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

S3-A SRAL Cyclic Performance Report

Cycle No. 011

Start date: 10/11/2016

End date: 07/12/2016



Mission
Performance
Centre

SENTINEL 3



Ref.: S3MPC.ISR.PR.04-011

Issue: 1.0

Date: 13/12/2016

Contract: 4000111836/14/I-LG

| Customer: | ESA | Document Ref.: | S3MPC.ISR.PR.04-011 |
|---------------|-------------------------------|----------------|---------------------|
| Contract No.: | 4000111836/14/I-LG | Date: | 13/12/2016 |
| isardSAT Doc. | Ref.: ISARD_ESA_S3_MPC_RP_491 | Issue: | 1.0 |

| Project: | PREPARATION AND OPERATION FOR THE COPERNICUS SENTIN | | PERFORMANCE CENTRE (MPC) |
|-----------------|--|---------------|--|
| Title: | S3-A SRAL Cyclic Performance Report | | |
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| Distribution: | ESA, EUMETSAT, S3MPC consortium | | 1 |
| Accepted by ESA | P. Féménias, MPC TO | | |
| Filename | S3MPC.ISD.PR.04-011 - i1r0 - SRAL Cyclic Report 011.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.









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Changes Log

| Version | Date | Changes |
|---------|------------|---------------|
| 1.0 | 13/12/2016 | First Version |
| | | |
| | | |
| | | |

List of Changes

| Version | Section | Answers to RID | Changes |
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1 Introduction

1.1 Applicable Documents

| AD. 1 | Cal/Val Plan for the MPC Commissioning Phase - STM, S3MPC.CLS.PLN.009, issue 1.1, |
|-------|---|
| AD. 1 | 26/05/2015. |

1.2 Acronyms

| ADF | Auxiliary Data File |
|---------|---|
| Cal/Val | Calibration / Validation |
| CNES | Centre National d'Études Spatiales |
| DEM | Digital Elevation Model |
| ESA | European Space Agency |
| ESL | Expert Support Laboratory |
| ESTEC | European Space Technology Centre |
| НКТМ | House Keeping Temperatures Monitoring |
| IOCR | In-Orbit Commissioning Review |
| LRM | Low Resolution Mode |
| MPC | Mission Performance Centre |
| PTR | Point Target Response |
| SAR | Synthetic Aperture Radar |
| SCCDB | Satellite Calibration and Characterisation Database |
| SCT | Satellite Commissioning Team |
| SRAL | Synthetic Aperture Radar Altimeter |
| TBD | To Be Done |



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1.3 Scope of the document

This document is dedicated to describe the cyclic monitoring of the SRAL instrument calibration parameters within the Sentinel-3 MPC project. Also a whole mission analysis is given.

It will be distributed during the Commissioning Ramp-up Phase to the MPC team and to ESA, on a cyclic basis.



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2 SRAL Internal Calibration Monitoring.

2.1 Introduction

The SRAL instrumental calibration is assessed during the mission. Several parameters are monitored and analysed in detail in order to characterise the altimeter performance along the mission lifetime.

Two main groups of calibration parameters are monitored.

The first is derived from the Point Target Response (PTR) calibration (CAL-1 mode and product). The PTR signal follows the same circuitry path as the science waveforms within the calibration loop. The delay caused by the travel through the calibration path can be measured and afterwards compensated in the total range computation. The attenuation suffered by the waveforms when traveling through the instrument also needs to be monitored and the waveform needs to be compensated for. Moreover, there are a collection of other parameters to be checked, such as the PTR width and the secondary lobes features. These CAL-1 parameters are produced separately for LRM and SAR modes, as they follow different instrumental paths, and also they are duplicated for Ku-band and C-band. Also there are different options for characterising the delay and power of the closed loop signal, such as the PTR maximum power or PTR maximum position.

The second is related to the Instrument Transfer Function (CAL-2). The science waveforms spectra is distorted by the on-board instrumental sections. Therefore, in order to retrieve the original echo shape, we need to undo this effect. Several parameters are derived from the analysis of the CAL-2 waveforms for characterizing it and dissect any feature along the mission lifetime. The CAL-2 waveform is the same for both modes LRM and SAR, but there is a distinction between bands Ku and C.

Additionally, for SAR mode, the two intra-burst corrections are monitored: power and phase progression within a burst. Some characteristics are computed for describing and following up their behaviour along the S3 mission.

It is also of major importance the monitoring of the on-board clocks. The altimeter clock counter, responsible for computing the echo travel time, has the biggest impact in the range determination. The platform clock is responsible for the overall platform instruments datation. Their stability and performance are to be supervised along the mission.

Finally, the data coming from the thermistors located in the different sections of the on-board HW (HKTM products), are to be analysed in order to check the relation of any calibration parameters anomaly with the thermal behaviour, and find solutions for modelling the instrument characterisation (for instance orbital oscillations) if needed.

The above instrumental characterisation is checked in different time baselines, depending on how interesting is to show each parameter progression. It could be an orbital or a cyclic series, yearly, or a complete mission for long term-drift assessments. Also comparison between similar periods could be developed (inter-orbital or inter-cycle analysis) when appropriate.



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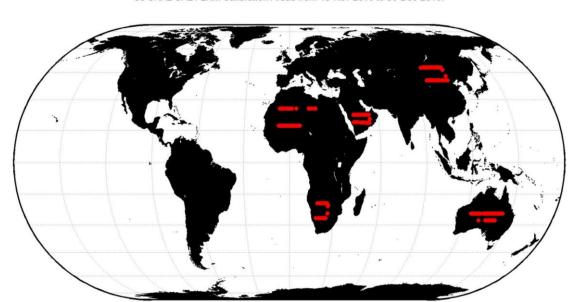
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2.2 Cycle 11 In-Flight Internal Calibration.

In this chapter, the monitoring of all CAL1 modes is described, including figures of the main parameters and a brief explanation of the observations on the results.

2.2.1 CAL1 LRM

The geographical distribution of the SRAL CAL1 LRM measurements is shown in Figure 2.2-1.



S3 SRAL CAL1 LRM Calibration Areas from 10-Nov-2016 to 06-Dec-2016.

Figure 2.2-1. Location of the CAL1 LRM measurements.

The two main variables computed from the PTR waveforms are used for the power (total power of the PTR) and range (difference of travel between the transmission and reception lines) corrections. Their monitoring results are detailed from Figure 2.2-2 to Figure 2.2-5.

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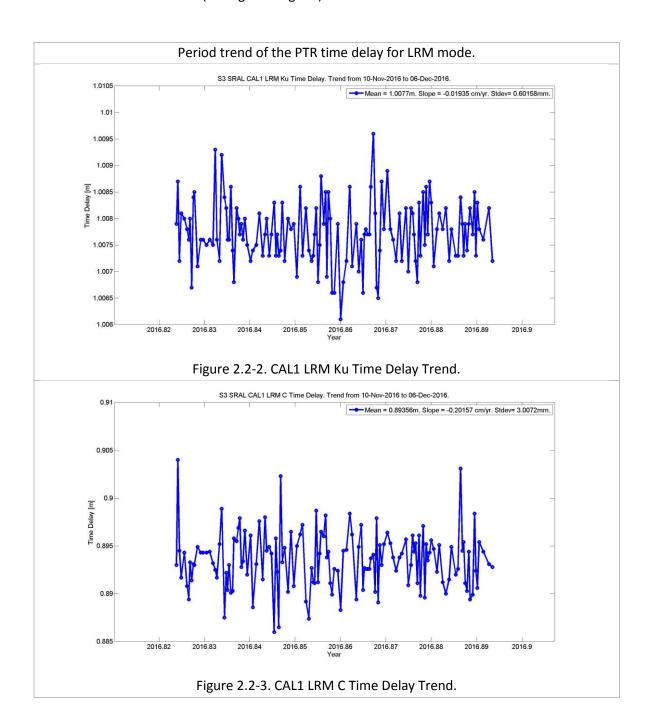
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In terms of CAL1 time delay, the Ku band inter-annual slope is lower in absolute terms than the C band. The peak to peak of the C band is higher, showing more variability than the Ku band series, visible also in the standard deviations results (see figure's legend).





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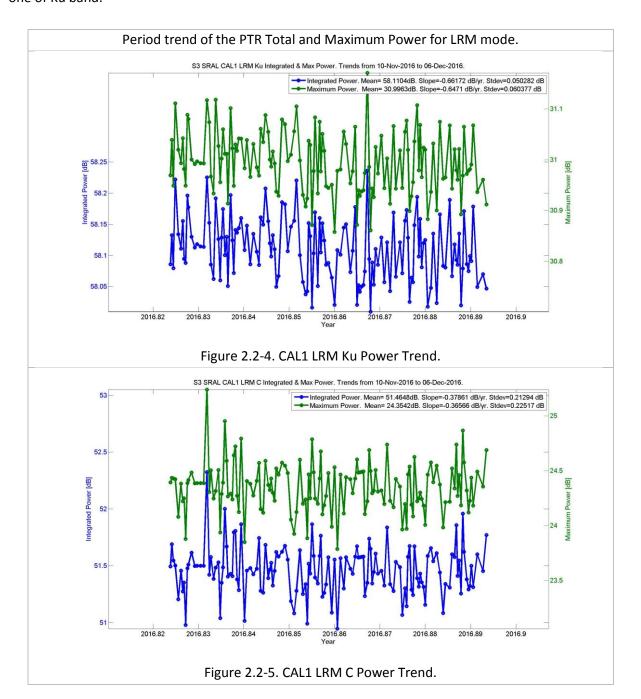
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In terms of CAL1 power, the Ku band inter-annual slope is high, of -0.66 dB/yr. Here again the variability for the C band is higher than for the Ku band series: C band standard deviation is more than 2 times the one of Ku band.





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The variable selected for determining the SRAL CAL1 time delay is the difference of travel between transmission and reception lines. But there are also other PTR time delay related variables that are sensible to the CAL1 delay measurement, represented in Figure 2.2-6 and Figure 2.2-7. They are the CAL1 waveform median position, and the PTR maximum power position. The Ku band shows a significantly lower standard deviation and trend than the C band for the PTR delay parameters. The Tx/Rx difference of travel and PTR median position shows an extremely similar behaviour in each band case.

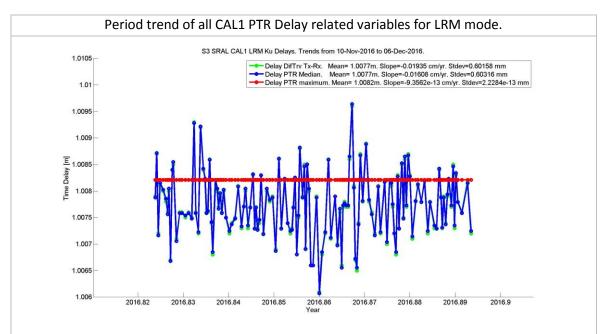


Figure 2.2-6. CAL1 LRM Ku Time Delay related variables trend. The green line (Diff of travel between Tx & Rx lines) is hidden below the blue line (PTR Median Delay).

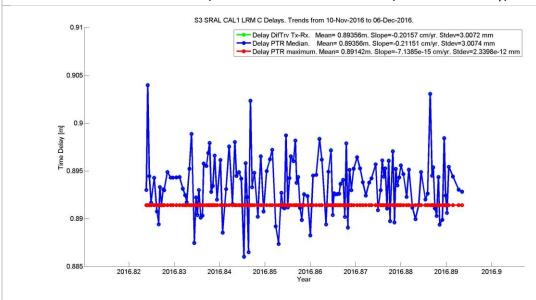


Figure 2.2-7. CAL1 LRM C Time Delay related variables trend.

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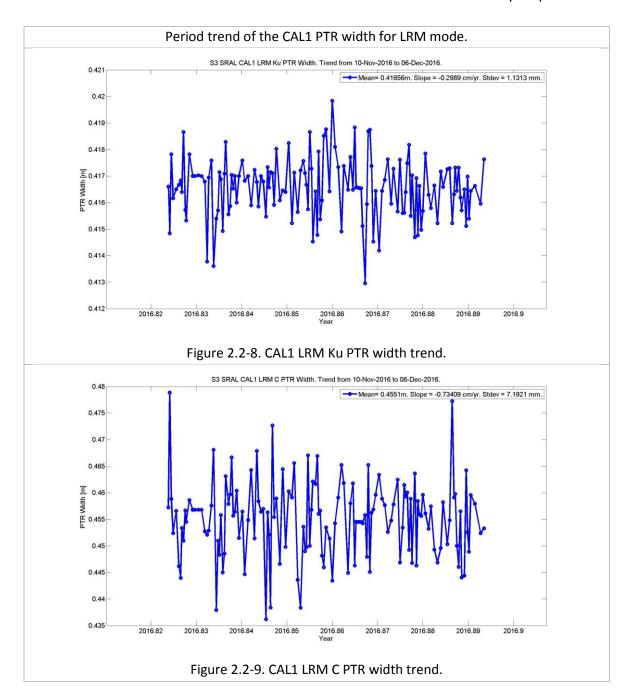
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Also the PTR width is monitored. This instrumental calibration parameter has an impact on the SWH L2 variable retrievals. The two bands CAL1 PTR width trends are shown in Figure 2.2-8 and Figure 2.2-9. The Ku band show lower standard deviation of the PTR width than the C band in the analysed period.





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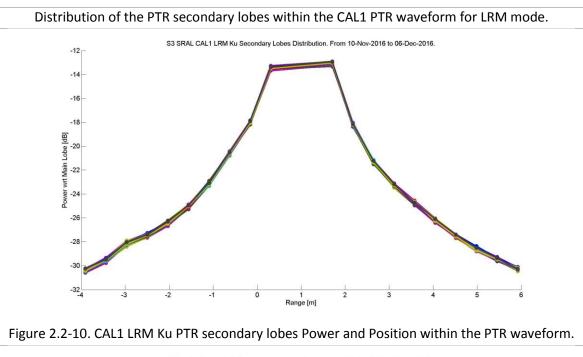
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Finally for CAL1 LRM, the secondary lobes parameters are shown. In Figure 2.2-10 and Figure 2.2-11 we can see the power and position of every secondary lobe measured by the CAL1 L1b processor. We observe here again a better behaviour of the Ku band (with a more stable series) with respect to the C band.



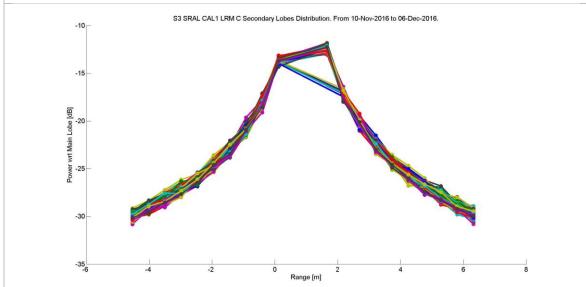


Figure 2.2-11. CAL1 LRM C PTR secondary lobes Power and Position within the PTR waveform.



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The secondary lobes power trend along the analysed period is shown in Figure 2.2-12 and Figure 2.2-13. It is visible the lower variability of the Ku band PTR power trend with respect to that of the C band.

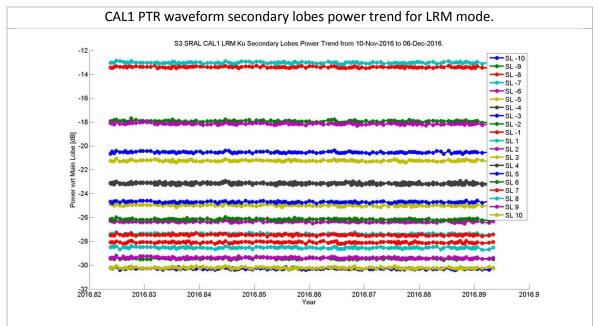


Figure 2.2-12. CAL1 LRM Ku PTR secondary lobes Power trend. In the legend it is specified the secondary lobe index.

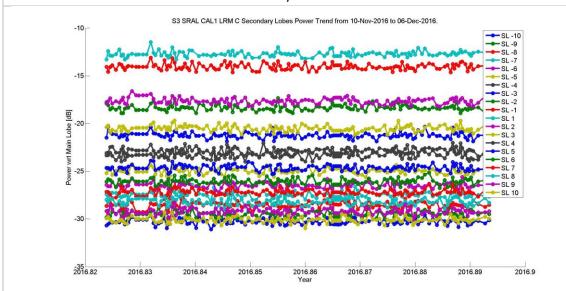


Figure 2.2-13. CAL1 LRM C PTR secondary lobes Power trend. In the legend it is specified the secondary lobe index.



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The standard deviation and inter-annual slope of each of the secondary lobes is represented in Figure 2.2-14. In the X axis we see the index of each of the secondary lobes. In the legend we can check the colour code of each line. Here again, we observe a higher dispersion of the C band data (cyan line) with respect to the Ku band (green line), and a less stable power slope behaviour along the collection of secondary lobes of the C band (red line) than those of the Ku band (blue line).

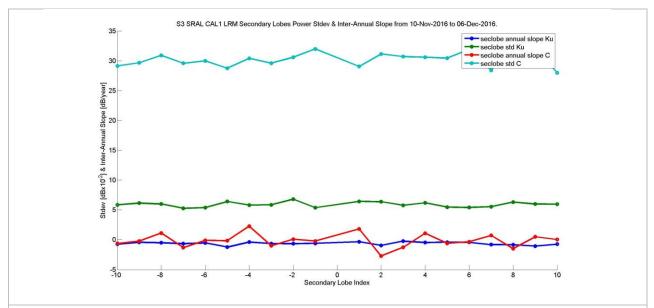


Figure 2.2-14. CAL1 LRM PTR secondary lobes characterisation. The inter-annual slope (in dB/year) and standard deviation (in dBx10^-2) of each of the secondary lobes during the period are shown.



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2.2.2 CAL1 SAR

The geographical distribution of the SRAL CAL1 SAR measurements is shown in Figure 2.2-15.

S3 SRAL CAL1 SAR Calibration Areas from 10-Nov-2016 to 06-Dec-2016.

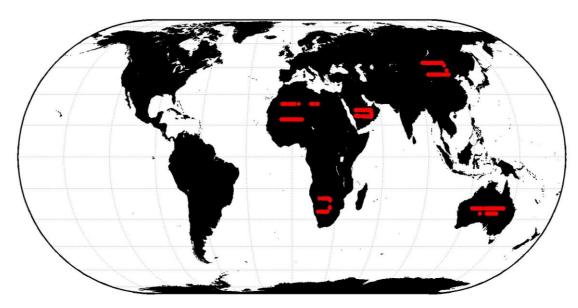


Figure 2.2-15. Location of the CAL1 SAR measurements.

The PTR power (total power of the PTR) and time delay (difference of travel between the transmission and reception lines) corrections are shown from Figure 2.2-16 to Figure 2.2-19.

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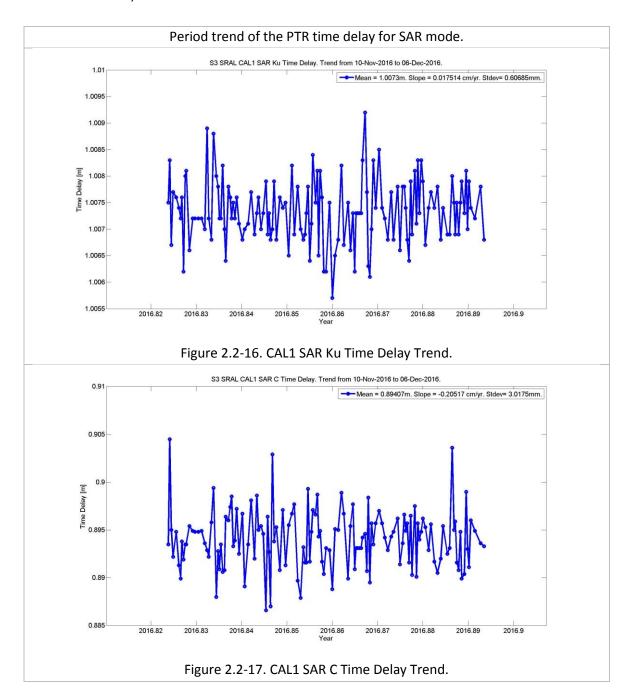
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In terms of CAL1 time delay, the Ku band inter-annual slope is lower in absolute terms than the one of C band. The peak to peak of the C band is higher, than the one of the Ku band series (see also the standard deviation differences).





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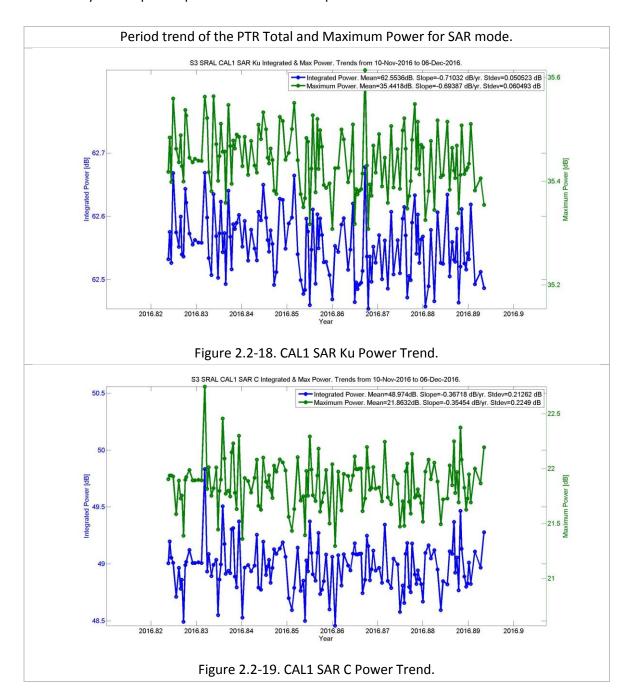
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In terms of CAL1 power, the Ku band inter-annual slope is high, of -0.71 dB/yr. The standard deviation of the C band is much higher than the one of the Ku band series. The CAL1 SAR power series shows a very similar stability and slope compared to the CAL1 LRM power series in both bands.





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The three SRAL CAL1 time delay variables are represented in Figure 2.2-20 and Figure 2.2-21. Here we see the CAL1 waveform median position, and the PTR maximum power position, in addition to the selected PTR Delay variable for the SRAL mission. The Ku band series shows here again a lower dispersion and slope than the C band. The Tx/Rx difference of travel and PTR median position shows an extremely similar behaviour.

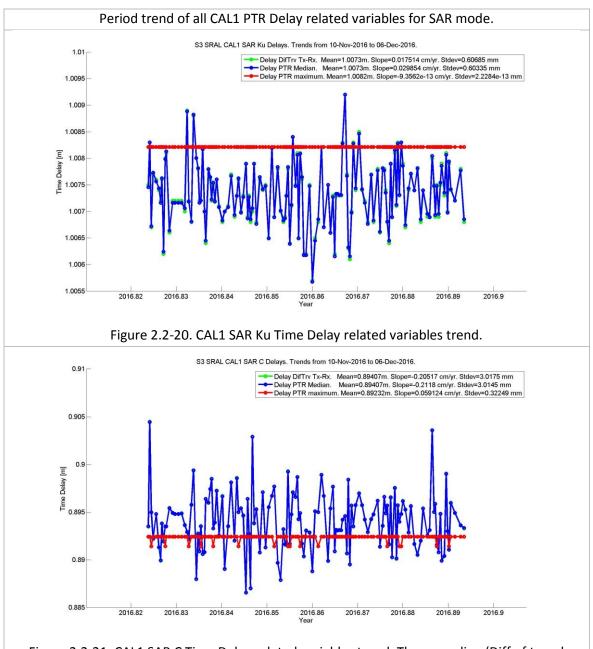


Figure 2.2-21. CAL1 SAR C Time Delay related variables trend. The green line (Diff of travel between Tx & Rx lines) is hidden below the blue line (PTR Median Delay).



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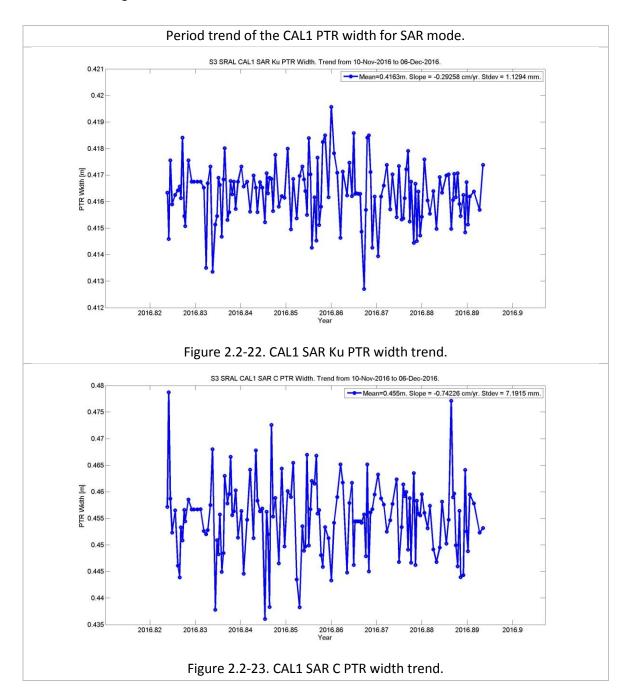
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The PTR width is shown in Figure 2.2-22 and Figure 2.2-23 for the two bands. The Ku band show much lower standard deviation of the PTR width than the C band in the analysed period. Both bands PTR width are decreasing. All PTR width statistics are similar to the LRM IQ mode case.





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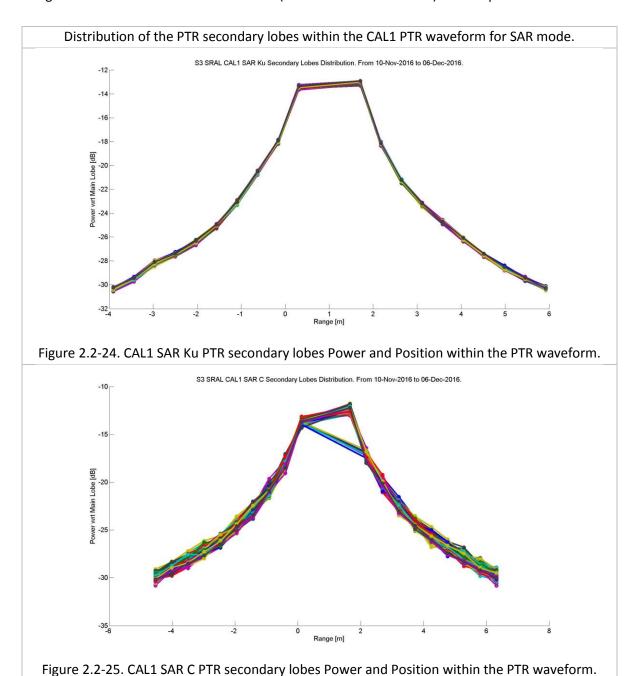
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The CAL1 SAR secondary lobes parameters are shown in Figure 2.2-24 and Figure 2.2-25, where we can see the power and position of every secondary lobe measured by the CAL1 L1b processor. We observe here again a better behaviour of the Ku band (with a more stable series) with respect to the C band.





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The secondary lobes power trend along the analysed period is shown in Figure 2.2-26 and Figure 2.2-27. It is notable the lower variability of the Ku band PTR power trend with respect to that of the C band.

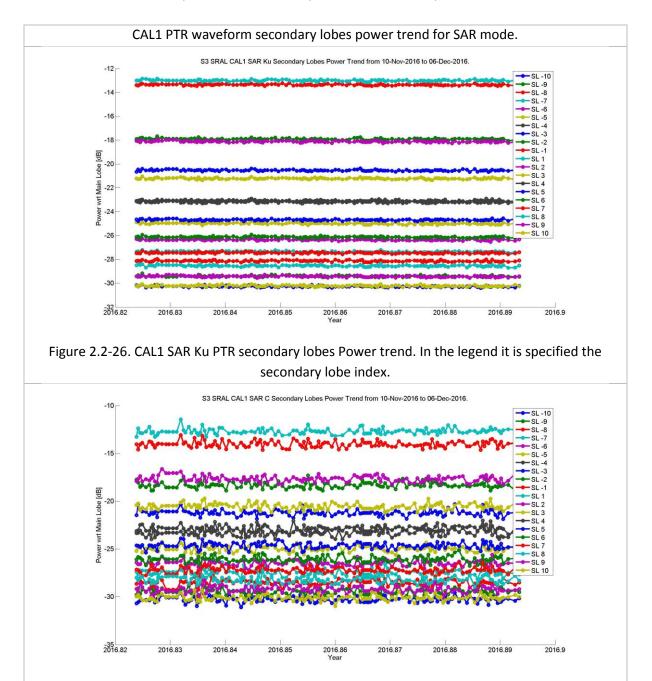


Figure 2.2-27. CAL1 SAR C PTR secondary lobes Power trend. In the legend it is specified the secondary lobe index.



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The standard deviation and inter-annual slope of each of the secondary lobes is represented in Figure 2.2-28. Here again, we observe a higher dispersion of the C band data (cyan line) with respect to the Ku band (green line), and a less stable power slope behaviour along the collection of secondary lobes of the C band (red line) than those of the Ku band (blue line), although the mean power slope is similar for some indexes.

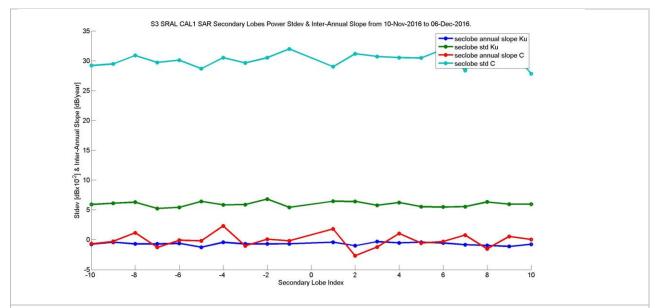


Figure 2.2-28. CAL1 SAR PTR secondary lobes characterisation. The inter-annual slope (in dB/year) and standard deviation (in dBx10^-2) of each of the secondary lobes during the analysed period are shown.



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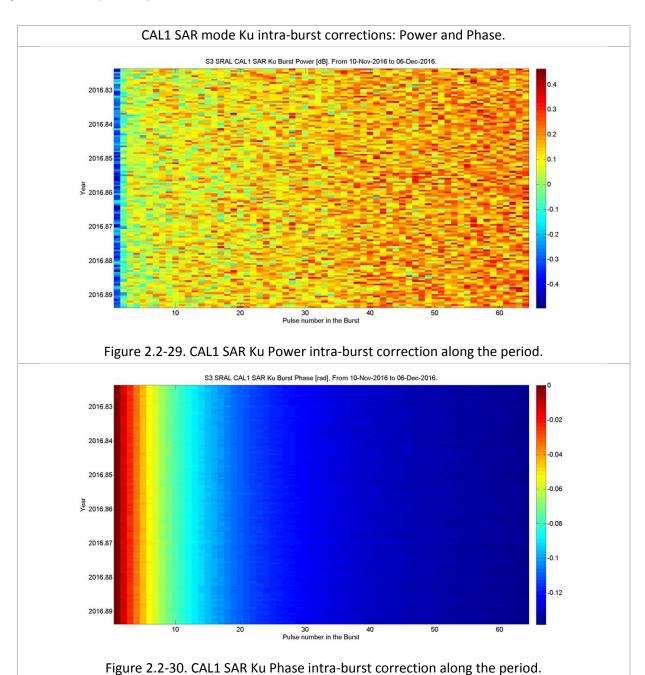
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Additionally, and only for SAR mode in Ku band, the intra-burst corrections are monitored. They are used for the correction of the SAR burst data during the L1b processing, in power and phase. First, the Power and Phase Arrays history over the monitored period, are shown in Figure 2.2-29 and Figure 2.2-30 respectively.





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The slopes of both corrections are monitored along the analysis period. It is shown in Figure 2.2-31.

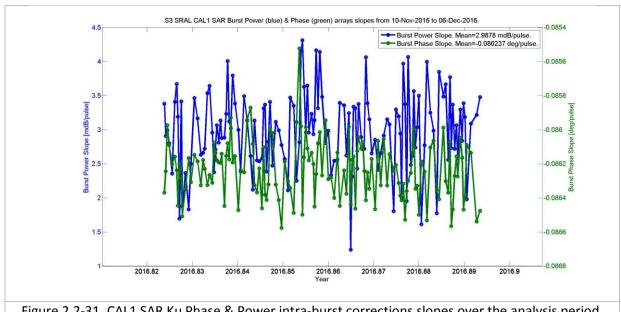


Figure 2.2-31. CAL1 SAR Ku Phase & Power intra-burst corrections slopes over the analysis period.

Finally, each of the pulses indexes in the burst are analysed in terms of standard deviation, with the aim of detecting any anomalous behaviour in a particular pulse index. As we can see in Figure 2.2-32, the stability behaviour is quite similar along the burst pulses. The first phase pulse index is always zero (hence, showing a null standard deviation), because the phase intra-burst correction is computed as a phase difference with respect to the first pulse index in the burst.

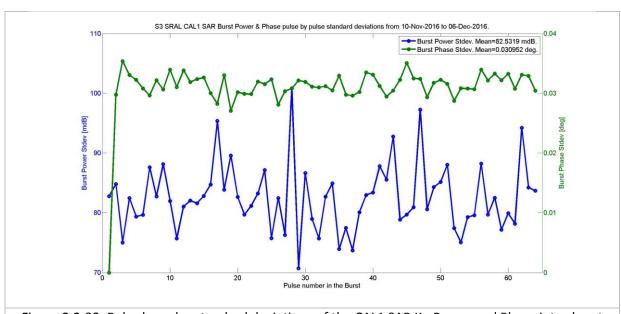


Figure 2.2-32. Pulse by pulse standard deviations of the CAL1 SAR Ku Power and Phase intra-burst corrections.



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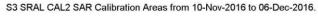
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2.2.3 System Transfer Function (CAL-2)

The System Transfer Function (CAL-2) is given as a waveform that enables the L1b Calibration Processing to correct the echo shape distortions caused by the on-board instrument along the spectra.

The geographical distribution of the SRAL CAL2 (Ku in green, C in red) measurements is shown in Figure 2.2-33.



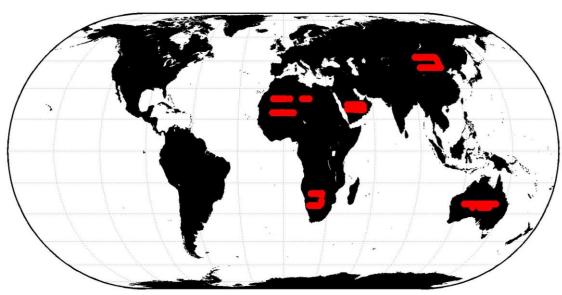


Figure 2.2-33. Location of the CAL2 measurements.



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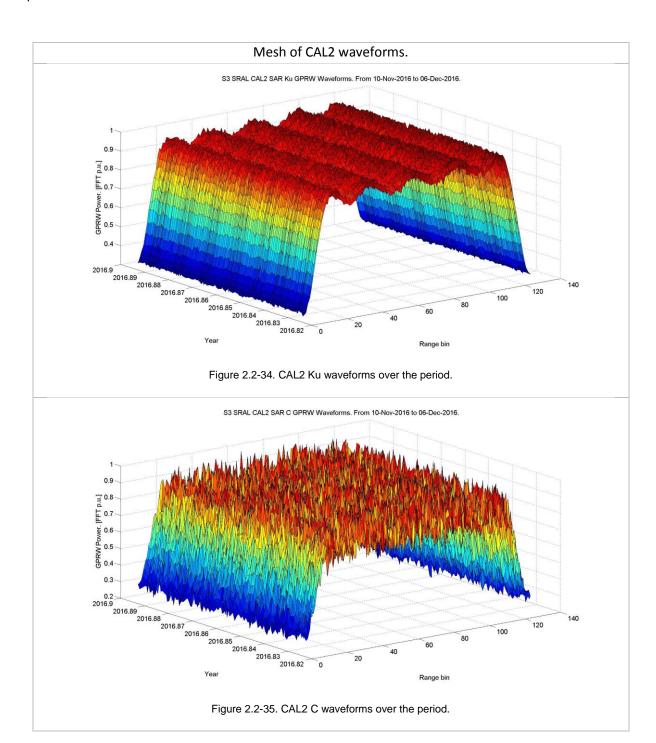
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A general overview of the CAL2 waveforms shape along the analysis period is shown in Figure 2.2-34 and Figure 2.2-35. There we can observe how the CAL2 Ku band waveforms are more similar between themselves than the ones of the C band, showing more clearly in Ku band the typical oscillations along the spectra of the transfer function.





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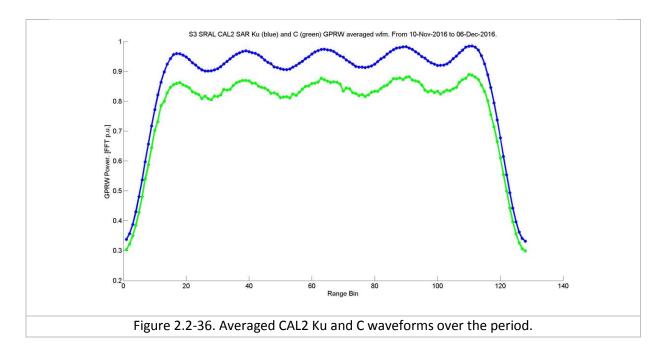
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If we average these CAL2 waveforms, we get the results of Figure 2.2-36. Again here we observe the cleaner oscillations of the CAL2 spectra of the Ku band waveform with respect to the one of the C band, although they look aligned.



Other CAL2 parameters are computed in the L1b calibration processing and contained in the L1b CAL products. They are computed separately for the right and left sides of the CAL2 spectra, and are here below shown.



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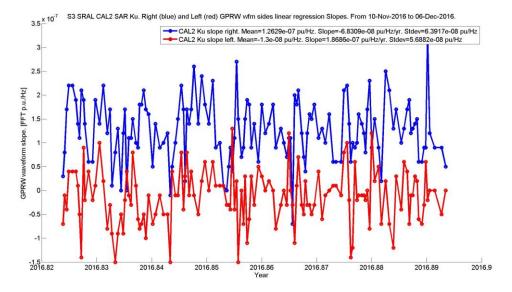


Figure 2.2-37 and

In

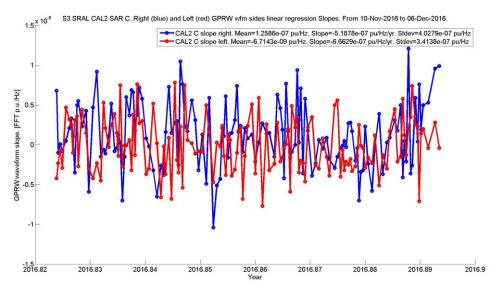


Figure 2.2-38 we can observe the series of the CAL2 waveform right and left side slopes over the analysed period. For the C case we see a better agreement between both sides slopes series than for the Ku band case; in this last case the GPRW spectra starts with a lower slope than how it ends. We do not observe a clear drift in any of the Slope series.

Time series of CAL2 waveforms right and left sides Slope.

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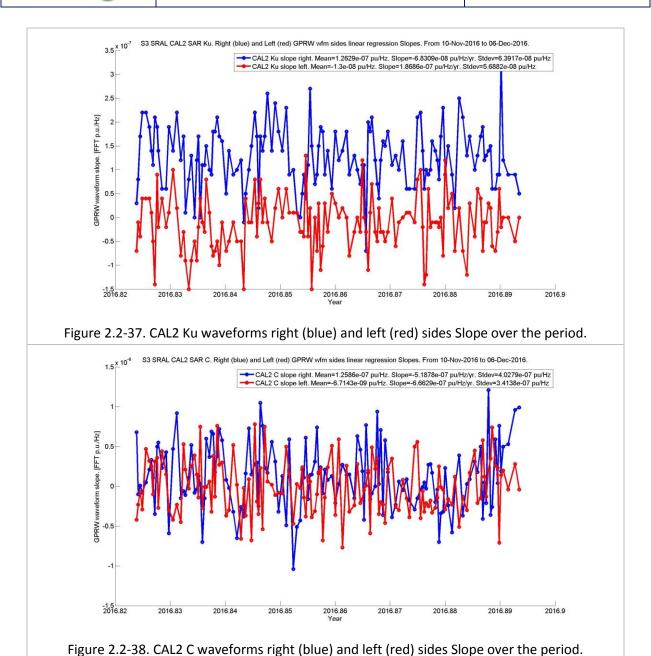
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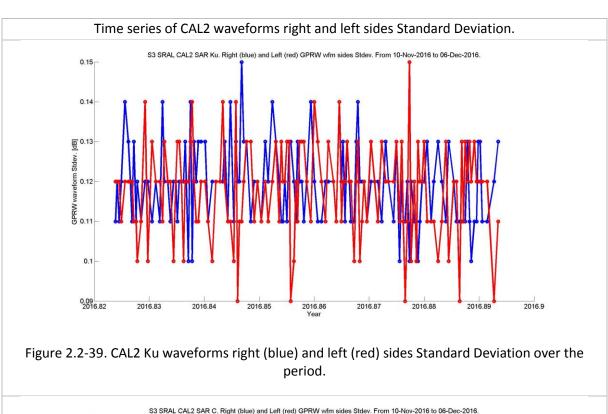
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In Figure 2.2-39 and Figure 2.2-40 we can check the Standard Deviation of both CAL2 waveform sides and bands. We see here clearer the persistently higher Standard Deviation of the C band case with respect of that of Ku band.



S3 SRAL CAL2 SAR C. Right (blue) and Left (red) GPRW v/m sides Stdev. From 10-Nov-2016 to 06-Dec-2016.

0.35
0.25
0.20
2016.82 2016.83 2016.84 2016.85 2016.86 2016.87 2016.88 2016.89 2016.9

Figure 2.2-40. CAL2 C waveforms right (blue) and left (red) sides Standard Deviation over the period.

If we compute the Standard Deviation over the slope (i.e. after de-sloping the CAL2 waveform sides), we have a better idea of the dispersion without the effect of a slope. Due to the very little slope values of

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the CAL2 waveform sides, the standard deviation results before and after de-sloping are very similar. Hence, the ones after de-sloping are not shown here.

There are other CAL2 waveform sides parameters that are checked but will not be shown here, such as the mean, the maximum position and the peak to peak power. The above plotted parameters give an overall idea (and the most important information) of the CAL2 data characterisation. If any of the not plotted parameters have a strange behaviour, it will be analysed in this report.



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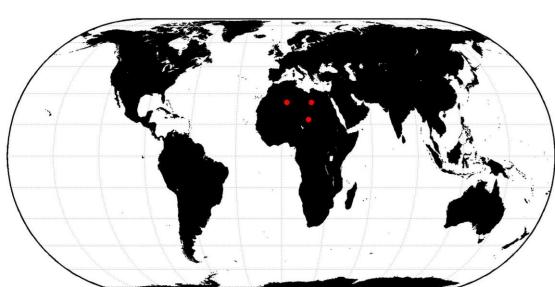
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2.2.4 AutoCal (CAL1 SAR Auto)

This CAL1 SAR configuration is devoted to the auto-calibration of the Attenuation Steps. The instrument has a series of Attenuation Steps that ideally has 63 levels of attenuation from 0 to 62 dB. But the instrument does not perform ideally, hence the real attenuations values of each attenuation step have to be monitored and accounted for in the sigma-0 retrievals. For instance, for an ideal attenuation value of 20 dB, the instrument could be actually attenuating 20.33 dB.

The geographical distribution of the SRAL AutoCal measurements is shown in Figure 2.2-41.



S3 SRAL CAL1 Auto-Calibration Areas from 12-Nov-2016 to 30-Nov-2016.

Figure 2.2-41. Location of the AutoCal measurements.

The ideal and real attenuation tables are present in the L1b products for the two bands, Ku and C. If we subtract one table to the other, we can observe how far the real attenuation values are from the ideal values. An average of this subtraction during the analysis period is shown in Figure 2.2-42.



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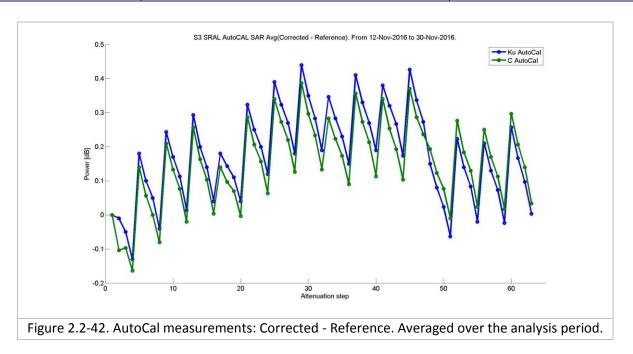
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The on-board attenuation is in general over the ideal reference values.

2.2.5 On-board Clock Performance

The altimeter and platform clock frequencies will be here below depicted and analysed when available. Their assessment is very important for the identification of the range anomalies causes, all along with calibration parameters such as the PTR time delay, and the datation issues during the mission.

Anyhow, the clock counter data, needed for the study of the clock frequency behaviour, is not included in L0 or L1b files, the products available so far.

2.2.6 Housekeeping Temperatures

The orbital behaviour of the instrumental HW and waveguides is very much related to the on-board thermal conditions. The identification of the reasons for any calibration parameter orbital excursion or mid-long term drift needs the assessment of its correlation with the temperatures on-board.

The results of such assessment can be essential for modelling the orbital oscillations of any calibration parameter if it is possible (i.e. if the calibration parameter is measured along the orbit), or analysing the long-term on-board instrumental conditions.

The thermal parameters to be monitored are contained in the Calibration ISP telemetered product as a collection of "THERM" fields.



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From Figure 2.2-43 to Figure 2.2-48 we represent the thermistors values versus time, for each calibration mode, packed in two groups of thermistors for the sake of clarity, and averaged over each calibration products duration.

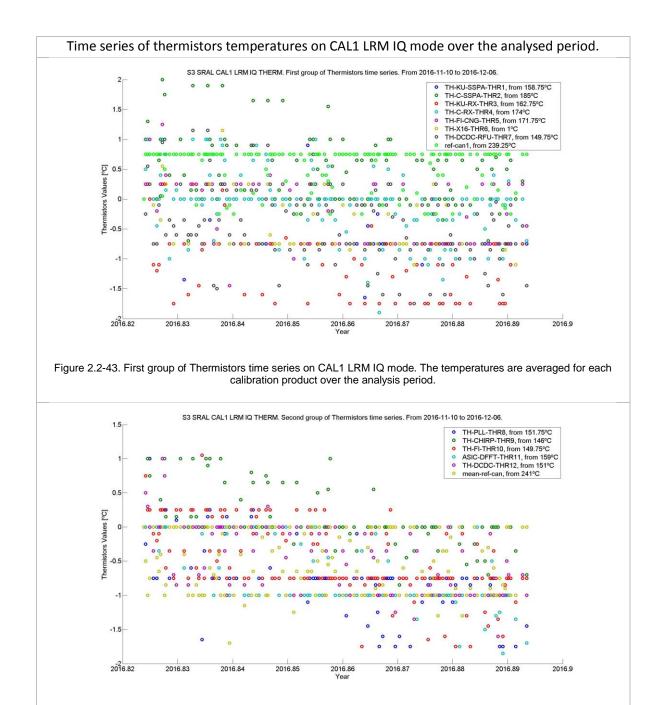


Figure 2.2-44. Second group of Thermistors time series on CAL1 LRM IQ mode. The temperatures are averaged for each calibration product over the analysis period.



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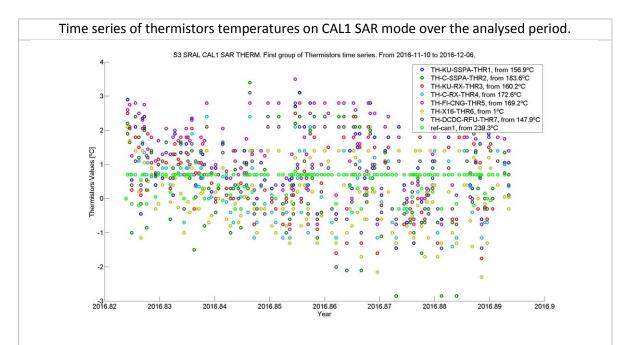


Figure 2.2-45. First group of Thermistors time series on CAL1 SAR mode. The temperatures are averaged for each calibration product over the analysis period.

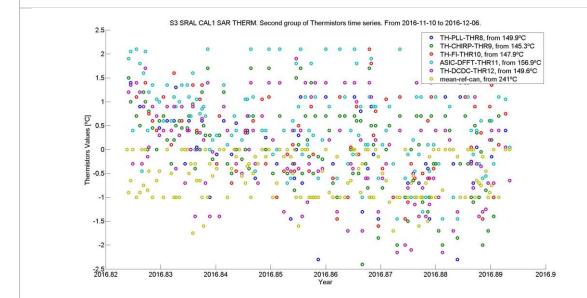


Figure 2.2-46. Second group of Thermistors time series on CAL1 SAR mode. The temperatures are averaged for each calibration product over the analysis period.



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The thermal behaviour above observed is quite stable for all modes in both thermistors groups for the whole cycle, although a decreasing slope is observed in general. This slope is better observed in the whole mission series, in Figure 2.5-11 and Figure 2.5-12.



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2.3 SRAL Dedicated Investigations

This chapter is devoted to the investigations derived from observations in the previous sections.

The on-going investigations results will be updated in each new version of the report, and information about SPRs and Anomaly Reports will be included accordingly.

Each independent investigation will be addressed in a separate subchapter. When a particular issue can be considered as solved and no more interesting, it will be dismissed from the report.

Two minor issues have been detected so far, not impacting the quality of the science data:

The flagging of some L1b CAL2 parameters (slope, mean and standard deviation over the slope) is reversed.

Also a previously detected issue has been studied and here below described:

The PTR maximum position show a variation along the monitored period with a much larger quantization step compared to the other two CAL1 delays parameters. This PTR maximum behaviour has been already identified, based in the CAL1 L1b processing. The nature of this variable behaviour comes from the CAL1 L1b processing particularities, being different from the other two CAL1 power variables showing more resolution. Its value is nominal and it is not the time delay variable used for the science range instrumental correction.

2.4 Cycle 11 SRAL Status Summary

This section is dedicated to a summary of the cyclic performances and status of the altimeter parameters exposed in section 0.

For the analysed period, none of the calibration parameters is showing a significant anomalous behaviour, although some specific observations are explained here below.

As expected, the Ku band (SAR science main band) calibration parameters performances are better than the ones from the C band. The calibration data dispersion is higher for the C band.

For a comparison between some L1b CAL1 parameters values with the on-ground reference values (read from the Characterisation auxiliary file), we can check the Table 2-1.



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| Calibration Parameter | In-flight Ku | On-ground Ku | In-flight C | On-ground C | |
|-----------------------|------------------|--------------|-------------------|-------------|--|
| LRM CAL1 time delay | 1.0077 m | 1.0048 m | 0.8936 m | 0.8923 m | |
| | Delta = 2.9 mm | | Delta = 1.3 mm | | |
| SAR CAL1 time delay | 1.0073 m | 1.0030 m | 0.8941 m | 0.8931 m | |
| | Delta = 4.3 mm | | Delta = 1.0 mm | | |
| LRM CAL1 power | 58.11 dB | 61.55 dB | 51.47 dB | 60.01 dB | |
| | Delta = -3.44 dB | | Delta = -8.54 dB | | |
| SAR CAL1 power | 62.55 dB | 59.81 dB | 48.97 dB | 60.00 dB | |
| | Delta = 2.74 dB | | Delta = -11.03 dB | | |
| LRM CAL1 PTR width | 0.4166 m | 0.4159 m | 0.4551 m | 0.4555 m | |
| | Delta = 0.7 mm | | Delta = -0.4 mm | | |
| SAR CAL1 PTR width | 0.4163 m | 0.4160 m | 0.4550 m | 0.4555 m | |
| | Delta = 0.3 mm | | Delta = -0.5 mm | | |

Table 2-1. Comparative table with in-flight and on-ground calibration parameters values.

In Table 2-1 we can see that, although the CAL1 time delay parameters stability is better for the Ku band than for the C band (see previous figures standard deviations in the legends), the current Ku band time delay values are farer from the reference ones than the C band values.

The CAL1 power trend for Ku band in both modes, is no longer close to -1 dB/yr as in previous cycles (see section 2.5).

We have to state that all the observed CAL1 power differences with respect to the on-ground values are very high, and that further checks have to be made in order to clarify the reason of these magnitudes. For example, for the SAR C case the in-flight value is around 11 dB below the on-ground reference value, meaning that it is more than 12 times smaller: an unrealistic difference.

For the C band PTR width, we see similar little differences for LRM and SAR where the in-flight PTR main lobe is narrower than its on-ground reference value. The Ku band main lobe width looks wider than its reference value also in less than 1 mm for the two modes.



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The CAL2 parameters are showing in some cases a worsening of the instrument performance with respect to the pre-launch values. For instance, the in-flight standard deviations of the C band GPRW waveform sides are around 0.3 dB, and the on-ground correspondent values are far below, around 0.12 dB. In the Ku band case, the in-flight values are around 0.12 dB, closer to the on-ground values, around 0.10 dB, hence a lower degradation is observed.

The thermistors values are showing a stable series over the analysed period except for a slight temperatures decrease in general.

All these observations are related to the different SRAL calibration parameters during this cycle. We must be cautious by making extrapolations of the cyclic behaviour for the overall mission instrument performance, as it may change from cycle to cycle.

Therefore, a whole mission observation is needed, and is here below developed.

2.5 Mission SRAL Status Summary

The main L1b calibration parameters series are gathered and plotted in this section, in order to observe their whole mission behaviour. For the sake of simplicity, the C band has been excluded.

They are:

- CAL1 time delay
- CAL1 power
- PTR width
- Burst corrections (power and phase)
- CAL2 waveform shape
- Autocal averaged differences

Also the SAR mode thermistors series is plotted.

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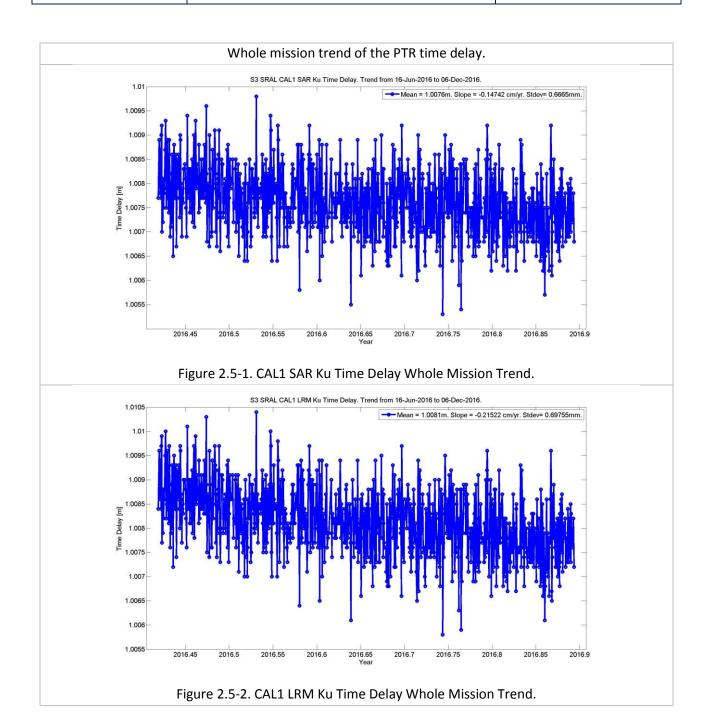
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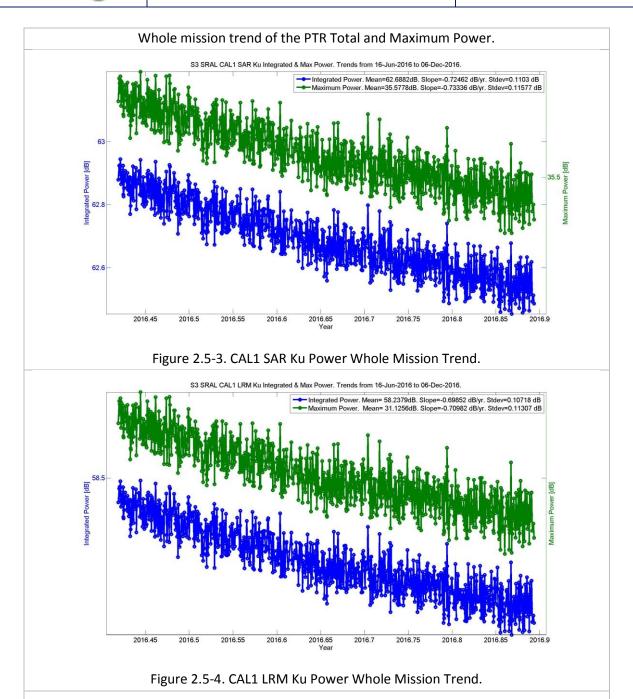
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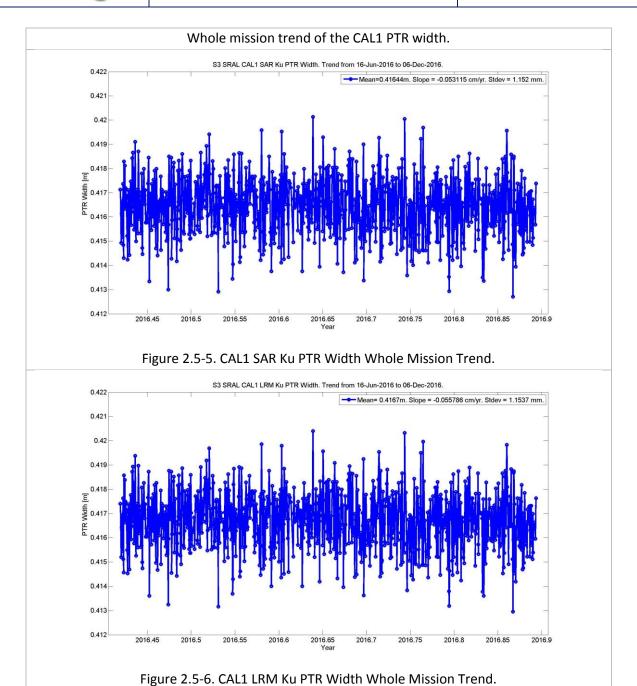
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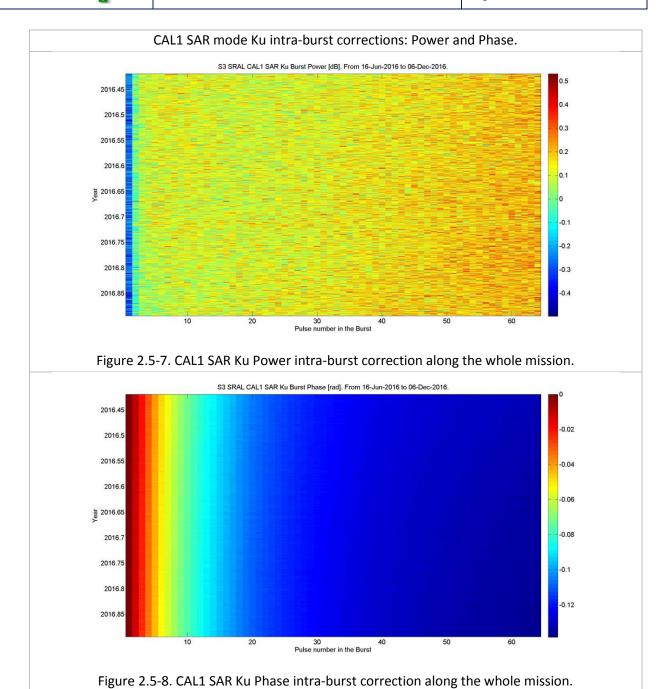
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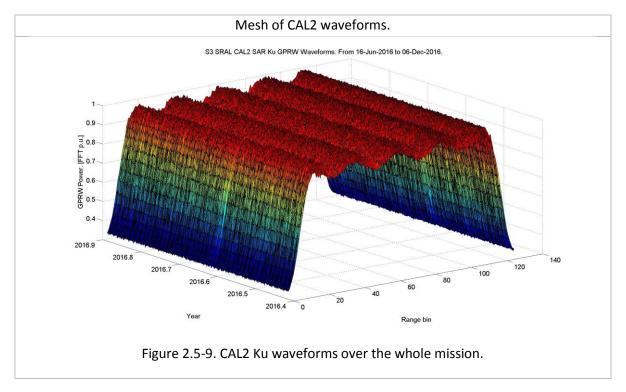
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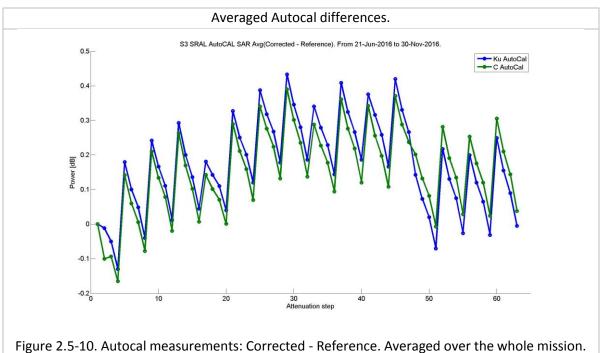
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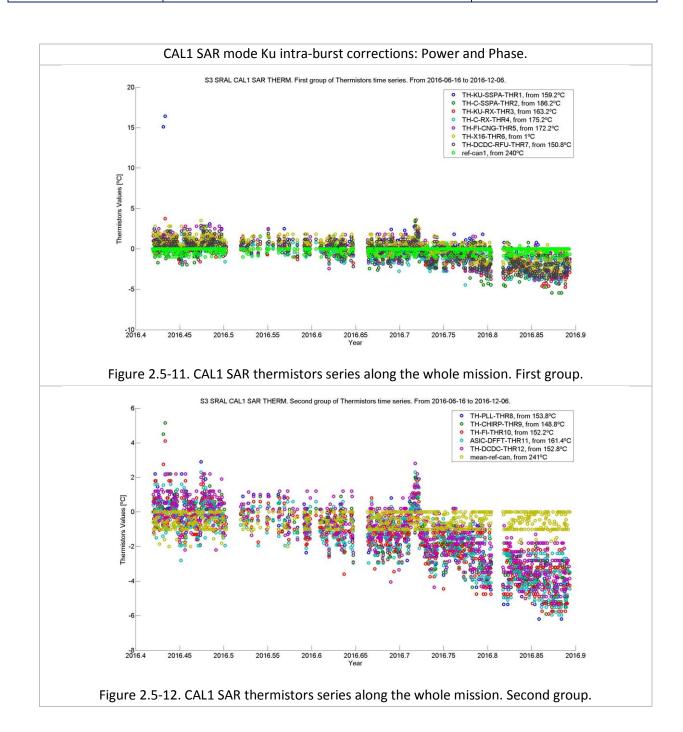
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We could say that the only clear and notable drift observed in the whole mission series is in the CAL1 Ku Power series, where we observe for both modes a significant power decay. Anyhow, it begins to show signs of change in the last cycles, decreasing the observed trend so far. In cycles 6, 7, 8, 9, 10 and 11 the whole mission power trend was respectively of 1.02, 0.94, 0.89, 0.81, 0.76 and 0.72 dB/year. Hence, we can state a slow stabilisation of this parameter.

For a comparison with the on-ground reference values, a similar table as in the previous subchapter (Table 2-1) is shown hereafter in Table 2-2.



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| Calibration Parameter | In-flight Ku | On-ground Ku | In-flight C | On-ground C | |
|-----------------------|------------------|-------------------|-------------------|-------------|--|
| LRM CAL1 time delay | 1.0081 m | 1.0081 m 1.0048 m | | 0.8923 m | |
| | Delta = 3.3 mm | | Delta = 1.4 mm | | |
| SAR CAL1 time delay | 1.0076 m | 1.0030 m | 0.8941 m | 0.8931 m | |
| | Delta = 4.6 mm | | Delta = 1 mm | | |
| LRM CAL1 power | 58.24 dB | 61.55 dB | 51.41 dB | 60.01 dB | |
| | Delta = -3.31 dB | | Delta = -8.60 dB | | |
| SAR CAL1 power | 62.69 dB | 59.81 dB | 48.92 dB | 60.00 dB | |
| | Delta = 2.88 dB | | Delta = -11.08 dB | | |
| LRM CAL1 PTR width | 0.4167 m | 0.4159 m | 0.4549 m | 0.4555 m | |
| | Delta = 0.8 mm | | Delta = -0.6 mm | | |
| SAR CAL1 PTR width | 0.4164 m | 0.4160 m | 0.4548 m | 0.4555 m | |
| | Delta = 0.4 mm | | Delta = -0.7 mm | | |

Table 2-2. Comparative table with in-flight (whole mission) and on-ground calibration parameters values.

The CAL1 Time Delay for both bands and modes are less than half a centimetre from the ground reference values.

The CAL1 Power show the same big differences addressed in the previous subchapter. This are to be studied and eventually corrected.

The PTR width for both bands and modes are less than one centimetre from the reference values. For the Ku band it is bigger and with a small negative trend (around -0.5 mm/yr), while for the C band it is smaller and with a positive trend (around 0.8 mm/year), hence both approaching the reference value. The PTR width standard deviation for the C band is around 6 times higher than the one from the Ku band, for both modes.

Finally, the collection of statistics for the main calibration parameters is depicted in Table 2-3 for both modes and bands. Once more we observe the better performance (less standard deviation) of the Ku band with respect to the C band, and the general similar values between modes (with some exceptions such as the time delay slope).



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| | Ku band | | | C band | | |
|-----------------------|----------|-----------------|-----------------------|----------|-----------------|-----------------------|
| Calibration Parameter | mean | annual slope | standard deviation | mean | annual slope | standard deviation |
| LRM CAL1 time delay | 1.0081 m | -2.15 mm | 0.70 mm | 0.8936 m | -0.04 mm | 2.84 mm |
| SAR CAL1 time delay | 1.0076 m | -1.47 mm | 0.67 mm | 0.8941 m | 0.17 mm | 2.84 mm |
| LRM CAL1 power | 58.24 dB | -0.70 dB | 0.11 dB | 51.41 dB | 0.18 dB | 0.21 dB |
| SAR CAL1 power | 62.69 dB | -0.73 dB | 0.11 dB | 48.92 dB | 0.19 dB | 0.21 dB |
| LRM CAL1 PTR width | 0.4167 m | -0.06 cm | 1.15 mm | 0.4549 m | 0.85 mm | 7.00 mm |
| SAR CAL1 PTR width | 0.4164m | -0.05 cm | 1.15 mm | 0.4548 m | 0.83 mm | 7.00 mm |

Table 2-3. Collection of calibration parameters statistics for all modes and bands covering the whole mission.

The long term drift for the time delay and power variables is higher in absolute terms for the Ku band than for the C band, while the standard deviation is always lower for the Ku band. This means that, although the Ku band chain performance is better than the one from C band, the Ku band ageing is faster than the one from C band, probably caused by the more stressed Ku band instrumental operations (e.g. bursts transmission & reception only in Ku band).

The thermistors data series are generally showing a decreasing slope, as shown in Figure 2.5-11 and Figure 2.5-12. In some cases the temperatures have decayed 5 degrees Celsius. Anyhow, this decreasing thermal behaviour and others like temperatures excursions (e.g. around decimal year 2016.7) are not correlated with the calibration parameters series.

We observe that the behaviour of all calibration parameters is nominal. Nevertheless the different values shall be compared to the official S3 mission SRAL instrumental requirements in order to make a final statement. Once they are gathered, the calibration performance check versus requirements will be exposed in this document.



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3 Events

No SRAL special events have been observed during the cycle.



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4 Appendix A

Other reports related to the STM mission are:

- S3-A MWR Cyclic Performance Report, Cycle No. 011 (ref. S3MPC.CLS.PR.05-011)
- S3-A Ocean Validation Cyclic Performance Report, Cycle No. 011 (ref. S3MPC.CLS.PR.06-011)
- S3-A Winds and Waves Cyclic Performance Report, Cycle No. 011 (ref. S3MPC.ECM.PR.07-011)
- \$3-A Land and Sea Ice Cyclic Performance Report, Cycle No. 011 (ref. S3MPC.UCL.PR.08-CCC)

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