performance Report (ref. S3MPC.CLS.PR.06-011)
- S3-A Winds and Waves Cyclic Performance Report (ref. S3MPC.ECM.PR.07-011)

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

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