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

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#### Disclaimer

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## **Changes Log**

Version	Date	Changes
1.0	28/10/2020	First Version

## List of Changes

Version	Section	Answers to RID	Changes



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# **1** Processing Baseline Version

IPF	IPF / Processing Baseline version	Date of deployment							
S3A									
SL1	06.17 / 2.59	CGS: 15/01/2020 11:36 UTC							
		PAC: 15/01/2020 11:36 UTC							
SL2	06.16 / 2.61	PAC: 15/01/2020 11:36 UTC							

IPF	IPF / Processing Baseline version	Date of deployment							
S3B									
SL1	06.17 / 1.40	PAC: 09/06/2020 09 :57 UTC							
SL2	06.16 / 1.33	PAC: 15/01/2020 11:36 UTC							

Note that more details of the processing baseline version can be found in the SLSTR Product Notice.



# 2 Instrument monitoring

### 2.1 Instrument temperatures

As a thermal infrared instrument, thermal stability and uniformity of the optical mechanical enclosure (OME) is critical to the radiometric calibration. Figure 1 and Figure 2 show the orbital average temperature of the OME and instrument baffles for SLSTR-A and SLSTR-B during the cycle. The temperatures were stable (on top of a daily variation cycle).

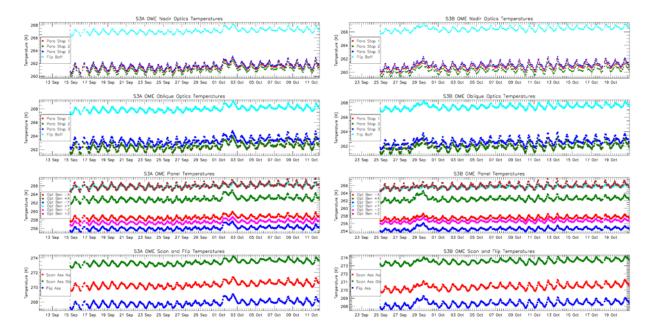


Figure 1: OME temperature trends for SLSTR-A Cycle 063 (left) and SLSTR-B Cycle 044 (right) showing the paraboloid stops and flip baffle (top two plots) and optical bench and scanner and flip assembly (lower two plots). The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit.

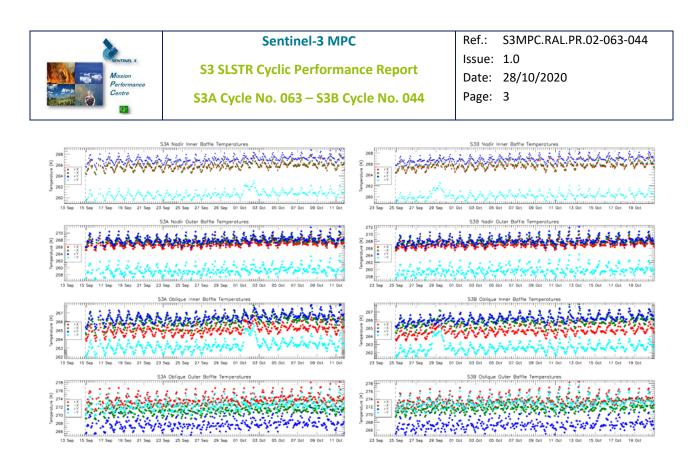


Figure 2: Baffle temperature trends for SLSTR-A Cycle 063 (left) and SLSTR-B Cycle 044 (right). The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit.



## **2.2** Detector temperatures

The detector temperatures for both SLSTR-A and SLSTR-B were stable at their expected values following the latest decontamination phases. Decontamination was performed for SLSTR-A in Cycle 054 between 3<sup>rd</sup> and 11<sup>th</sup> February 2020, and in Cycle 058 following the instrument anomaly on 13th May 2020. Decontamination was last performed for SLSTR-B in Cycle 030 from 19<sup>th</sup> to 25<sup>th</sup> September 2019. Decontamination involves warming up the infrared focal plane assembly (FPA) in order to remove water ice contamination from the cold surfaces. Figure 3 and Figure 4 show the SLSTR-A and SLSTR-B detector temperatures for the past year. The decontaminations are clearly visible as a rise in detector temperature.

A few orbits (e.g. Cycle 60 for SLSTR-A) show slightly lower average visible channel detector temperatures due to instrument operations that were performed on those days.

In Cycle 37 for SLSTR-B, the cooler cold tip temperature was adjusted on 30<sup>th</sup> March. This has the effect of increasing the detector temperatures for the SWIR and TIR channels, and appears as a step in Figure 4.

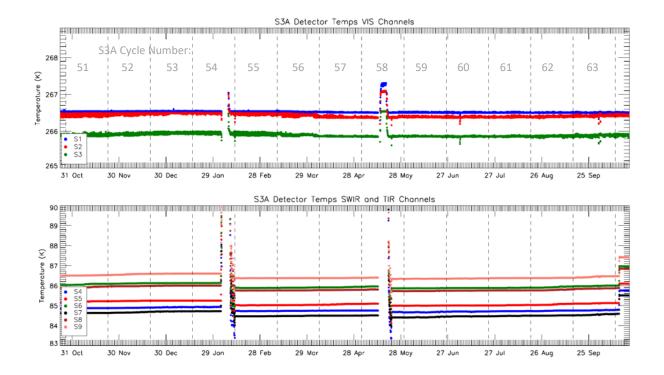


Figure 3: SLSTR-A detector temperatures for each channel for the last year of operations. Discontinuities occur for the infrared channels where the FPA was heated for decontamination. The vertical dashed lines indicate the start and end of each cycle. Each dot represents the average temperature in one orbit. The different colours indicate different detectors.

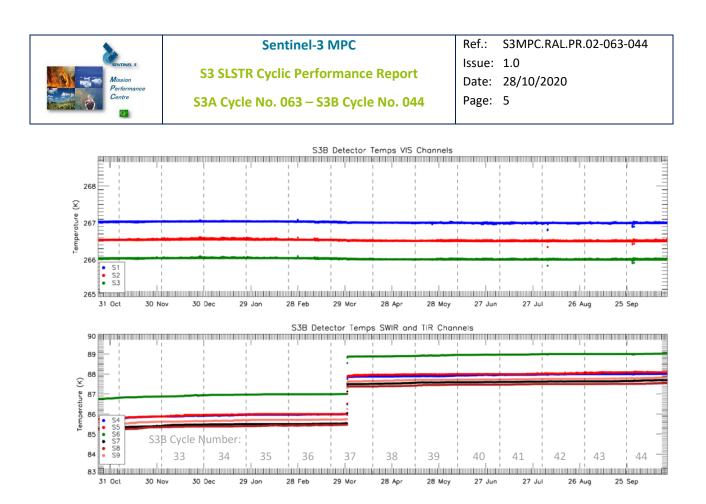


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## 2.3 Scanner performance

Scanner performance has been consistent with previous operations and within required limits for SLSTR-A and Figure 5 shows the trends in Cycle 063.

Figure 6 shows the trend for SLSTR-B in Cycle 044. Although the values are generally within the required limits, the scan and flip mirror deviations have larger variations than for SLSTR-A. This should be monitored carefully to make sure the jitter statistics do not get worse in the longer term.

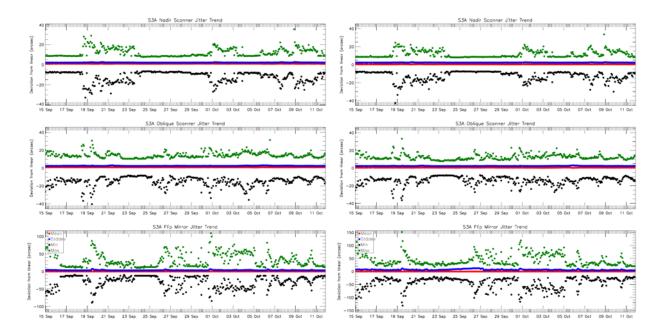


Figure 5: SLSTR-A scanner and flip jitter for Cycle 063, showing mean, stddev and max/min difference from expected position per orbit (red, blue, green and black respectively) for the nadir view (left) and oblique view (right). The plots show the nadir scanner (top), oblique scanner (middle) and flip mirror (bottom).

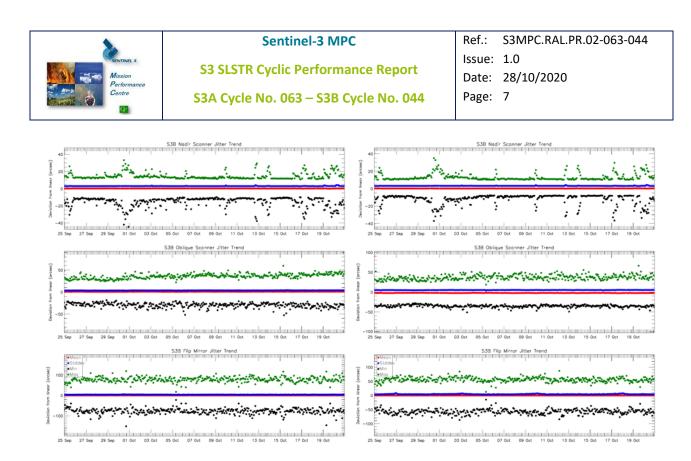


Figure 6: SLSTR-B scanner and flip jitter long term in Cycle 044, showing mean, stddev and max/min difference from expected position per orbit (red, blue, green and black respectively) for the nadir view (left) and oblique view (right). The plots show the nadir scanner (top), oblique scanner (middle) and flip mirror (bottom).



## 2.4 Black-Bodies

The orbital average blackbody temperatures for SLSTR-A are shown in Figure 7, and SLSTR-B are shown in Figure 9. The temperatures were stable on top of a daily variation cycle. There are also longer term cycle-to-cycle trends which show a yearly variation, with temperatures rising as the Earth approaches perihelion at the beginning of January (see Figure 8 and Table 5). Figure 7 and Figure 9 show the gradients across the blackbody baseplate (i.e. each PRT sensor reading relative to the mean). The gradients are stable and within their expected range of  $\pm 20$  mK, except for the +YBB for SLSTR-B which has a higher gradient. This higher gradient is expected and consistent with measurements made before launch. Note that blackbody crossover tests were performed for SLSTR-A from 1<sup>st</sup>-3<sup>rd</sup> October and for SLSTR-B from 28<sup>th</sup>-30<sup>th</sup> September (see Sections 6.1 and 6.2).

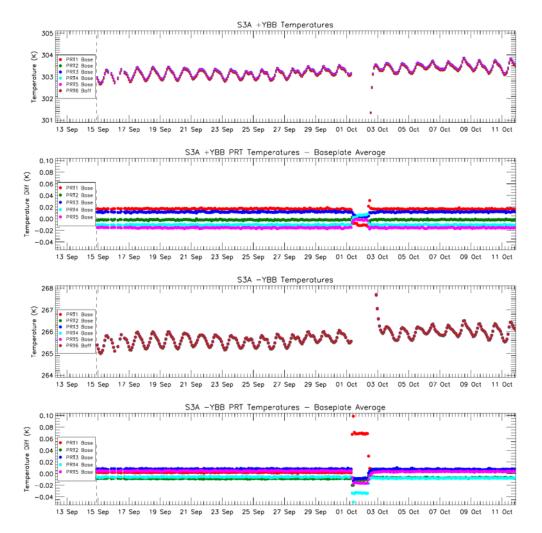
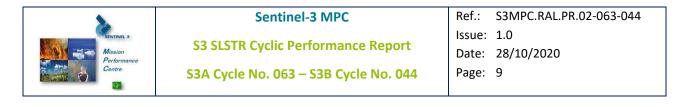


Figure 7: SLSTR-A blackbody temperature and baseplate gradient trends during Cycle 063. The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit.



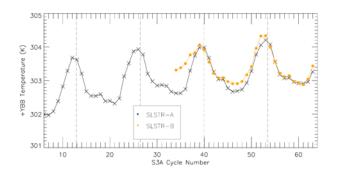
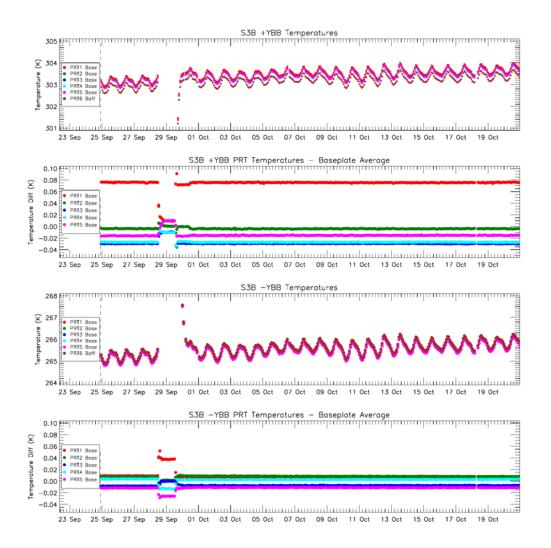


Figure 8: SLSTR-A and SLSTR-B long term trends in average +YBB temperature, showing yearly variation. The vertical dashed lines approximately indicate the 1<sup>st</sup> January 2017, 2018, 2019 and 2020.



*Figure 9: SLSTR-B blackbody temperature and baseplate gradient trends during Cycle 044. The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit.* 



## **2.5** Detector noise levels

#### 2.5.1 SLSTR-A VIS and SWIR channel signal-to-noise

The VIS and SWIR channel noise for SLSTR-A in Cycle 063 was stable and consistent with previous operations - the signal-to-noise ratio of the measured VISCAL signal over the past year is plotted in Figure 10. Table 1 and Table 2 give the average signal-to-noise in each cycle (excluding the instrument decontaminations). These values average over the significant detector-detector dispersion for the SWIR channels that is shown in Figure 10.

 Table 1: Average SLSTR-A reflectance factor, and signal-to-noise ratio of the measured VISCAL signal for the last

 11 cycles, averaged over all detectors for the nadir view.

	Average		Nadir Signal-to-noise ratio									
	Reflectance Factor	Cycle 053	Cycle 054	Cycle 055	Cycle 056	Cycle 057	Cycle 058	Cycle 059	Cycle 060	Cycle 061	Cycle 062	Cycle 063
<b>S1</b>	0.187	242	248	240	243	240	238	236	242	239	238	246
S2	0.194	250	250	246	245	245	243	239	240	243	242	243
<b>S3</b>	0.190	237	235	235	230	233	232	225	225	229	231	231
<b>S4</b>	0.191	171	172	175	172	170	166	165	164	166	169	170
S5	0.193	288	293	291	285	283	279	281	279	279	282	284
<b>S6</b>	0.175	184	186	185	182	179	176	177	178	178	181	184

 Table 2: Average SLSTR-A reflectance factor, and signal-to-noise ratio of the measured VISCAL signal for the last

 11 cycles, averaged over all detectors for the oblique view.

	Average		Oblique Signal-to-noise ratio									
	Reflectance Factor	Cycle 053	Cycle 054	Cycle 055	Cycle 056	Cycle 057	Cycle 058	Cycle 059	Cycle 060	Cycle 061	Cycle 062	Cycle 063
<b>S1</b>	0.166	266	269	263	268	257	252	245	258	255	253	262
S2	0.170	274	273	267	267	266	258	249	256	261	261	260
<b>S3</b>	0.168	254	245	244	239	238	237	226	227	233	241	241
<b>S4</b>	0.166	141	141	140	139	138	136	133	135	137	138	139
S5	0.166	214	210	211	215	214	214	210	213	211	216	214
<b>S6</b>	0.155	136	134	133	134	132	131	130	130	131	133	133



#### Sentinel-3 MPC

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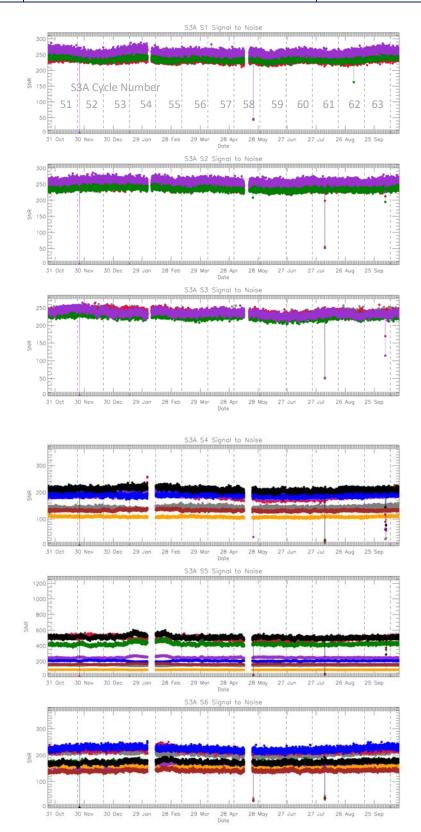


Figure 10: VIS and SWIR channel signal-to-noise of the measured VISCAL signal in each orbit for the last year of operations for SLSTR-A. Different colours indicate different detectors. The vertical dashed lines indicate the start and end of each cycle.



#### 2.5.2 SLSTR-B VIS and SWIR channel signal-to-noise

The average VIS and SWIR channel signal-to-noise ratios for SLSTR-B in Cycle 044 are shown in Table 3 and Table 4. These values average over a significant detector-detector dispersion for the SWIR channels.

 Table 3: Average SLSTR-B reflectance factor, and signal-to-noise ratio of the measured VISCAL signal for the last

 11 cycles, averaged over all detectors for the nadir view.

	Average		Nadir Signal-to-noise ratio									
	Reflectance Factor	Cycle 034	Cycle 035	Cycle 036	Cycle 037	Cycle 038	Cycle 039	Cycle 040	Cycle 041	Cycle 042	Cycle 043	Cycle 044
<b>S1</b>	0.177	240	239	231	232	226	224	224	224	228	228	230
<b>S2</b>	0.192	225	229	221	223	216	217	214	218	219	219	222
<b>S3</b>	0.194	234	241	232	230	229	219	223	225	221	227	233
<b>S4</b>	0.186	133	134	132	130	129	129	129	129	130	131	131
S5	0.184	245	247	245	243	241	241	240	239	241	241	241
<b>S6</b>	0.162	167	169	165	162	161	160	159	159	162	160	159

 Table 4: Average SLSTR-B reflectance factor, and signal-to-noise ratio of the measured VISCAL signal for the last

 11 cycles, averaged over all detectors for the oblique view.

	Average	Oblique Signal-to-noise ratio												
	Reflectance Factor	Cycle 034	Cycle 035	Cycle 036	Cycle 037	Cycle 038	Cycle 039	Cycle 040	Cycle 041	Cycle 042	Cycle 043	Cycle 044		
<b>S1</b>	0.157	230	229	225	223	221	215	216	216	218	220	223		
S2	0.168	263	265	258	259	250	247	241	247	246	251	255		
<b>S3</b>	0.172	269	272	263	266	257	251	254	250	251	259	257		
<b>S4</b>	0.168	132	131	128	128	127	126	125	127	127	127	128		
S5	0.172	253	253	252	247	243	242	242	242	242	242	241		
<b>S6</b>	0.152	189	187	187	184	182	179	178	179	181	183	184		



#### 2.5.3 SLSTR-A TIR channel NEDT

The thermal channel NEDT values for SLSTR-A in Cycle 063 are consistent with previous operations and within the requirements. NEDT trends calculated from the hot and cold blackbody signals are shown in Figure 11. NEDT values for each cycle, averaged over all detectors and both Earth views, are shown in Table 5. Note that a blackbody crossover test was performed for SLSTR-A from 1<sup>st</sup>-3<sup>rd</sup> October (see Section 6.1).

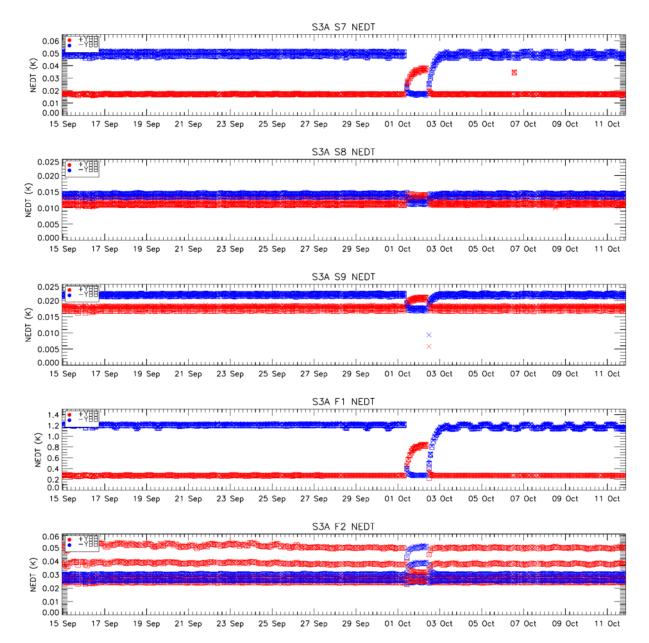


Figure 11: SLSTR-A NEDT trend for the thermal channels in Cycle 063. Blue points were calculated from the cold blackbody signal and red points from the hot blackbody. The square symbols show results calculated from the nadir view and crosses show results from the oblique view. Results are plotted for all detectors and integrators, which is why there are several different levels within the same colour points (particularly for S8 and F2).



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# Table 5: NEDT for SLSTR-A in the last 11 cycles averaged over all detectors for both Earth views towards the hot+YBB (top) and the cold -YBB (bottom).

SLSTR-A		Cycle 053	Cycle 054	Cycle 055	Cycle 056	Cycle 057	Cycle 058	Cycle 059	Cycle 060	Cycle 061	Cycle 062	Cycle 063
+YBB temp (K)		304.206	304.073	303.560	303.181	303.067	303.078	302.957	302.920	302.914	302.962	303.265
	S7	16.8	16.8	17.2	17.1	17.2	17.2	17.3	17.4	17.4	17.3	17.9
NEDT	<b>S8</b>	11.2	11.4	11.2	11.4	11.4	11.2	11.3	11.4	11.5	11.4	11.6
NEDT (mK)	<b>S9</b>	17.9	17.8	17.4	17.5	17.6	17.3	17.5	17.5	17.6	17.6	17.8
(1110)	F1	265	261	271	274	276	268	274	277	277	274	342
	F2	35.7	34.9	35.8	36.0	35.3	35.3	35.3	35.0	35.1	36.0	35.1

SLSTR-A		Cycle 053	Cycle 054	Cycle 055	Cycle 056	Cycle 057	Cycle 058	Cycle 059	Cycle 060	Cycle 061	Cycle 062	Cycle 063
-YBB temp (K)		266.941	266.707	266.088	265.669	265.675	265.797	265.645	265.545	265.438	265.401	265.731
	S7	46.6	48.4	48.8	49.9	50.0	50.4	49.5	49.4	49.5	49.6	48.0
	<b>S8</b>	14.0	14.1	14.0	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.2
NEDT (mK)	S9	21.9	22.0	21.5	21.7	21.7	21.5	21.5	21.6	21.7	21.7	21.6
(1110)	F1	1121	1141	1176	1232	1231	1196	1197	1205	1204	1206	1173
	F2	28.1	28.0	27.8	28.0	28.0	27.8	27.8	27.8	27.8	27.9	28.2



#### 2.5.4 SLSTR-B TIR channel NEDT

The thermal channel NEDT values for SLSTR-B in Cycle 044, calculated from the hot and cold blackbody signals are shown in Figure 12 and Table 6. Note that a blackbody crossover test was performed for SLSTR-B from 28<sup>th</sup>-30<sup>th</sup> September (see Section 6.2).

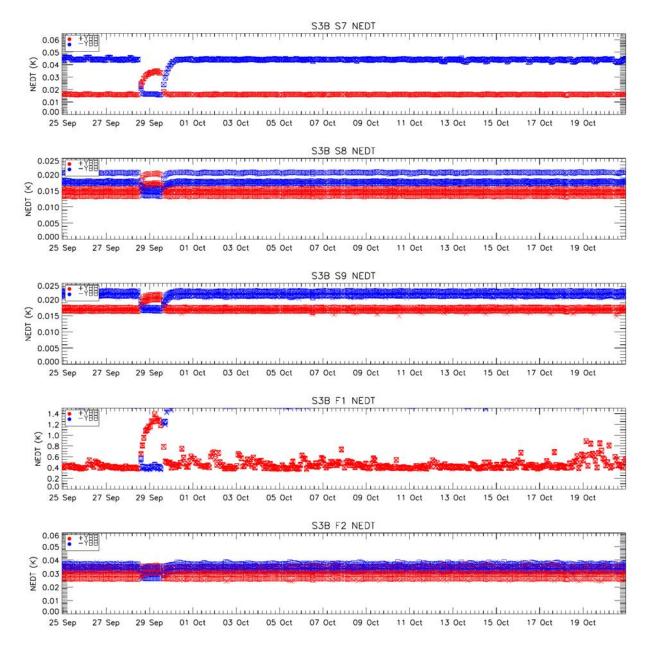


Figure 12: SLSTR-B NEDT trend for the thermal channels in Cycle 044. Blue points were calculated from the cold blackbody signal and red points from the hot blackbody. The square symbols show results calculated from the nadir view and crosses show results from the oblique view. Results are plotted for all detectors and integrators, which is why there are several different levels within the same colour points (particularly for S8 and F2).



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# Table 6: NEDT for SLSTR-B in the last 11 cycles averaged over all detectors for both Earth views towards the hot+YBB (top) and the cold -YBB (bottom).

SLSTR-B		Cycle 034	Cycle 035	Cycle 036	Cycle 037	Cycle 038	Cycle 039	Cycle 040	Cycle 041	Cycle 042	Cycle 043	Cycle 044
+YBB temp (K)		304.334	303.991	303.566	303.220	303.115	303.145	302.971	302.930	302.882	303.045	303.435
	S7	15.7	15.9	16.1	16.0	16.0	16.0	16.2	16.3	16.3	16.2	16.7
NEDT	<b>S8</b>	12.9	13.0	13.1	13.9	14.3	14.4	14.5	14.5	14.5	14.5	14.6
NEDT (mK)	<b>S9</b>	14.5	14.6	14.7	15.7	16.4	16.5	16.6	16.7	16.8	16.9	17.0
(	F1	357	369	412	414	395	413	442	406	435	466	481
	F2	30.1	30.0	29.9	30.2	30.4	30.5	30.5	30.5	30.4	30.3	30.5

SLSTR-B		Cycle 034	Cycle 035	Cycle 036	Cycle 037	Cycle 038	Cycle 039	Cycle 040	Cycle 041	Cycle 042	Cycle 043	Cycle 044
-YBB temp (K)		266.613	266.112	265.579	265.263	265.293	265.443	265.224	265.105	264.952	265.097	265.506
	S7	42.4	42.7	44.0	43.9	43.9	44.1	44.0	44.2	44.8	44.5	42.8
NEDT	<b>S8</b>	16.8	16.8	16.9	17.6	18.2	18.2	18.2	18.2	18.3	18.4	18.2
NEDT (mK)	<b>S</b> 9	18.4	18.6	18.8	20.2	21.1	21.2	21.3	21.5	21.6	21.7	21.5
(1110)	F1	1481	1520	1762	1774	1669	1756	1875	1687	1844	2002	1871
	F2	30.7	30.9	31.0	32.5	33.5	33.6	33.6	33.8	34.1	34.2	34.1



## **2.6 Calibration factors**

#### 2.6.1 VIS and SWIR radiometric response

The visible channels show oscillations in their radiometric response due to the build-up of ice on the optical path within the focal plane assembly (FPA). Similar oscillations were observed for the corresponding channels on ATSR-2 and AATSR. As described in Section 2.2, periodic decontamination of the infrared FPA is necessary to remove the water ice contamination.

The radiometric responses of the SWIR channels appear to be more stable and not affected by the buildup of water ice contamination, although there is a seasonal cycle of the response that could be caused by variations in the solar zenith angle on the diffuser or partial vignetting of the Sun's disc by the VISCAL baffle.

It should be noted that the data from the VISCAL unit and blackbodies calibrates the signal and counteracts the degradation of the optics and other variations in signal.

Figure 13 and Figure 14 show the variation of the radiometric gain derived from the VISCAL signals for SLSTR-A over the past year, and Figure 15 and Figure 16 show the variation of the radiometric gain for SLSTR-B since the start of the S3B mission. Note that the period of the oscillations depends on the rate of build up of the ice layer, which is faster for SLSTR-B because it has had less time to decontaminate.

Note that decontaminations for SLSTR-A were performed in Cycles 45 and 54 and 58. For SLSTR-B, a decontamination was performed during Cycle 24 and Cycle 30.

There is a step in the SWIR channel radiometric response for SLSTR-B in Cycle 37 on 30<sup>th</sup> March 2020 due to the change in temperature of the detectors caused by the cooler set point change.

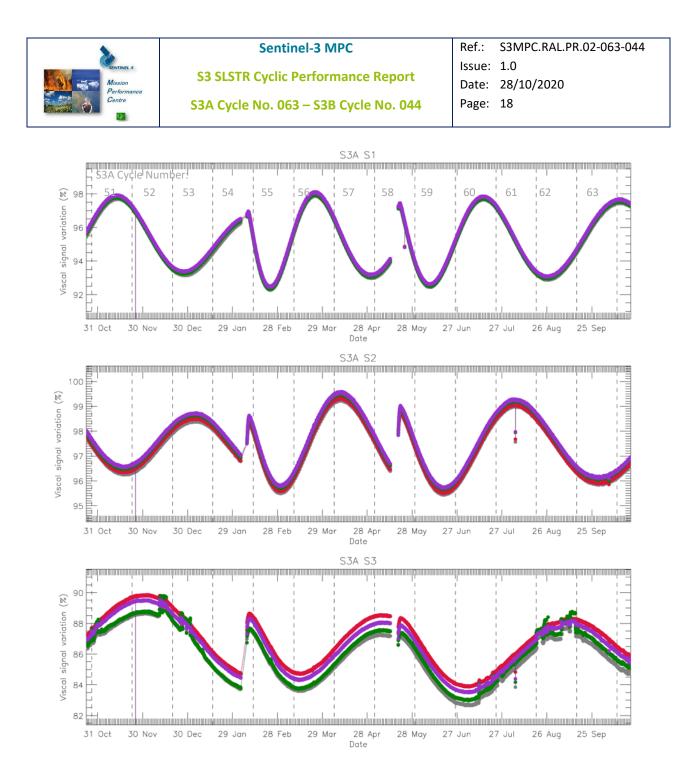


Figure 13: Variation of the radiometric gain derived from the VISCAL signals for SLSTR-A VIS channels for the last year of operations (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start and end of each cycle.

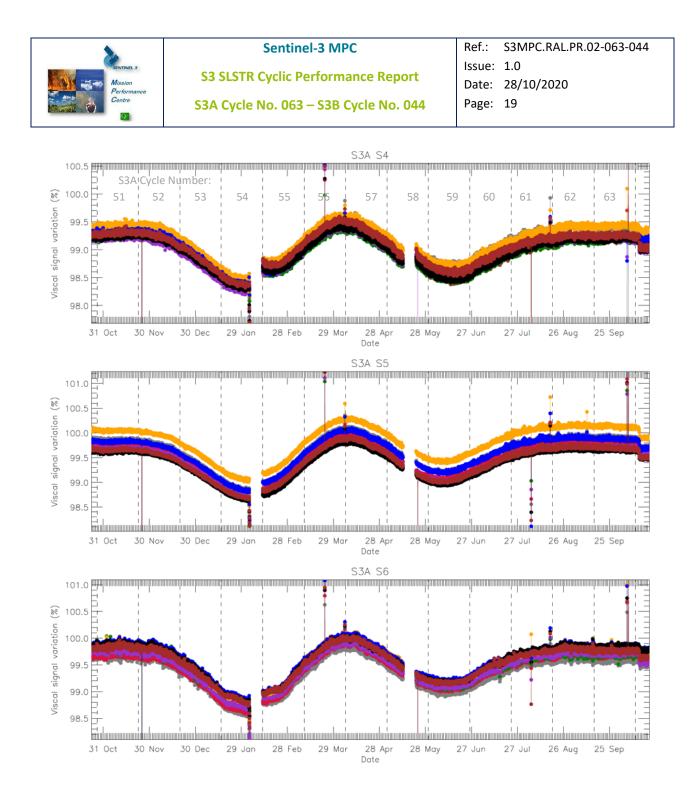


Figure 14: Variation of the radiometric gain derived from the VISCAL signals for SLSTR-A SWIR channels for the last year of operations (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start and end of each cycle. Note that the spikes in cycle 56 correspond to orbits where there were missing data (Section 6.1).

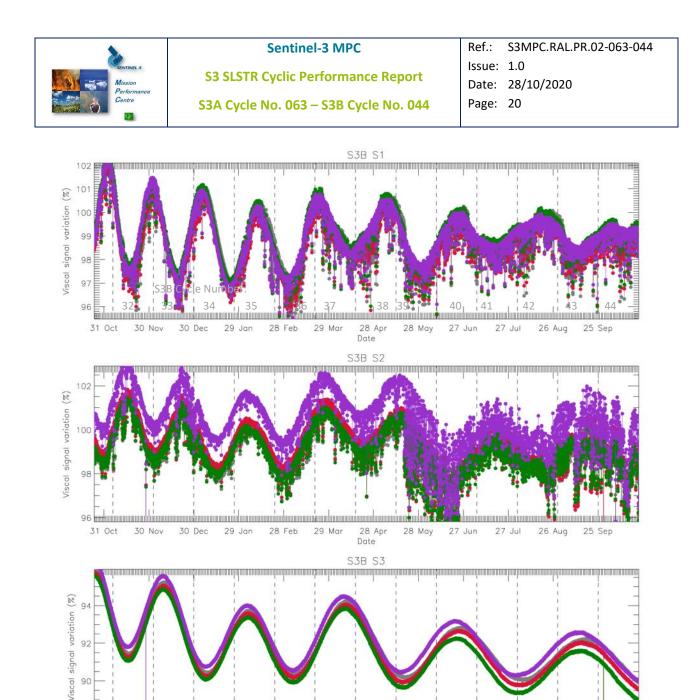


Figure 15: Variation of the radiometric gain derived from the VISCAL signals for SLSTR-B VIS channels for the past year (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start and end of each cycle.

28 Apr

Date

29 Mar

27 Jun

27 Jul

28 May

25 Sep

26 Aug

92

90

31 Oct

30 Nov

29 Jan

28 Feb

30 Dec

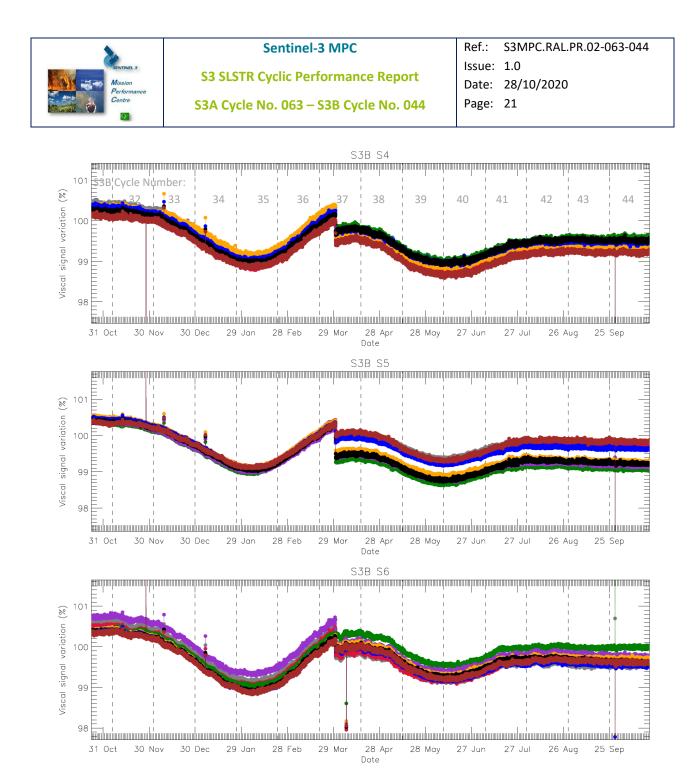


Figure 16: Variation of the radiometric gain derived from the VISCAL signals for SLSTR-B SWIR channels for the past year (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start and end of each cycle.



# 3 Level-1 product validation

## 3.1 Geometric calibration/validation

Regular monitoring using the GeoCal Tool implemented at the MPC is being carried out. This monitors the geolocation performance in Level-1 images by correlation with ground control point (GCP) imagettes. Each Level-1 granule typically contains several hundred GCPs, which are filtered based on signal-to-noise to obtain a daily average in the across and along track directions. The results are plotted in Figure 17 for SLSTR-A in Cycle 063 and Figure 18 for SLSTR-B in Cycle 044, giving the average positional offsets in kilometres for Nadir and Oblique views.

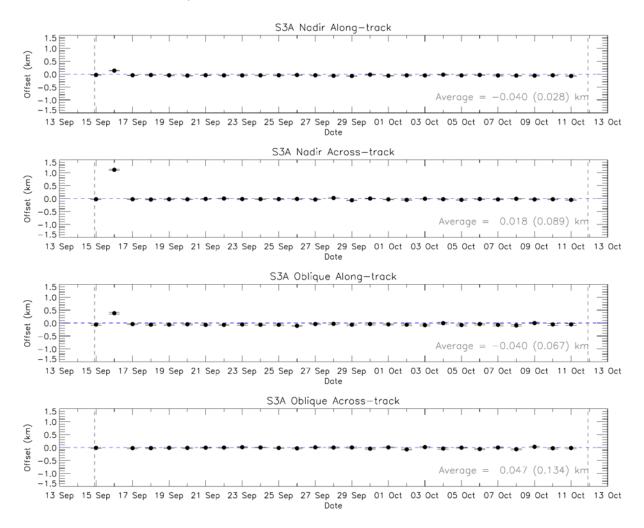
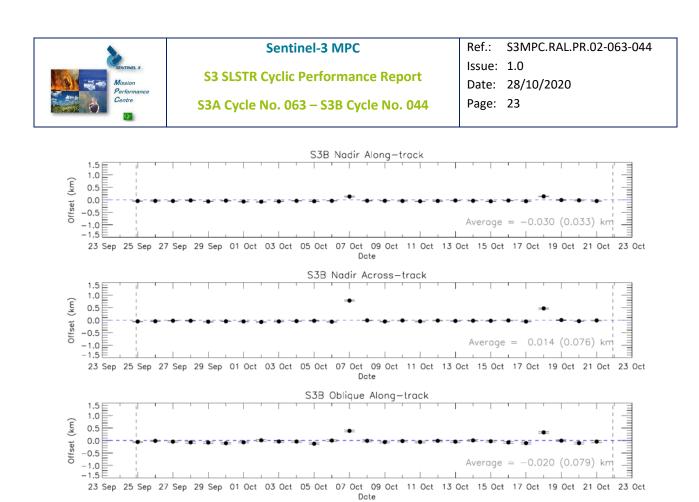


Figure 17: SLSTR-A daily offset results in km from the GeoCal Tool analysis for Nadir along- and across-track (top two plots) and Oblique along- and across-track (bottom two plots) for Cycle 063. The error bars show the standard deviation.



23 Sep 25 Sep 27 Sep 29 Sep 01 Oct 03 Oct 05 Oct 07 Oct 09 Oct 11 Oct 13 Oct 15 Oct 17 Oct 19 Oct 21 Oct 23 Oct Dote
 Figure 18: SLSTR-B daily offset results in km from the GeoCal Tool analysis for Nadir along- and across-track (top two plots) and Oblique along- and across-track (bottom two plots) for Cycle 044. The error bars show the standard deviation.

S3B Oblique Across-track

Average =

0.038 (0.105)

1.5 1.0

-1.0

Offset (km)

The offsets for SLSTR-B on 7<sup>th</sup> October are due to a scheduled out-of-plane manoeuvre performed on that day (see Section 6.2). The offsets for SLSTR-A on 16<sup>th</sup> September and SLSTR-B on 18<sup>th</sup> September correspond to the ground segment issues and problems in data transfer on those days (see Sections 6.1 and 6.2).



S3A Cycle No. 063 – S3B Cycle No. 044

## **3.2** Radiometric validation

The radiometric calibration of the visible and SWIR channels is monitored using the S3ETRAC service. The S3ETRAC service extracts OLCI and SLSTR Level-1 data and computes associated statistics over 49 sites corresponding to different surface types (desert, snow, ocean maximising Rayleigh signal, and ocean maximising sunglint scattering). These S3ETRAC products are used for the assessment and monitoring of the VIS and SWIR radiometry by the ESL.

Details of the S3ETRAC/SLSTR statistics are provided on the S3ETRAC website <u>http://s3etrac.acri.fr/index.php?action=generalstatistics#pageSLSTR</u>

- Number of SLSTR products processed by the S3ETRAC service
- Statistics per type of target (DESERT, SNOW, RAYLEIGH, SUNGLINT)
- Statistics per site
- Statistics on the number of records

Figure 19 and Figure 20 show the results of the inter-comparison analysis of SLSTR-A with OLCI-A and SLSTR-B with OLCI-B over desert sites. Figure 21 and Figure 22 show the results of an inter-comparison analysis of SLSTR-A and SLSTR-B with AATSR, and Figure 23 and Figure 24 show the results of the inter-comparison analysis with MODIS. Average ratios in each case are given in the figures.

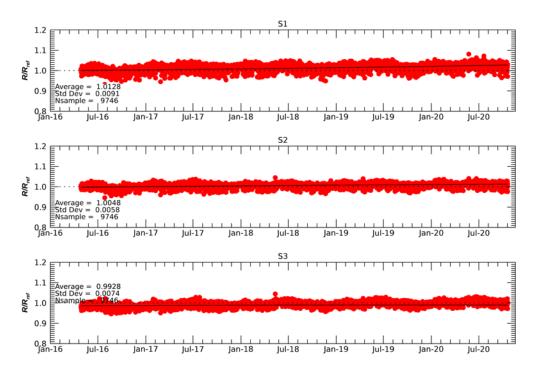


Figure 19: Ratio of SLSTR-A and OLCI-A radiances for the visible channels in Nadir view using combined results for all desert sites.

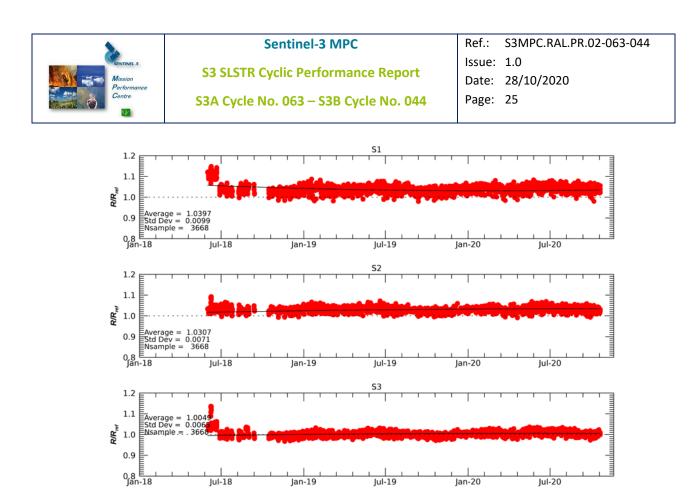
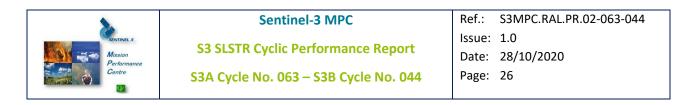


Figure 20: Ratio of SLSTR-B and OLCI-B radiance for the visible channels in Nadir view using combined results for all desert sites.



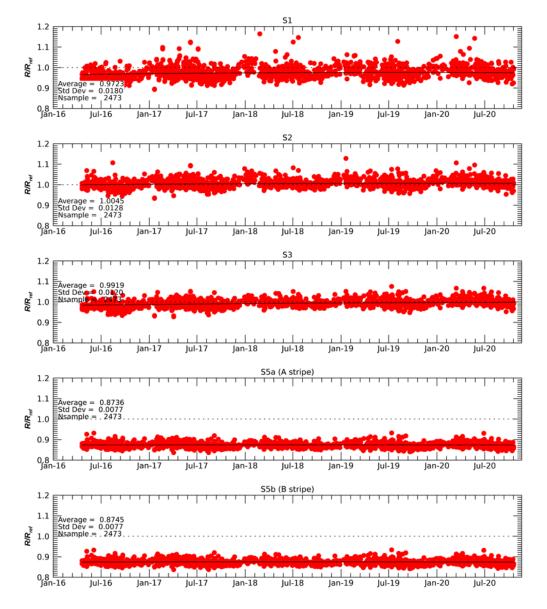


Figure 21: Ratio of SLSTR-A and AATST radiances in Nadir view using combined results for all desert sites.



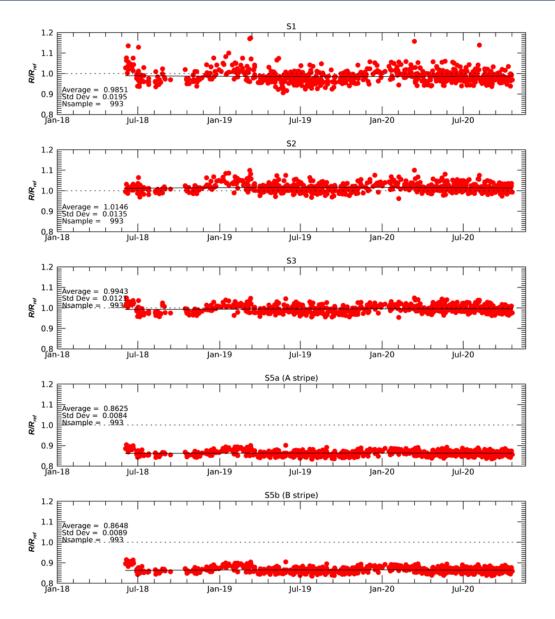


Figure 22: Ratio of SLSTR-B and AATSR in Nadir view using combined results for all desert sites.



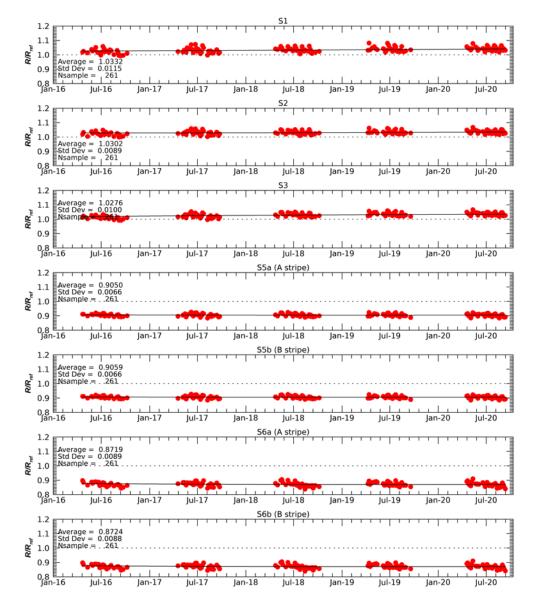
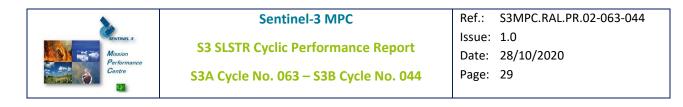


Figure 23: Ratio of SLSTR-A and MODIS radiances radiances in Nadir view using combined results for all desert sites.



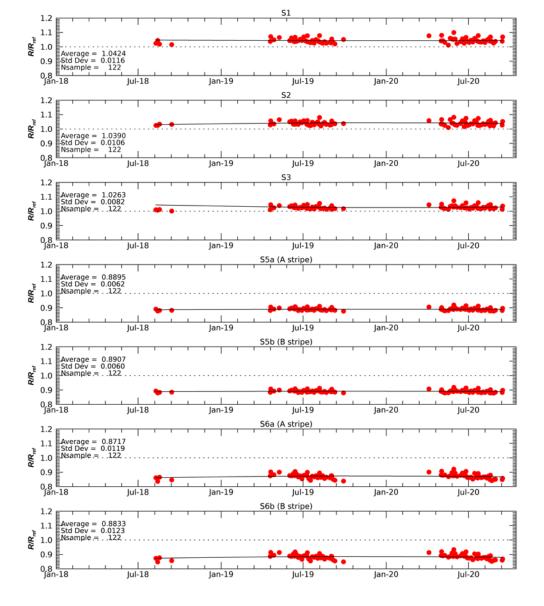
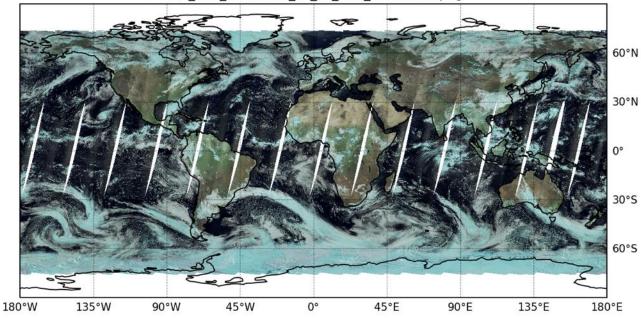


Figure 24: Ratio of SLSTR-B and MODIS radiances in Nadir view using combined results for all desert sites.



## 3.3 Image quality

The Level-1 image quality is assessed when data are available at the MPC. For example by combining all granules over one day into a single combined image. The S3A and S3B satellites are configured to be 140 degrees out of phase in order to observe complimentary portions of the earth. Figure 25 shows an example combined SLSTR-A/SLSTR-B image for the visible channels from the previous cycle on 4<sup>th</sup> October 2020 (daytime only).



S3A\_S3B\_combined\_SL\_L3\_RSB\_20201004.png

*Figure 25: Daytime combined SLSTR-A and SLSTR-B Level-1 image for visible channels on 4<sup>th</sup> October 2020.* 



S3A Cycle No. 063 – S3B Cycle No. 044 Pa

# 4 Level-2 SST validation

Level-2 SST validation is under the responsibility of EUMETSAT.



S3A Cycle No. 063 – S3B Cycle No. 044

# 5 Level 2 LST validation

Level 2 Land Surface Temperature products have been validated against *in situ* observations (Category-A validation) from twelve "Gold Standard" Stations, and intercompared (Category-C validation) with respect to an independent operational reference product (SEVIRI from LSA SAF). In all cases it is the NTC products that are validated, and the Probabilistic cloud masking implementation is used for all cloud masking. Level-3C products for the full Cycles 063 for SLSTR-A and 044 for SLSTR-B are evaluated for identifying any gross problems. Both S3A and S3B L2 products are produced with the updated LST coefficients following the operational release on 25<sup>th</sup> February 2019. In each case the latest temporal interpolation for the probabilistic cloud mask is applied following the L1 operational release on 15<sup>th</sup> January 2020.

## 5.1 Category-A validation

Category-A validation uses a comparison of satellite-retrieved LST with *in situ* measurements collected from radiometers sited at a number of stations spread across the Earth, for which the highest-quality validation can be achieved. Here we concentrate on twelve "Gold Standard" stations which are installed with well-calibrated instrumentation: seven from the SURFRAD network (Bondville, Illinois; Desert Rock, Nevada; Fort Peck, Montana; Goodwin Creek, Mississippi; Penn State University, Pennsylvania; Sioux Fall, South Dakota; Table Mountain, Colorado); two from the ARM network (Southern Great Plains, Oklahoma; Barrow, Alaska); and three from the USCRN network (Williams, Arizona; Des Moines, Iowa; Manhatten, Kansas). The results can be summarised as follows:

Satellite	Average absolute accuracy vs. Gold Standard (K)		
	Day	Night	
S3A	1.2	0.8	
S3B	1.2	0.9	

For both SLSTR-A and SLSTR-B both the daytime and night-time accuracies are within or close to the mission requirement of 1K, even though they are impacted to some extent by very small number of matchups for some stations in the cycle due to actual cloud, or over-masking. The number of matchups across most stations for daytime are very low particularly during the day, and have impacted the biases to an extent. This may be a case of the cloud coefficients ADF not being optimum following the introduction of the temporal interpolation to the probabilistic cloud mask. An updated cloud coefficients ADF has been delivered for implementation in the next product release.



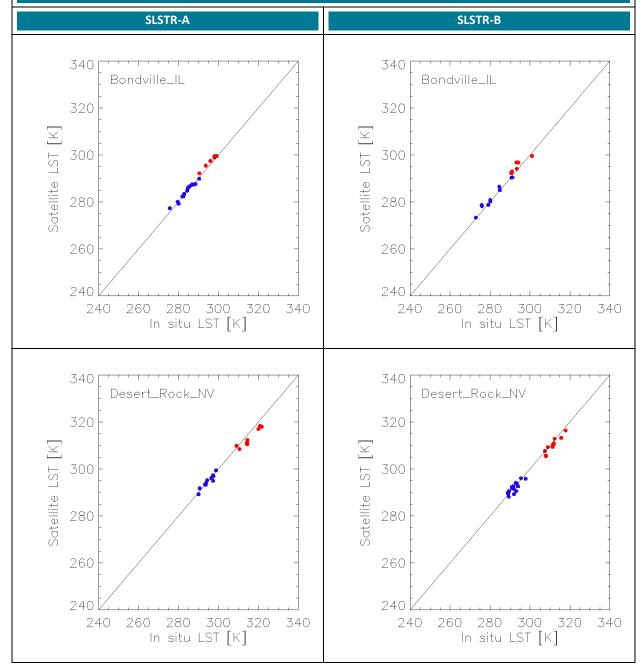
#### Sentinel-3 MPC

**S3 SLSTR Cyclic Performance Report** 

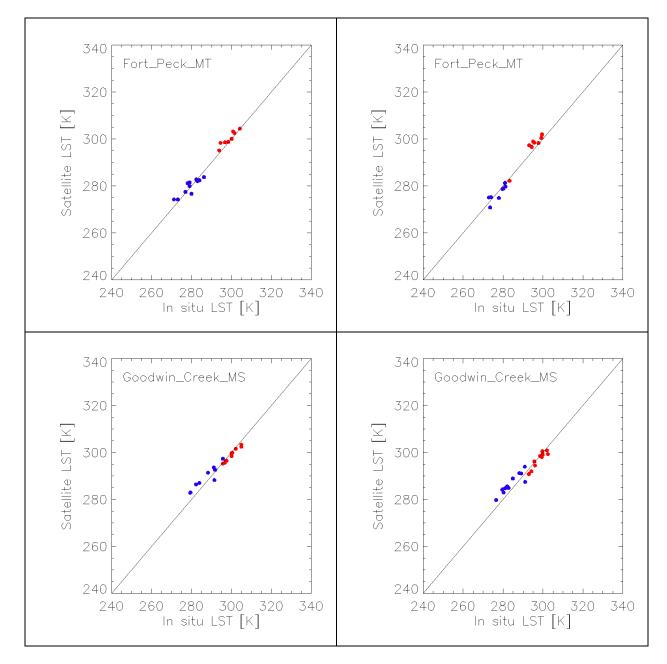
Ref.: S3MPC.RAL.PR.02-063-044 Issue: 1.0 Date: 28/10/2020 Page: 33

#### S3A Cycle No. 063 - S3B Cycle No. 044

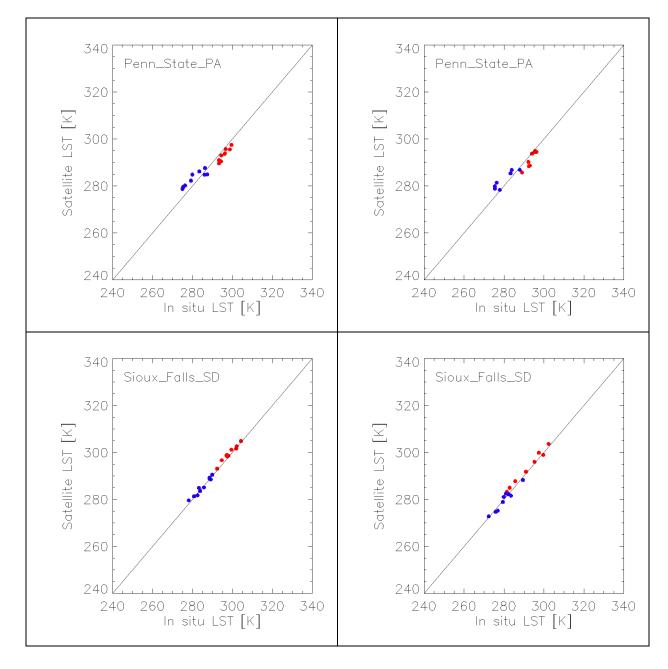
Validation of the SL\_2\_LST product over Cycle 063 (SLSTR-A) and Cycle 044 (SLSTR-B) at seven Gold Standard in situ stations of the SURFRAD network plus two Gold Standard station from the ARM network, and two Gold Standard station from the USCRN network



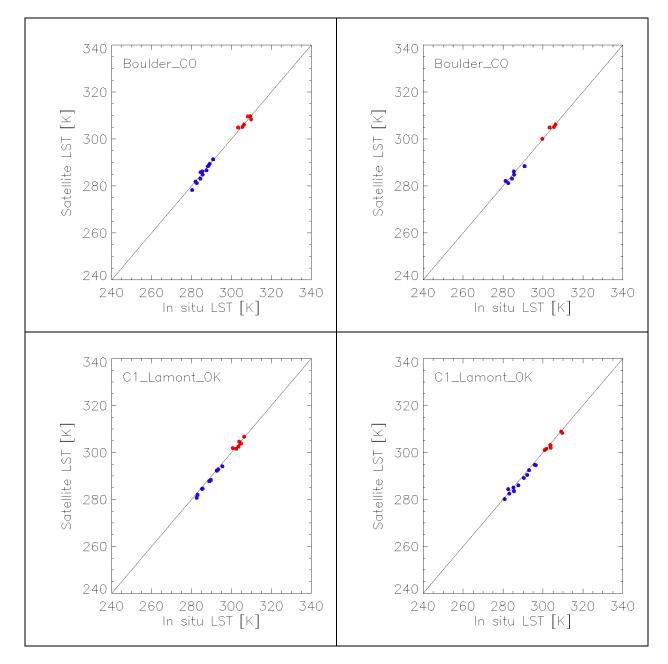




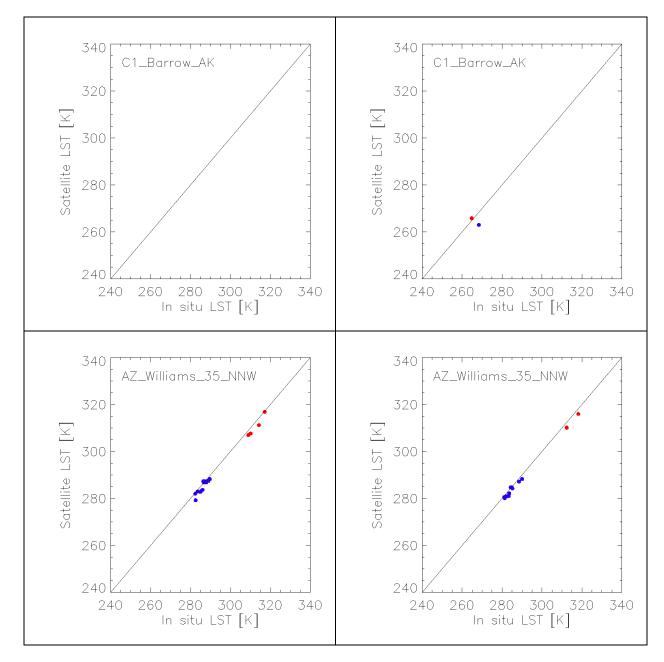


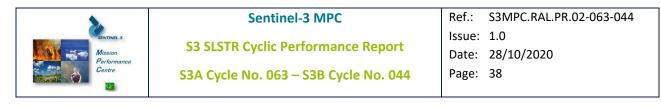


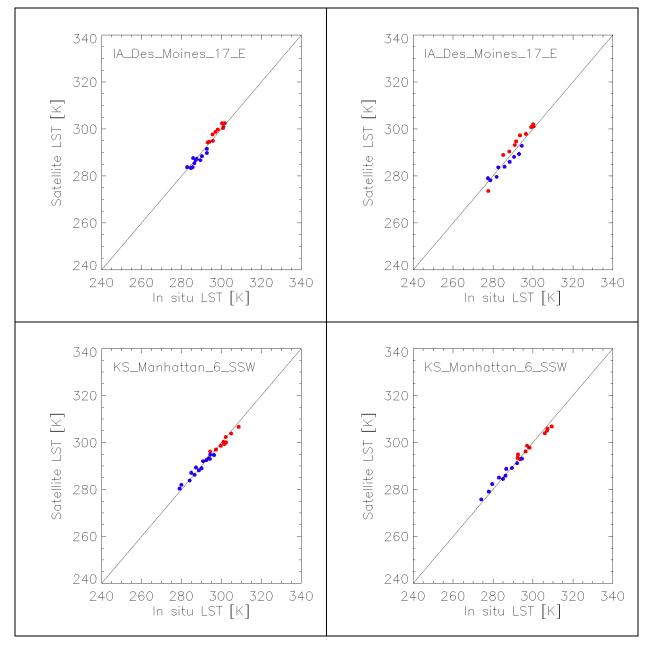












As with past cycles cloud has reduced the number of matchups per station to single figures for most stations during day or night, with some missing statistics entirely. It is therefore challenging to determine robust statistics. Nonetheless, it can be seen that overall the matchups are in general close to the 1:1 line with very few outliers. No systematic bias is evident from these matchups.



## 5.2 Category-C validation

Category-C validation uses inter-comparisons with similar LST products from other sources such as other satellite sensors, which give important quality information with respect to spatial patterns in LST deviations. Here we compare the SL\_2\_LST product from both SLSTR-A and SLSTR-B with the operational SEVIRI L2 product available from the LSA SAF. The results can be summarised:

Continent	Median differences in K from the intercomparison of the SL_2_LST product with respect to the operational LSA SAF SEVIRI LST product for the period of Cycle 063 (SLSTR-A) and Cycle 044 (SLSTR-B)			
	SLSTR-A		SLSTR-B	
	Day	Night	Day	Night
Africa	0.1	0.5	0.2	0.3
Europe	-0.1	0.3	-0.3	0.4

For both Africa and Europe, the differences across the continent for both SLSTR-A and SLSTR-B are relatively small, with very few locations with larger differences. This is the same for both SLSTR-A and SLSTR-B and is primarily driven by differences in viewing geometry between the SLSTR instruments and SEVIRI and is expected. Eastern matchups (such as over the Arabian Peninsula) are towards the edge of the SEVIRI disk and therefore represent large viewing angles. At these extreme viewing angles it is expected that SLSTR LST would be increasingly higher than SEVIRI LST. For both daytime and night-time the differences are mainly < 1K for Africa for both SLSTR-A and SLSTR-B. During daytime differences are over 1K for Europe as a result of increasing differences due to geometry as days get warmer. Differences are not the same as previous cycles for both Europe and Africa which may indicate responses due to changing seasons.

Other analysis can be summarised as follows:

- Differences with respect to biomes tend to be larger during the day for surfaces with more heterogeneity and/or higher solar insolation
- Differences increase for both day and night towards the edge of the SEVIRI disk as the SEVIRI zenith angles become larger

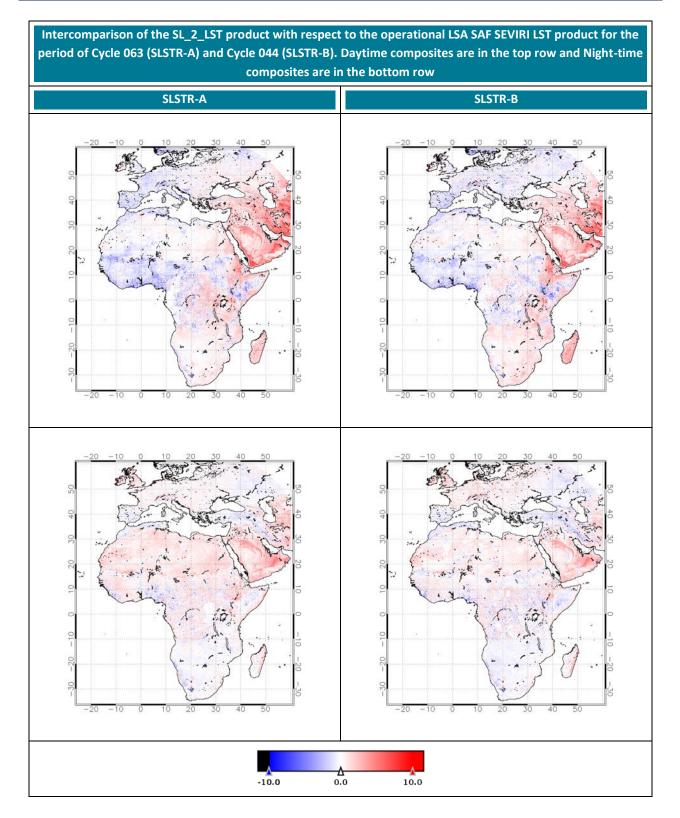


#### Sentinel-3 MPC

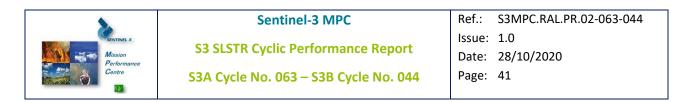
S3 SLSTR Cyclic Performance Report

Ref.: S3MPC.RAL.PR.02-063-044 Issue: 1.0 Date: 28/10/2020 Page: 40

S3A Cycle No. 063 – S3B Cycle No. 044



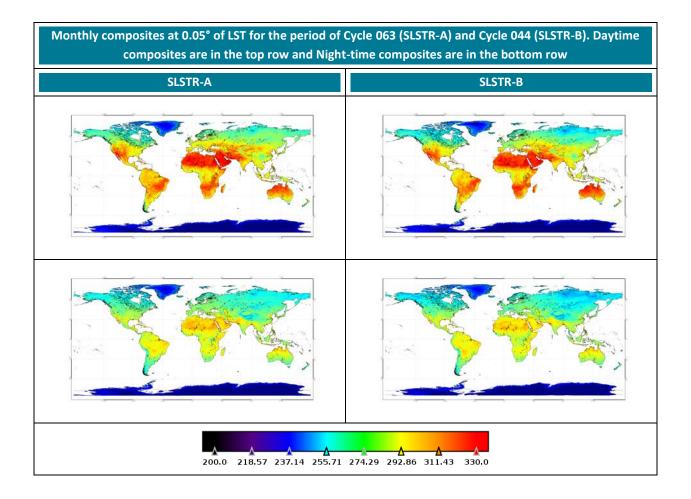
While some of these differences are > 1 K they are all within the corresponding uncertainty of SEVIRI at the pixel-scale (> 2K), and so the **two products can be assessed as being consistent**. It should also be noted that there are no significant differences between the two products in terms of biome-dependency - the differences are consistent across biomes. Some residual cloud contamination is evident from the large differences at the edge of cloud cleared features. While the cloud contamination is seen for both



SLSTR (strong negative differences) and SEVIRI (strong positive differences), compared with cycles where the basic cloud mask was used the contamination for SLSTR is lower indicating improved masking with the Probabilistic Cloud Mask. However, less matchups are evident which suggests the cloud masking could be slightly over conservative in some biomes. This will be monitored over the following Cycles to identify whether an optimisation to the cloud coefficients should be considered for some biomes.

## 5.3 Level-3C Assessment

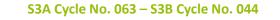
To better understand the global product and identify any gross issues Level-3 evaluation is also performed. Here we generate monthly daytime and night-time 0.05° composites of the LST field and corresponding sampling ratios. The sampling ratios are derived as clear\_pixels / (clear\_pixels + cloudy\_pixels).

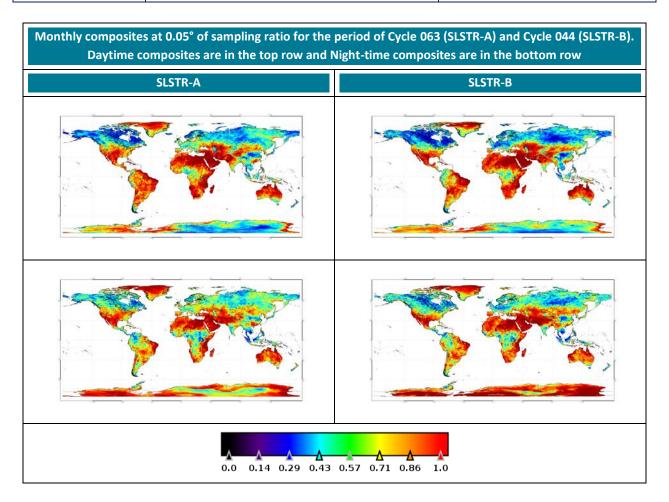




#### Sentinel-3 MPC

S3 SLSTR Cyclic Performance Report





The LST fields indicate the SL\_2\_LST product is producing values in line with expectations for both SLSTR-A and SLSTR-B. There are no distinct issues or non-physical values evident. The sampling ratio is now closer to what would be expected across the globe following the implementation of the temporal interpolation for the probabilistic cloud mask on 15<sup>th</sup> January 2020. Cloud contamination appears to be low, although there appears to be some excessive cloud clearing in some regions and undermasking in other, indicating the cloud coefficients ADF will need tuning for both instruments now the issue regarding the temporal interpolation has been resolved. The update to the ADF is has now been delivered for implementation in the next product release.



## 6 Events

## 6.1 SLSTR-A

SLSTR-A was switched on and operating nominally during the cycle, with SUE scanning and autonomous switching between day and night modes, except for the following events:

- 15<sup>th</sup> 16<sup>th</sup> September 2020 may be issues with data gaps and pointing errors, especially with NRT data due to data production problem.
- 16<sup>th</sup> September 2020, 14:48-14:53 data gaps caused by radio frequency interference.
- 22<sup>nd</sup> September 2020, 14:48-14:53 data gaps caused by radio frequency interference.
- 25<sup>th</sup> September 2020, 10:55-11:10 possible data gaps due to data transfer delay.
- 28<sup>th</sup> September 2020, 06:19-06:49 possible data gaps due to data transfer delay.
- 28<sup>th</sup> September 2020, 07:51-07:56 possible data gaps due to data transfer delay.
- 28<sup>th</sup> September 2020, 07:26-10:48 possible pointing errors due to data transfer delay.
- 1<sup>st</sup> October 2020, 08:14 3<sup>rd</sup> October 2020, 05:00 Blackbody cross-over test. This test involves heating the cold blackbody and cooling the hot blackbody to swap their temperatures over, and then repeating the procedure to put the temperatures back to their nominal state. During this process, the separation in temperature between the two blackbodies changes, and therefore the calibration is degraded. Uncertainty in the thermal channel calibration increases as the difference in temperature between the two blackbodies decreases. Products around the crossover in blackbody temperatures are not processed to L1 and will not be available. The remaining data recorded during the time period above should be considered to have higher than normal uncertainty for the thermal channels.
- 6<sup>th</sup> October 2020, 11:43-11:52 possible data gaps due to data circulation issue.
- 6<sup>th</sup> October 2020, 13:42-13:48 possible data gaps due to data circulation issue.
- 6<sup>th</sup> October 2020, 19:20-19:26 possible data gaps due to data circulation issue.
- 7<sup>th</sup> October 2020, 06:29-06:38 possible data gaps due to data circulation issue.
- 7<sup>th</sup> October 2020, 12:10-13:04 possible data gaps due to data circulation issue.
- 7<sup>th</sup> October 2020, 15:56-16:05 possible data gaps due to data circulation issue.
- 9<sup>th</sup> October 2020, 09:37-09:43 data gap for NRT data only.
- 10<sup>th</sup> October 2020, 16:30-16:35 data gaps caused by radio frequency interference.



## 6.2 SLSTR-B

SLSTR-B was switched on and operating nominally during the cycle, with SUE scanning and autonomous switching between day and night modes, except for the following events:

- 28<sup>th</sup> September 2020, 12:14 30<sup>th</sup> September 2020, 08:10 Blackbody cross-over test. As for SLSTR-A, this test involves heating the cold blackbody and cooling the hot blackbody to swap their temperatures over, and then repeating the procedure to put the temperatures back to their nominal state. During this process, the separation in temperature between the two blackbodies changes, and therefore the calibration is degraded. Uncertainty in the thermal channel calibration increases as the difference in temperature between the two blackbodies decreases. Products around the crossover in blackbody temperatures are not processed to L1 and will not be available. The remaining data recorded during the time period above should be considered to have higher than normal uncertainty for the thermal channels
- 5<sup>th</sup> October 2020, 01:01-01:16 data gaps caused by radio frequency interference.
- 6<sup>th</sup> October 2020, 13:23-13:26 possible data gaps due to data circulation issue.
- 7<sup>th</sup> October 2020, 04:56-05:05 possible data gaps due to data circulation issue.
- 7<sup>th</sup> October 2020, 09:28-09:55 possible pointing errors due to a scheduled out-of-plane manoeuvre.
- 7<sup>th</sup> October 2020, 21:51-22:00 possible data gaps due to data circulation issue.
- 13<sup>th</sup> October 2020, 12:15-12:21 data gap for NRT data only.
- 18<sup>th</sup> October 2020, 05:03-06:52 data gap for NRT data due to ground segment issue.
- 20<sup>th</sup> October 2020, 07:31-07:37 possible data gaps due to data transfer delay.
- 20<sup>th</sup> October 2020, 09:32-09:42 data gaps caused by radio frequency interference.
- 20<sup>th</sup> October 2020, 10:52-11:04 possible data gaps due to data transfer delay.
- 21<sup>st</sup> October 2020, 12:52-12:57 data gaps caused by radio frequency interference.



# 7 Appendix A

Other reports related to the Optical mission are:

 S3 OLCI Cyclic Performance Report, S3A Cycle No. 063, S3B Cycle No. 044 (ref. S3MPC.ACR.PR.01-063-044)

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

End of document