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

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Cycle No. 052	Cycle No. 033
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Mission Performance Centre

SENTINEL 3



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Changes Log

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1.0	10/01/2020	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	06.16 / 2.37	CGS: 02/08/2018 09:22 UTC
		PAC: 02/08/2018 09:32 UTC
SL2	06.14 / 2.47	PAC: 25/02/2019 09:33 UTC

IPF	IPF / Processing Baseline version	Date of deployment
	S3B	
SL1	06.16 / 1.12	PAC: 15/10/2018 15:28 UTC
SL2	06.14 / 1.19	PAC: 25/02/2019 09:24 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).

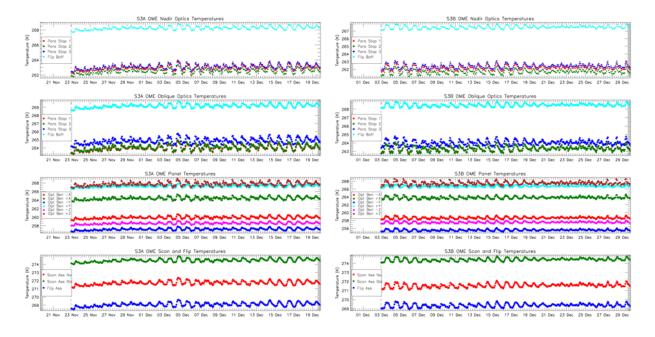


Figure 1: OME temperature trends for SLSTR-A Cycle 052 (left) and SLSTR-B Cycle 033 (right) showing the paraboloid stops and flip baffle (top two plots) and optical bench and scanner and flip assembly (lower two plots). The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit.

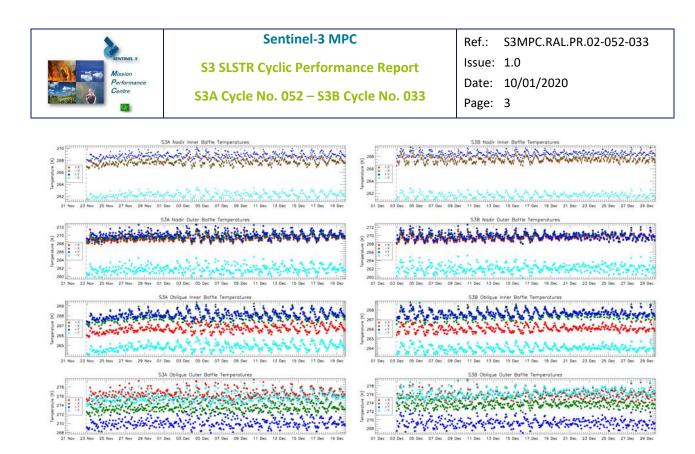


Figure 2: Baffle temperature trends for SLSTR-A Cycle 052 (left) and SLSTR-B Cycle 033 (right). The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit.



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 045 from 20th to 26th May. Decontamination was performed for SLSTR-B in Cycle 030 from 19th to 25th 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 (Cycle 43, 49) show slightly lower average SLSTR-A detector temperatures due to instrument tests that were performed on those days. The detector temperatures for SLSTR-B show a few orbits in Cycle 29 with lower VIS channel temperatures corresponding to the start and end of the SLSTR-B blackbody crossover test.

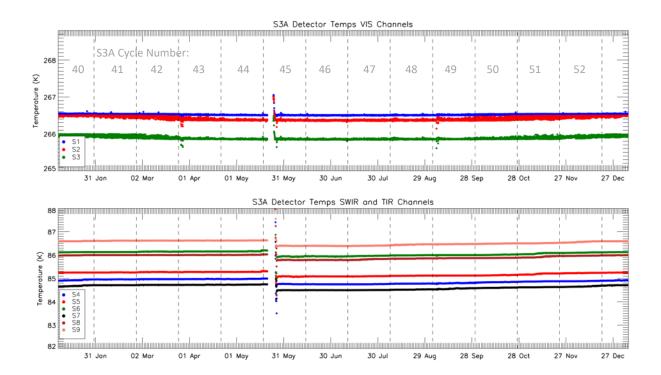


Figure 3: SLSTR-A detector temperatures for each channel for the last year of operations. Discontinuities occur for the infrared channels where the FPA was heated for decontamination. The vertical dashed lines indicate the start and end of each cycle. Each dot represents the average temperature in one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

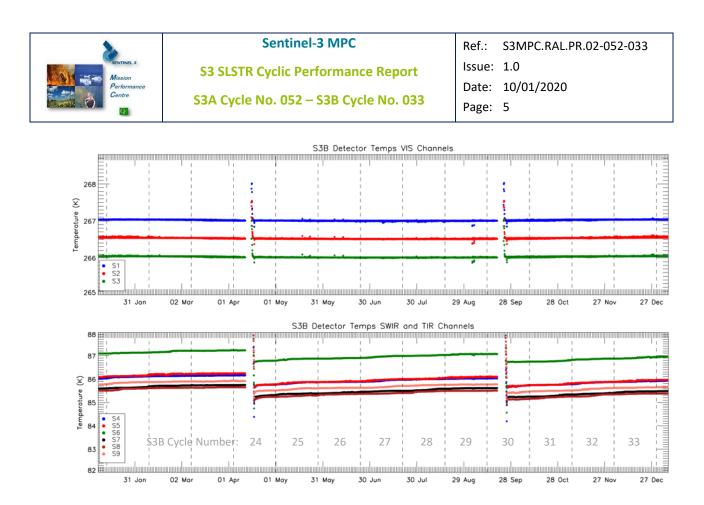


Figure 4: SLSTR-B detector temperatures for each channel for the last year of operations. Discontinuities occur for the infrared channels where the FPA was heated for decontamination. The vertical dashed lines indicate the start and end of each cycle. Each dot represents the average temperature in one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



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 052.

Figure 6 shows the trend for SLSTR-B in Cycle 033. 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.

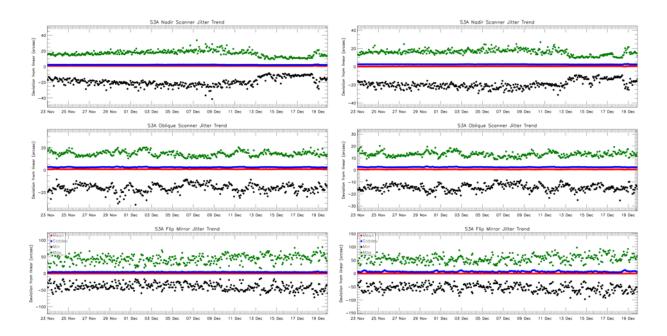


Figure 5: SLSTR-A scanner and flip jitter for Cycle 052, showing mean, stddev and max/min difference from expected position per orbit (red, blue, green and black respectively) for the nadir view (left) and oblique view (right). The plots show the nadir scanner (top), oblique scanner (middle) and flip mirror (bottom).

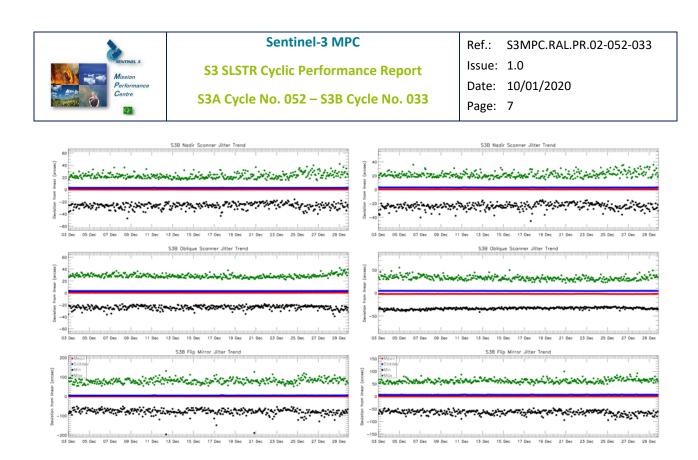


Figure 6: SLSTR-B scanner and flip jitter long term in Cycle 033, showing mean, stddev and max/min difference from expected position per orbit (red, blue, green and black respectively) for the nadir view (left) and oblique view (right). The plots show the nadir scanner (top), oblique scanner (middle) 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 ± 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.

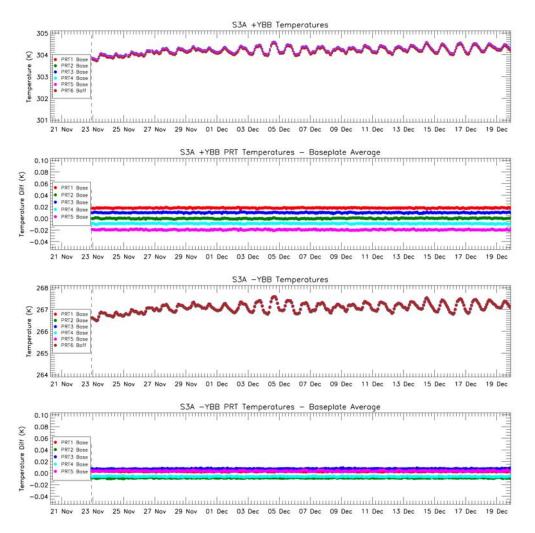
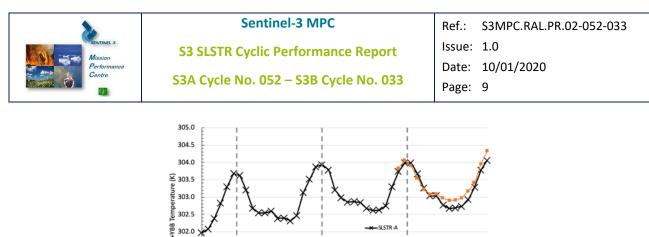


Figure 7: SLSTR-A blackbody temperature and baseplate gradient trends during Cycle 052. The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit.



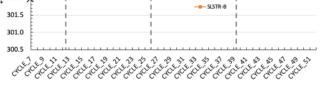


Figure 8: SLSTR-A and SLSTR-B long term trends in average +YBB temperature, showing yearly variation. The vertical dashed lines indicate the 1st January 2017, 2018 and 2019.

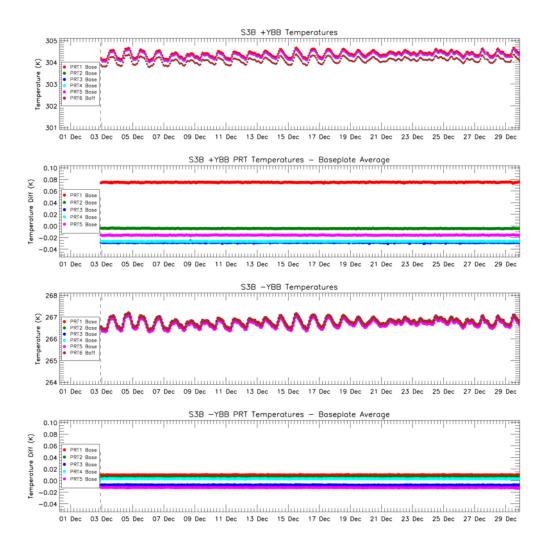


Figure 9: SLSTR-B blackbody temperature and baseplate gradient trends during Cycle 033. The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit.



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 052 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 042	Cycle 043	Cycle 044	Cycle 045	Cycle 046	Cycle 047	Cycle 048	Cycle 049	Cycle 050	Cycle 051	Cycle 052
S1	0.187	243	245	240	236	241	237	244	242	244	248	242
S2	0.194	246	244	244	240	241	242	242	247	247	246	247
S3	0.190	235	233	236	230	229	234	234	231	234	238	240
S4	0.191	171	170	167	161	161	161	164	166	168	170	170
S5	0.193	286	284	282	280	279	279	280	283	285	286	286
S6	0.175	183	181	179	173	174	175	176	179	180	182	183

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 042	Cycle 043	Cycle 044	Cycle 045	Cycle 046	Cycle 047	Cycle 048	Cycle 049	Cycle 050	Cycle 051	Cycle 052
S1	0.166	265	267	257	246	257	252	260	261	260	271	270
S2	0.170	271	265	260	250	256	260	257	264	269	268	270
S3	0.168	252	243	243	233	232	242	243	240	242	250	256
S4	0.166	138	137	137	134	134	136	138	139	140	141	141
S5	0.166	214	216	215	210	213	213	214	216	216	217	218
S6	0.155	133	133	131	131	131	131	133	134	134	136	136



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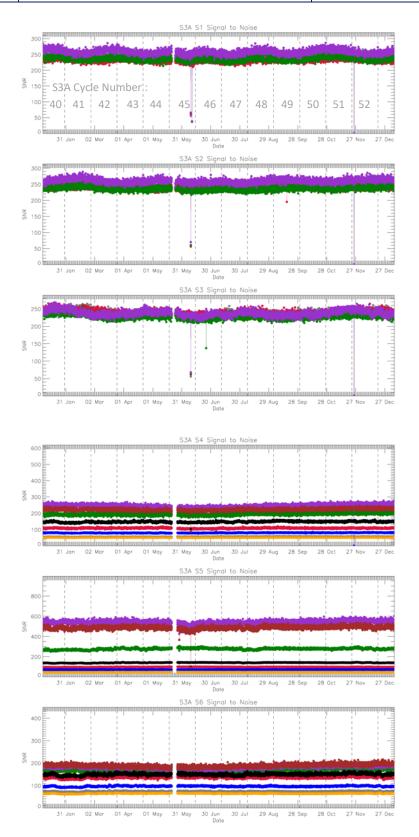


Figure 10: VIS and SWIR channel signal-to-noise of the measured VISCAL signal in each orbit for the last year of operations for SLSTR-A. Different colours indicate different detectors. The vertical dashed lines indicate the start and end of each cycle.



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 033 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 023	Cycle 024	Cycle 025	Cycle 026	Cycle 027	Cycle 028	Cycle 029	Cycle 030	Cycle 031	Cycle 032	Cycle 033		
S1	0.177	232	228	224	224	225	226	228	229	231	233	235		
S2	0.192	223	220	215	214	215	216	218	220	221	224	224		
S3	0.194	237	231	230	229	228	228	233	232	236	231	239		
S4	0.186	131	129	129	129	128	130	129	130	132	132	133		
S5	0.184	244	241	240	240	239	239	241	241	244	245	245		
S6	0.162	163	161	160	159	158	159	160	158	161	164	163		

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 023	Cycle 024	Cycle 025	Cycle 026	Cycle 027	Cycle 028	Cycle 029	Cycle 030	Cycle 031	Cycle 032	Cycle 033		
S1	0.157	226	223	219	218	217	218	220	224	228	228	230		
S2	0.168	257	254	250	247	246	248	251	257	259	262	264		
S3	0.172	272	267	263	261	261	258	264	263	270	268	276		
S4	0.168	128	129	129	128	128	129	130	128	130	131	131		
S 5	0.172	251	251	250	251	249	250	251	250	251	253	255		
S6	0.152	187	187	185	183	183	185	186	184	185	189	189		



2.5.3 SLSTR-A TIR channel NEDT

The thermal channel NEDT values for SLSTR-A in Cycle 052 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.

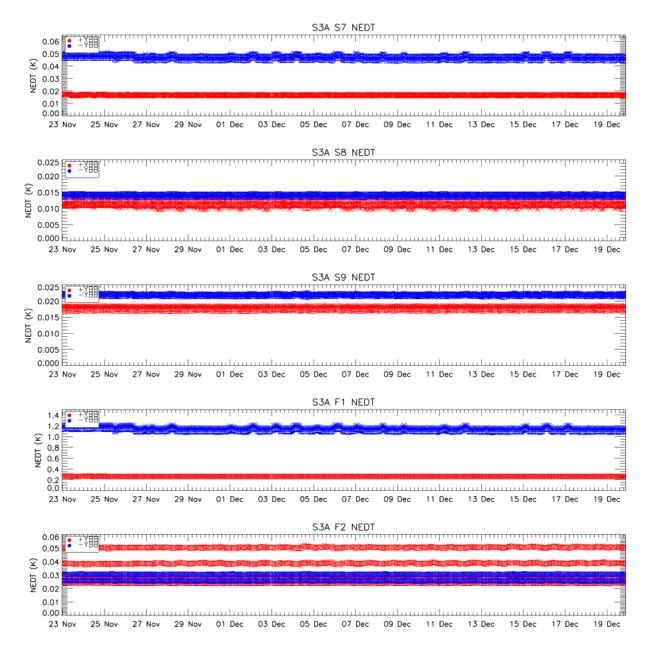


Figure 11: SLSTR-A NEDT trend for the thermal channels in Cycle 052. Blue points were calculated from the cold blackbody signal and red points from the hot blackbody. The square symbols show results calculated from the nadir view and crosses show results from the oblique view. Results are plotted for all detectors and integrators, which is why there are several different levels within the same colour points (particularly for S8 and F2).



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 042	Cycle 043	Cycle 044	Cycle 045	Cycle 046	Cycle 047	Cycle 048	Cycle 049	Cycle 050	Cycle 051	Cycle 052
+YBB temp (K)		303.257	303.036	303.036	302.773	302.672	302.691	302.732	302.931	303.284	303.775	304.059
	S7	17.3	17.4	17.3	17.6	17.6	17.6	17.6	18.0	17.2	17.1	16.8
NEDT	S8	11.5	11.5	11.5	11.5	11.4	11.4	11.5	11.5	11.4	11.4	11.2
NEDT (mK)	S 9	18.1	18.2	18.2	17.7	17.7	17.7	17.8	17.9	17.8	17.9	17.8
(1110)	F1	275	279	281	280	281	282	281	296	273	271	266
	F2	33.8	33.7	33.7	33.7	33.9	33.9	33.9	33.6	33.8	35.2	35.5

SLSTF	SLSTR-A		Cycle 043	Cycle 044	Cycle 045	Cycle 046	Cycle 047	Cycle 048	Cycle 049	Cycle 050	Cycle 051	Cycle 052
-YBB temp (K)		265.767	265.604	265.769	265.503	265.354	265.286	265.226	265.427	265.814	266.475	266.863
	S7	50.1	50.4	50.4	50.5	49.9	49.9	49.8	48.5	49.3	48.2	47.0
NEDT	S8	14.3	14.3	14.3	14.1	14.2	14.1	14.1	14.0	14.1	14.1	14.0
NEDT (mK)	S 9	22.2	22.3	22.4	21.6	21.7	21.7	21.8	21.7	21.9	21.9	21.9
(F1	1223	1245	1253	1230	1233	1235	1234	1192	1212	1171	1134
	F2	28.3	28.3	28.4	27.9	28.0	28.0	28.0	28.2	28.1	28.0	28.1



2.5.4 SLSTR-B TIR channel NEDT

The thermal channel NEDT values for SLSTR-B in Cycle 033, calculated from the hot and cold blackbody signals are shown in Figure 12 and Table 6.

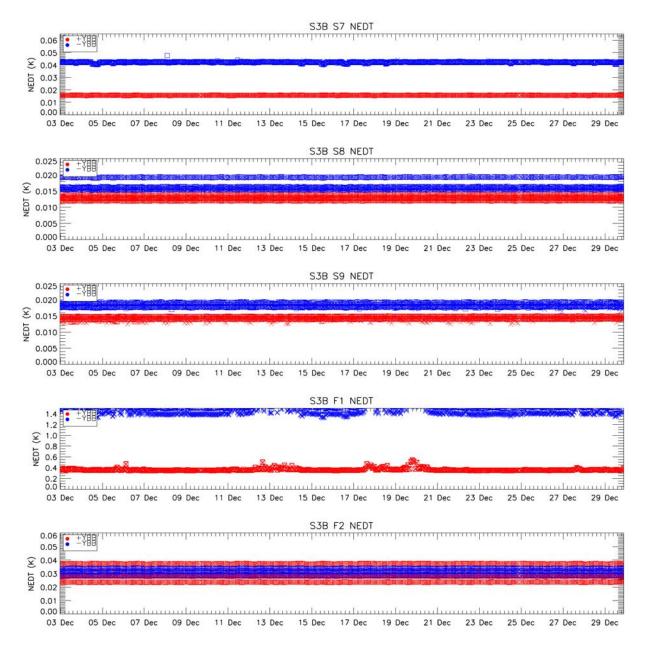


Figure 12: SLSTR-B NEDT trend for the thermal channels in Cycle 033. Blue points were calculated from the cold blackbody signal and red points from the hot blackbody. The square symbols show results calculated from the nadir view and crosses show results from the oblique view. Results are plotted for all detectors and integrators, which is why there are several different levels within the same colour points (particularly for S8 and F2).

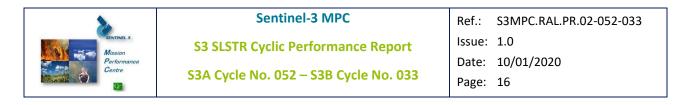


Table 6: NEDT for SLSTR-B in the last 11 cycles averaged over all detectors for both Earth views towards the hot+YBB (top) and the cold -YBB (bottom).

							•	,				
SLSTR-B		Cycle 023	Cycle 024	Cycle 025	Cycle 026	Cycle 027	Cycle 028	Cycle 029	Cycle 030	Cycle 031	Cycle 032	Cycle 033
+YBB temp (K)		303.216	303.079	303.086	303.972	302.907	302.910	302.974	303.171	303.412	303.962	304.326
	S7	16.0	16.0	16.0	16.2	16.3	16.2	16.8	16.0	16.0	15.9	15.7
NEDT	S8	13.4	13.1	12.9	13.0	13.1	13.2	13.3	12.9	12.8	12.9	12.9
NEDT (mK)	S9	15.3	14.5	14.3	14.4	14.6	14.7	14.9	14.3	14.1	14.2	14.3
(F1	436	400	366	378	390	379	403	376	372	370	364
	F2	29.8	30.0	30.0	30.0	30.0	29.9	29.8	29.9	30.0	30.2	30.2

SLSTR-B		Cycle 023	Cycle 024	Cycle 025	Cycle 026	Cycle 027	Cycle 028	Cycle 029	Cycle 030	Cycle 031	Cycle 032	Cycle 033
-YBB temp (K)		265.256	265.092	265.205	265.117	265.002	264.927	264.918	265.109	265.510	266.245	266.679
	S7	44.0	43.8	43.9	43.9	44.5	44.8	43.5	44.4	44.0	42.8	42.4
NEDT	S8	17.2	16.9	16.8	16.8	16.9	17.0	16.9	16.8	16.7	16.7	16.7
NEDT (mK)	S9	19.6	18.6	18.2	18.4	18.6	18.8	18.8	18.3	18.1	18.2	18.3
(F1	1870	1754	1574	1615	1675	1633	1584	1618	1573	1538	1513
	F2	31.6	31.0	30.7	30.7	30.9	31.1	31.1	30.7	30.5	30.5	30.6



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 at the end of Cycle 35 and in Cycle 45. For SLSTR-B, a decontamination was performed during Cycle 24 and Cycle 30.

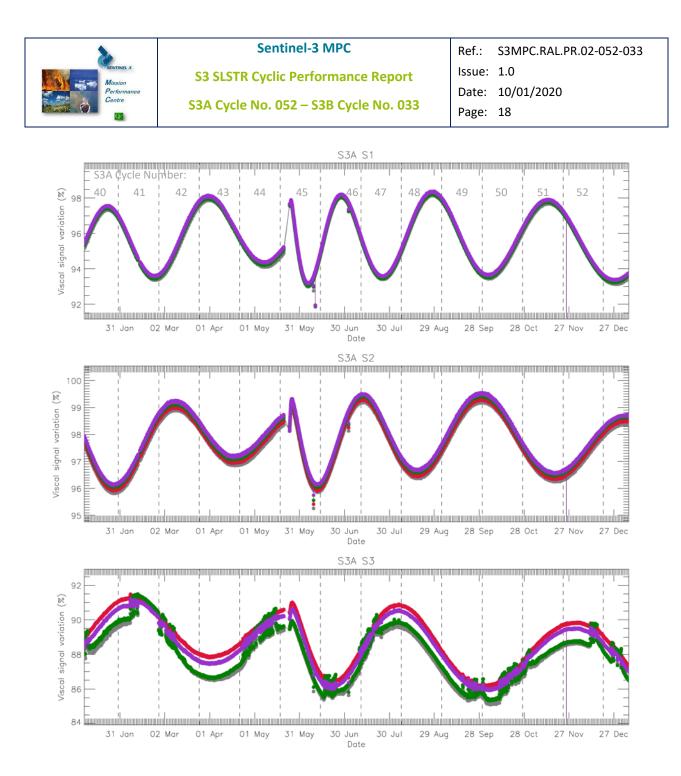
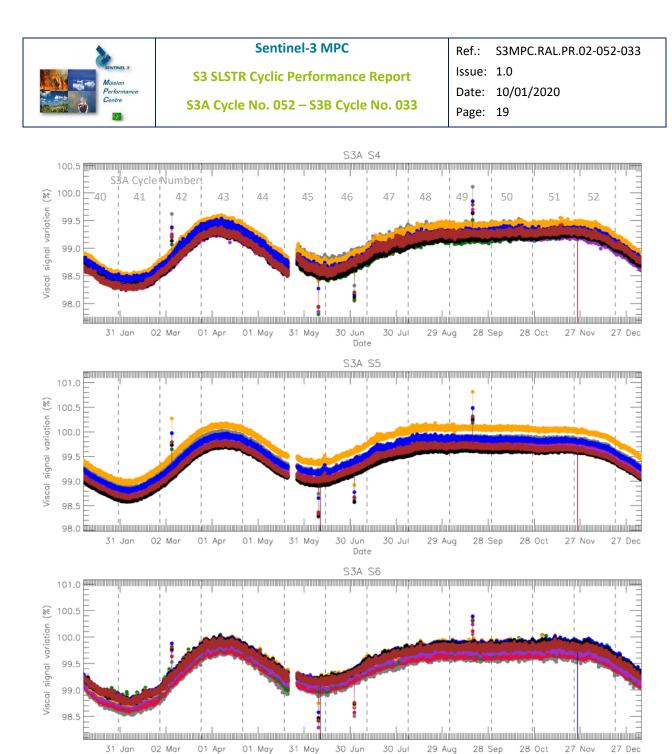


Figure 13: Variation of the radiometric gain derived from the VISCAL signals for SLSTR-A VIS channels for the last year of operations (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start and end of each cycle.



Date

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.

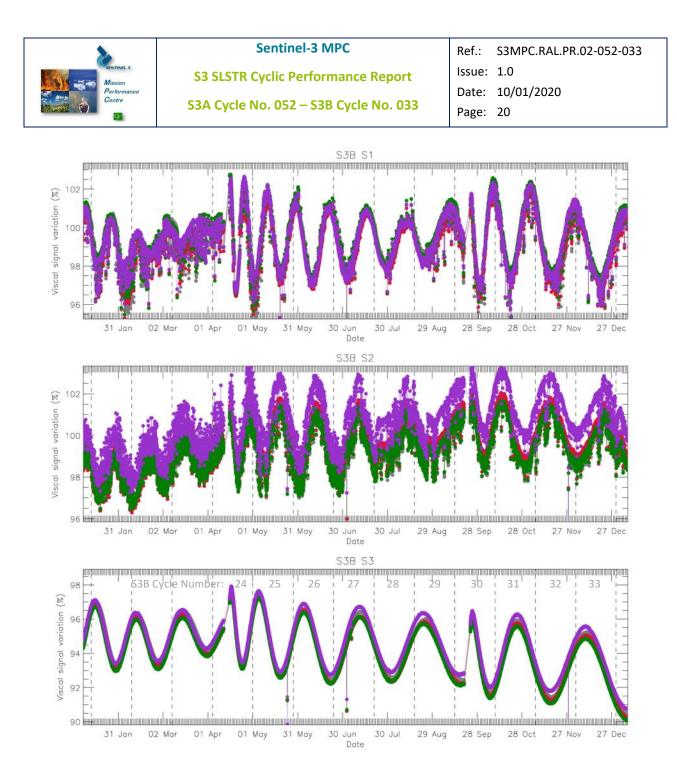


Figure 15: Variation of the radiometric gain derived from the VISCAL signals for SLSTR-B VIS channels for the past year (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start and end of each cycle.

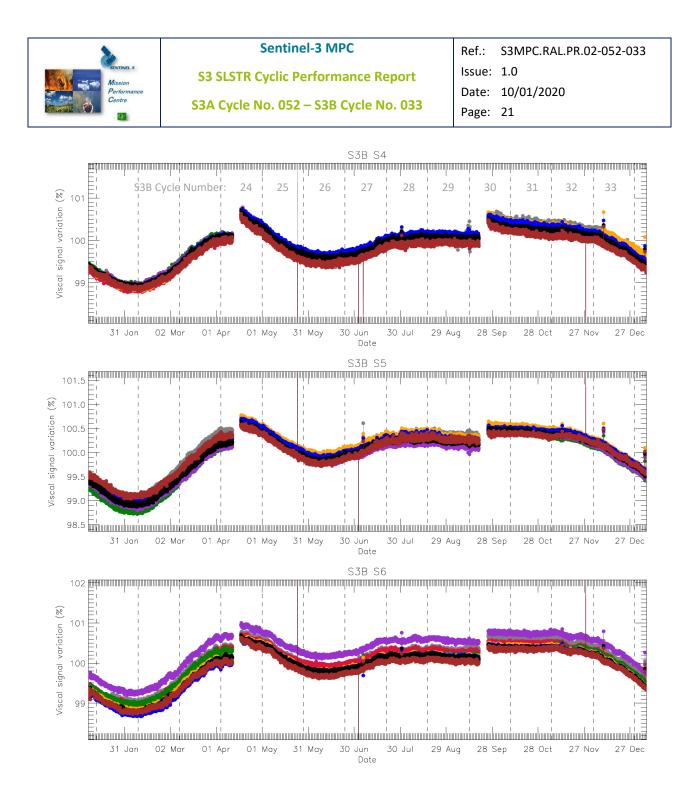


Figure 16: Variation of the radiometric gain derived from the VISCAL signals for SLSTR-B SWIR channels for the past year (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start and end of each cycle.



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 052 and Figure 18 for SLSTR-B in Cycle 033, giving the average positional offsets in kilometres for Nadir and Oblique views.

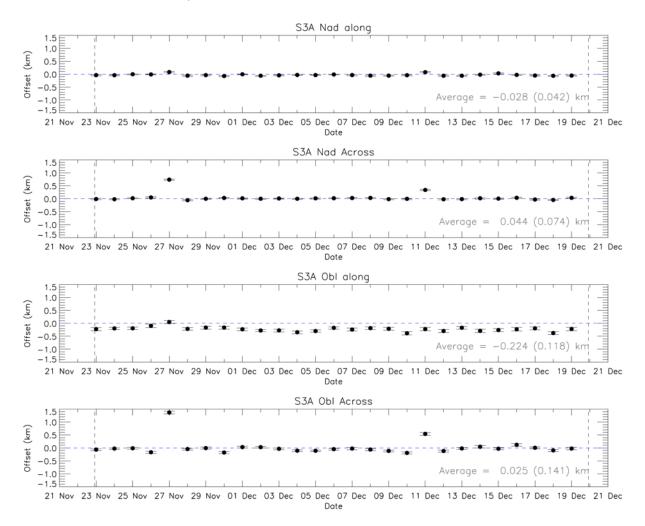


Figure 17: SLSTR-A daily offset results in km from the GeoCal Tool analysis for Nadir along- and across-track (top two plots) and Oblique along- and across-track (bottom two plots) for Cycle 052. The error bars show the standard deviation.



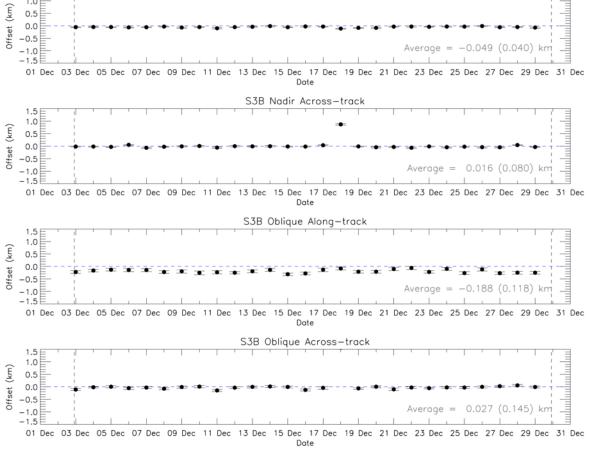


Figure 18: SLSTR-B daily offset results in km from the GeoCal Tool analysis for Nadir along- and across-track (top two plots) and Oblique along- and across-track (bottom two plots) for Cycle 033. The error bars show the standard deviation.

The large offsets for SLSTR-A on 27th November and 11th December are caused by the manoeuvres performed on those days (see Section 6.1). The offsets for SLSTR-B on 18th December are caused the manoeuvre performed on that day (see Section 6.2).



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. Average ratios in each case are given in the figures.

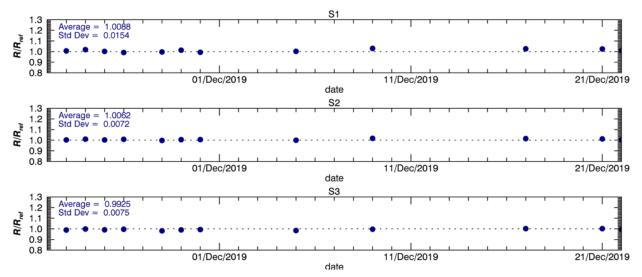


Figure 19: Ratio of SLSTR-A and OLCI-A radiances for the visible channels in Nadir view using combined results for all desert sites processed in Cycle 052.

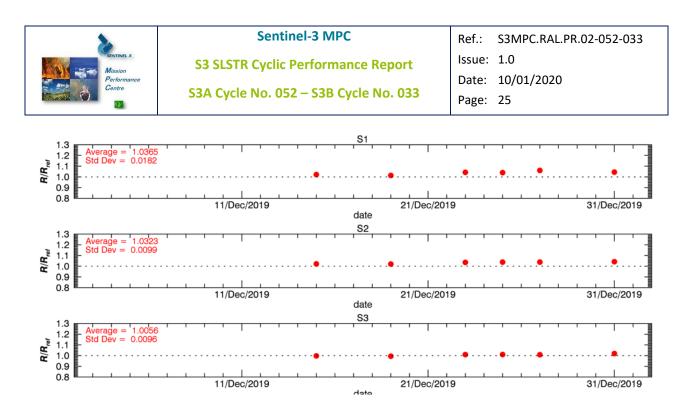


Figure 20: Ratio of SLSTR-B and OLCI-B radiances for the visible channels in Nadir view using combined results for all desert sites processed in Cycle 033.

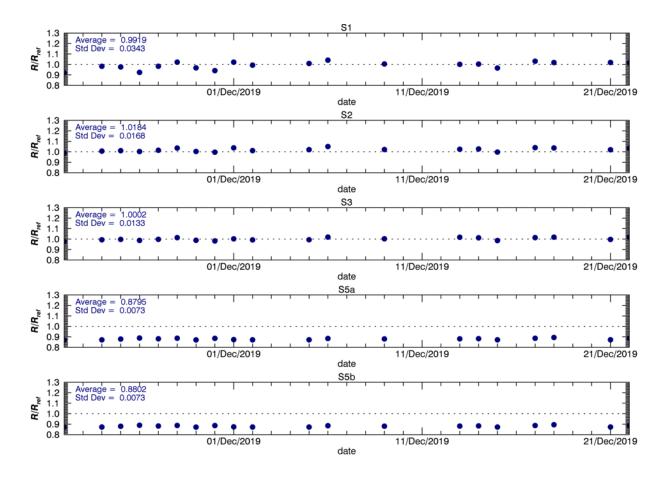


Figure 21: Ratio of SLSTR-A and AATSR radiances in Nadir view using combined results for all desert sites processed in Cycle 052.

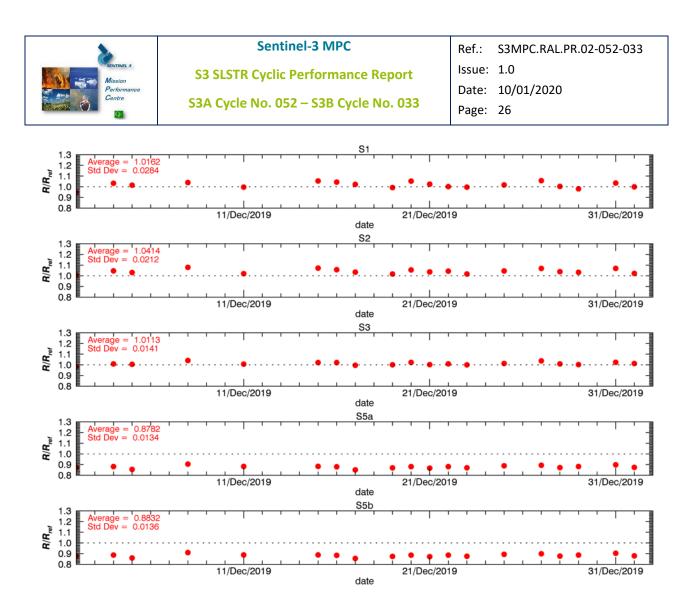


Figure 22: Ratio of SLSTR-B and AATSR radiances in Nadir view using combined results for all desert sites processed in Cycle 033.



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 23 shows an example combined SLSTR-A/SLSTR-B image for the visible channels from 14th December 2019 (daytime only).

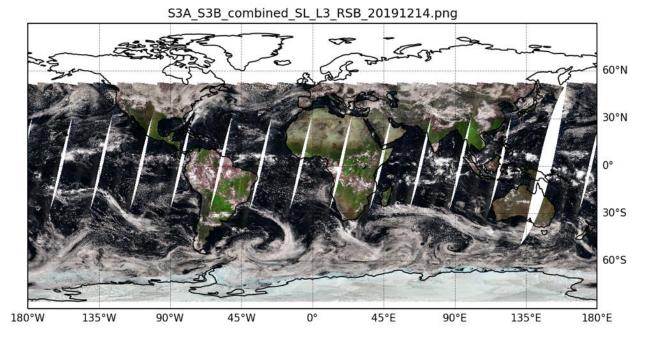


Figure 23: Daytime combined SLSTR-A and SLSTR-B Level-1 image for visible channels on 14th December 2019.



4 Level 2 SST validation

SLSTR level 2 WST SSTs have been validated for SLSTR-A Cycle 052 and SLSTR-B Cycle 033, 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 WST SSTs have also been validated using Copernicus Marine Environment Monitoring Service (CMEMS) *in situ* data. Match-ups between SLSTR and *in situ* data are provided by the EUMESAT Ocean and Sea Ice Satellite Application Facility (OSI-SAF).

4.1 Level 3

Level 3 spatially averaged SST maps for daytime and nighttime are shown in Figure 24 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 24 are the number of 1-km pixels contributing to each average and the mean difference to OSTIA (dt_analysis).



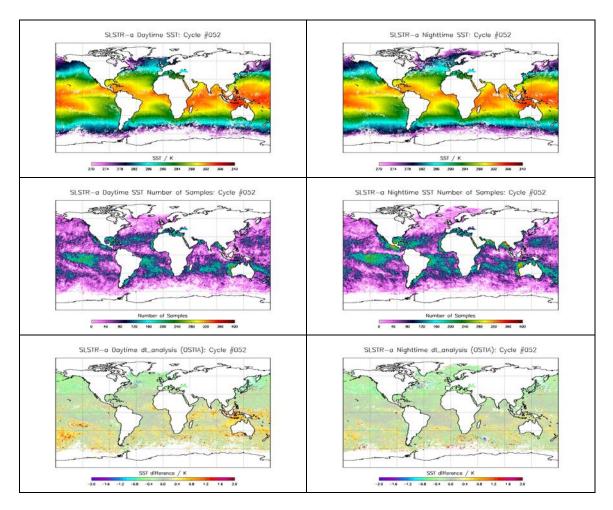


Figure 24: (Top) Level 3 spatially average SST for SLSTR-A Cycle 052 at a resolution of 0.05 degrees. Maps are shown for daytime (left) and nighttime (right). Also shown are (middle) number of 1-km samples in each average and (bottom) mean difference to OSTIA L4 SST analysis.



Level 3 spatially averaged SST maps for daytime and nighttime are shown in Figure 25 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 24 are the number of 1-km pixels contributing to each average and the mean difference to OSTIA (dt_analysis).

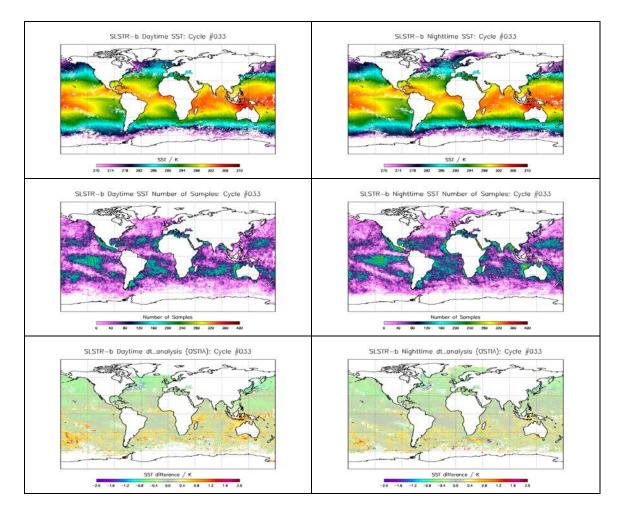


Figure 25: (Top) Level 3 spatially average SST for SLSTR-B Cycle 033 at a resolution of 0.05 degrees. Maps are shown for daytime (left) and nighttime (right). Also shown are (middle) number of 1-km samples in each average and (bottom) mean difference to OSTIA L4 SST analysis.



4.2 Dependence on latitude, TCWV, Satellite ZA and date

The dependence of the difference between SLSTR-A SST_{skin} and drifting buoy SST_{depth} for Cycle 052 is shown in Figure 26 and for SLSTR-B in Cycle 033 in Figure 27. 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_WST files. Daytime 2-channel (S8 and S9) results are shown in red and night time 3-channel results are shown in green. Note that as the data were generated from WST files and not WCT, there are no night time 2-channel results (normally shown in blue) and no data to show the dependency with total column of water vapour. Solid lines indicate dual-view retrievals, dashed lines indicate nadir-only retrievals. Bold lines indicate statistically significant (95% confidence) results.

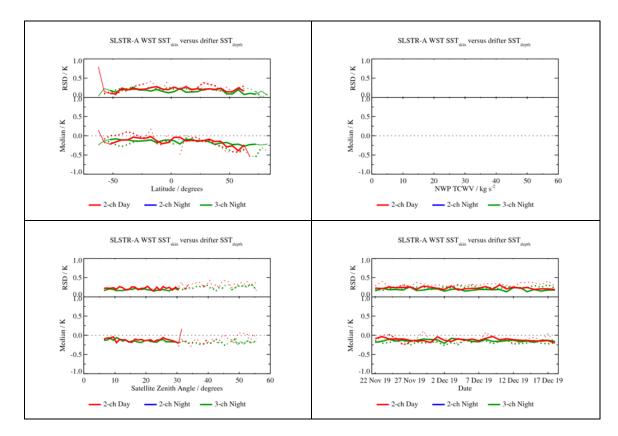


Figure 26: Dependence of median and robust standard deviation of match-ups between SLSTR-A SST_{skin} and drifting buoy SST_{depth} for Cycle 052 as a function of latitude, total column water vapour (TCWV), satellite zenith angle and date. Any data gaps are due to delays in match-up processing at the time this report was generated as well as instrument outages. Note that the dependence on TCWV could not be calculated.

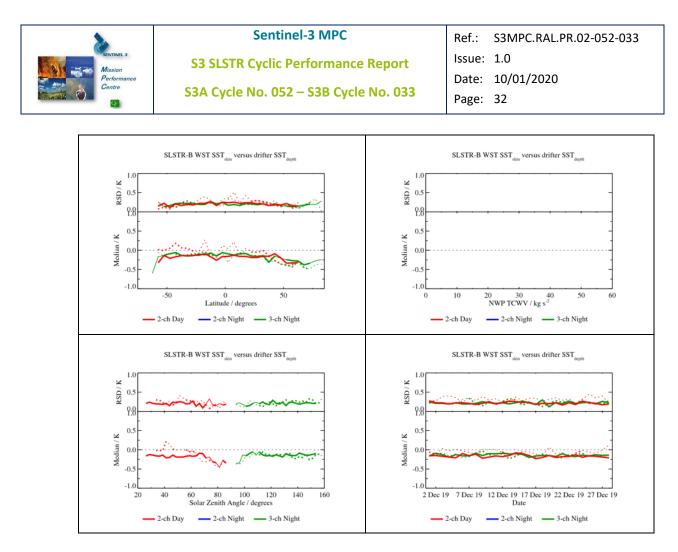
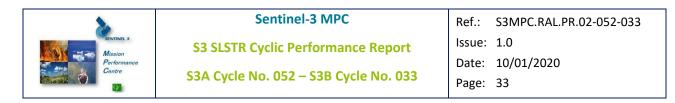


Figure 27: Dependence of median and robust standard deviation of match-ups between SLSTR-B SST_{skin} and drifting buoy SST_{depth} for Cycle 033 as a function of latitude, total column water vapour (TCWV), satellite zenith angle and date. Any data gaps are due to delays in match-up processing at the time this report was generated as well as instrument outages. Note that the dependence on TCWV could not be calculated.



4.3 Spatial distribution of match-ups

The spatial distribution of SLSTR-A/drifter match-ups for Cycle 052 is shown in Figure 28. No adjustments have been made for difference in depth or time between the satellite and *in situ* measurements.

The spatial distribution of SLSTR-B/drifter match-ups for Cycle 033 is shown in Figure 29.

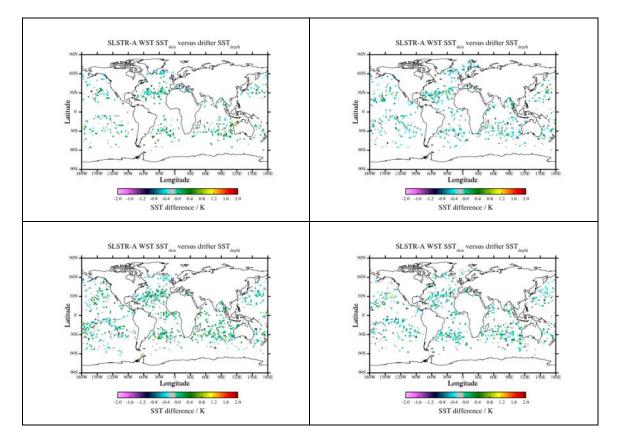


Figure 28: Spatial distribution of match-ups between SLSTR-A SST_{skin} and drifting buoy SST_{depth} for Cycle 052. Clockwise from top left, the matchups relate to the N2 day, N3 night, D3 night and D2 day retrievals.

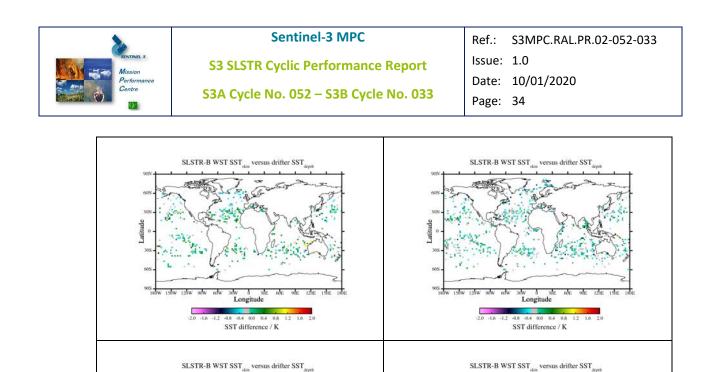


Figure 29 Spatial distribution of match-ups between SLSTR-B SST_{skin} and drifting buoy SST_{depth} for Cycle 033. Clockwise from top left, the matchups relate to the N2 day, N3 night, D3 night and D2 day retrievals.

Longitude

-0.8 -0.4 0.0 0.4 0.8 1.2 1.6 2.0 SST difference / K

-2.0

atitude

Longitude

-0.8 -0.4 0.0 0.4 0.8 SST difference / K

1.2 1.6 2.0



4.4 Match-up statistics

Match-up statistics (median and robust standard deviation, RSD) for SLSTR-A and SLSTR-B are shown in Table 7 and in Table 8. 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 that both SLSTR-A and SLSTR-B are providing SSTs mostly within their target accuracy (0.3 K). Note that no statistics for night time 2-channel results are available because the match-ups are generated using WST data.

Retrieval	Number	Median (K)	RSD (K)
N2 day	962	-0.120	0.326
D2 day	2260	-0.120	0.222
N3 night	1380	-0.180	0.245
D3 night	1801	-0.140	0.193

Table 7: SLSTR-A drifter match-up statistics for Cycle 052.

Table 8: SLSTR-B drifter match-up statistics for Cycle 033.

Retrieval	Number	Median (K)	RSD (K)
N2 day	967	-0.060	0.311
D2 day	2221	-0.170	0.222
N3 night	1463	-0.140	0.237
D3 night	1875	-0.140	0.222



S3A Cycle No. 052 – S3B Cycle No. 033

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 052 for SLSTR-A and 033 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 25th February 2019.

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 accuracy vs. Gold Standard (K)		
	Day	Night	
\$3A	0.9	0.7	
S3B	0.8	0.9	

For both SLSTR-A and SLSTR-B both the daytime 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 actual cloud, or over-masking. The number of matchups across most stations for daytime are very low or zero. It is suspected that during the winter period the cloud scheme is over-masking, but there is an expectation this will improve with the implementation of the temporal interpolation in the next processing baseline. Note, a previous data gap at Barrow has ended and normal flow of data has resumed.



Sentinel-3 MPC

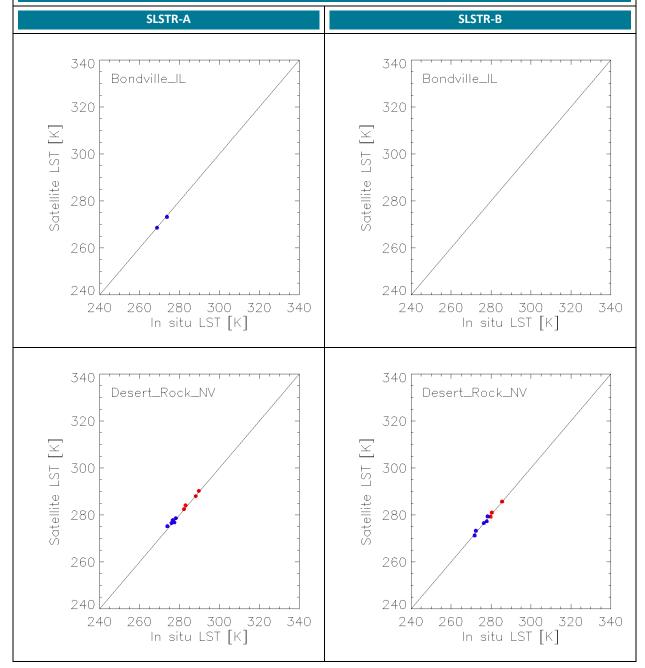
S3 SLSTR Cyclic Performance Report

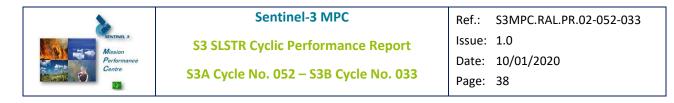
Ref.: S3MPC.RAL.PR.02-052-033 Issue: 1.0 Date: 10/01/2020

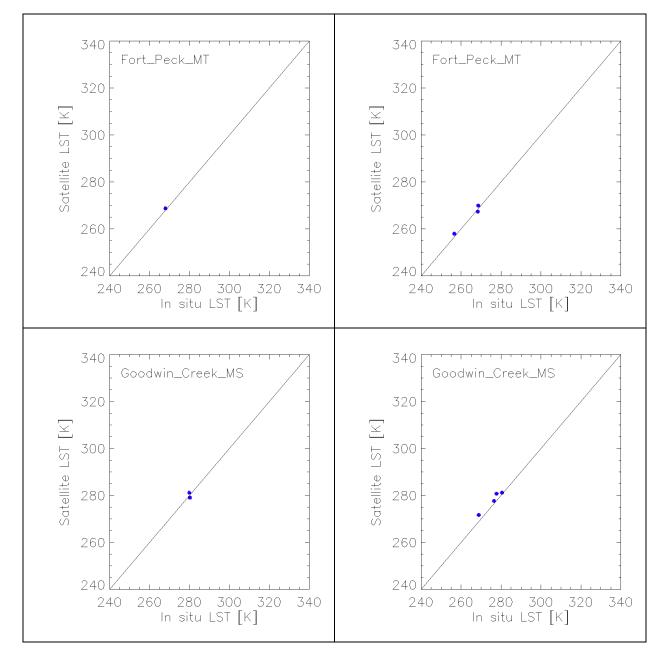
S3A Cycle No. 052 – S3B Cycle No. 033

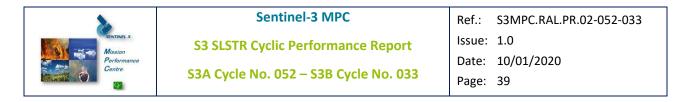
Page: 37

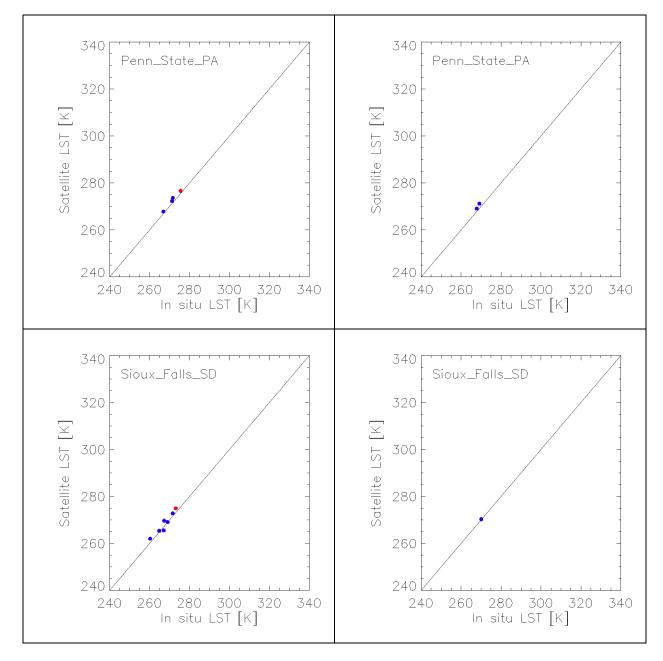


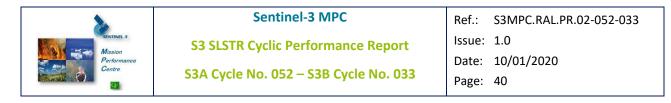


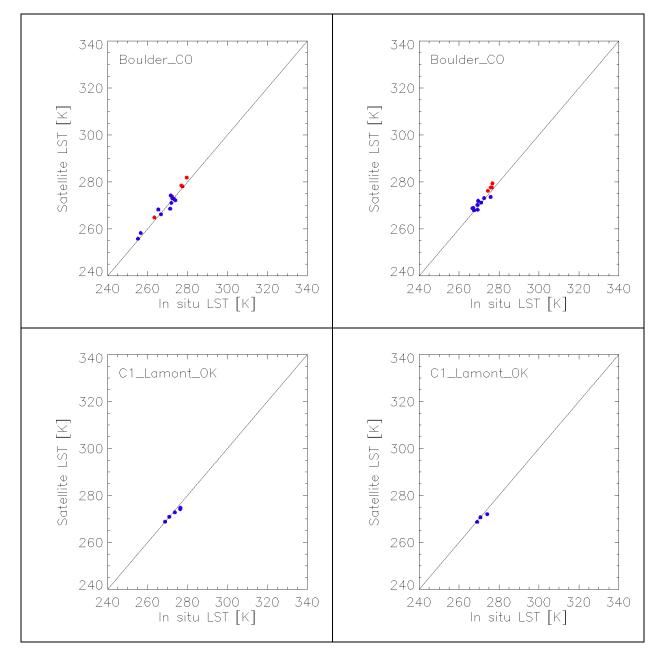


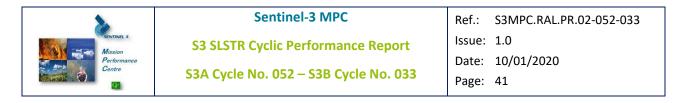


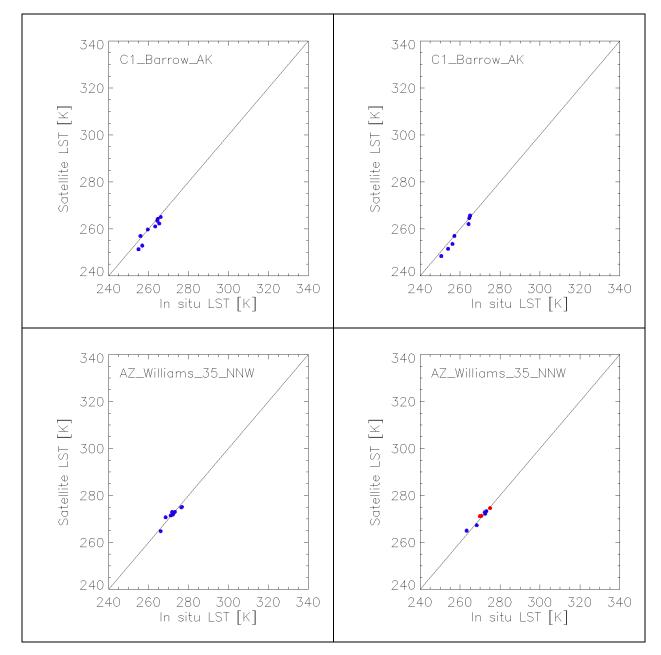


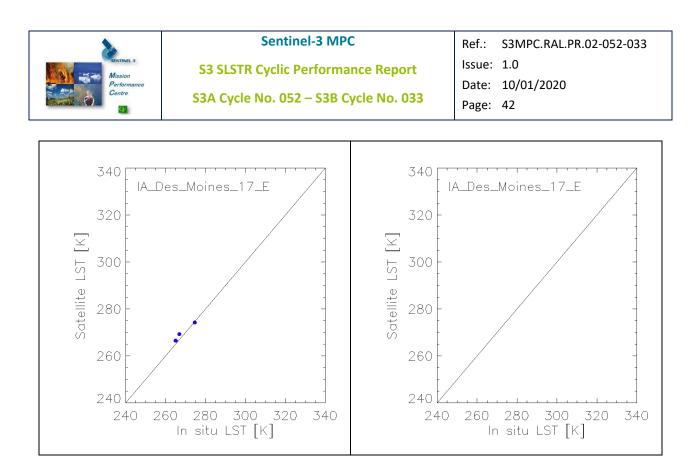












As with past cycles cloud has reduced the number of matchups per station to single figures for most stations during day or night, with some missing statistics entirely. It is therefore challenging to determine robust statistics. Nonetheless, it can be seen that overall the matchups are in general close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



S3A Cycle No. 052 – S3B Cycle No. 033

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 052 (SLSTR-A) and Cycle 033 (SLSTR-B)				
	SLSTR-A		SLSTR-B		
	Day	Night	Day	Night	
Africa	0.4	0.6	0.7	0.6	
Europe	0.4	1.2	0.6	1.3	

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 over both Africa and Europe for both SLSTR-A and SLSTR-B. 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

S3A Cycle No. 052 – S3B Cycle No. 033

Ref.: S3MPC.RAL.PR.02-052-033 Issue: 1.0 Date: 10/01/2020 Page: 44

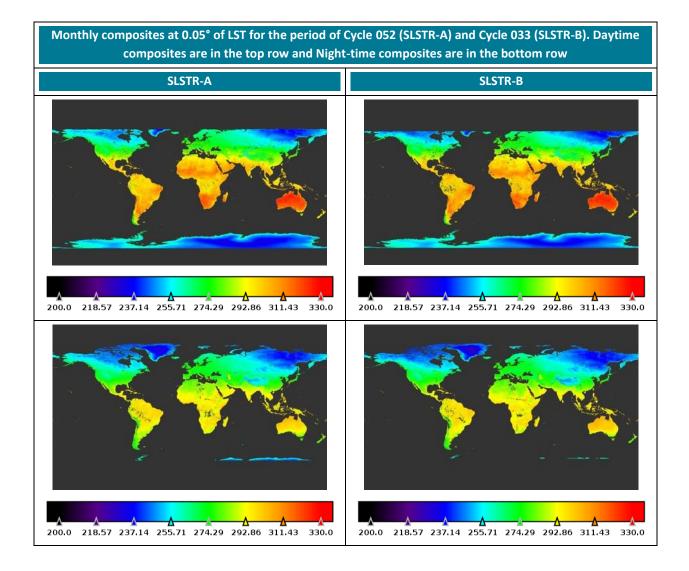
Intercomparison of the SL_2_LST product with respect to the operational LSA SAF SEVIRI LST product for the period of Cycle 052 (SLSTR-A) and Cycle 033 (SLSTR-B). Daytime composites are in the top row and Night-time composites are in the bottom row SLSTR-A SLSTR-B -10.0 0.0 10.0 -10.0 0.0 10.0 Δ 0.0 0.0 -10.0 10.0 -10.0 10.0

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).



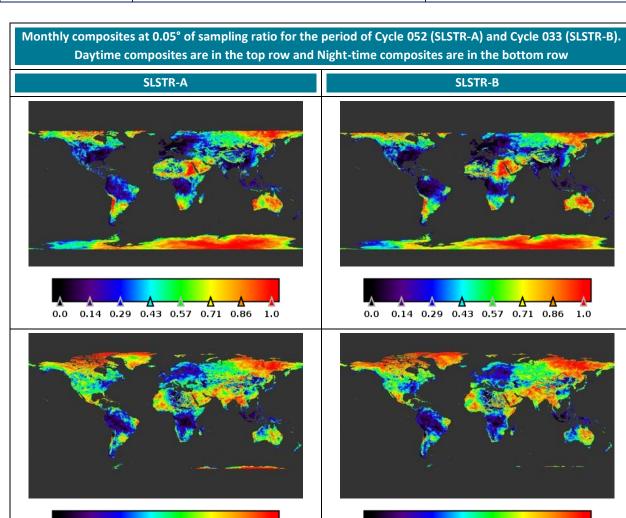


Sentinel-3 MPC

S3 SLSTR Cyclic Performance Report

S3A Cycle No. 052 – S3B Cycle No. 033

Ref.: S3MPC.RAL.PR.02-052-033 Issue: 1.0 Date: 10/01/2020 Page: 46



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 Asia. The excessive cloud clearing seems to be equally evident in SLSTR-A and SLSTR-B which indicate the cloud coefficients ADF need tuning for both instruments once the ongoing issue regarding the temporal interpolation is resolved. Comparing this effect from the previous cycles indicates the same regions are subject to excessive cloud clearing. This issue is being implemented into the next release – due for operational implementation imminently.

1.0

0.0

0.14 0.29 0.43 0.57 0.71 0.86

1.0

0.14 0.29 0.43 0.57 0.71 0.86

0.0



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:

- 27th November 2019 07:55-08:10 possible pointing errors due to in-plane manoeuvre.
- 2nd December 2019, 23:37-23:47 data gap due to radio frequency interference.
- 11th December 2019, 11:45-12:25 possible pointing errors due to out-of-plane manoeuvre.

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:

- 9th December 2019, 16:59-17:04 data gap due to sequencing errors.
- 18th December 2019, 08:15-08:30 possible pointing errors due to in-plane manoeuvre.
- 24th December 2019, 21:51-22:01 data gap due to radio frequency interference.



7 Appendix A

Other reports related to the Optical mission are:

 S3 OLCI Cyclic Performance Report, S3A Cycle No. 052, S3B Cycle No. 033 (ref. S3MPC.ACR.PR.01-052-033)

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

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