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

# **S3-A MWR Cyclic Performance Report**

Cycle No. 034

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SENTINEL 3



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# **Changes Log**

Version	Date	Changes
1.0	04/10/2018	First Version

# **List of Changes**

Version	Section	Answers to RID	Changes



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# 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 34.

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.



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# 2 Overview of Cycle 034

## 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
Long-term monitoring		Nominal for three analyses

Table 1 : General overview of the MWR quality assessment

# **Color legend:**





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# 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:

	: processing time of the first product
	: processing time of the last product

## **MWR L1B CAL**

IPF version	NRT ( Svalbard )
06.07	

#### **MWR L1B**

IPF version	NTC ( LN3)
06.07	

#### **SRAL/MWR Level 2**

IPF version	NTC ( Marine)
06.14	



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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.

# **Side Lobe Correction file**

Filename	NTC ( LN3)
S3A_MW_1_SLC_AX_20000101T000000_20991231T235959_20160603 T120000MPC_O_AL_002.SEN3	

## **MWR CCDB**

Filename	NTC ( LN3)
S3A_MWCHDNAX_20160216T000000_20991231T235959_2016101 4T120000MPC_O_AL_002.SEN3	

# **Level2 Configuration file**

Filename	NTC ( Marine)
S3A_SR_2_CON_AX_20160216T000000_20991231T235959_20180213	
T120000MPC_O_AL_011.SEN3	



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# 3 MWR Monitoring over Cycle 034

This section is dedicated to the functional verification of the MWR sensor behaviour during cycle 34 (24 July 2018 - 20 August 2018). 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.

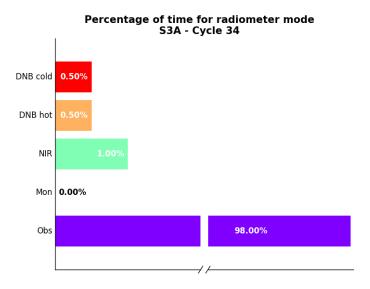


Figure 1: Distribution of operating mode

The distribution has slightly changed with respect to previous cycle due to update of calibration timeline of the 1<sup>st</sup> March 2018. Before the update, a calibration sequence is 9s long composed of and occurs 3 times per orbit. After that update, the calibration sequences are much shorter (~0.6s) but occurs every 30 seconds. Moreover, due to more frequent calibration, the monitoring measurements are no longer needed to monitore the noise diode.



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For measurements in the Intermonitoring mode (Obs 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 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.

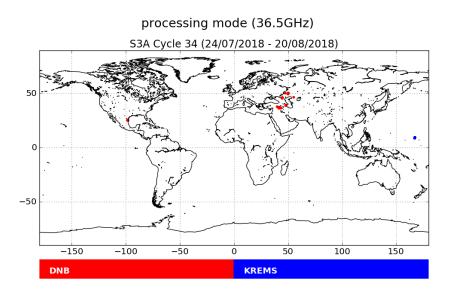


Figure 2 : Map of measurements with DNB processing for 36.5GHz channel (red) and safety mode for both channels over KREMS (blue)

# 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.

Data used for the diagnosis presented here are data generated by PDGS at Svalbard core ground station.



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#### 3.2.1 Gain

Figure 3 shows the monitoring of the receiver gain for the current cycle. The mean value over the cycle is 4.77mv/K and 4.54mV/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 channels 23.8GHz and 36.5GHz respectively).

Before the update of the calibration timeline of the 1<sup>st</sup> March 2018, a calibration sequence is 9s long composed of 30 measurements of NIR calibration, 15 measurements of each DNB calibration (cold and hot) and occurs 3 times per orbit. The 30/15 measurements were averaged in the calibration processor, providing only three calibration parameters per orbit. After that update, the calibration sequences are much shorter (~0.6s ) but occurs every 30 seconds. The monitoring presented here shows parameters extracted from the calibration product, averaged over the sequence. This explains the increase of variability after the update of the 1<sup>st</sup> March, before the monitored parameters was averaged over 15 measurements, after over only 1 measurement.

Nominal behavior is observed since only 1 cycle of data is considered in this section.

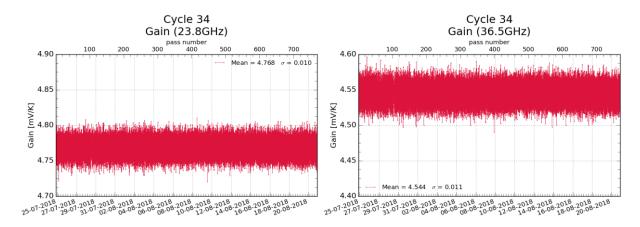


Figure 3: Monitoring of receiver gain for both channels: 23.8GHz (left) and 36.5GHz (right)

#### 3.2.2 Noise Injection Temperature

Figure 4 shows the monitoring of the noise injection temperature for the current cycle. The noise injection temperature show no trend over the cycle for both channels. The average value of the noise inection temperatures are 313.8K/288.4K for channels 23.8GHz/36.5GHz respectively.

Before the update of the calibration timeline of the 1<sup>st</sup> March 2018, a calibration sequence is 9s long composed of 30 measurements of NIR calibration, 15 measurements of each DNB calibration (cold and hot) and occurs 3 times per orbit. The 30/15 measurements were averaged in the calibration processor, providing only three calibration parameters per orbit. After that update, the calibration sequences are much shorter (~0.6s) but occurs every 30 seconds. The monitoring presented here shows parameters extracted from the calibration product, averaged over the sequence. This explains the increase of



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variability after the update of the 1<sup>st</sup> March: before the monitored parameters was averaged over 30 measurements, after over only 2 measurements.

Nominal behavior is observed since only 1 cycle of data is considered in this section.

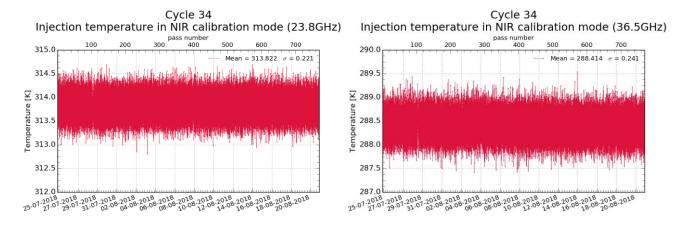


Figure 4: Monitoring of Noise Injection temperature for both channels: 23.8GHz (left) and 36.5GHz (right)

# 3.3 Brightness Temperatures

Data used for the diagnosis presented here are data generated at Land Surface Topography Mission Processing and Archiving Centre [LN3].

The two following figures show maps of brightness temperatures for both channels split by ascending (right part) and descending (left part) passes. 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. 30 orbit products were not received by the MPC resulting in the data gaps shown in both figures.

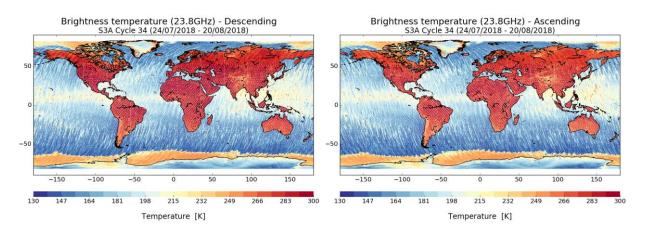


Figure 5: Map of Brightness temperatures of channel 23.8GHz for ascending (right) and descending (left) passes



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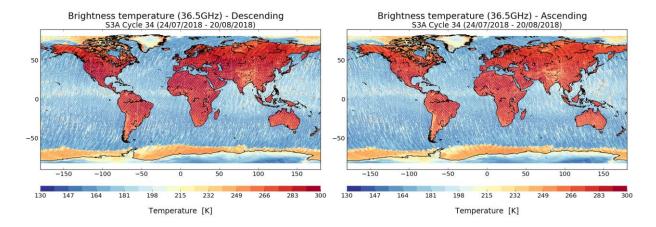


Figure 6: Map of Brightness temperatures of channel 36.5GHz for ascending (right) and descending (left) passes

# 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 ( $\Delta$ WTC) for cycle 27. In this figure, Sentinel-3A/MWR correction is compared to the correction retrieved by Jason-3/AMR (IGDR) and SARAL/MWR (IGDR) over the same period.

The standard deviation of the difference MWR-ECMWF corrections for S-3A is around 1.37cm for SAR and PLRM corrections respectively while it is 1.5cm for SARAL and 1.17cm for Jason-3. First Jason-3 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  $\Delta$ WTC for the three instruments are directly comparable since all use ECMWF analyses for the computation of the model correction. The standard deviation of  $\Delta$ 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-3 gives the best performances with the smallest deviation. Moreover, one can



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notice that both SAR and PLMR corrections have very similar performances: mean(std) of ΔWTC being close to 0.22cm(1.37cm) and 0.24cm(1.36cm) for SAR and PLRM respectively.

Figure 8 presents a map of the  $\Delta$ 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 Jason-3 map of  $\Delta$ WTC (Figure 9) shows similarities although Sentinel-3A  $\Delta$ WTC is larger than Jason3 because of their different instrument configuration.

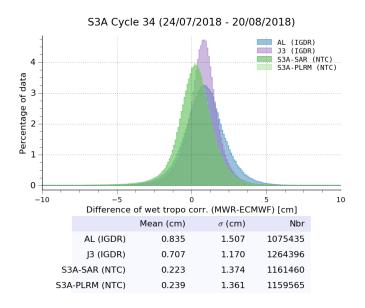


Figure 7: Histograms of MWR-ECMWF difference of wet tropospheric correction for SARAL/MWR , Jason3/AMR and Sentinel-3A/MWR SAR and PLRM (selection of latitude between -60°/60° for all instruments, distance to shoreline >50km for S3A)

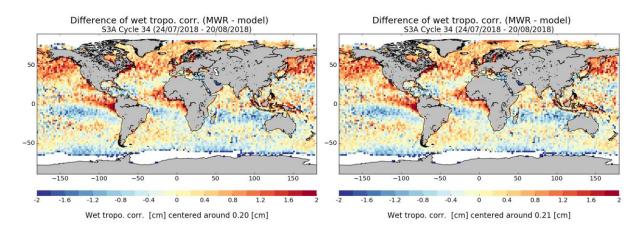


Figure 8 : MWR-ECMWF difference of wet tropospheric correction : using SAR (left) and PLRM altimeter backscatter (right)



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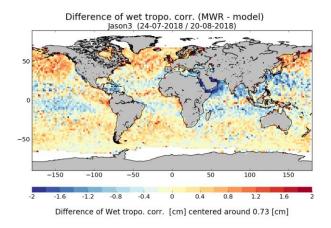


Figure 9: Jason3/AMR MWR-ECMWF difference of wet tropospheric correction (IGDR product)

#### 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 model attenuation computed from ECMWF analyses and Jason3 attenuation from IGDR products. The results for both instruments are very similar to model results with an average attenuation close to 0.22dB for S-3A , 0.20dB for Jason3 and 0.2dB for model attenuation. Note that the model attenuation shows in that histogram is the attenuation computed at Sentinel-3A time and geolocation. The right panel 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 0.01 dB between MWR and model attenuation can be estimated from this plot.

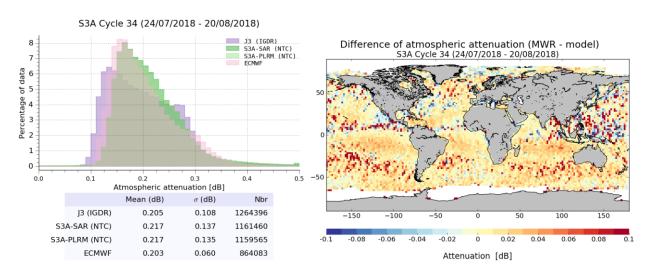


Figure 10: Ku band Atmospheric attenuation of the Sigma0

Left: Histograms for Sentinel-3A/MWR, Jason3/AMR, Model attenuation(selection of latitude between -60°/60° for all instruments, distance to shoreline >50km for S3A); Right: Map of difference of MWR-model atmospheric attenuation for Sentinel-3A



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# 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 (processing baseline 2.15) from cycle 1 to cycle 16
- 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 shown here is performed with products generated during the reprocessing using the processing baseline 2.15, the second part using NRT products from the day of the IPF update on the Svalbard ground station forward.

From the two panels of Figure 11, one can see that the receiver gain has a different evolution for each channel. The gain for the 23.8GHz channel has slowly increased since the beginning of the mission showing four slopes and three inflexion points at August 2016, Februray 2017 and June 2017. It seems to be almost stable since cycle 19 (July 2017). The gain has increased of +0.03mv/K since the beginning of the mission. For the 36.5GHz channel, the gain is increasing from cycle 1 and then starts to decrease at the beginning of cycle 4. During cycle 15, it started to increase again until cycle 18 and then starts a decrease. The gain has decreased of 0.03mV/K since the beginning of the mission. 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.

The update of the calibration timeline of the 1<sup>st</sup> March 2018 has an impact on the standard deviation and minimum and maximum values of the gain (as explained in section 3.2.1), but there is no evidence of a change in the daily mean value.



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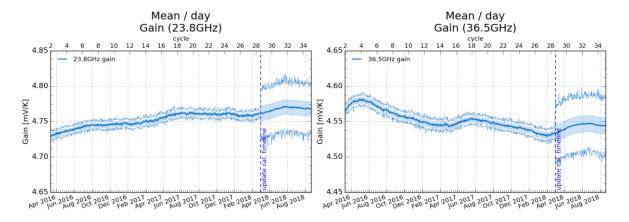


Figure 11: Daily mean of the gain for both channels: 23.8GHz (left) and 36.5GHz (right)

#### 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 products generated during the reprocessing os processing baseline 2.15, the second part using NRT calibration products from the day of the IPF update on the ground station.

From the two panels of Figure 12, one can see that the noise injection parameter has a different evolution for each channel. For the 23.8GHz channel, the noise injection temperature has decreased of less than 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 injection temperature is not stable: it seems to follow some kind of periodic signal combined with a trend. Since cycle 19, the gain is slowly decreasing as it has done from July 2016 to February 2017. The monitoring will be pursued and data checked for any impact.

The update of the calibration timeline of the 1<sup>st</sup> March 2018 has an impact on the standard deviation and minimum and maximum values of the gain (as explained in section 3.2.1), but there is no evidence of a change in the daily mean value.

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 and 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.



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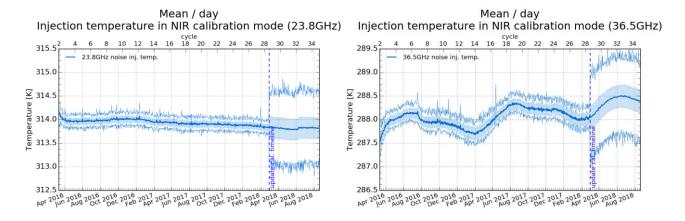


Figure 12 : Daily statistics of the noise injection temperature for channel 23.8GHz (left) and 36.5GHz (right): mean (bold line), min/max (thin line), standard deviation (shade)

#### 4.2 Vicarious calibration

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

- Coldest ocean temperature analysis uses Level 2 data
  - o data from processing baseline 2.15 reprocessing from June 2016 to April 2017.
  - STC Marine data from December 2016 to December 2017
  - NTC Marine data since cycle 26
- Amazon forest analysis uses Level 1B data:
  - data from processing baseline 2.15 reprocessing from June 2016 to April 2017.
  - STC Land data from LN3 processing center
  - NTC Marine data since cycle 26

#### 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 four other microwave radiometers: AltiKa/MWR, Jason2/Jason3/AMR and Metop-A/AMSU-A. For AMSU-A, the two pixels of smallest incidence (closest to



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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/Jason3 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 light green line is for the reprocessed data of processing baseline 2.15 that is with the same configuration than the on-the-fly products after January. One can notice the very good agreement on the overlaping period.

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/Jason3 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/Jason3 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. The STC and NTC products reprocessed using the new MWR characterisation file (light green curves) show hottest temperatures like 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.

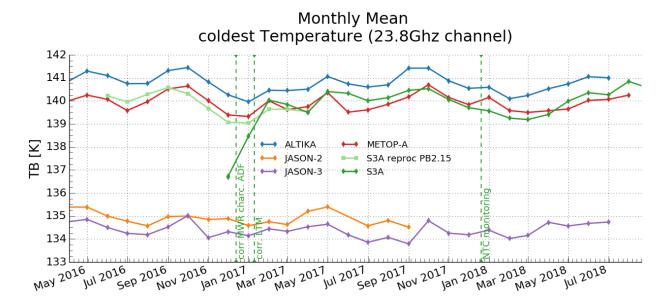


Figure 13 : Coldest temperature over ocean at 23.8GHz for Sentinel-3A, SARAL/AltiKa, Jason2, Jason3 and Metop-A/AMSU-A



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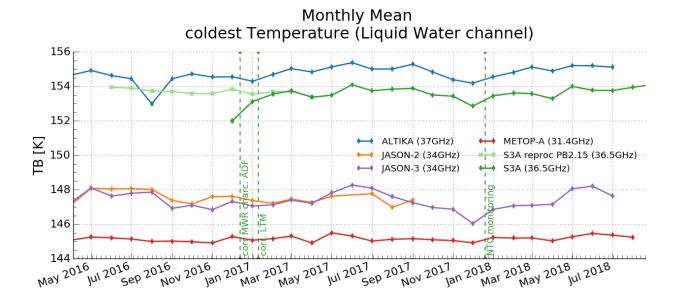


Figure 14 : Coldest temperature over ocean for the liquid water channel Sentinel-3A, SARAL/AltiKa, Jason2, Jason3 and Metop-A/AMSU-A

#### 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 one month for all missions.

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 reprocessed data using processing baseline 2.15 (light green line) and the on-the-fly products, here STC L1B products . As for the coldest ocean temperatures, the period is too short to allow a drift analysis.

# Mission Performance Centre

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# Mean of Brightness Temperature (23.8GHz) over Amazon forest

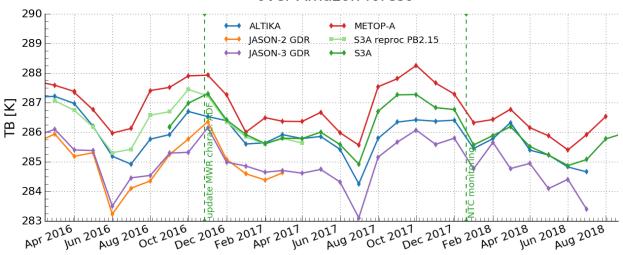


Figure 15 : Average temperature over Amazon forest at 23.8GHz channel for Sentinel-3A, SARAL/AltiKa, Jason2,

Jason3, and Metop-A/AMSU-A

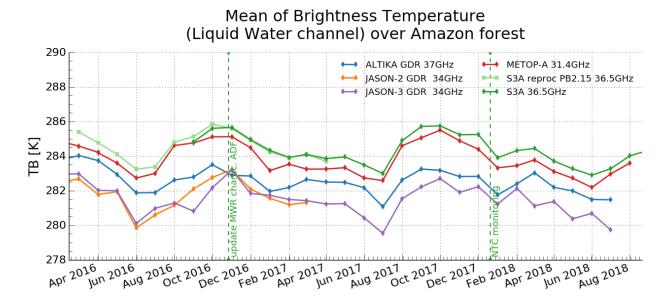


Figure 16 : Average temperature over Amazon forest at 36.5GHz channel for Sentinel-3A, SARAL/AltiKa, Jason2, Jason3 and Metop-A/AMSU-A



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- RD 6 R. Kroodsma, D. McKague, C. Ruf, 2012: Inter-Calibration of Microwave Radiometers Using the Vicarious Cold Calibration Double Difference Method, Applied Earth Obs. and Remote Sensing, 5, 1939-1404
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# 4.3 Geophysical products

#### 4.3.1 Monitoring of geophysical products

In this section, comparisons of MWR-model fields are performed for several instruments. The selected instruments are Jason2/Jason3/AMR and SARAL/AltiKa. For a long-term monitoring perspective, GDR products are used to compute the difference with respect to model values. Model values for each field are computed using ECMWF analyses data. GDR products for each mission have their own latency due to cycle curation and mission constraints such as the cold-sky calibration for Jason-2 and Jason-3 missions. Indeed, AltiKa GDR is available with delay of 35 days, while for Jason2 or Jason3 this delay is up to 60 days.

#### 4.3.1.1 Wet tropospheric correction

Figure 17 shows the monitoring of the MWR-model differences of wet tropospheric correction (ΔWTC) using Level2 STC products from the Marine Center. Sentinel-3A correction is compared to Jason2/AMR, Jason3/AMR and SARAL/MWR corrections. For SARAL (annoted AL in Figure 17), Jason2 (J2) and Jason3 (J3), GDR products were selected. A 30-days moving window averaging is applied in order to smooth the day-to-day variations. The daily data is shown by the points, and the averaging shown by the line, both with the same color corresponding to each mission.



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The daily average of  $\Delta$ WTC for Sentinel-3A is close to 0cm since 10<sup>th</sup> of January up to 0.2cm since October 2017 while it is around 0.6cm for SARAL and Jason-2. This difference is small and results partialy from the inversion algorithm. The more relevant parameter to assess the performance of a correction is the standard deviation of  $\Delta$ WTC. First Jason-2 and Jason3 benefit from their 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  $\Delta$ 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  $\Delta$ 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 and Jason-3 give the best performances with the smallest deviation. Moreover, one can notice that both SAR and PLMR corrections have very similar performances.

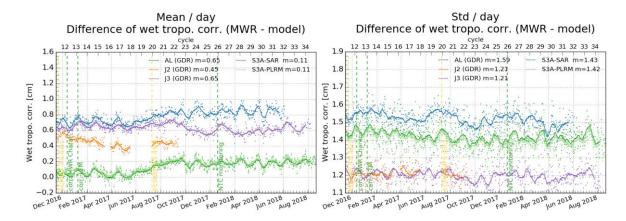


Figure 17: Monitoring of difference MWR-model wet tropo. correction: daily average (left) and standard deviation (right). Selection of points with latitude between -60° and 60°, distance to coast >50km for S3A



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#### 4.3.1.2 Atmospheric attenuation

Figure 18 shows the monitoring of the MWR-model differences of atmospheric attenuation (ΔATM\_ATT) using Level2 STC products from the Marine Center. Sentinel-3A correction in Ku band is compared to Jason2/AMR andJason3/AMR. SARAL/AltiKa is not shown here because the altimeter uses the Ka band. A 30-days moving window averaging is applied in order to smooth the day-to-day variations. The daily data is shown by the points, and the averaging shown by the line, both with the same color corresponding to each mission.

Figure 18 shows that the several evolutions affected mainly the average value of  $\Delta$ ATM\_ATT: the daily average show steps when the configuration of the IPF is updated, while the standard deviation remains stable over the period. The mean of  $\Delta$ ATM\_ATT for Jason2 and Jason-3 is 0.004dB and 0.003dB respectively, a little larger for S-3A with 0.014dB. The evolution is stable for Jason2/3, some jumps are observable for Sentinel-3A. The steps at the beginning of the period are due to processing configuration changes (MWR characterisation file, Long Term Monitoring file). During cycle 25, a step is observed over the mean and standard deviation of the difference. This step corresponds to the IPF update correcting the coding of the atmospheric attenuation in the product. The atmospheric attenuation can now have higher values in case of strong attenuation events. These points have an impact on the mean and the standard deviation because they have very high values with respect to the average attenuation in Ku band. A finer tuning of the retrieval algorithm is expected to correct for that.

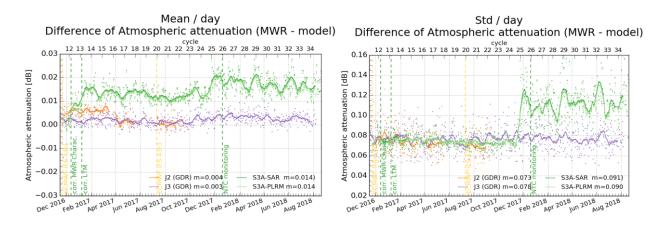


Figure 18 : Monitoring of difference MWR-model atmospheric attenuation: daily average (left) and standard deviation (right). Selection of points with latitude between -60° and 60°



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#### 4.3.1.3 Water vapor content

Figure 19 shows the monitoring of the MWR-model differences of atmospheric attenuation (ΔWV) using Level2 ShortTimeCritical (STC) and Non Time Critical (NTC) products from the Marine Center. Sentinel-3A correction is compared to Jason2/AMR and Jason3/AMR. A 30-days moving window averaging is applied in order to smooth the day-to-day variations. The daily data is shown by the points, and the averaging shown by the line, both with the same color corresponding to each mission.

Figure 19 shows that the several evolutions affected mainly the average value of  $\Delta$ 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  $\Delta$ WV for Jason2 is around -0.75kg/m2, very close to AltiKa results of -0.58kg/m2, around -1.06kg/m2 for Jason3, and a little larger for Sentinel-3A: around 0.25kg/m2 in average. The standard deviation of  $\Delta$ WV is very similar between AltiKa (2.50kg/m2) and S-3A (2.25kg/m2 for PLRM), and a little smaller for Jason2 and Jason3 around 2kg/m2. A finer tuning of the retrieval algorithm is expected to correct for the small difference of the daily average.

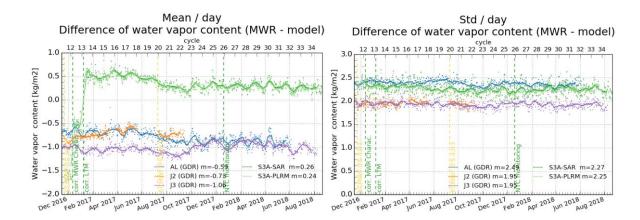


Figure 19 : Monitoring of difference MWR-ECMWF water vapour content: daily average (left) and standard deviation (right). Selection of points with latitude between -60° and 60°



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#### 4.3.1.4 Cloud liquid water content

Figure 20 shows the monitoring of the MWR-model differences of cloud liquid water content (ΔWC) using Level2 STC products from the Marine Center. Sentinel-3A fields is compared to Jason2/AMR, Jason3/AMR and SARAL/AltiKa. A 30-days moving window averaging is applied in order to smooth the day-to-day variations. The daily data is shown by the points, and the averaging shown by the line, both with the same color corresponding to each mission.

Figure 20 shows that the several evolutions affected mainly the average value of  $\Delta$ 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  $\Delta$ WC is close to 0.04kg/m2 for AltiKa, Jason2 and S-3A but around 0.03kg/m2 for Jason3. The standard deviation of Sentinel-3A is little higher than for the three other missions:  $\sim$  0.3kg/m2 for S3-A,  $\sim$  0.2 kg/m2 for the other missions. This point needs to be analyzed.

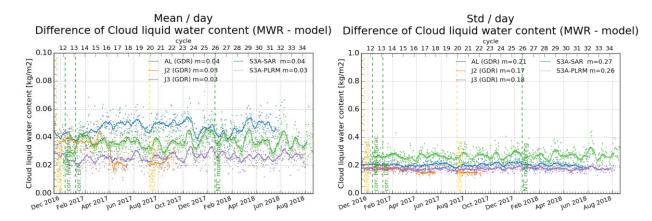


Figure 20 : Monitoring of difference MWR-ECMWF cloud liquid water content: daily average (left) and standard deviation (right). Selection of points with latitude between -60° and 60°

#### 4.3.2 Comparison to in-situ measurements

The database is under construction and validation. Studies are on-going.



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# 5 Appendix A

Other reports related to the STM mission are:

- S3-A SRAL Cyclic Performance Report, Cycle No. 034 (ref. S3MPC.ISR.PR.04-034)
- S3-A Ocean Validation Cyclic Performance Report, Cycle No. 034 (ref. S3MPC.CLS.PR.06-034)
- \$ S3-A Winds and Waves Cyclic Performance Report, Cycle No. 034 (ref. S3MPC.ECM.PR.07-034)
- S3-A Land and Sea Ice Cyclic Performance Report, Cycle No. 034 (ref. S3MPC.UCL.PR.08-034)

All Cyclic Performance Reports are available on MPC pages in Sentinel Online website, at: <a href="https://sentinel.esa.int">https://sentinel.esa.int</a>

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