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

## **S3 SLSTR Cyclic Performance Report**

**S3-A** 

Cycle No. 039

Start date: 06/12/2018

End date: 02/01/2019

**S3-B** 

Cycle No. 020

Start date: 16/12/2018

End date: 12/01/2019



Mission
Performance
Centre

SENTINEL 3



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**S3 SLSTR Cyclic Performance Report** 

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019

Page: iii

## **Changes Log**

Version	Date	Changes
1.0	18/01/2019	First Version

## **List of Changes**

Version	Section	Answers to RID	Changes



### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: iv

### **Table of content**

1	PRO	CESSING BASELINE VERSION	1
2	INST	RUMENT MONITORING	2
	2.1	INSTRUMENT TEMPERATURES	2
	2.2	DETECTOR TEMPERATURES	
	2.3	SCANNER PERFORMANCE	6
	2.4	BLACK-BODIES	7
	2.5	DETECTOR NOISE LEVELS	9
	2.5.1	SLSTR-A VIS and SWIR channel signal-to-noise	9
	2.5.2	SLSTR-B VIS and SWIR channel signal-to-noise	11
	2.5.3	SLSTR-A TIR channel NEDT	12
	2.5.4	SLSTR-B TIR channel NEDT	14
	2.6	CALIBRATION FACTORS	16
	2.6.1	VIS and SWIR radiometric response	16
3	LEVE	L-1 PRODUCT VALIDATION	21
	3.1	GEOMETRIC CALIBRATION/VALIDATION	21
	3.2	RADIOMETRIC VALIDATION	23
	3.3	IMAGE QUALITY	25
4	LEVE	EL 2 SST VALIDATION	26
	4.1	LEVEL 3	26
	4.2	DEPENDENCE ON LATITUDE, TCWV, SATELLITE ZA AND DATE	
	4.3	SPATIAL DISTRIBUTION OF MATCH-UPS	30
	4.4	MATCH-UPS STATISTICS	31
5	LEVE	L 2 LST VALIDATION	32
	5.1	CATEGORY-A VALIDATION	32
	5.2	CATEGORY-C VALIDATION	
	5.3	LEVEL-3C ASSESSMENT	
6	EVEN	NTS	43
	6.1	SLSTR-A	43
	6.2	SLSTR-B	
7	ΔDDI	ENDIX A	44



### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: v

## **List of Figures**

Figure 1: OME temperature trends for SLSTR-A Cycle 039 (left) and SLSTR-B Cycle 020 (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 039 (left) and SLSTR-B Cycle 020 (right). The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit
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.—————4
Figure 4: SLSTR-B detector temperatures for each channel since the launch of S3B. 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 detectors5
Figure 5: SLSTR-A scanner and flip jitter for Cycle 039, 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)
Figure 6: SLSTR-B scanner and flip jitter for Cycle 020, 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)
Figure 7: SLSTR-A blackbody temperature and baseplate gradient trends during Cycle 039. 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 long term trends in average +YBB temperature, showing yearly variation. The vertical dashed lines indicate the 1 <sup>st</sup> January 2017, 2018 and 20198
Figure 9: SLSTR-B blackbody temperature and baseplate gradient trends during Cycle 020. The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit
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. Note the step at the beginning of cycle 38 is not due to a change in instrument behaviour but rather an improvement in the way the noise has been calculated. 10
Figure 11: SLSTR-A NEDT trend for the thermal channels in Cycle 039. 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



### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: vi

all detectors and integrators, which is why there are several different levels within the same colour points (particularly for S8 and F2)12
Figure 12: SLSTR-B NEDT trend for the thermal channels in Cycle 020. 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)
Figure 13: VISCAL signal trend 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 cycle17
Figure 14: VISCAL signal trend 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 cycle18
Figure 15: VISCAL signal trend for SLSTR-B VIS channels for Cycle 020 (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start and end of each cycle19
Figure 16: VISCAL signal trend for SLSTR-B SWIR channels for Cycle 020 (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start and end of each cycle. Note that the spike corresponds to the SRAL cross calibration on 20 <sup>th</sup> December (see Section 6.2), which was carried out at the same time that the VISCAL source was illuminated20
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). The error bars show the standard deviation21
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). The error bars show the standard deviation22
Figure 19: Ratio of SLSTR-A and OLCI-A radiances for the visible channels in Nadir view (shown as a percentage) using combined results for all desert sites processed in Cycle 03923
Figure 20: Ratio of SLSTR-A and AATSR radiances in Nadir view (shown as a percentage) using combined results for all desert sites processed in Cycle 03924
Figure 21: Daytime combined SLSTR-A and SLSTR-B Level-1 image for visible channels on 21 <sup>st</sup> December 201825
Figure 22: (Top) Level 3 spatially average SST for SLSTR-A Cycle 039 at a resolution of 0.05 degrees. Maps are shown for daytime (left) and nighttime (right). Also shown are (middle) number of 1-km samples in each average and (bottom) mean difference to OSTIA L4 SST analysis27
Figure 23: (Top) Level 3 spatially average SST for SLSTR-B Cycle 020 at a resolution of 0.05 degrees. Maps are shown for daytime (left) and nighttime (right). Also shown are (middle) number of 1-km samples in each average and (hottom) mean difference to OSTIA L4 SST analysis.

### Sentinel-3 MPC

### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019

Page: vii

Figure 24: Dependence of median and robust standard deviation of match-ups between SLSTR-A $SST_skin$
and drifting buoy $SST_{depth}$ for Cycle 039 as a function of latitude, total column water vapour (TCWV),
satellite zenith angle and date. Any data gaps are due to delays in match-up processing at the time this
report was generated as well as instrument outages29
Figure 25: Spatial distribution of match-ups between SLSTR-A SST <sub>skin</sub> and drifting buoy SST <sub>depth</sub> for Cycle
03930

## SENTINEL 3 Mission Performance

### Sentinel-3 MPC

## S3 SLSTR Cyclic Performance Report

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019

Page: viii

### **List of Tables**

cycles 028-039, averaged over all detectors for the nadir view. Note the increase in cycle 38 is due to an improved algorithm not due to an instrument change9
Table 2: Average SLSTR-A reflectance factor, and signal-to-noise ratio of the measured VISCAL signal for cycles 028-039, averaged over all detectors for the oblique view. Note the increase in cycle 38 is due to an improved algorithm not due to an instrument change9
Table 3: Average SLSTR-B reflectance factor, and signal-to-noise ratio of the measured VISCAL signal for cycle 020, averaged over all detectors for the nadir view (left) and oblique view (right)11
Table 4: NEDT for SLSTR-A in cycles 028-039 averaged over all detectors for both Earth views towards the hot +YBB (top) and the cold -YBB (bottom)13
Table 5: NEDT for SLSTR-B in cycle 020 averaged over all detectors for both Earth views towards the hot +YBB (top) and the cold -YBB (bottom)
Table 6: SLSTR-A drifter match-up statistics for Cycle 03931

## Sentinel 3 Mission Performance Centre

#### **Sentinel-3 MPC**

**S3 SLSTR Cyclic Performance Report** 

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019

Page: 1

## 1 Processing Baseline Version

IPF	IPF / Processing Baseline version	Date of deployment			
	S3A				
SL1	06.16 / 2.37	CGS: 02/08/2018 09:22 UTC (NRT) PAC: 02/08/2018 09:32 UTC (NTC)			
SL2	06.14 / 2.37	CGS: 02/08/2018 09:19 UTC (NRT) PAC: 02/08/2018 09:36 UTC (NTC)			

IPF	IPF / Processing Baseline version	Date of deployment						
S3B								
SL1	06.16 / 1.12	PAC: 15/10/2018 15:28 UTC						

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

## Mission Performance

#### **Sentinel-3 MPC**

**S3 SLSTR Cyclic Performance Report** 

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 2

## 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, and a longer term rise as the Earth approaches perihelion at the beginning of January).

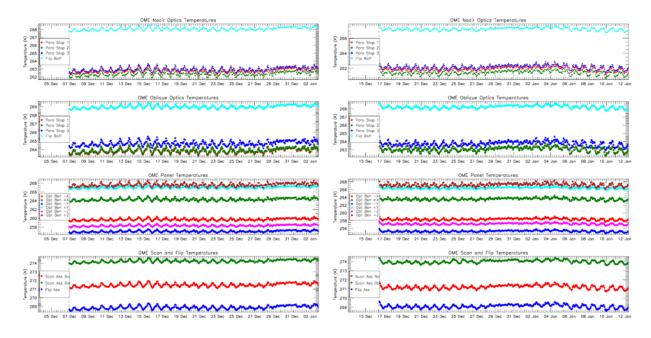


Figure 1: OME temperature trends for SLSTR-A Cycle 039 (left) and SLSTR-B Cycle 020 (right) showing the paraboloid stops and flip baffle (top two plots) and optical bench and scanner and flip assembly (lower two plots). The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit.

## SENTINEL 3 Mission Performance Centre

#### **Sentinel-3 MPC**

#### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019

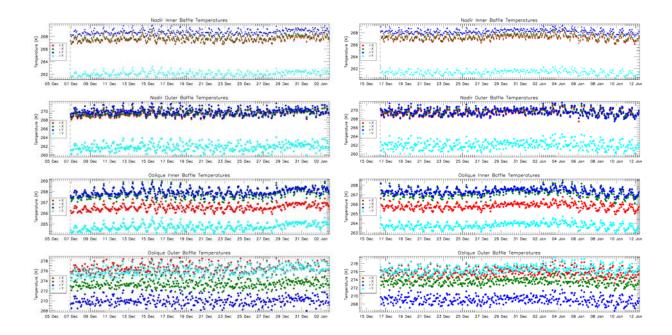


Figure 2: Baffle temperature trends for SLSTR-A Cycle 039 (left) and SLSTR-B Cycle 020 (right). The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit.



### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 4

#### 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 last performed for SLSTR-A at the end of Cycle 035 and start of Cycle 036, and for SLSTR-B in Cycle 016. Decontamination involves warming up the infrared focal plane assembly (FPA) in order to remove water ice contamination from the cold surfaces. Figure 3 shows the SLSTR-A detector temperatures for the past year, and Figure 4 shows the SLSTR-B detector temperatures since the launch in May 2018. The decontaminations are clearly visible as a rise in detector temperature.

The step in temperature for SLSTR-A in the SWIR and TIR channels in S3A Cycle 33 (18<sup>th</sup> July 2018) is due to an increase in the cooler cold tip temperature which was designed to allow an increased time between decontaminations. A few orbits in Cycle 32 and Cycle 35 show slightly lower average SLSTR-A detector temperatures due to instrument tests that were performed connected to the commissioning of S3B. The detector temperatures for SLSTR-B show many such orbits due to commissioning phase tests carried out between May and October 2018.

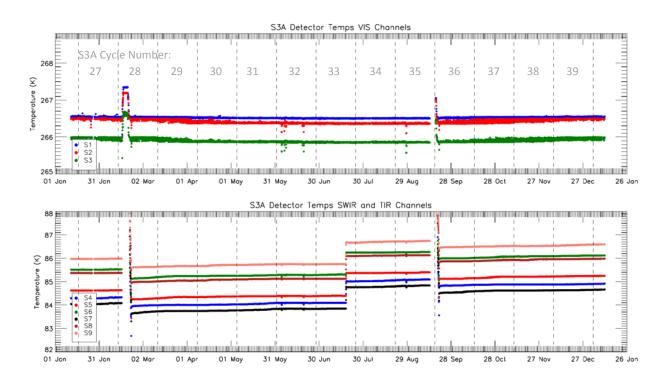


Figure 3: SLSTR-A detector temperatures for each channel for the last year of operations. Discontinuities occur for the infrared channels where the FPA was heated for decontamination. The vertical dashed lines indicate the start and end of each cycle. Each dot represents the average temperature in one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

## SENTINEL 3 Mission Performance Centre

#### Sentinel-3 MPC

#### **S3 SLSTR Cyclic Performance Report**

S3A Cycle No. 039 - S3B Cycle No. 020

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019

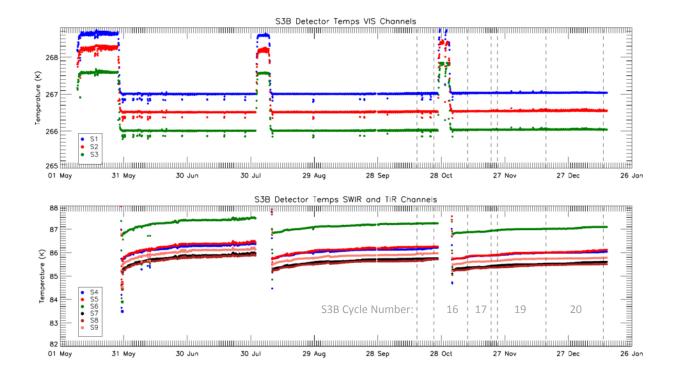


Figure 4: SLSTR-B detector temperatures for each channel since the launch of S3B. Discontinuities occur for the infrared channels where the FPA was heated for decontamination. The vertical dashed lines indicate the start and end of each cycle. Each dot represents the average temperature in one orbit. The different colours indicate different detectors.



### **S3 SLSTR Cyclic Performance Report**

S3A Cycle No. 039 - S3B Cycle No. 020

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 6

### 2.3 Scanner performance

Scanner performance has been consistent with previous operations and within required limits for both SLSTR-A (Figure 5) and SLSTR-B (Figure 6).

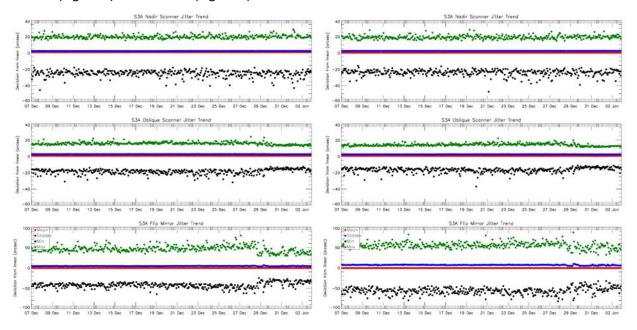


Figure 5: SLSTR-A scanner and flip jitter for Cycle 039, showing mean, stddev and max/min difference from expected position per orbit (red, blue, green and black respectively) for the nadir view (left) and oblique view (right).

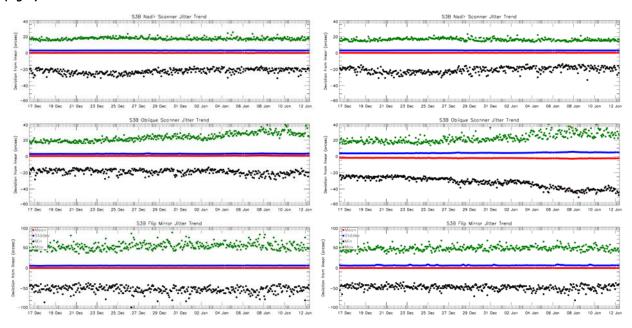


Figure 6: SLSTR-B scanner and flip jitter for Cycle 020, showing mean, stddev and max/min difference from expected position per orbit (red, blue, green and black respectively) for the nadir view (left) and oblique view (right).



**S3 SLSTR Cyclic Performance Report** 

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 7

#### 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 and a slight rise through the cycle. The rise in temperature through the cycle is part of a longer term trend which shows a yearly variation, with temperatures rising as the Earth approaches perihelion at the beginning of January (see Figure 8 and Table 4 for SLSTR-A). 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.

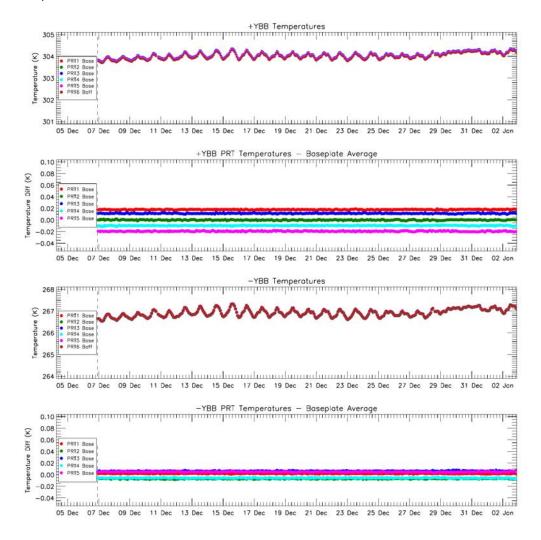


Figure 7: SLSTR-A blackbody temperature and baseplate gradient trends during Cycle 039. The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit.

## SENTINEL 3 Mission Performance Contre

#### Sentinel-3 MPC

**S3 SLSTR Cyclic Performance Report** 

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

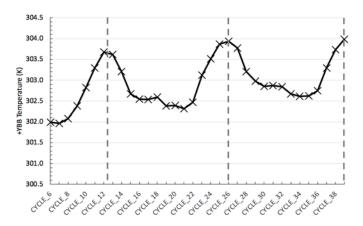


Figure 8: SLSTR-A long term trends in average +YBB temperature, showing yearly variation. The vertical dashed lines indicate the 1<sup>st</sup> January 2017, 2018 and 2019.

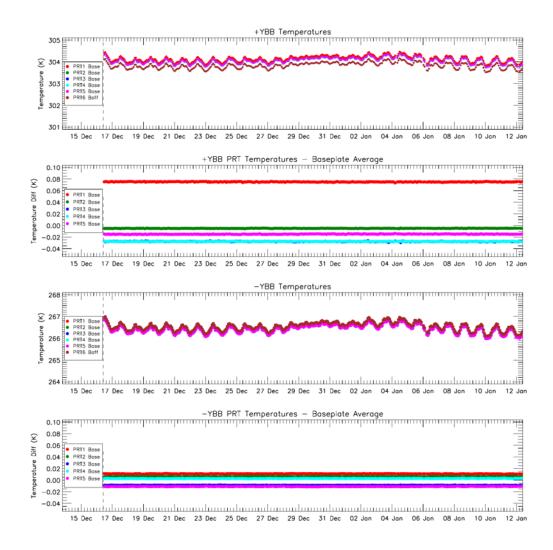


Figure 9: SLSTR-B blackbody temperature and baseplate gradient trends during Cycle 020. The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit.



### **S3 SLSTR Cyclic Performance Report**

S3A Cycle No. 039 - S3B Cycle No. 020

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 9

#### 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 039 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.

Note that the algorithm to calculate the noise on the VISCAL peak was updated in Cycle 038 to use a narrower window, and this gives a lower noise. Although it appears from the plots and tables that there has been a step change in signal-to-noise ratio, this is purely due to the algorithm change and the actual instrument behaviour has not changed.

Table 1: Average SLSTR-A reflectance factor, and signal-to-noise ratio of the measured VISCAL signal for cycles 028-039, averaged over all detectors for the nadir view. Note the increase in cycle 38 is due to an improved algorithm not due to an instrument change.

	Average Nadir Signal-to-noise ratio												
	Reflectance Factor	Cycle 028	Cycle 029	Cycle 030	Cycle 031	Cycle 032	Cycle 033	Cycle 34	Cycle 035	Cycle 036	Cycle 037	Cycle 038	Cycle 039
<b>S1</b>	0.187	223	228	232	234	226	233	231	234	233	232	300	293
<b>S2</b>	0.194	229	232	237	233	231	232	236	235	235	236	303	306
<b>S3</b>	0.190	223	229	228	228	221	223	229	226	225	229	294	285
<b>S4</b>	0.191	138	138	140	139	139	137	139	138	140	140	174	173
<b>S5</b>	0.193	236	232	233	235	236	232	231	230	234	235	262	260
<b>S6</b>	0.175	143	143	142	143	143	142	141	141	141	142	175	175

Table 2: Average SLSTR-A reflectance factor, and signal-to-noise ratio of the measured VISCAL signal for cycles 028-039, averaged over all detectors for the oblique view. Note the increase in cycle 38 is due to an improved algorithm not due to an instrument change.

	3												
	Average	Oblique Signal-to-noise ratio											
	Reflectance Factor	Cycle 028	Cycle 029	Cycle 030	Cycle 031	Cycle 032	Cycle 033	Cycle 34	Cycle 035	Cycle 036	Cycle 037	Cycle 038	Cycle 039
<b>S1</b>	0.166	235	237	242	249	239	245	236	241	240	240	293	281
<b>S2</b>	0.170	238	243	249	249	247	246	245	246	245	251	297	298
<b>S3</b>	0.168	229	235	234	239	234	232	232	237	234	238	286	270
<b>S4</b>	0.166	107	109	109	110	108	109	111	109	107	109	129	127
<b>S5</b>	0.166	171	170	170	169	172	168	169	170	168	171	172	165
S6	0.155	107	109	109	110	110	108	109	109	112	110	132	129

#### **Sentinel-3 MPC**

#### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

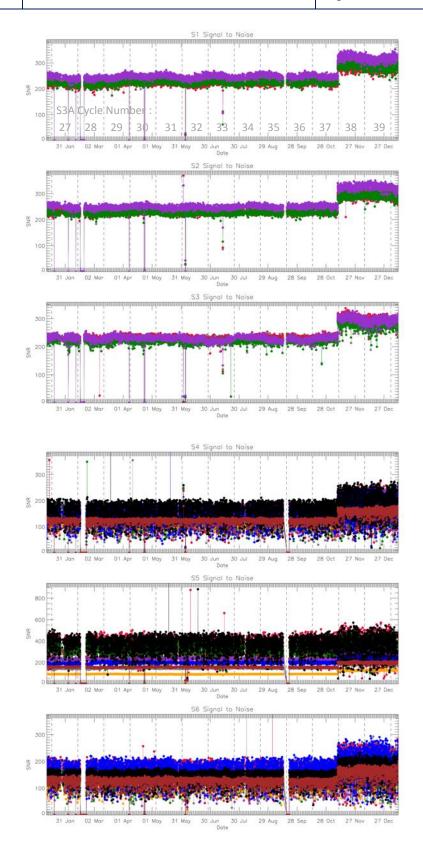


Figure 10: VIS and SWIR channel signal-to-noise of the measured VISCAL signal in each orbit for the last year of operations for SLSTR-A. Different colours indicate different detectors. The vertical dashed lines indicate the start and end of each cycle. Note the step at the beginning of cycle 38 is not due to a change in instrument behaviour but rather an improvement in the way the noise has been calculated.

# SENTINEL 3 Mission Performance Centre

#### **Sentinel-3 MPC**

#### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019

Page: 11

#### 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 020 are shown in Table 3. 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 cycle 020, averaged over all detectors for the nadir view (left) and oblique view (right).

	Average Reflectance	Nadir Signal-to- noise ratio				
	Factor		Cycle 020			
<b>S1</b>	0.177		271			
<b>S2</b>	0.192		170			
<b>S3</b>	0.194		328			
<b>S4</b>	0.186		159			
<b>S5</b>	0.184		248			
<b>S6</b>	0.162		184			

	Average Reflectance Factor		Oblique Signal- to-noise ratio Cycle 020
<b>S1</b>	0.157		249
<b>S2</b>	0.168		189
<b>S3</b>	0.172		358
<b>S4</b>	0.168		143
<b>S5</b>	0.172		226
S6	0.152		172



#### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 12

#### 2.5.3 SLSTR-A TIR channel NEDT

The thermal channel NEDT values for SLSTR-A in Cycle 039 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 4.

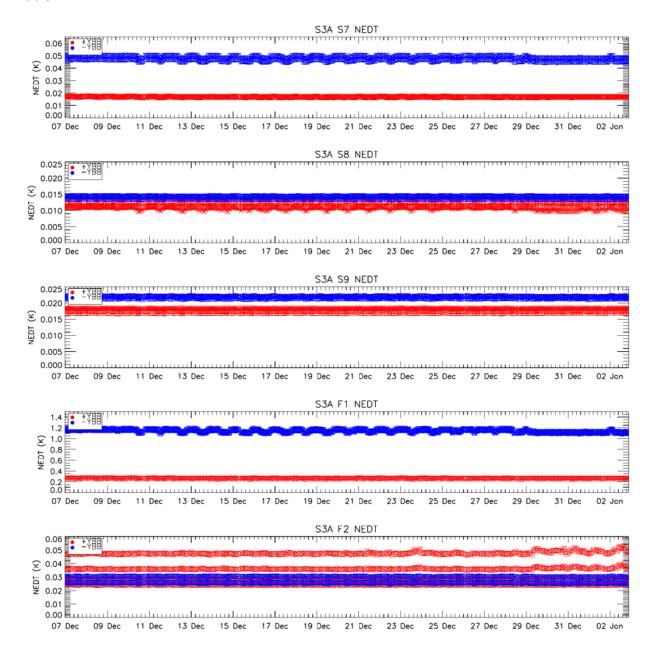


Figure 11: SLSTR-A NEDT trend for the thermal channels in Cycle 039. Blue points were calculated from the cold blackbody signal and red points from the hot blackbody. The square symbols show results calculated from the nadir view and crosses show results from the oblique view. Results are plotted for all detectors and integrators, which is why there are several different levels within the same colour points (particularly for S8 and F2).

#### Sentinel-3 MPC

#### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 13

## Table 4: NEDT for SLSTR-A in cycles 028-039 averaged over all detectors for both Earth views towards the hot +YBB (top) and the cold -YBB (bottom).

SLSTF	R-A	Cycle 028	Cycle 029	Cycle 030	Cycle 031	Cycle 032	Cycle 033	Cycle 034	Cycle 035	Cycle 036	Cycle 037	Cycle 038	Cycle 039
+YBB to		303.203	302.977	302.850	302.868	302.841	302.669	302.622	302.624	302.744	303.295	303.738	303.985
	<b>S7</b>	17.1	17.2	17.5	17.4	18.1	17.6	17.7	17.7	17.6	17.4	17.3	17.0
NEDT	<b>S8</b>	11.7	11.6	11.8	12.0	12.1	12.3	12.4	12.6	12.1	12.3	11.7	11.3
NEDT (mK)	<b>S9</b>	16.9	16.8	16.9	17.0	17.3	17.6	18.3	18.3	17.7	17.7	17.8	17.8
(,	F1	265	268	273	274	295	279	279	279	277	273	271	266
	F2	34	33.7	33.7	33.8	33.6	33.6	33.7	33.6	33.9	34.0	34.1	34.2

SLSTF	R-A	Cycle 028	Cycle 029	Cycle 030	Cycle 031	Cycle 032	Cycle 033	Cycle 034	Cycle 035	Cycle 036	Cycle 037	Cycle 038	Cycle 039
-YBB to	-	265.683	265.460	265.439	265.600	265.621	265.337	265.203	265.110	265.245	265.920	266.506	266.817
	<b>S7</b>	49.3	49.8	49.9	49.9	48.8	50.0	50.6	51.0	50.7	49.6	48.7	47.9
NEDT	<b>S8</b>	13.8	13.8	13.8	13.9	13.9	14.0	14.4	14.4	14.2	14.2	14.1	14.1
NEDT (mK)	<b>S9</b>	20.8	20.8	20.9	21.1	21.0	21.5	22.3	22.5	21.7	21.7	21.8	21.8
(,	F1	1179	1201	1207	1206	1195	1207	1209	1224	1229	1199	1168	1144
	F2	27.3	27.3	27.3	27.5	27.8	27.6	28.2	28.3	28.1	28.1	28.1	28.0

## SENTINEL 3 Mission Performance

#### **Sentinel-3 MPC**

**S3 SLSTR Cyclic Performance Report** 

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 14

#### 2.5.4 SLSTR-B TIR channel NEDT

The thermal channel NEDT values for SLSTR-B in Cycle 020, calculated from the hot and cold blackbody signals are shown in Figure 12 and Table 5.

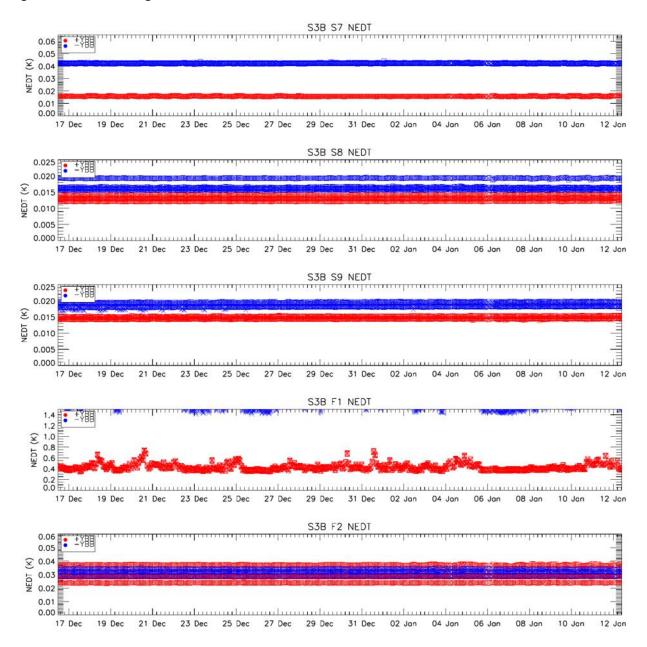


Figure 12: SLSTR-B NEDT trend for the thermal channels in Cycle 020. Blue points were calculated from the cold blackbody signal and red points from the hot blackbody. The square symbols show results calculated from the nadir view and crosses show results from the oblique view. Results are plotted for all detectors and integrators, which is why there are several different levels within the same colour points (particularly for S8 and F2).

#### **Sentinel-3 MPC**

#### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019

Table 5: NEDT for SLSTR-B in cycle 020 averaged over all detectors for both Earth views towards the hot +YBB (top) and the cold -YBB (bottom).

SLSTR	Cycle 020	
+YBB to	304.069	
	<b>S7</b>	15.8
NEDT	<b>S8</b>	13.1
NEDT (mK)	<b>S9</b>	14.7
()	F1	433
	F2	30.3

SLSTR	Cycle 020	
-YBB te	266.435	
	<b>S7</b>	42.3
NEDT	<b>S8</b>	16.9
(mK)	<b>S9</b>	18.7
()	F1	1844
	F2	31.1

## SENTINEL 3 Mission Performance

#### **Sentinel-3 MPC**

## S3 SLSTR Cyclic Performance Report

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 16

#### 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 during Cycle 020.

Note that the latest decontamination for SLSTR-A was started at the end of Cycle 35 and finished at the beginning of Cycle 36, and the previous decontamination was performed in Cycle 28. For SLSTR-B, the latest decontamination was performed at the end of October 2018.

#### **Sentinel-3 MPC**

**S3 SLSTR Cyclic Performance Report** 

S3A Cycle No. 039 – S3B Cycle No. 020

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019

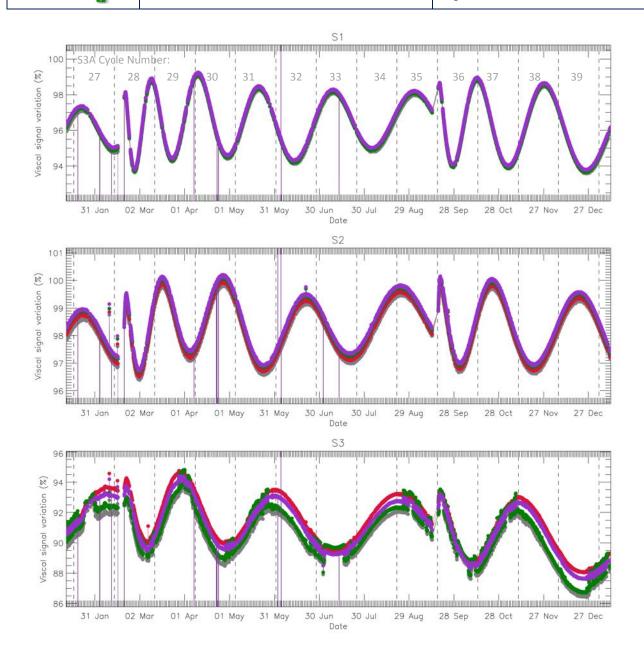


Figure 13: VISCAL signal trend for SLSTR-A VIS channels for the last year of operations (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start and end of each cycle.

## Sentinel 3 Mission Performance Centre

#### **Sentinel-3 MPC**

**S3 SLSTR Cyclic Performance Report** 

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019

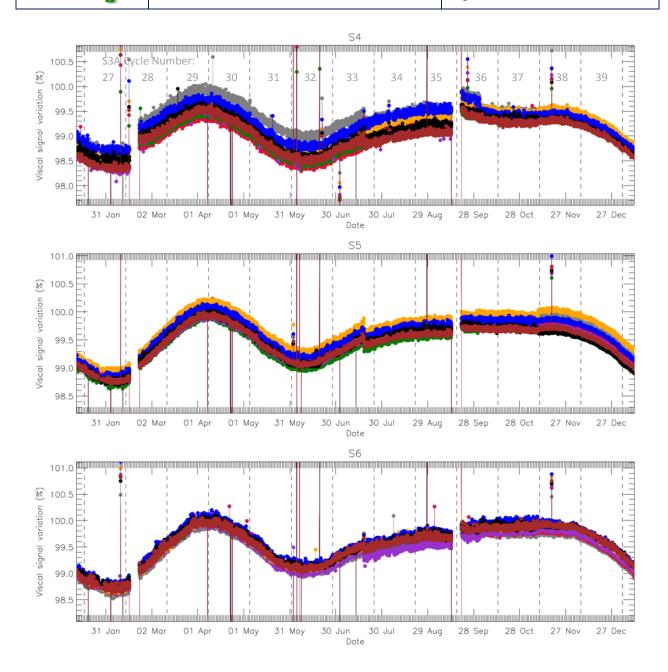


Figure 14: VISCAL signal trend for SLSTR-A SWIR channels for the last year of operations (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start and end of each cycle.

#### **Sentinel-3 MPC**

**S3 SLSTR Cyclic Performance Report** 

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

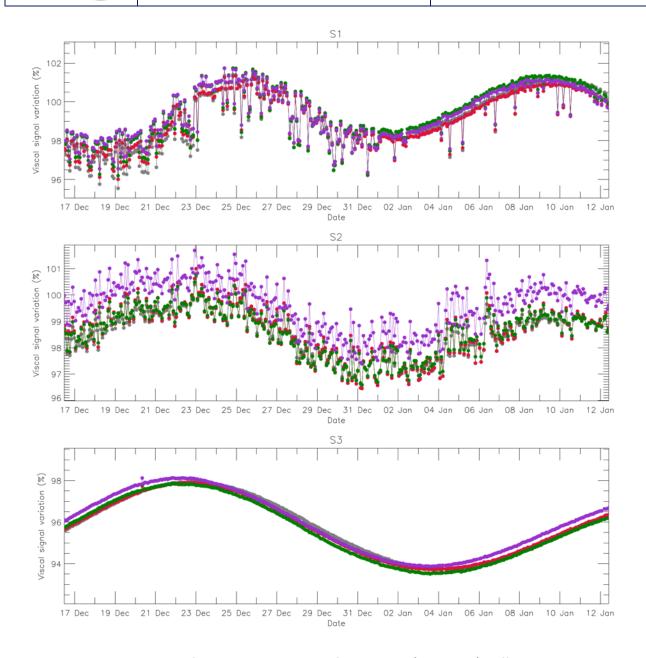


Figure 15: VISCAL signal trend for SLSTR-B VIS channels for Cycle 020 (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start and end of each cycle.

## Sentinel 3 Mission Performance Centre

#### **Sentinel-3 MPC**

**S3 SLSTR Cyclic Performance Report** 

S3A Cycle No. 039 – S3B Cycle No. 020

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019

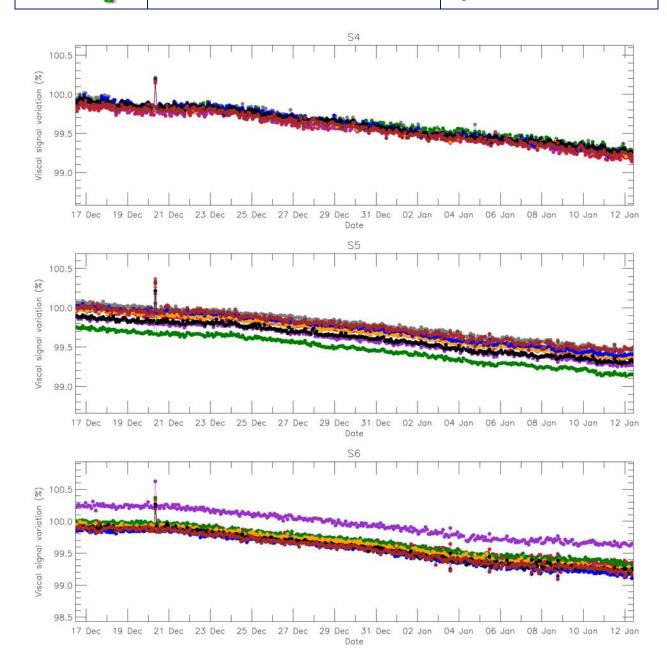


Figure 16: VISCAL signal trend for SLSTR-B SWIR channels for Cycle 020 (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start and end of each cycle. Note that the spike corresponds to the SRAL cross calibration on 20<sup>th</sup> December (see Section 6.2), which was carried out at the same time that the VISCAL source was illuminated.



**S3 SLSTR Cyclic Performance Report** 

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 21

## 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 039 and Figure 18 for SLSTR-B in Cycle 020, giving the average positional offsets in kilometres for Nadir and Oblique views.

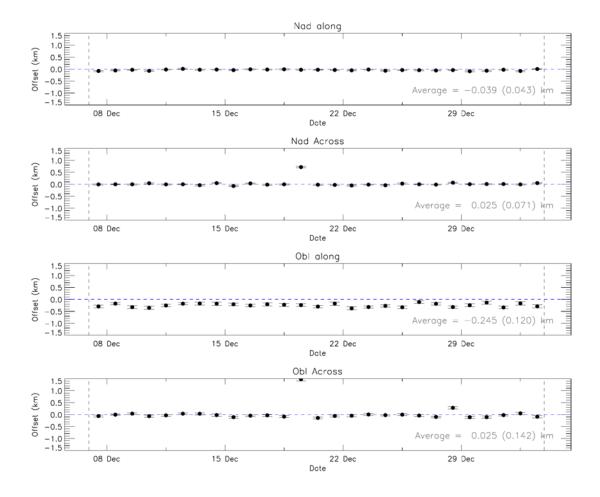


Figure 17: SLSTR-A daily offset results in km from the GeoCal Tool analysis for Nadir along- and across-track (top two plots) and Oblique along- and across-track (bottom two plots). The error bars show the standard deviation.

On 19<sup>th</sup> December, an out-of-plane manoeuvre was executed for S3A, increasing the positional offsets slightly in the across-track direction for the Nadir and Oblique views in one orbit.

#### **Sentinel-3 MPC**

#### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

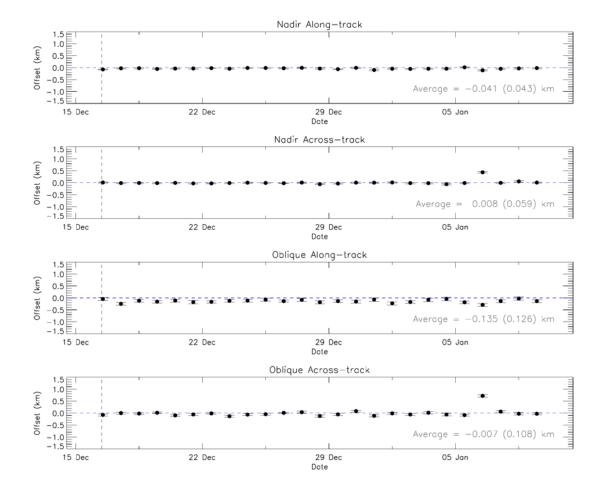


Figure 18: SLSTR-B daily offset results in km from the GeoCal Tool analysis for Nadir along- and across-track (top two plots) and Oblique along- and across-track (bottom two plots). The error bars show the standard deviation.



#### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 23

#### 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 <a href="http://s3etrac.acri.fr/index.php?action=generalstatistics#pageSLSTR">http://s3etrac.acri.fr/index.php?action=generalstatistics#pageSLSTR</a>

- 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

At the current stage, only S3TRAC data for SLSTR-A are available. The S3ETRAC data for SLSTR-B will be processed soon, and presented in forthcoming cycle reports.

Figure 19 and Figure 20 show the results of the inter-comparison analysis of SLSTR-A with OLCI-A and AATSR over desert sites processed in Cycle 039. SLSTR-A agrees with OLCI-A and AATSR for the visible channels, but channel S5 differs from AATSR by 12%.

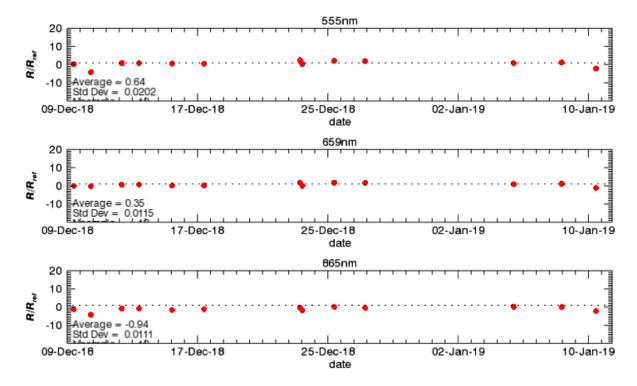


Figure 19: Ratio of SLSTR-A and OLCI-A radiances for the visible channels in Nadir view (shown as a percentage) using combined results for all desert sites processed in Cycle 039.

## SENTINEL 3 Mission S3

#### **Sentinel-3 MPC**

**S3 SLSTR Cyclic Performance Report** 

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019

Page: 24

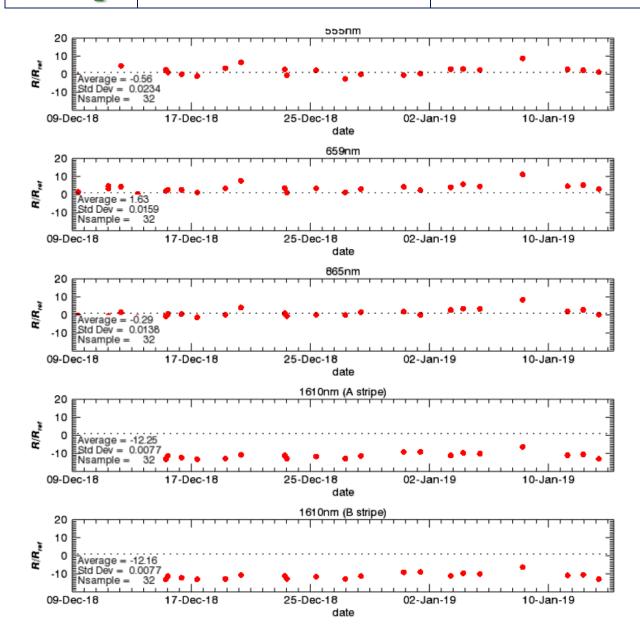


Figure 20: Ratio of SLSTR-A and AATSR radiances in Nadir view (shown as a percentage) using combined results for all desert sites processed in Cycle 039.

Oblique view comparisons using desert sites are not available due to geometric differences between the different sensors. A full analysis for visible and SWIR channels in Nadir and Oblique views was made using radiative transfer modeling of sun-glints. Results can be found in the presentation, "WED-0900-SL-Etxaluze WEB.pdf" in the Joint SLSTR session of the fourth S3VT meeting, and in the latest Product Notice for processing baseline v2.37. However, note that the radiometric validation is still in progress and these numbers are currently under review and will be updated with better values in the near future (in particular for channel S6).

## Seame 3 Mission Performance Centre

#### **Sentinel-3 MPC**

**S3 SLSTR Cyclic Performance Report** 

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019

Page: 25

### 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 21 shows an example combined SLSTR-A/SLSTR-B image for the visible channels from 21<sup>st</sup> December 2018 (daytime only).

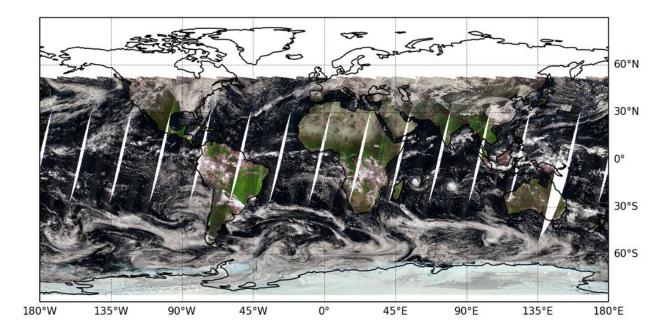


Figure 21: Daytime combined SLSTR-A and SLSTR-B Level-1 image for visible channels on 21<sup>st</sup> December 2018.

#### **Sentinel-3 MPC**

### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 26

### 4 Level 2 SST validation

SLSTR level 2 WST SSTs have been validated for SLSTR-A Cycle 039 and SLSTR-B Cycle 020, by binning to level 3 across the entire cycle and compared to the Met Office Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) L4 analysis. The WST product contains a single SST field derived from the best-performing SST retrieval algorithm.

SLSTR level 2 WCT SSTs have been validated using Copernicus Marine Environment Monitoring Service (CMEMS) *in situ* data for SLSTR-A Cycle 039. The WCT product contains the SSTs derived from all the SST algorithms (single view, dual view, 2 and 3 channel) and is not disseminated to users. Match-ups between SLSTR and *in situ* data are provided by the EUMESAT Ocean and Sea Ice Satellite Application Facility (OSI-SAF).

Note that SLSTR-B level 2 products are still in a phase of adjustment and are not yet delivered to the users. In addition, issues with the data transfer of match-up data from mid-December means that there is no matchup analysis for much of SLSTR-B for Cycle 020.

#### 4.1 Level 3

Level 3 spatially averaged SST maps for daytime and nighttime are shown in Figure 22 for SLSTR-A. The figures are produced by spatial and temporal binning of quality\_level = 5 1-km pixels from all available SL\_2\_WST granules within the cycle. Also shown in Figure 22 are the number of 1-km pixels contributing to each average and the mean difference to OSTIA (dt\_analysis).

#### **Sentinel-3 MPC**

#### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

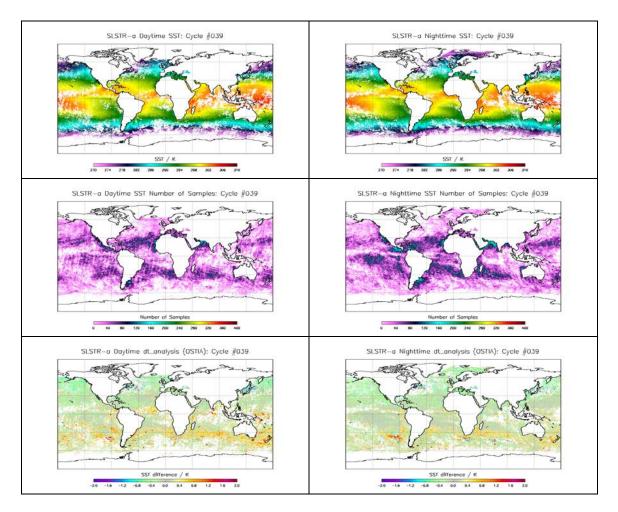


Figure 22: (Top) Level 3 spatially average SST for SLSTR-A Cycle 039 at a resolution of 0.05 degrees. Maps are shown for daytime (left) and nighttime (right). Also shown are (middle) number of 1-km samples in each average and (bottom) mean difference to OSTIA L4 SST analysis.



### **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 28

Level 3 spatially averaged SST maps for daytime and nighttime are shown in Figure 23 for SLSTR-B. The figures are produced by spatial and temporal binning of quality\_level = 5 1-km pixels from all available SL\_2\_WST granules within the cycle. Also shown in Figure 22 are the number of 1-km pixels contributing to each average and the mean difference to OSTIA (dt\_analysis).

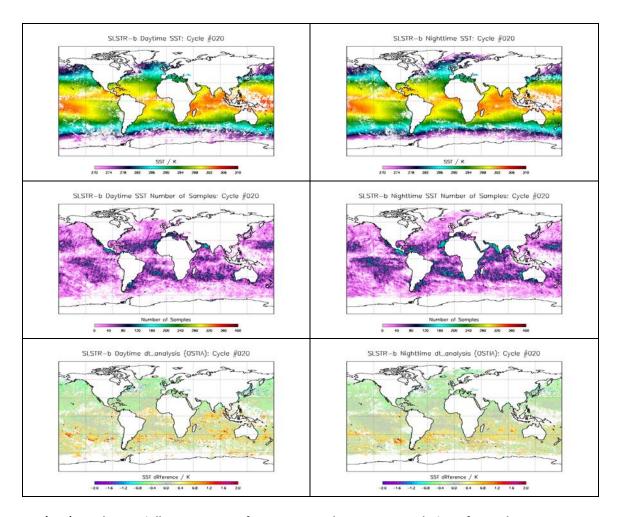


Figure 23: (Top) Level 3 spatially average SST for SLSTR-B Cycle 020 at a resolution of 0.05 degrees. Maps are shown for daytime (left) and nighttime (right). Also shown are (middle) number of 1-km samples in each average and (bottom) mean difference to OSTIA L4 SST analysis.



## **S3 SLSTR Cyclic Performance Report**

S3A Cycle No. 039 - S3B Cycle No. 020

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 29

## 4.2 Dependence on latitude, TCWV, Satellite ZA and date

The dependence of the difference between SLSTR-A SST<sub>skin</sub> and drifting buoy SST<sub>depth</sub> for Cycle 039 is shown in Figure 24. No adjustments have been made for difference in depth or time between the satellite and in situ measurements. SLSTR-A SSTs are extracted from the SL\_2\_WCT files. Daytime 2-channel (S8 and S9) results are shown in red, night time 2-channel results are shown in blue and night time 3-channel results are shown in green. Solid lines indicate dual-view retrievals, dashed lines indicate nadir-only retrievals. Bold lines indicate statistically significant (95% confidence) results.

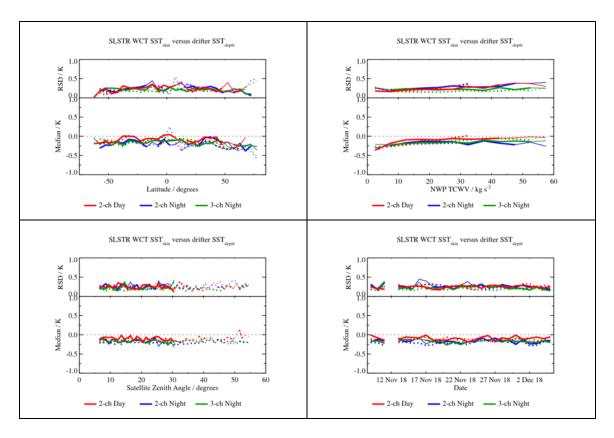


Figure 24: Dependence of median and robust standard deviation of match-ups between SLSTR-A SST<sub>skin</sub> and drifting buoy SST<sub>depth</sub> for Cycle 039 as a function of latitude, total column water vapour (TCWV), satellite zenith angle and date. Any data gaps are due to delays in match-up processing at the time this report was generated as well as instrument outages.

# Mission Performance

#### **Sentinel-3 MPC**

S3 SLSTR Cyclic Performance Report

S3A Cycle No. 039 - S3B Cycle No. 020

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 30

# 4.3 Spatial distribution of match-ups

The spatial distribution of SLSTR-A/drifter match-ups for Cycle 039 is shown in Figure 25. No adjustments have been made for difference in depth or time between the satellite and *in situ* measurements.

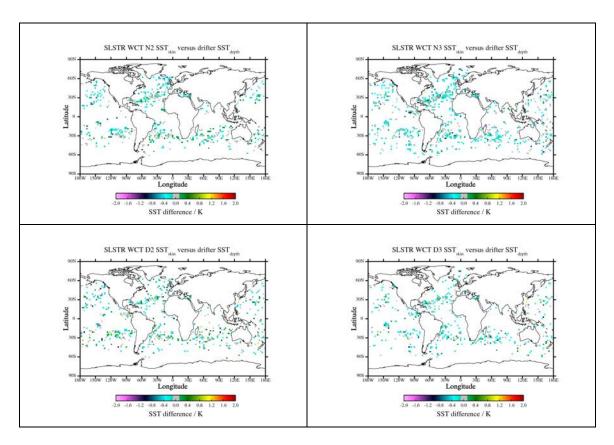


Figure 25: Spatial distribution of match-ups between SLSTR-A SST<sub>skin</sub> and drifting buoy SST<sub>depth</sub> for Cycle 039.

#### **Sentinel-3 MPC**

**S3 SLSTR Cyclic Performance Report** 

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019

Page: 31

# 4.4 Match-ups statistics

Match-ups statistics (median and robust standard deviation, RSD) of SLSTR-A/drifter match-ups for Cycle 039 are shown in Table 6. No adjustments have been made for difference in depth or time between the satellite and *in situ* measurements and so at night time (in the absence of diurnal warming) an offset of around -0.17 K is expected. The RSD values indicate SLSTR-A is providing SSTs mostly within its target accuracy (0.3 K).

Table 6: SLSTR-A drifter match-up statistics for Cycle 039.

Retrieval	Number	Median (K)	RSD (K)
N2 day	2049	-0.13	0.26
D2 day	1852	-0.09	0.25
N2 night	2208	-0.21	0.25
N3 night	2836	-0.15	0.19
D2 night	1435	-0.17	0.27
D3 night	1437	-0.17	0.22



## **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 32

## 5 Level 2 LST validation

Level 2 Land Surface Temperature products have been validated against *in situ* observations (Category-A validation) from eleven "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 039 for SLSTR-A and 020 for SLSTR-B are evaluated for identifying any gross problems. **Note: SLSTR-B L2 products are still in a phase of adjustment and are not yet delivered to the users**.

## 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 eleven "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 two from the USCRN network (Williams, Arizona; Des Moines, Iowa). The results can be summarised as follows:

Satellite	Average absolute accu	Average absolute accuracy vs. Gold Standard (K)			
	Day	Night			
S3A	1.0	0.6			
S3B	1.5	0.4			

For SLSTR-A both day-time and night-time accuracies are within 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 cloud, and slightly larger bias at the most heterogeneous stations. For SLSTR-B the number of daytime matchups are even lower causing a slightly larger bias. A primary cause of this is the Government shutdown in the US meaning no SURFRAD *in situ* observations are available after 26<sup>th</sup> December. Since the S3B cycle is phased later than the S3A cycle this means SLSTR-B is impacted more by the lack of data. Night-time bias is very low.

# Sentinel 3 Mission Performance Centre

### **Sentinel-3 MPC**

## **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

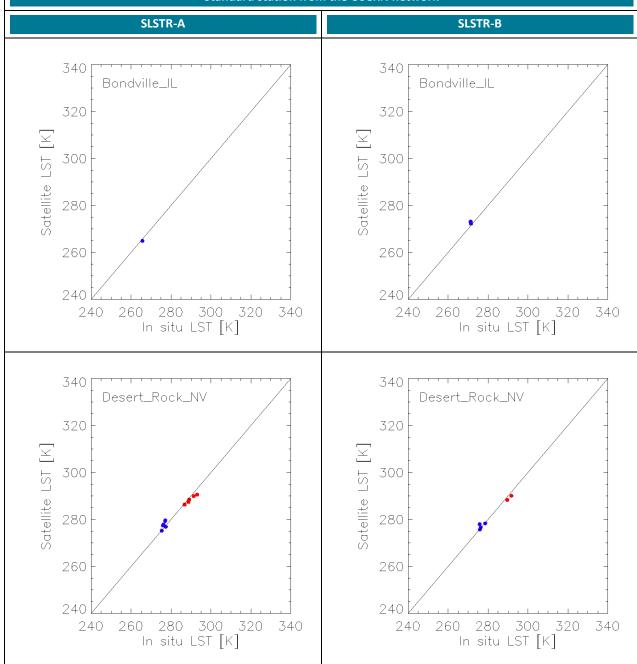
Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 33

Validation of the SL\_2\_LST product over Cycle 039 (SLSTR-A) and Cycle 020 (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



### **Sentinel-3 MPC**

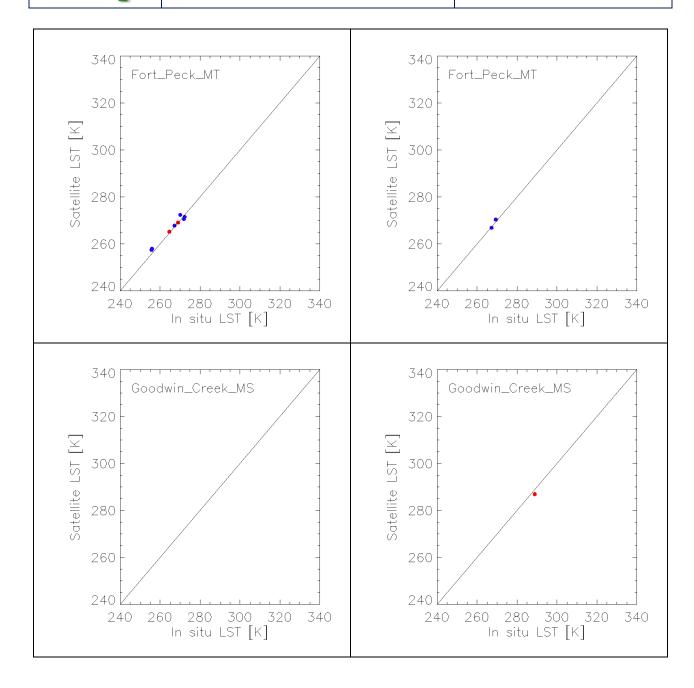
## **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019



### **Sentinel-3 MPC**

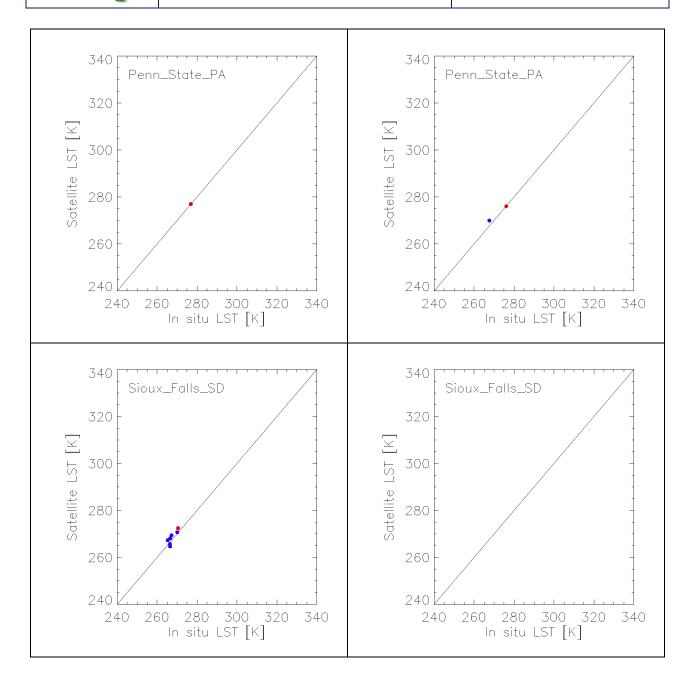
## **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019



### **Sentinel-3 MPC**

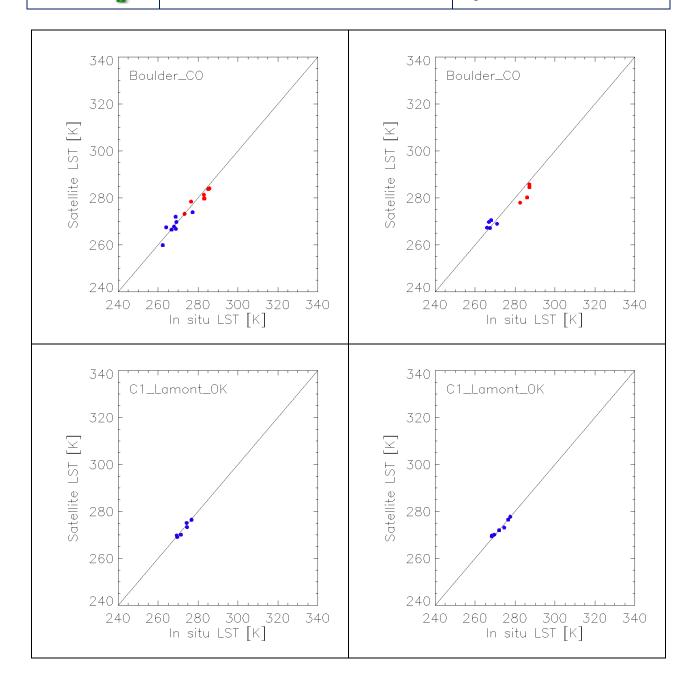
## **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019



### **Sentinel-3 MPC**

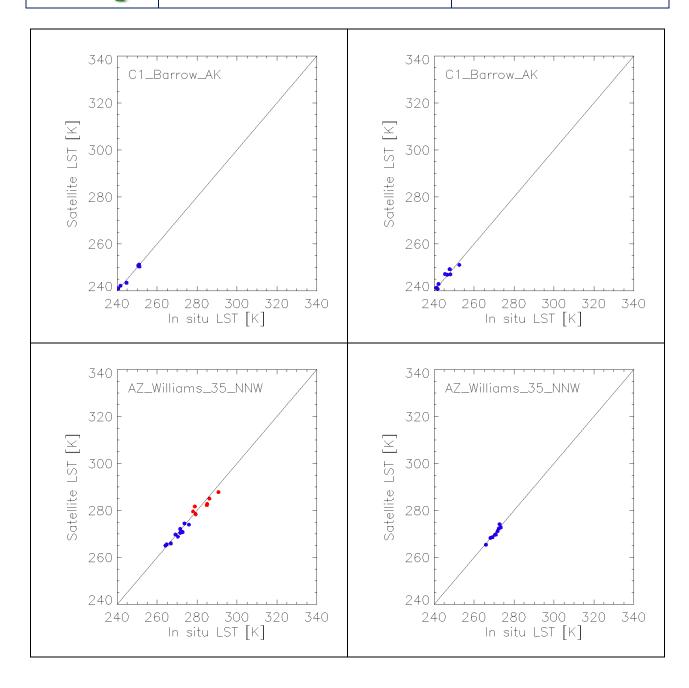
# **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039- 020

Issue: 1.0

Date: 18/01/2019



## **Sentinel-3 MPC**

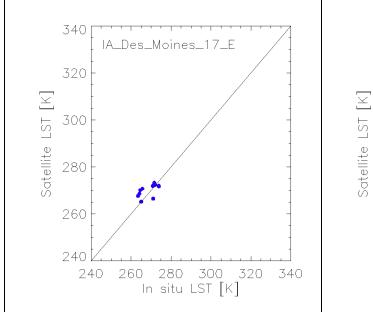
## **S3 SLSTR Cyclic Performance Report**

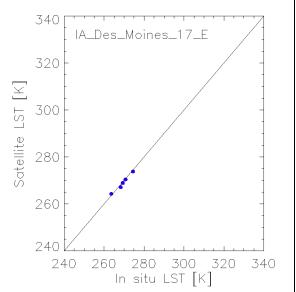
**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019





#### **Sentinel-3 MPC**

## **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 39

## 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 039 (SLSTR-A) and Cycle 020 (SLSTR-B)					
	SLSTR-A		SLSTR-B			
	Day	Night	Day	Night		
Africa	1.8	1.1	0.6	0.5		
Europe	1.1	2.1	1.1	2.1		

For Africa, the differences across the continent for SLSTR-A are relatively small, with some larger differences over the Central African tropical forest and the East Africa Rift during the day, and over the Sahara at night. In contrast for SLSTR-B, the differences are much lower – both day and night - with no obvious areas where larger differences are evident. For Europe the differences are small across the region with a mixture of positive and negative differences. This is the same for both SLSTR-A and SLSTR-B. 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 < 2K over both continents for both SLSTR-A and SLSTR-B. For SLSTR-A 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



## **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

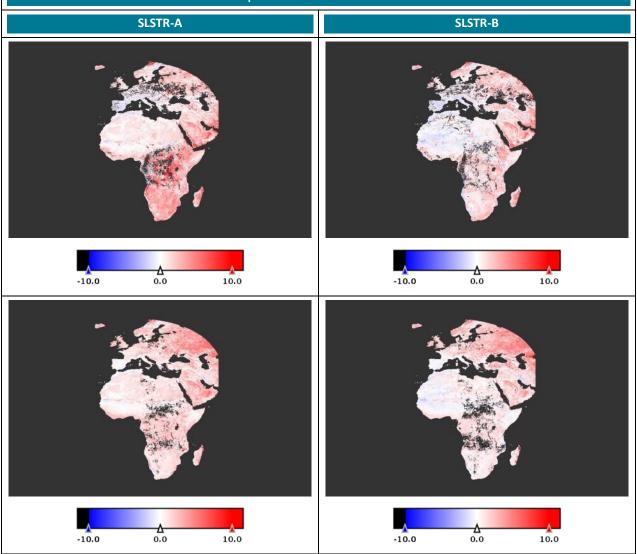
Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 40

Intercomparison of the SL\_2\_LST product with respect to the operational LSA SAF SEVIRI LST product for the period of Cycle 039 (SLSTR-A) and Cycle 020 (SLSTR-B). Daytime composites are in the top row and Night-time composites are in the bottom row



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.

#### **Sentinel-3 MPC**

**S3 SLSTR Cyclic Performance Report** 

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039- 020

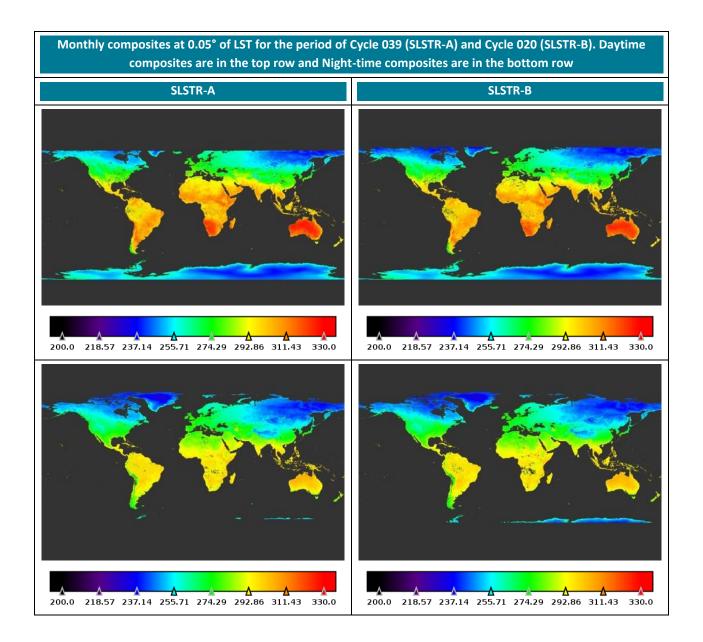
Issue: 1.0

Date: 18/01/2019

Page: 41

### 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).





## **S3 SLSTR Cyclic Performance Report**

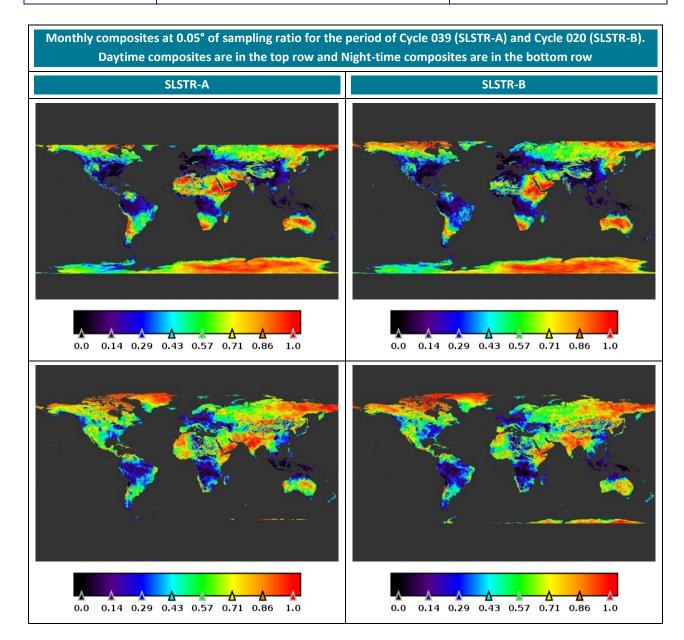
**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 42



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. Cloud contamination appears to be at a minimum, although there appears to be some excessive cloud clearing in some regions particularly at night. This is supported by the sampling ratio which is lower than would be expected over parts of the Sahara and Central Asia. The excessive cloud clearing seems to be more evident in SLSTR-B which indicates the cloud coefficients ADF needs further tuning. Comparing this effect from the previous cycles indicates the same regions are subject to excessive cloud clearing. This has been raised as a software problem report, with the lack of temporal interpolation of the ECMWF Skin Temperature being the root cause. This issue is high priority for being fixed in an upcoming release.



## **S3 SLSTR Cyclic Performance Report**

**S3A Cycle No. 039 – S3B Cycle No. 020** 

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 43

## **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> December 2018, 06:59-07:02 short gap due to radio frequency interference at the Svalbard ground station.
- 19<sup>th</sup> December 2018, 09:33-09:43 out-of-plane manoeuvre performed products can be affected following the manoeuvre.
- 26<sup>th</sup> December 2018, 02:56-03:02 short gap.
- 28<sup>th</sup> December 2018, 12:45-14:24 gap in data due to an antenna issue at the Svalbard ground station.
- 1<sup>st</sup> January 2019, 16:35 short gap.

### 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:

- 20<sup>th</sup> December 2018, 08:04-08:33 some products affected by gaps and degraded pointing due to the scheduled SRAL cross calibration manoeuvre.
- 4<sup>th</sup> January 2019, 05:55-06:28 gap due to a problem at the Svalbard ground station.
- 5<sup>th</sup> January 2019, 21:53-23:44 gap due to a problem at the Svalbard ground station.
- 6<sup>th</sup> January 2019, 02:55-04:48 gap due to a problem at the Svalbard ground station.

### **Sentinel-3 MPC**

## **S3 SLSTR Cyclic Performance Report**

S3A Cycle No. 039 – S3B Cycle No. 020

Ref.: S3MPC.RAL.PR.02-039-020

Issue: 1.0

Date: 18/01/2019

Page: 44

# 7 Appendix A

Other reports related to the Optical mission are:

S3 OLCI Cyclic Performance Report, S3A Cycle No. 039, S3B Cycle No. 020 (ref. S3MPC.ACR.PR.01-039-020)

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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