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MISSION PERFORMANCE CLUSTER SERVICE

Data Quality Report

Sentinel-3 SLSTR

January 2022

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Approved by:	D. Smith, OPT-MPC SLSTR ESL Coordinator	Authorized by	C. Hénocq, OPT-MPC S3 Technical Manager
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1 Processing Baseline Version

IPF	IPF / Processing Baseline version	Date of deployment
S3A		
SL1	06.18 / 2.75	CGS: 18/05/2021 08:10 UTC PAC: 18/05/2021 08:10 UTC
SL2 LST	06.17 / 2.77	PAC: 14/06/2021 08:21 UTC
SL2 FRP (NTC)	01.05 / 2.77	PAC: 14/06/2021 08:21 UTC

IPF	IPF / Processing Baseline version	Date of deployment
S3B		
SL1	06.18 / 1.53	PAC: 18/05/2021 08:10 UTC
SL2 LST	06.17 / 1.55	PAC: 14/06/2021 08:21 UTC
SL2 FRP (NTC)	01.05 / 1.55	PAC: 14/06/2021 08:21 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 month. The temperatures were stable (on top of a daily variation cycle).

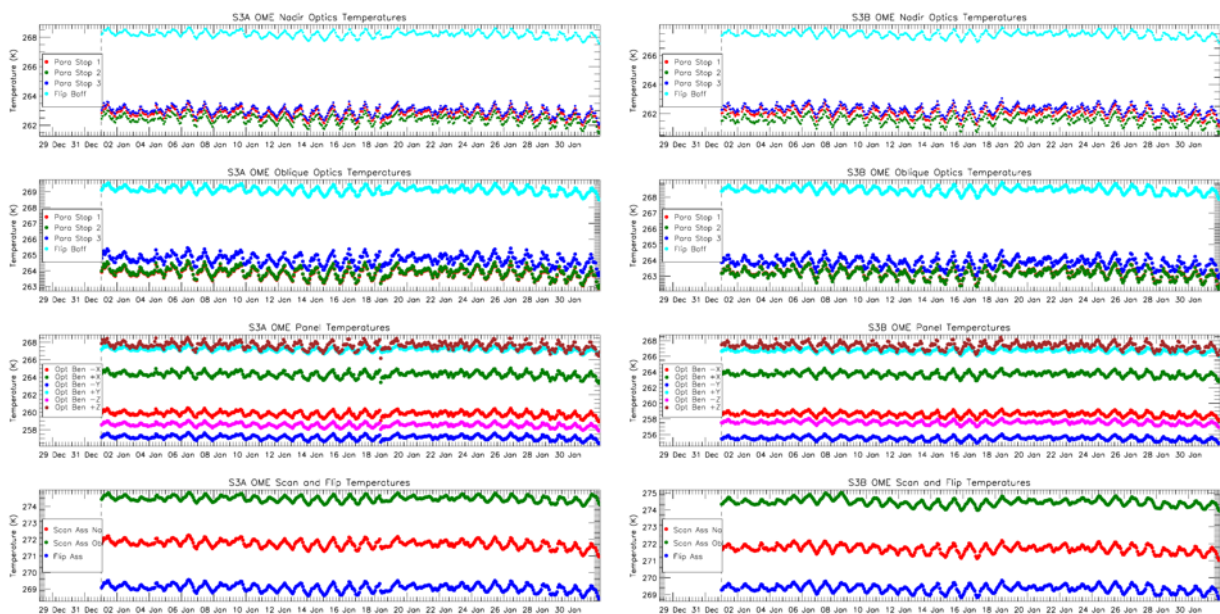


Figure 1: OME temperature trends for SLSTR-A (left) and SLSTR-B (right) during January 2022 showing the paraboloid stops and flip baffle (top two plots) and optical bench and scanner and flip assembly (lower two plots). Each dot represents the average temperature in one orbit.

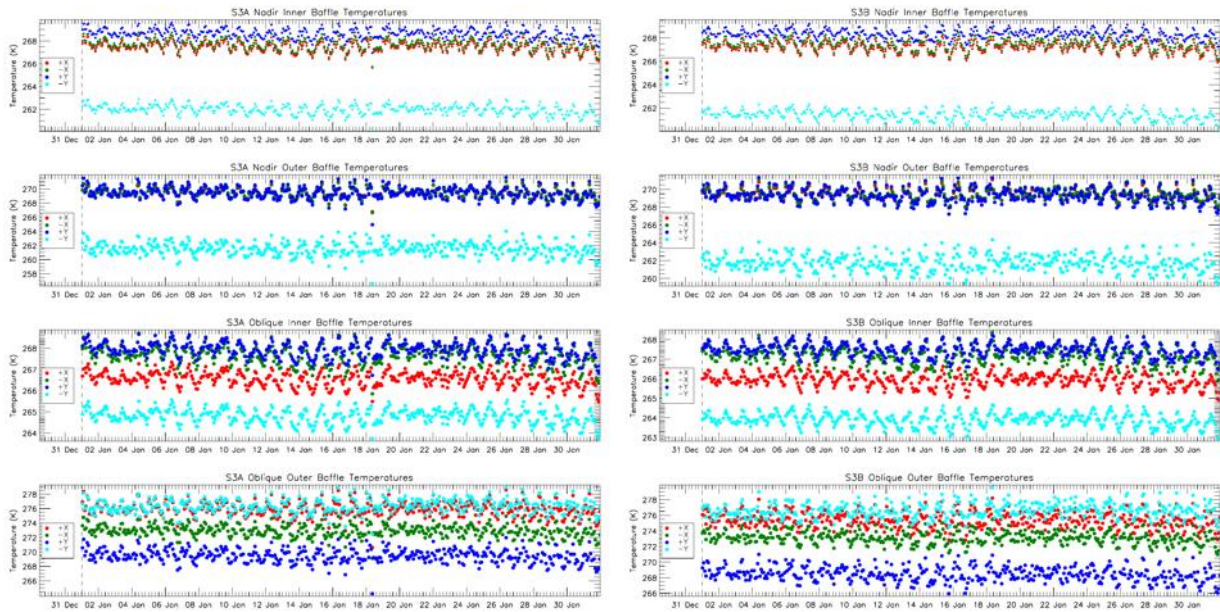


Figure 2: Baffle temperature trends for SLSTR-A (left) and SLSTR-B (right) during January 2022. Each dot represents the average temperature in one orbit.

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. A decontamination was last performed for SLSTR-A on 19th April 2021. Decontamination was last performed for SLSTR-B from 11th to 13th November 2020. Decontamination involves warming up the infrared focal plane assembly (FPA) in order to remove water ice contamination from the cold surfaces. Figure 3 and Figure 4 show the SLSTR-A and SLSTR-B detector temperatures for the past year. The decontaminations are clearly visible as a rise in detector temperature.

A few orbits (e.g. end of September 2021) show slightly lower average visible channel detector temperatures due to instrument operations that were performed on those days.

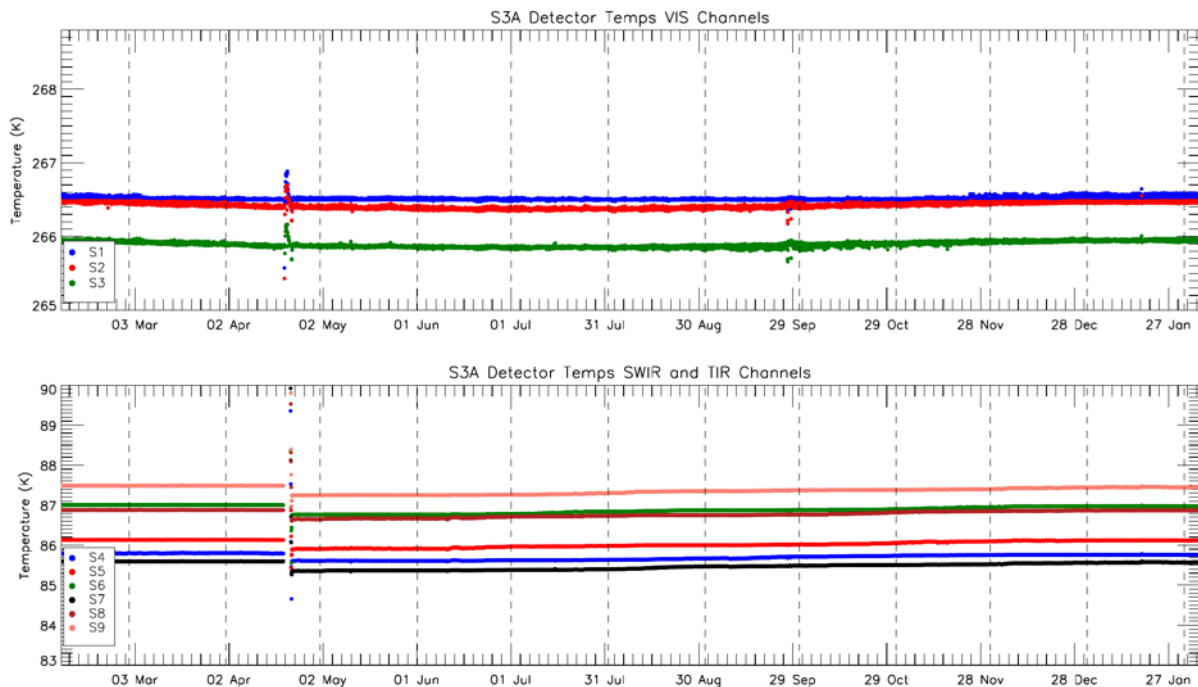


Figure 3: SLSTR-A detector temperatures for each channel for the last year of operations. Discontinuities occur for the infrared channels where the FPA was heated for decontamination. The vertical dashed lines indicate the start of each month. Each dot represents the average temperature in one orbit.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

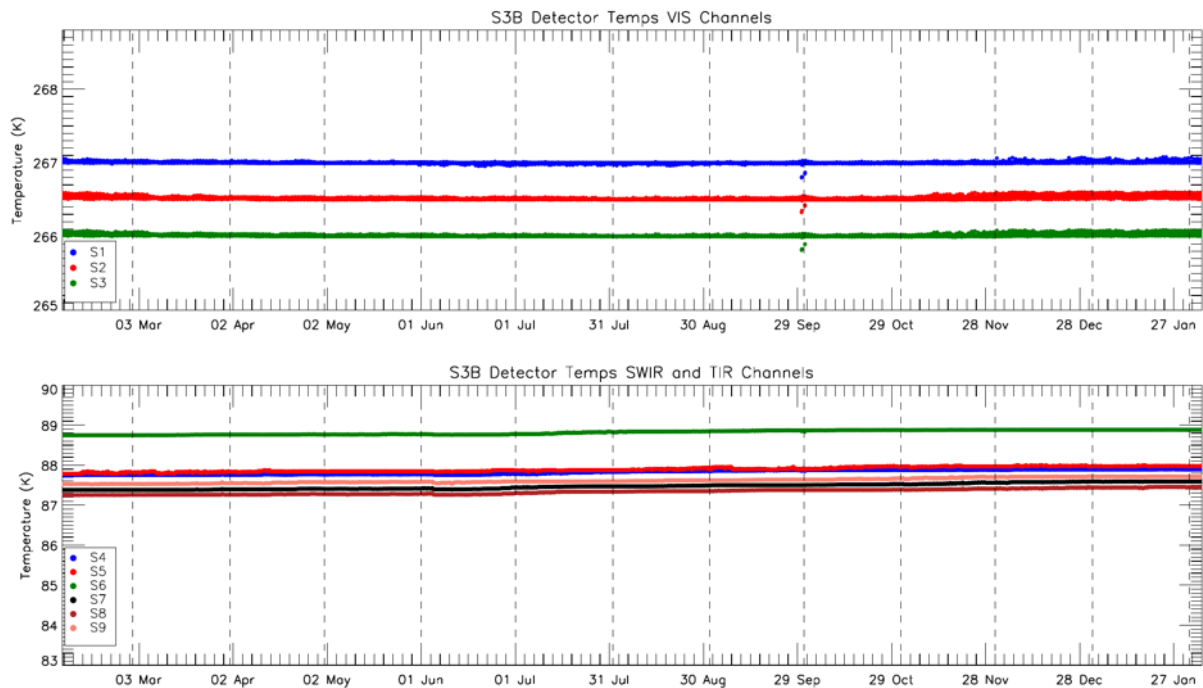


Figure 4: SLSTR-B detector temperatures for each channel for the last year of operations. Discontinuities occur for the infrared channels where the FPA was heated for decontamination. The vertical dashed lines indicate the start of each month. Each dot represents the average temperature in one orbit.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

2.3 Scanner performance

The actual position of the scan and flip mirrors is measured by the instrument, and Figure 5 shows the statistics of the difference from the expected linear control law for each mirror in each view for SLSTR-A during January 2022. Figure 6 shows the equivalent trends for SLSTR-B. The performance has been consistent with previous operations and does not appear to be degrading. For reference, one arcsecond corresponds to roughly 4m on the ground.

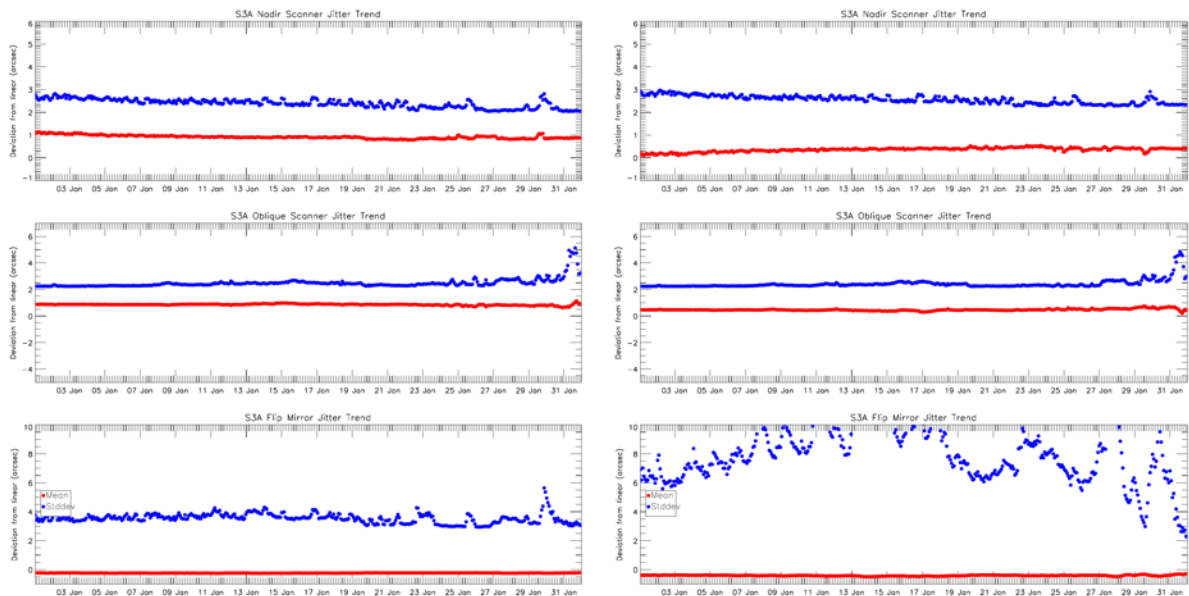


Figure 5: SLSTR-A scanner and flip jitter for January 2022, showing mean and stddev from expected position per orbit (red and blue respectively) for the nadir view (left) and oblique view (right). The plots show the nadir scanner (top), oblique scanner (middle) and flip mirror (bottom).

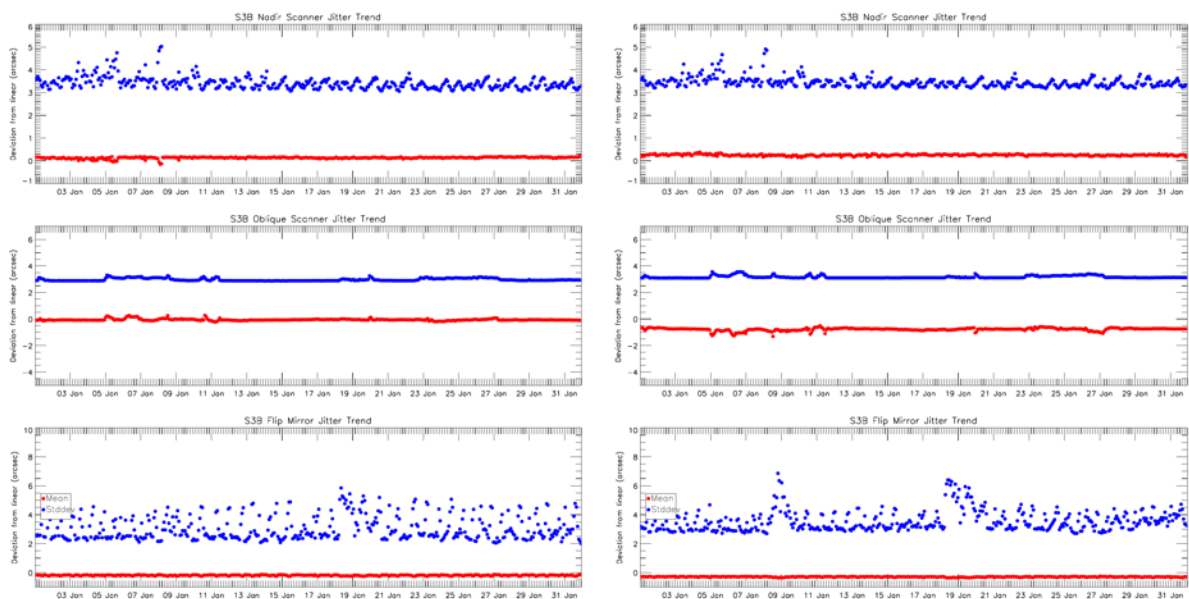


Figure 6: SLSTR-B scanner and flip jitter long term in January 2022, showing mean and stddev difference from expected position per orbit (red and blue respectively) for the nadir view (left) and oblique view (right). The plots show the nadir scanner (top), oblique scanner (middle) and flip mirror (bottom).

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 trends which show a yearly variation, with temperatures rising as the Earth approaches perihelion at the beginning of January – this variation is shown in the monthly averages in Figure 8 and Table 5.

Figure 7 and Figure 9 also 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 $\pm 20\text{mK}$, except for the +Y blackbody for SLSTR-B which has a higher gradient. This higher gradient is expected and consistent with measurements made before launch.

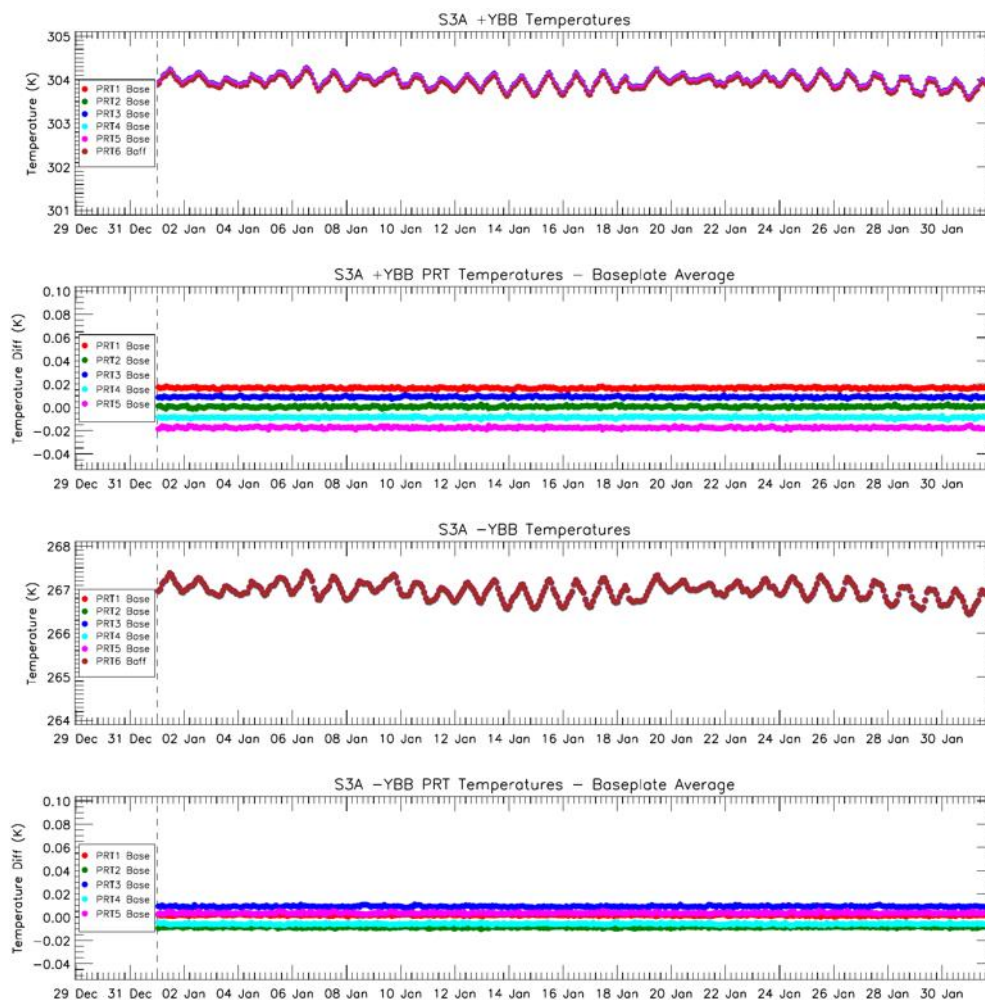


Figure 7: SLSTR-A blackbody temperature and baseplate gradient trends during January 2022. Each dot represents the average temperature in one orbit.

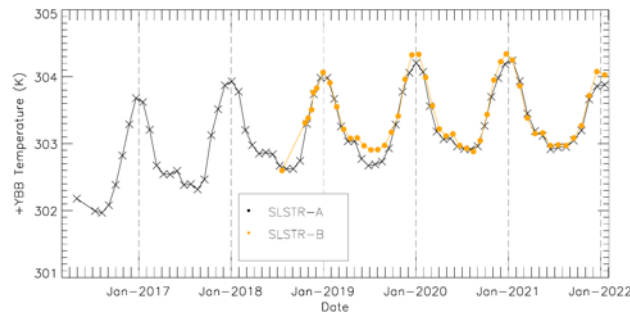


Figure 8: SLSTR-A and SLSTR-B long term trends in average +YBB temperature, showing yearly variation. The vertical dashed lines indicate the 1st January in each year.

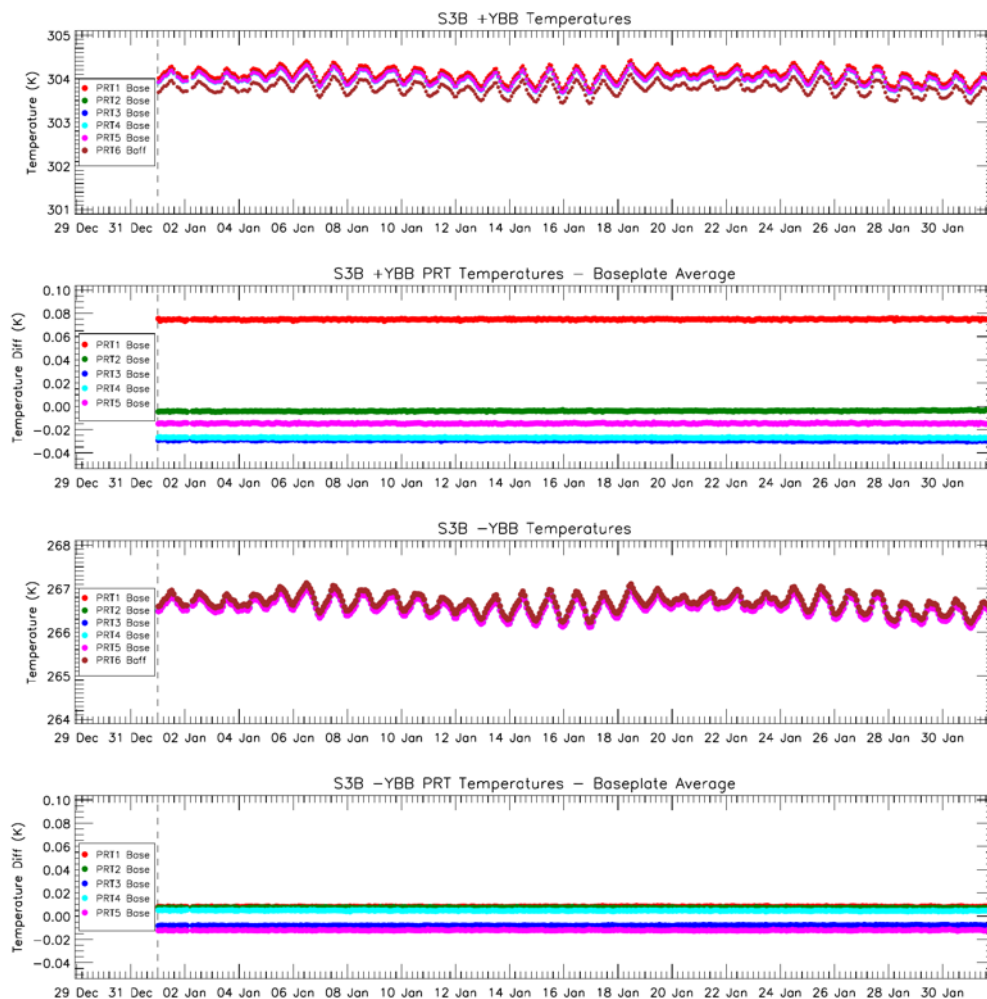


Figure 9: SLSTR-B blackbody temperature and baseplate gradient trends during January 2022. Each dot represents the average temperature in one orbit.

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 during January 2022 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 monthly signal-to-noise (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 these averages are now calculated for each calendar month, whereas in previous data quality reports they were aligned to the satellite 27 day repeat cycles.

Table 1: Average SLSTR-A reflectance factor, and signal-to-noise ratio of the measured VISCAL signal for the last 11 months, averaged over all detectors for the nadir view.

	Average Reflectance Factor	Nadir Signal-to-noise ratio										
		Mar 2021	Apr 2021	May 2021	Jun 2021	Jul 2021	Aug 2021	Sep 2021	Oct 2021	Nov 2021	Dec 2021	Jan 2022
S1	0.187	238	241	236	239	241	237	240	247	246	241	239
S2	0.194	245	246	240	239	242	243	242	244	246	247	248
S3	0.190	231	230	226	221	224	228	229	231	229	227	228
S4	0.191	174	172	168	166	167	170	172	173	176	176	177
S5	0.193	284	283	281	279	280	281	283	285	287	287	292
S6	0.175	185	181	178	176	178	180	182	184	186	188	188

Table 2: Average SLSTR-A reflectance factor, and signal-to-noise ratio of the measured VISCAL signal for the last 11 months, averaged over all detectors for the oblique view.

	Average Reflectance Factor	Oblique Signal-to-noise ratio										
		Mar 2021	Apr 2021	May 2021	Jun 2021	Jul 2021	Aug 2021	Sep 2021	Oct 2021	Nov 2021	Dec 2021	Jan 2022
S1	0.166	261	256	249	248	256	252	254	264	269	266	261
S2	0.170	265	264	255	247	257	261	260	261	266	271	271
S3	0.168	243	238	229	218	224	231	236	240	239	235	232
S4	0.166	139	138	136	134	137	138	139	140	141	141	140
S5	0.166	213	213	213	210	213	212	215	215	217	215	210
S6	0.155	133	132	129	129	129	131	132	132	135	135	132

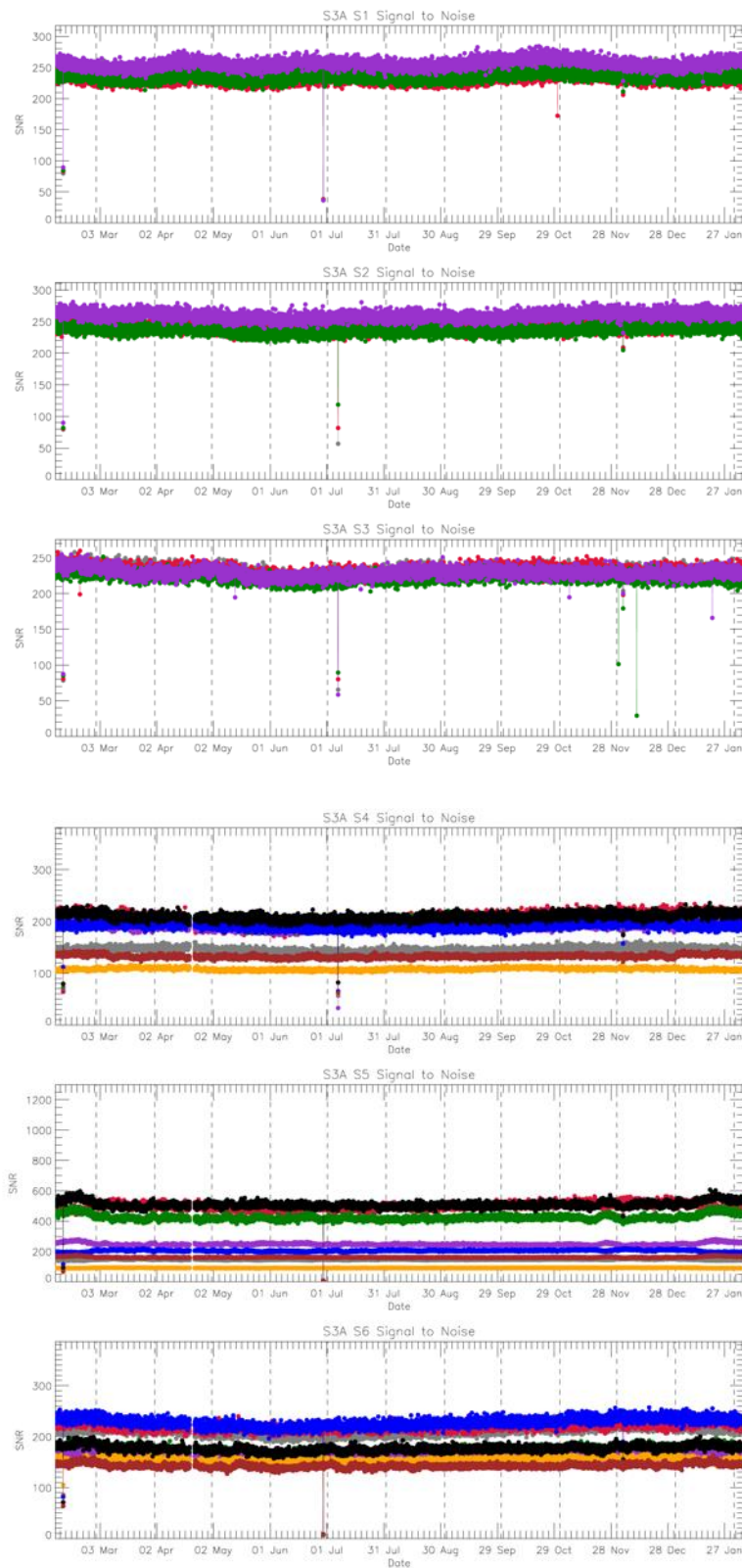


Figure 10: VIS and SWIR channel signal-to-noise of the measured VISICAL signal in each orbit for the last year of operations for SLSTR-A. Different colours indicate different detectors. The vertical dashed lines indicate the start of each month.

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

The monthly average VIS and SWIR channel signal-to-noise ratios for SLSTR-B are shown in Table 3 and Table 4. These values average over a significant detector-detector dispersion for the SWIR channels. Note that these averages are now calculated for each calendar month, whereas in previous data quality reports they were aligned to the satellite 27 day repeat cycles.

Table 3: Average SLSTR-B reflectance factor, and signal-to-noise ratio of the measured VISCAL signal for the last 11 months, averaged over all detectors for the nadir view.

	Average Reflectance Factor	Nadir Signal-to-noise ratio										
		Mar 2021	Apr 2021	May 2021	Jun 2021	Jul 2021	Aug 2021	Sep 2021	Oct 2021	Nov 2021	Dec 2021	Jan 2022
S1	0.177	235	224	223	220	222	227	224	232	232	227	236
S2	0.192	219	218	215	211	215	218	217	221	224	221	223
S3	0.194	228	227	220	218	221	225	221	221	226	232	228
S4	0.186	130	131	130	128	128	129	129	130	130	132	132
S5	0.184	244	241	241	241	238	241	241	242	244	245	244
S6	0.162	163	161	160	159	158	160	158	158	163	163	167

Table 4: Average SLSTR-B reflectance factor, and signal-to-noise ratio of the measured VISCAL signal for the last 11 months, averaged over all detectors for the oblique view.

	Average Reflectance Factor	Oblique Signal-to-noise ratio										
		Mar 2021	Apr 2021	May 2021	Jun 2021	Jul 2021	Aug 2021	Sep 2021	Oct 2021	Nov 2021	Dec 2021	Jan 2022
S1	0.157	225	217	216	211	216	215	218	223	221	225	224
S2	0.168	254	254	244	241	245	246	249	255	256	255	258
S3	0.172	261	254	245	249	248	249	249	253	260	257	252
S4	0.168	128	130	128	125	126	127	128	129	127	129	130
S5	0.172	247	248	246	246	245	245	245	245	249	250	248
S6	0.152	185	186	182	179	179	181	182	184	186	187	186

2.5.3 SLSTR-A TIR channel NEDT

The thermal channel NEDT values for SLSTR-A in January 2022 are consistent with previous operations and within the requirements. NEDT trends calculated from the hot and cold blackbody signals are shown in Figure 11. Monthly NEDT values, averaged over all detectors and both Earth views, are shown in Table 5. Note that these averages are now calculated for each calendar month, whereas in previous data quality reports they were aligned to the satellite 27 day repeat cycles.

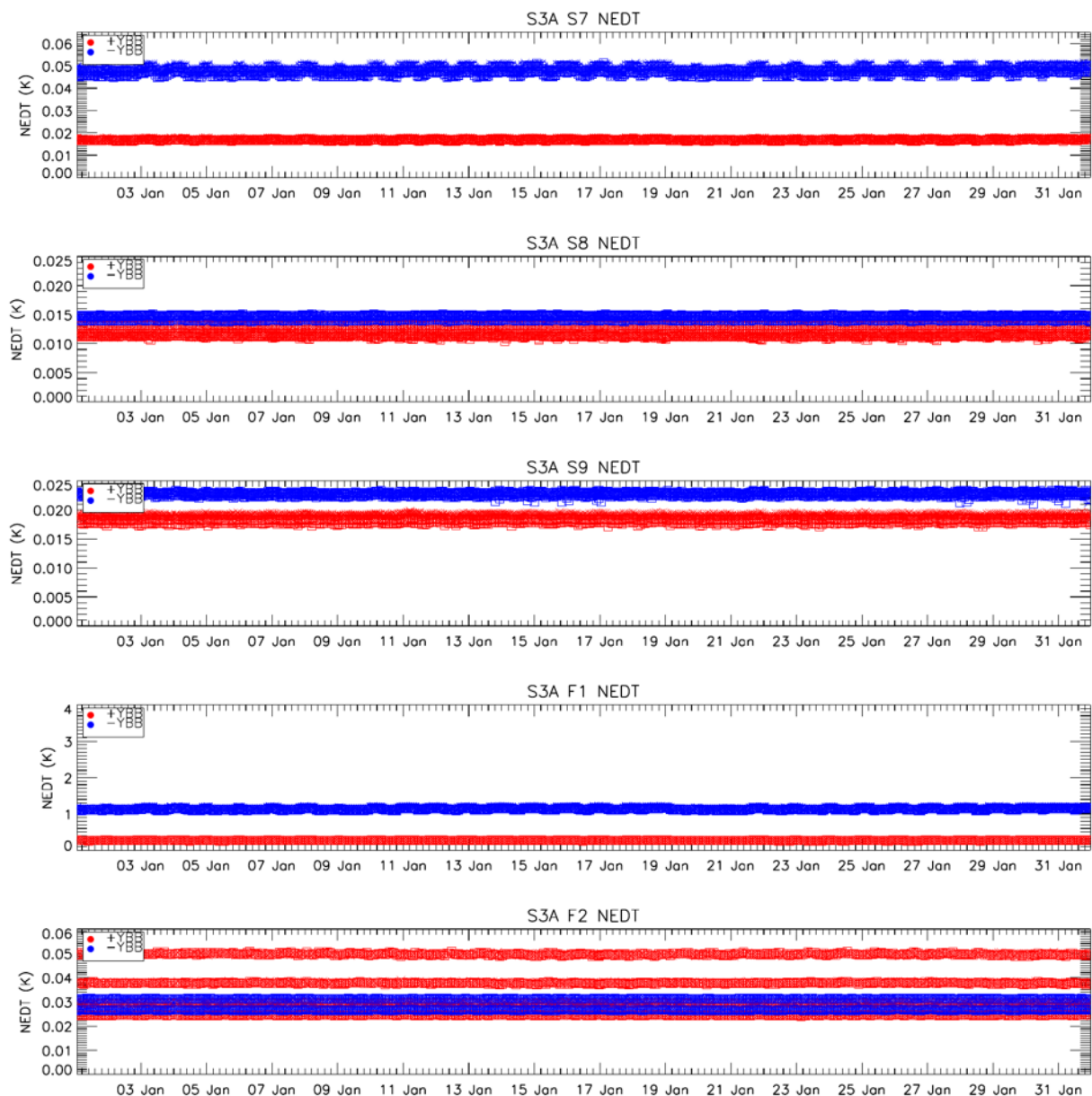


Figure 11: SLSTR-A NEDT trend for the thermal channels in January 2022. Blue points were calculated from the cold blackbody signal and red points from the hot blackbody. The square symbols show results calculated from the nadir view and crosses show results from the oblique view. Results are plotted 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 months averaged over all detectors for both Earth views towards the hot +YBB (top) and the cold -YBB (bottom).

SLSTR-A	Mar 2021	Apr 2021	May 2021	Jun 2021	Jul 2021	Aug 2021	Sep 2021	Oct 2021	Nov 2021	Dec 2021	Jan 2022	
+YBB temp (K)	303.451	303.189	303.115	302.915	302.943	302.951	303.047	303.197	303.661	303.858	303.879	
NEDT (mK)	S7	17.3	17.2	17.3	17.6	17.6	17.5	18.0	17.3	17.2	16.9	17.0
	S8	11.9	11.8	11.7	11.8	12.0	11.8	11.8	11.8	11.8	11.8	11.8
	S9	18.7	18.4	18.2	18.3	18.3	18.4	18.5	18.5	18.5	18.5	18.5
	F1	274	274	276	285	329	283	297	279	279	273	275
	F2	35.7	34.8	33.7	33.7	33.7	33.8	34.2	35.1	35.3	35.5	35.4

SLSTR-A	Mar 2021	Apr 2021	May 2021	Jun 2021	Jul 2021	Aug 2021	Sep 2021	Oct 2021	Nov 2021	Dec 2021	Jan 2022	
-YBB temp (K)	265.908	265.715	265.772	265.557	265.528	265.420	265.480	266.040	266.641	266.897	266.824	
NEDT (mK)	S7	49.9	50.6	50.5	50.8	50.8	50.6	49.2	49.4	48.3	47.2	47.8
	S8	14.8	14.7	14.5	14.5	14.6	14.5	14.5	14.5	14.5	14.5	14.5
	S9	23.1	22.9	22.5	22.5	22.6	22.6	22.5	22.7	22.7	22.7	22.8
	F1	1188	1197	1205	1227	1233	1223	1184	1186	1158	1132	1145
	F2	29.1	29.0	28.8	28.8	28.8	28.8	29.1	28.8	28.9	28.9	28.9

2.5.4 SLSTR-B TIR channel NEDT

The thermal channel NEDT values for SLSTR-B in January 2022, calculated from the hot and cold blackbody signals are shown in Figure 12 with monthly averages in Table 6. Note that these averages are now calculated for each calendar month, whereas in previous data quality reports they were aligned to the satellite 27 day repeat cycles.

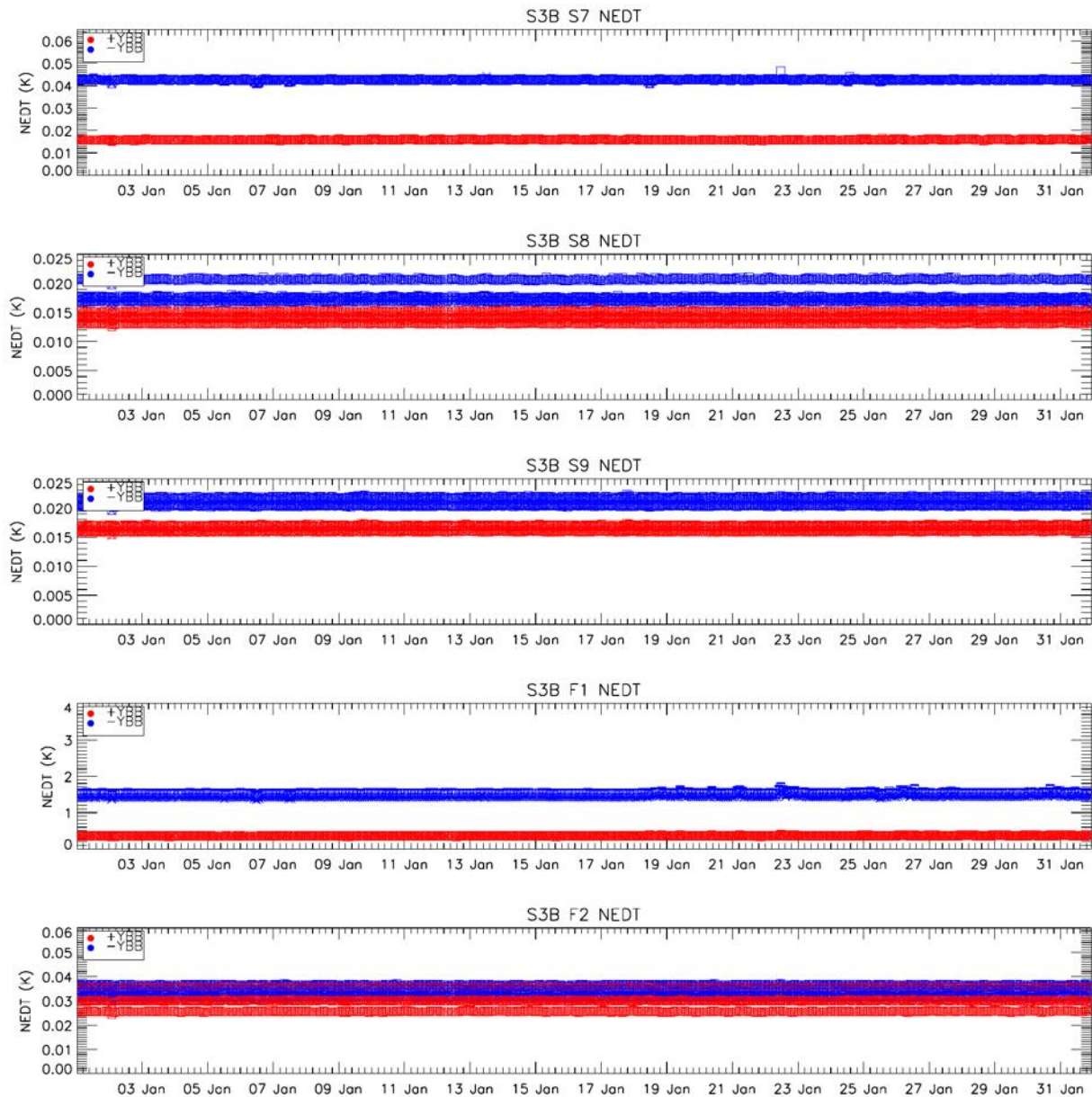



Figure 12: SLSTR-B NEDT trend for the thermal channels in January 2022. Blue points were calculated from the cold blackbody signal and red points from the hot blackbody. The square symbols show results calculated from the nadir view and crosses show results from the oblique view. Results are plotted 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 months averaged over all detectors for both Earth views towards the hot +YBB (top) and the cold -YBB (bottom).

SLSTR-B	Mar 2021	Apr 2021	May 2021	Jun 2021	Jul 2021	Aug 2021	Sep 2021	Oct 2021	Nov 2021	Dec 2021	Jan 2022	
+YBB temp (K)	303.383	303.151	303.160	302.970	302.981	302.972	303.084	303.268	303.717	304.077	304.027	
NEDT (mK)	S7	16.0	16.0	16.1	16.2	16.2	16.2	16.5	16.3	16.1	15.8	15.9
	S8	14.0	14.0	14.2	14.1	14.2	14.2	14.2	14.2	14.1	14.1	14.1
	S9	16.0	16.0	16.1	16.1	16.2	16.3	16.4	16.4	16.4	16.3	16.4
	F1	362	359	396	372	363	364	376	373	362	355	363
	F2	30.4	30.3	30.4	30.3	30.3	30.2	30.3	30.5	30.7	30.6	30.5

SLSTR-B	Mar 2021	Apr 2021	May 2021	Jun 2021	Jul 2021	Aug 2021	Sep 2021	Oct 2021	Nov 2021	Dec 2021	Jan 2022	
-YBB temp (K)	265.374	265.220	265.397	265.189	265.153	265.041	265.105	265.667	266.304	266.725	266.579	
NEDT (mK)	S7	44.1	44.0	44.2	44.1	44.1	44.6	44.1	43.5	42.7	42.2	42.6
	S8	18.0	17.9	18.0	17.9	18.0	18.1	18.1	18.0	18.1	18.1	18.1
	S9	20.5	20.6	20.7	20.7	20.8	20.9	20.9	20.9	20.9	20.9	21.0
	F1	1513	1500	1492	1532	1483	1515	1504	1489	1465	1439	1483
	F2	33.3	33.3	33.4	33.4	33.4	33.6	33.6	33.6	33.5	33.5	33.6

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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 build-up 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 recent decontaminations for SLSTR-A were performed in February and May 2020, and April 2021. For SLSTR-B, recent decontaminations were performed in September 2019 and November 2020.

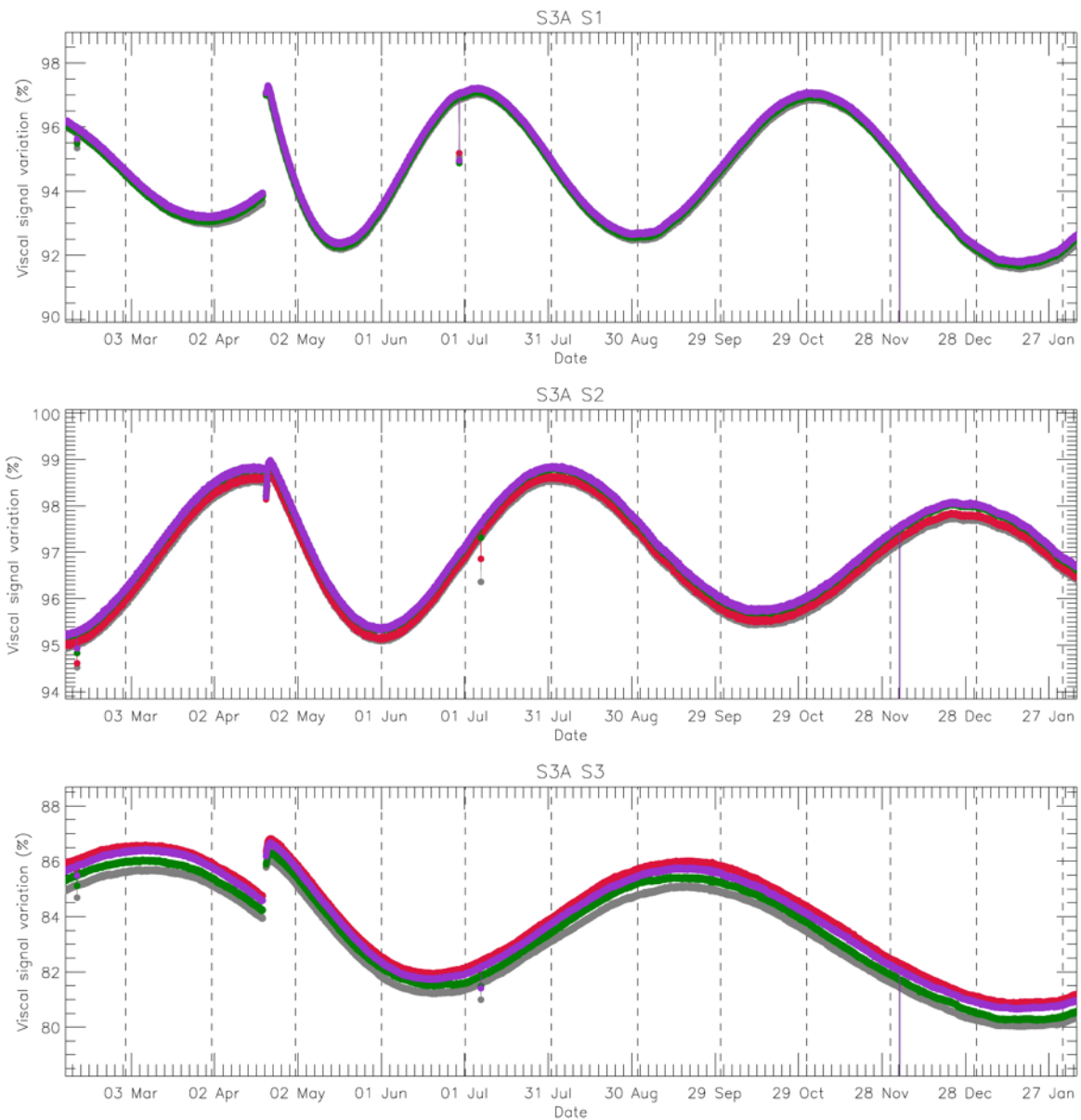


Figure 13: Variation of the radiometric gain derived from the VISCAL signals for SLSTR-A VIS channels for the last year of operations (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start of each month.

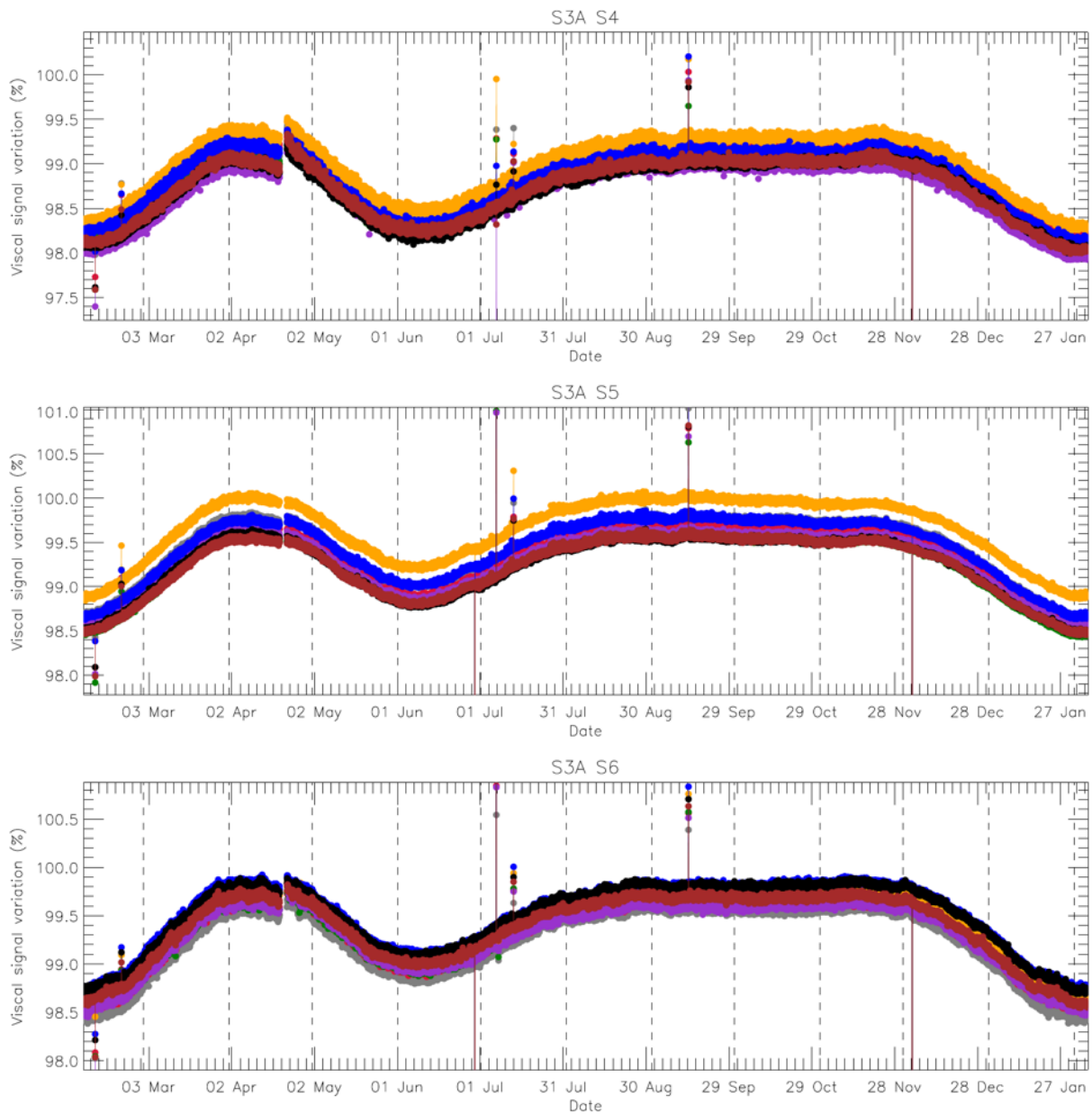


Figure 14: Variation of the radiometric gain derived from the VISCAL signals for SLSTR-A SWIR channels for the last year of operations (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start of each month.

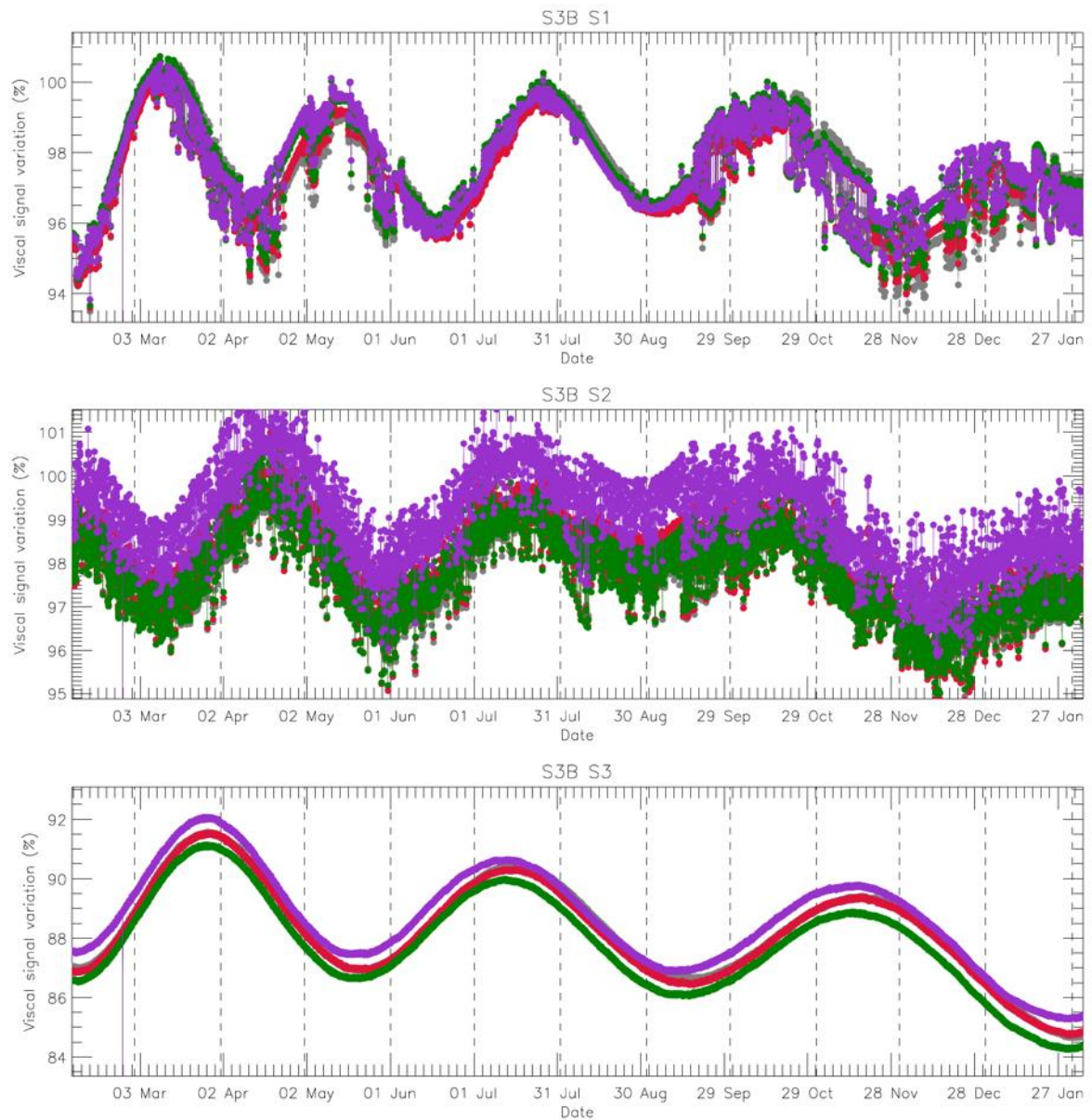


Figure 15: Variation of the radiometric gain derived from the VISCAL signals for SLSTR-B VIS channels for the past year (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start of each month.

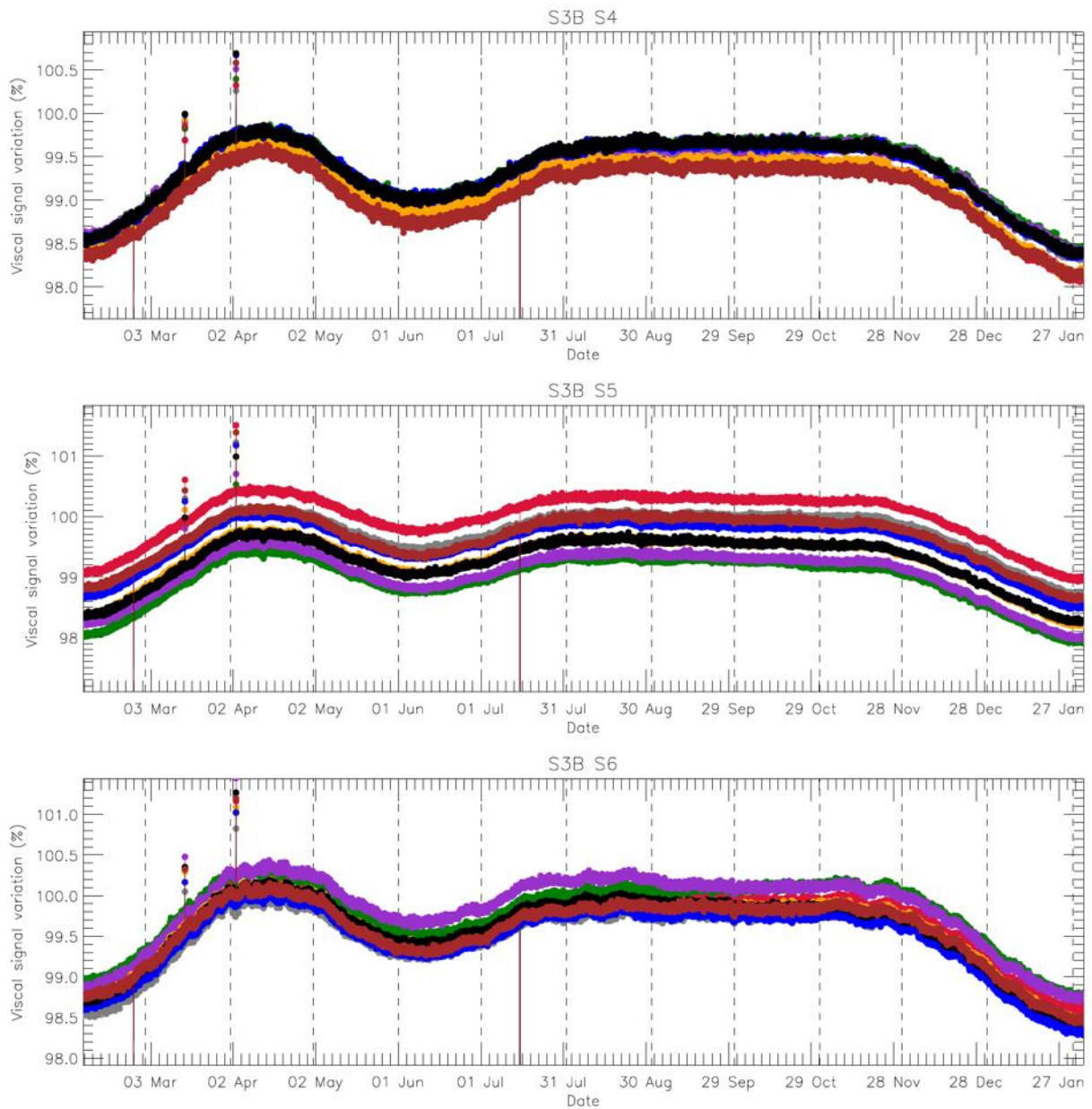


Figure 16: Variation of the radiometric gain derived from the VISCAL signals for SLSTR-B SWIR channels for the past year (nadir view). Different colours represent different detectors. The vertical dashed lines indicate the start of each month.

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) imagerettes. 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 for January 2022 are plotted in Figure 17 for SLSTR-A and Figure 18 for SLSTR-B, giving the average positional offsets in kilometres for Nadir and Oblique views.

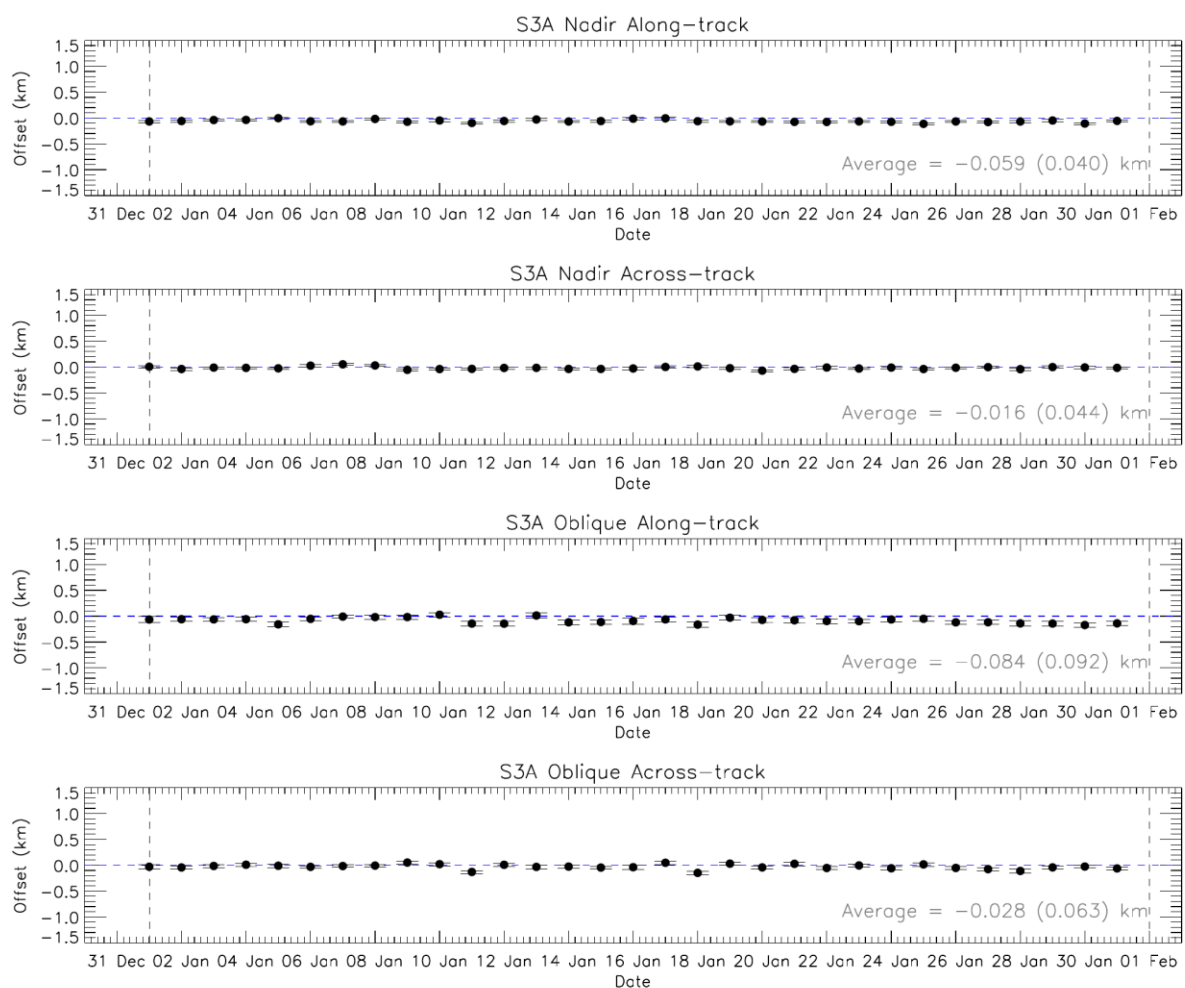


Figure 17: SLSTR-A daily offset results in km from the GeoCal Tool analysis for Nadir along- and across-track (top two plots) and Oblique along- and across-track (bottom two plots) for January 2022. The error bars show the standard deviation.

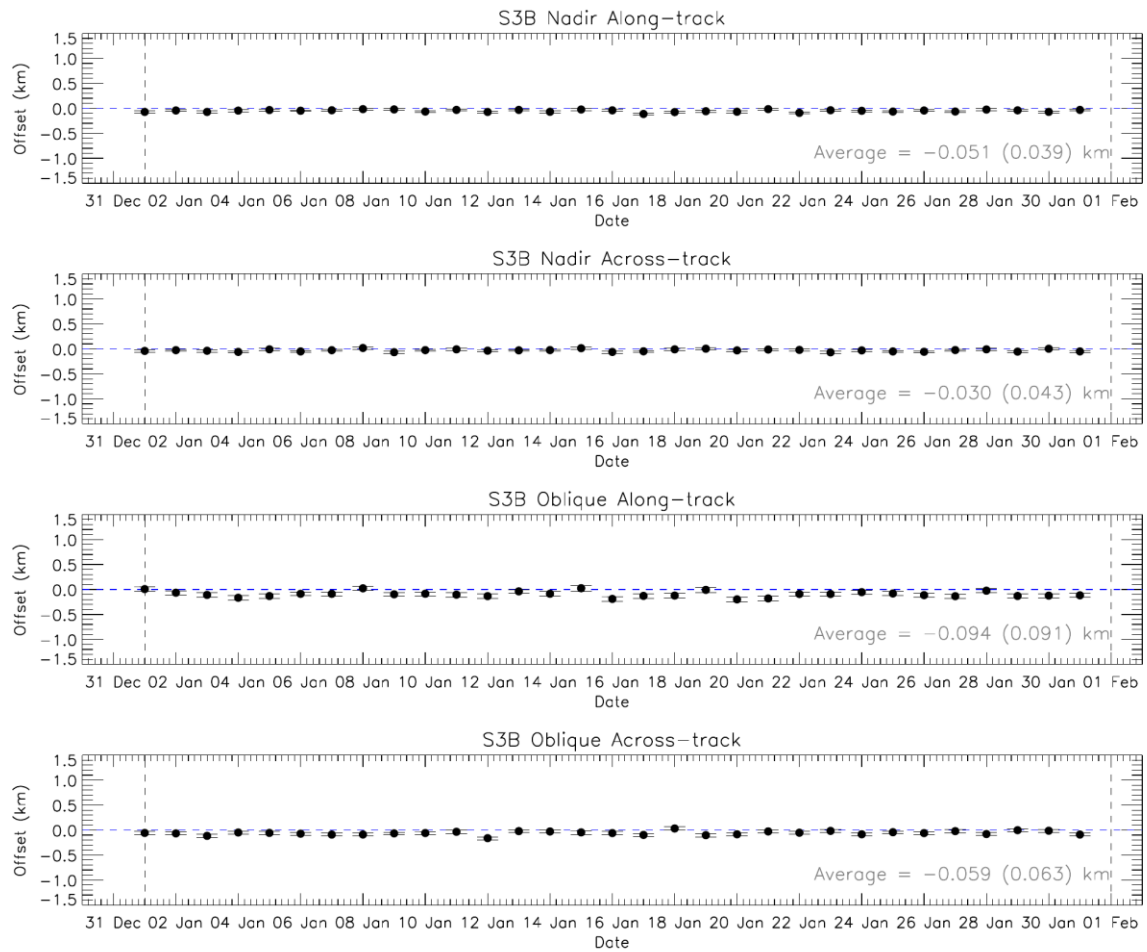


Figure 18: SLSTR-B daily offset results in km from the GeoCal Tool analysis for Nadir along- and across-track (top two plots) and Oblique along- and across-track (bottom two plots) for January 2022. The error bars show the standard deviation.

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

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

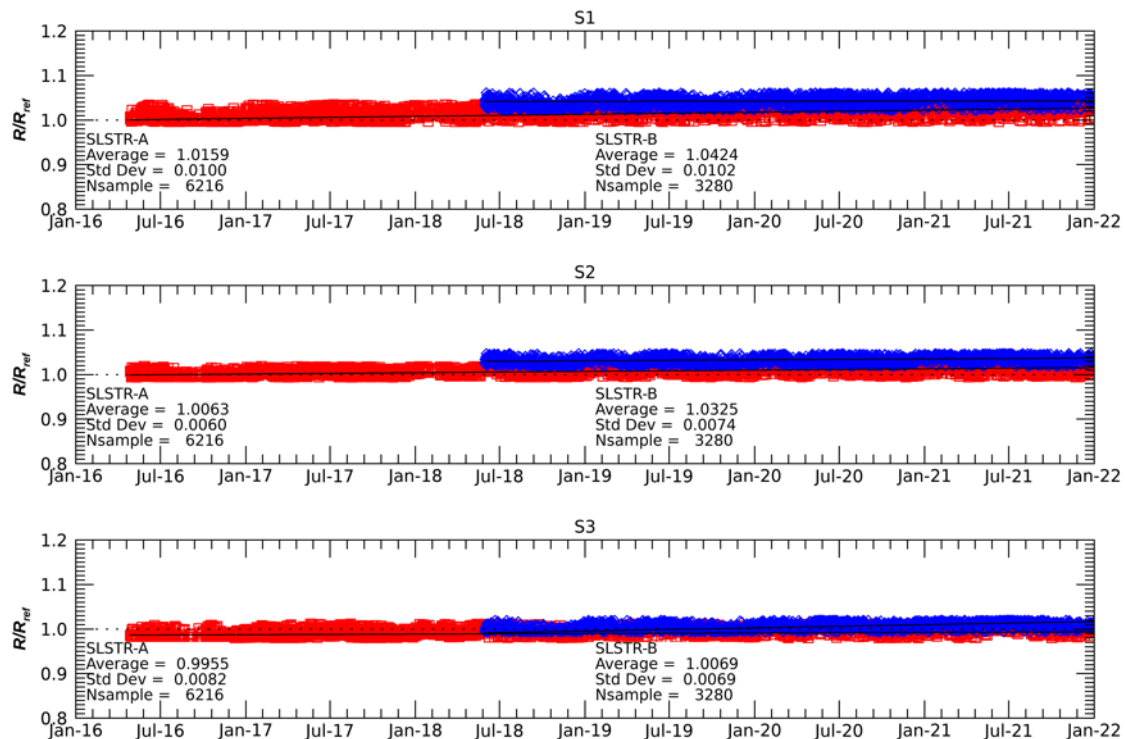


Figure 19: Ratio of SLSTR-A and OLCI-A radiances (red) and SLSTR-B and OLCI-B radiances (blue) for the visible channels in Nadir view using combined results for all desert sites.

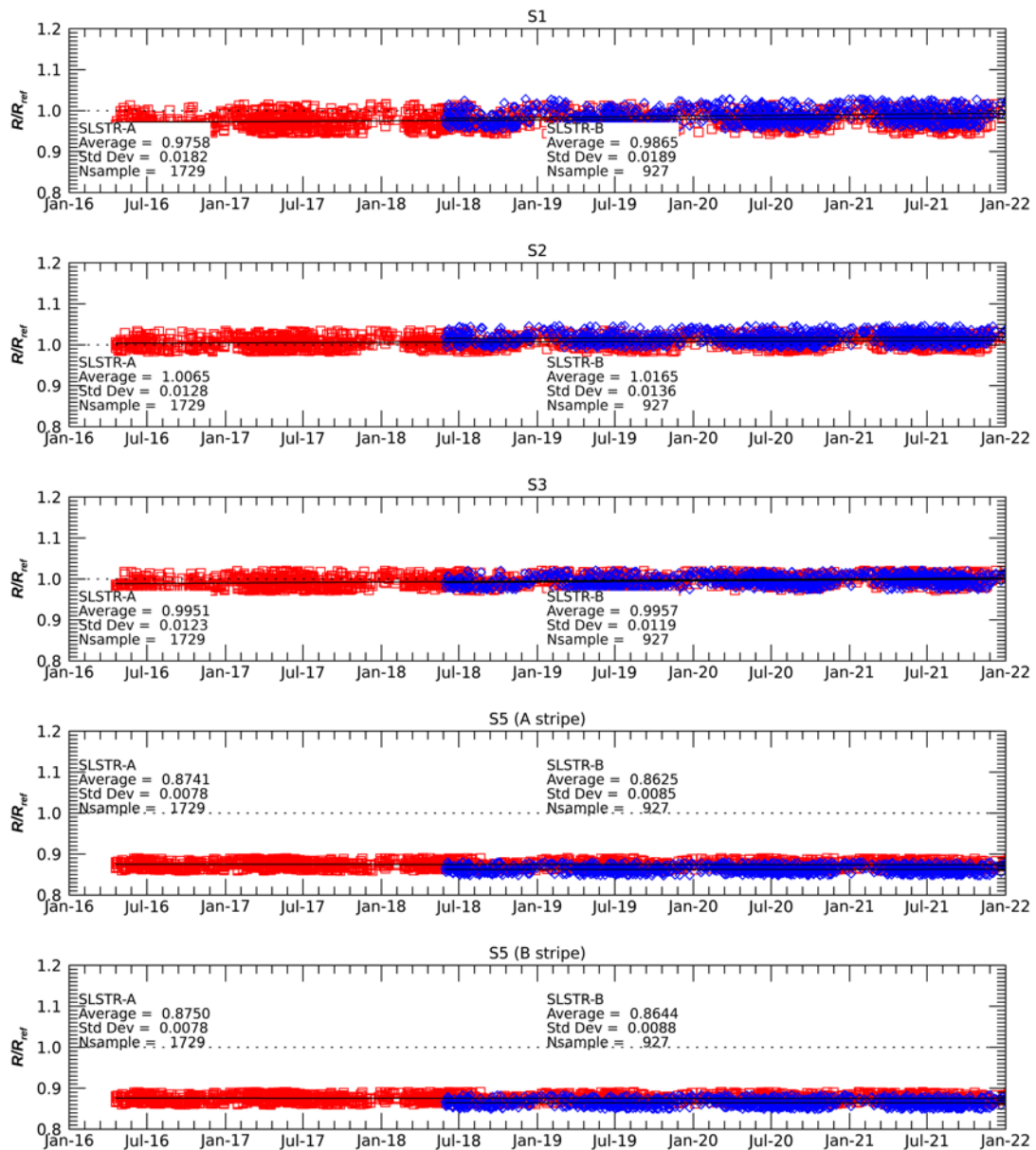


Figure 20: Ratio of SLSTR-A (red) and SLSTR-B (blue) with AATSR radiances in Nadir view using combined results for all desert sites.

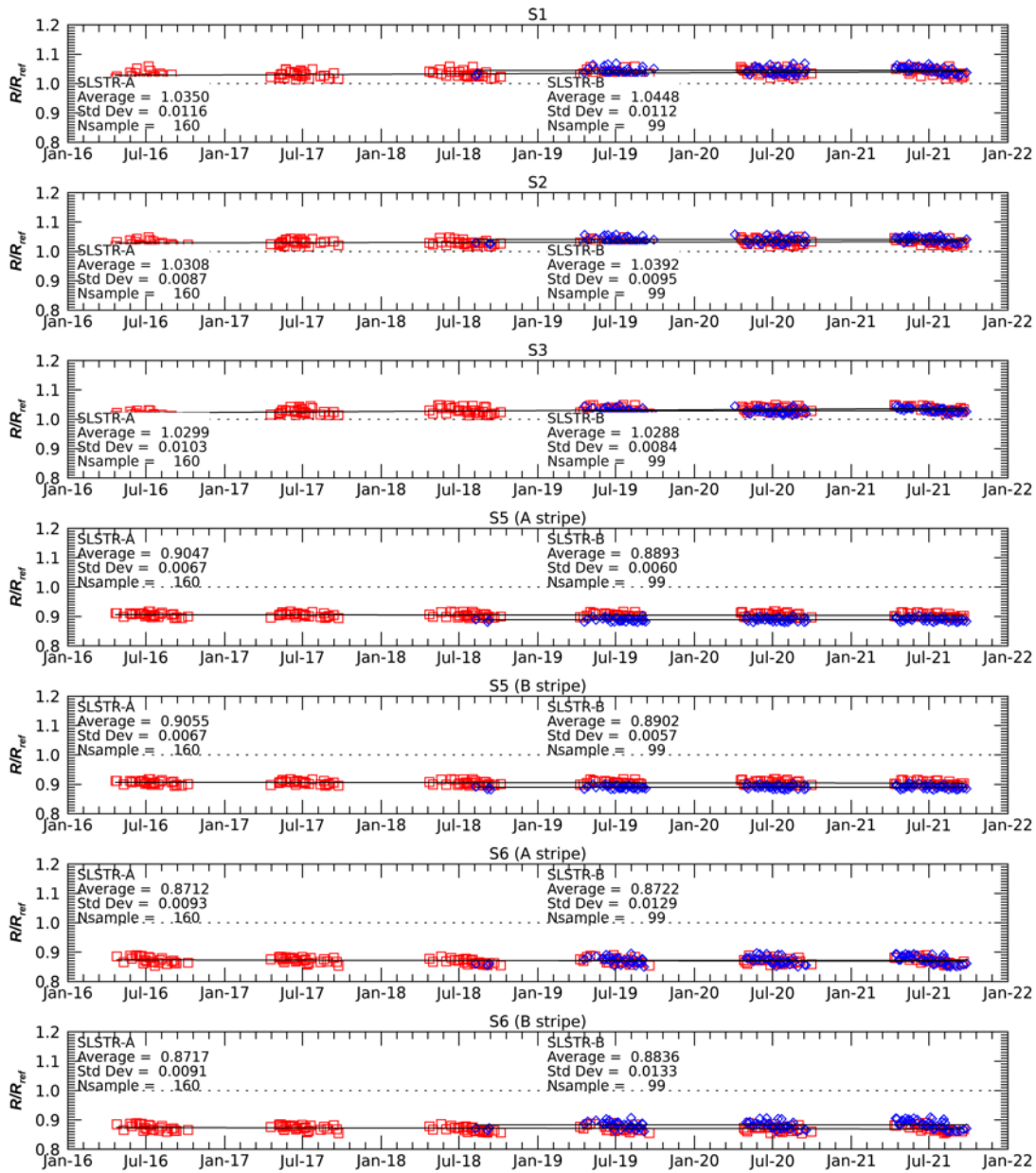


Figure 21: Ratio of SLSTR-A (red) and SLSTR-B (blue) with MODIS radiances in Nadir view using combined results for all desert sites.

3.3 Image quality

The Level-1 image quality is assessed when data are available at the MPC. For example by combining all granules over one day into a single combined image. The S3A and S3B satellites are configured to be 140 degrees out of phase in order to observe complimentary portions of the earth. Figure 22 shows an example combined SLSTR-A/SLSTR-B image for the visible channels on 15th January 2022 (daytime only).

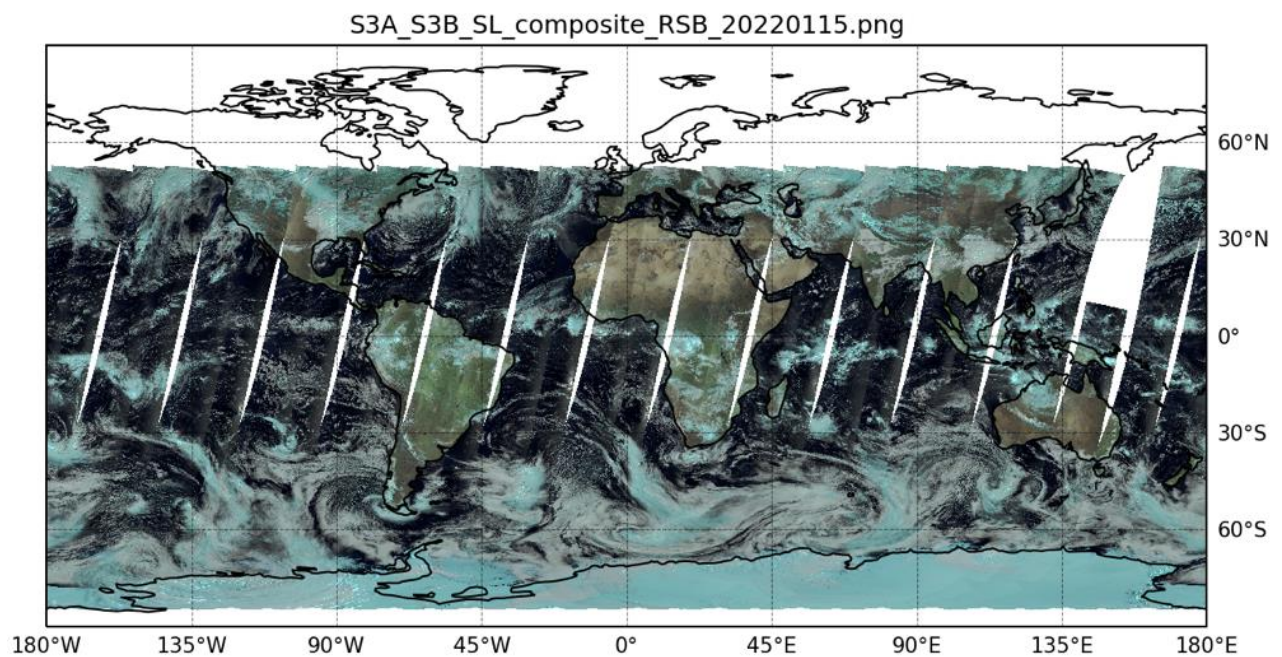
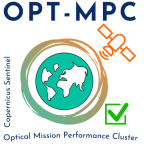


Figure 22: Daytime combined SLSTR-A and SLSTR-B Level-1 image for visible channels on 15th January 2022.

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4 Level-2 SST validation

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

5 Level 2 LST validation

Level 2 Land Surface Temperature products have been validated against *in situ* observations (Category-A validation) from twelve “Gold Standard” Stations, and intercompared (Category-C validation) with respect to an independent operational reference product (SEVIRI from LSA SAF). In all cases it is the NTC products that are validated, and the Probabilistic cloud masking implementation is used for all cloud masking. Level-3C products for the full month of January 2022 for SLSTR-A and 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. In each case the latest temporal interpolation for the probabilistic cloud mask is applied following the L1 operational release on 15th January 2020. The updated cloud coefficients ADF was applied on 23rd October 2020.

5.1 Category-A validation

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

Satellite	Average absolute accuracy vs. Gold Standard (K)	
	Day	Night
S3A	1.1	1.0
S3B	1.2	0.7

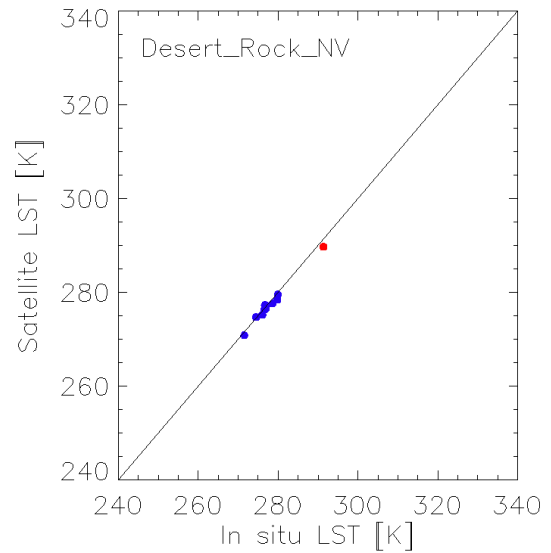
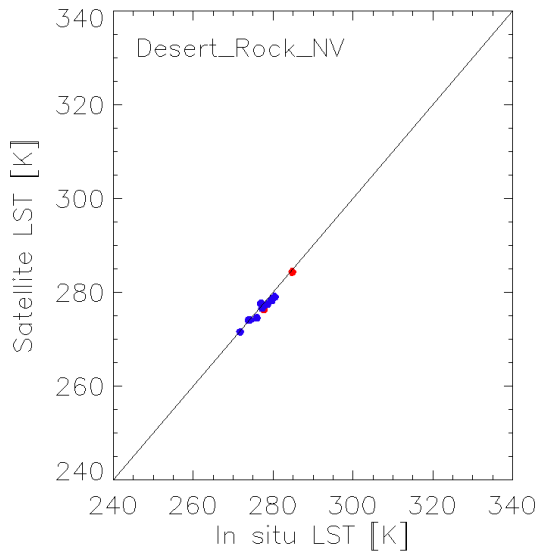
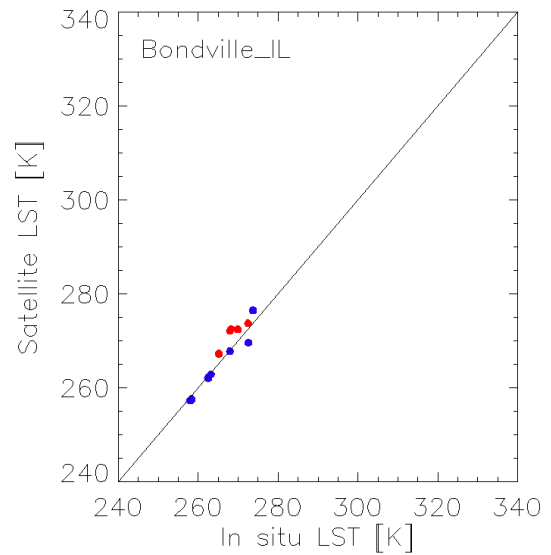
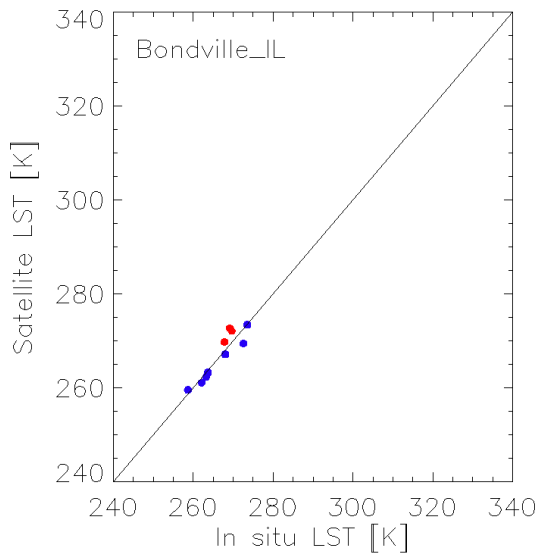
For both SLSTR-A and SLSTR-B both the daytime and night-time accuracies are within or very close to the mission requirement of 1K, even though they are impacted to some extent by very small number of matchups for some stations in the month due to actual cloud, or over-masking. The number of matchups across most stations for daytime are very low particularly during the day, and have impacted the biases to an extent. An updated cloud coefficients ADF was delivered on 23rd October 2020.

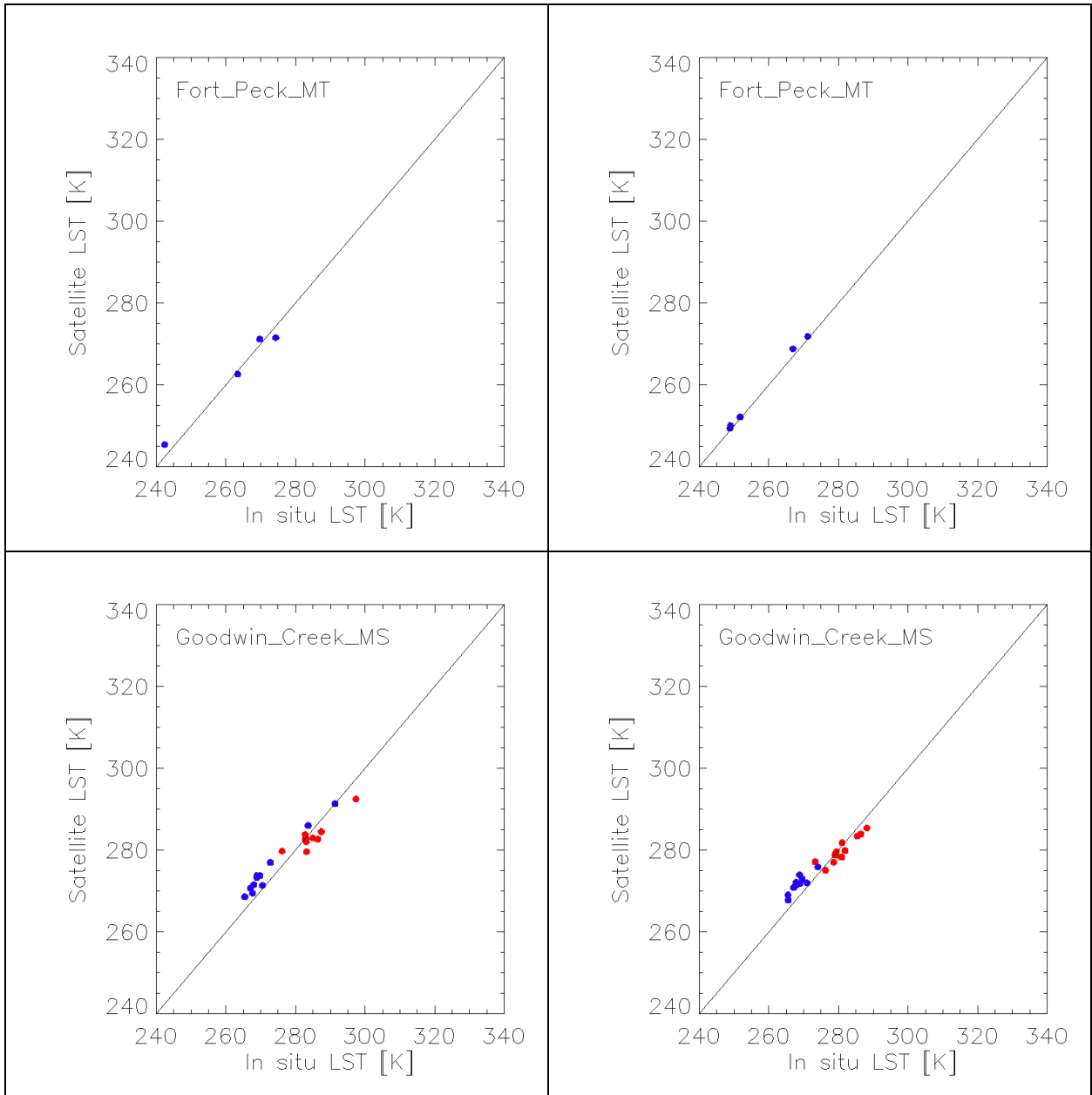


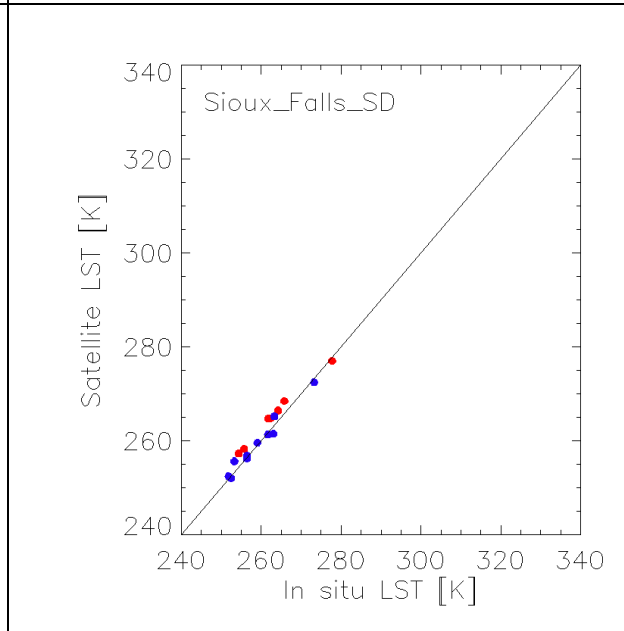
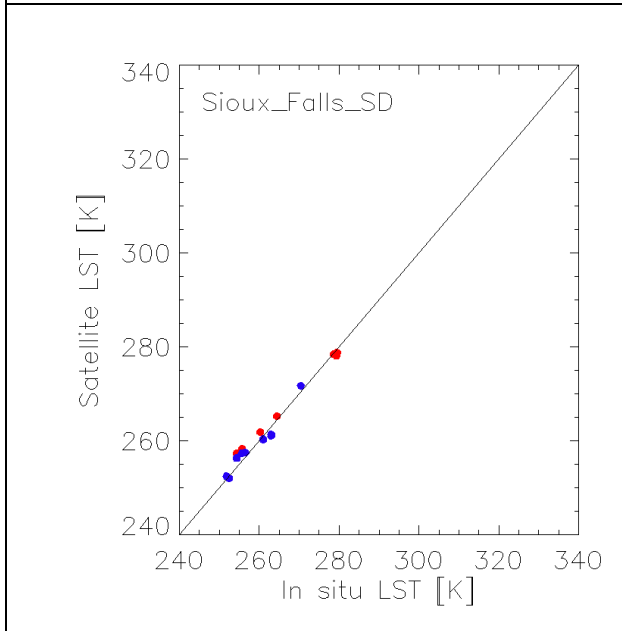
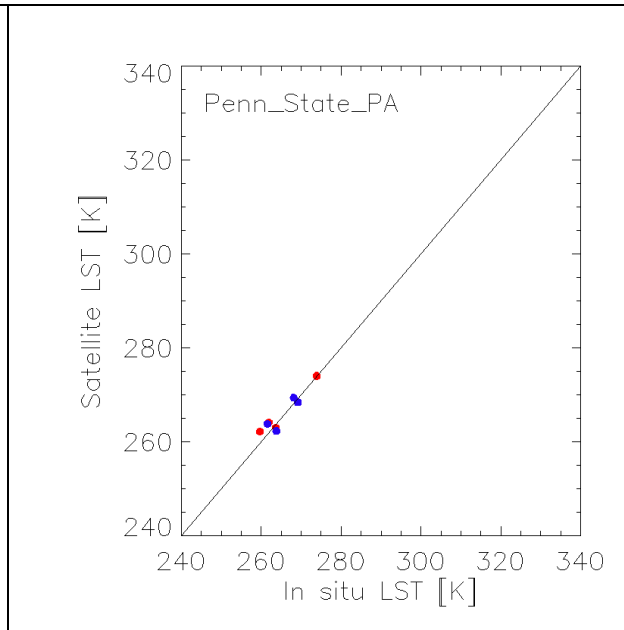
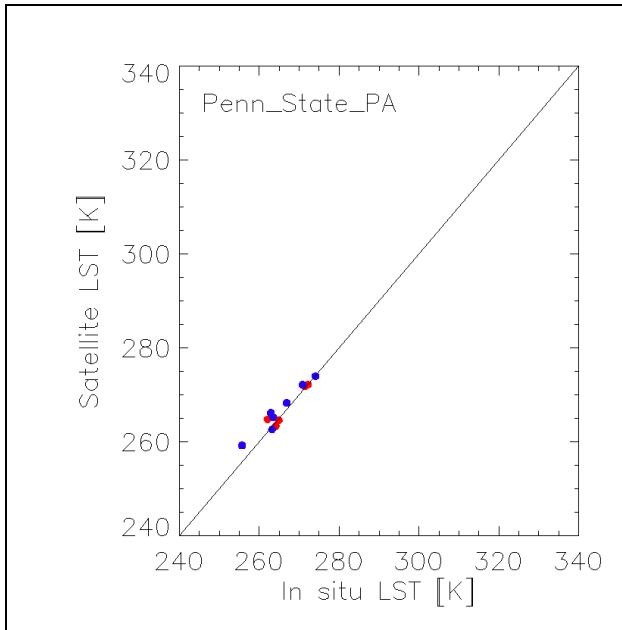
Validation of the SL_2_LST product in January 2022 for SLSTR-A (left) and SLSTR-B (right) at seven Gold Standard in situ stations of the SURFRAD network plus two Gold Standard station from the ARM network, and two Gold Standard station from the USCRN network

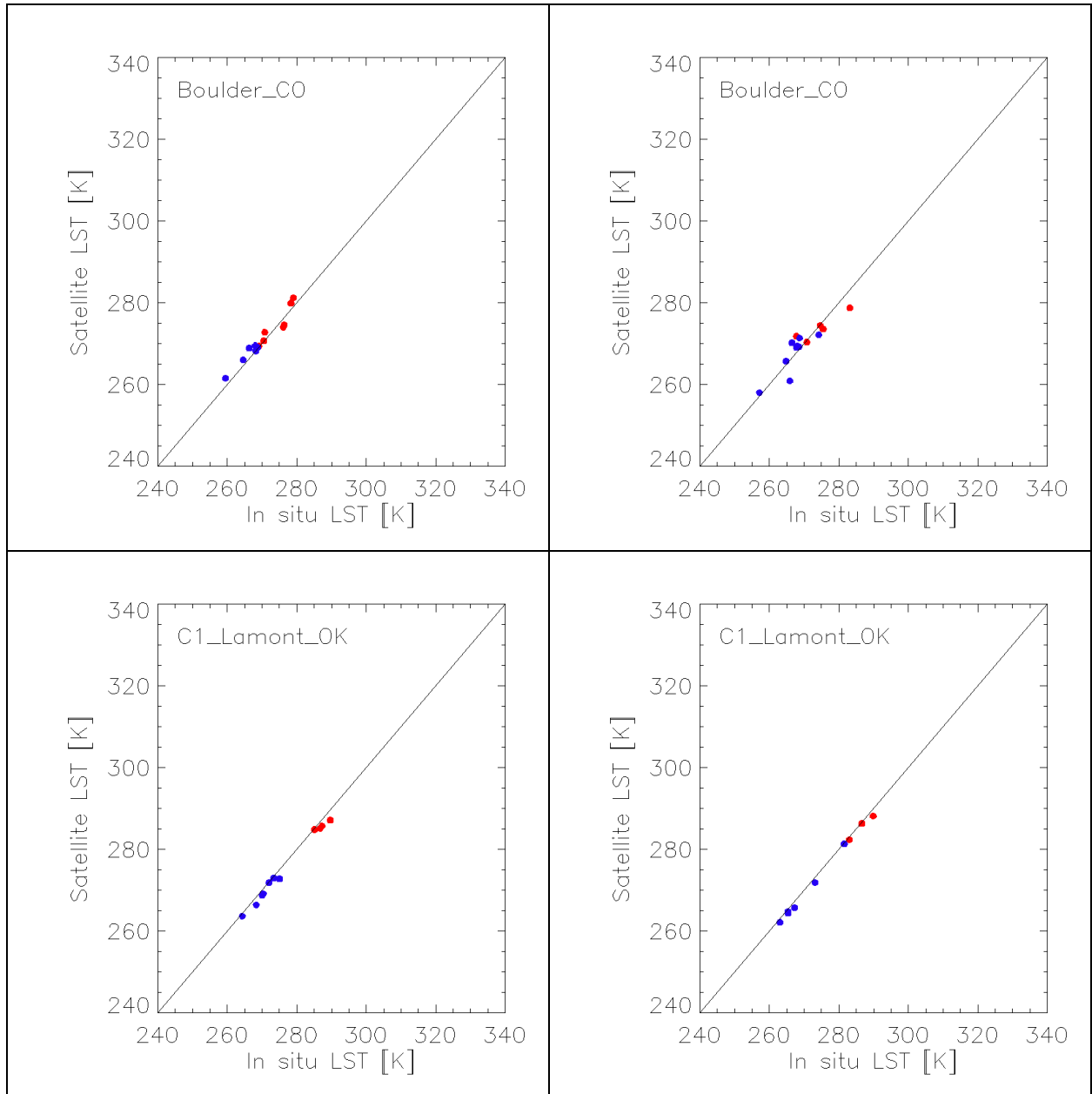
SLSTR-A

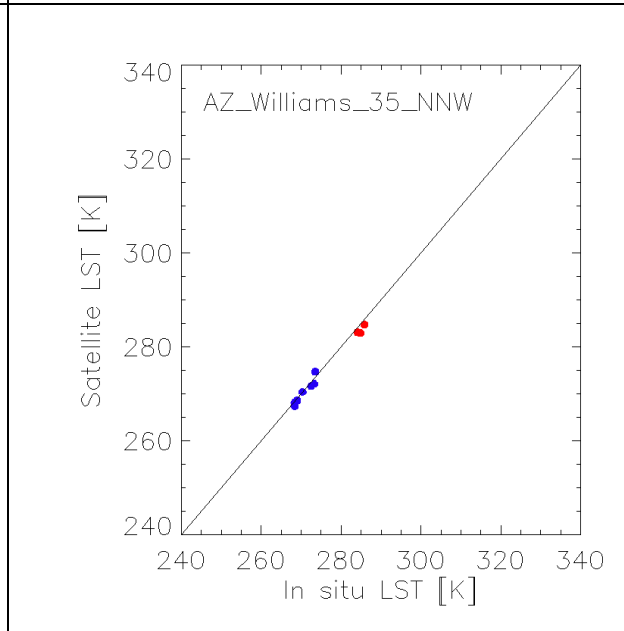
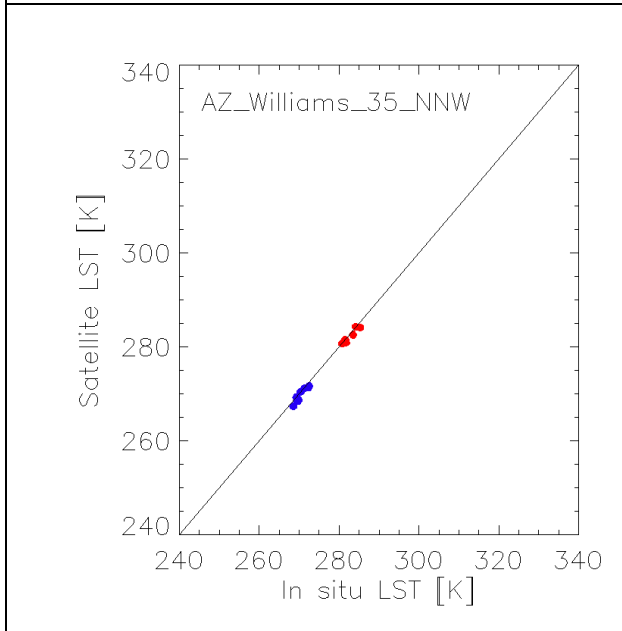
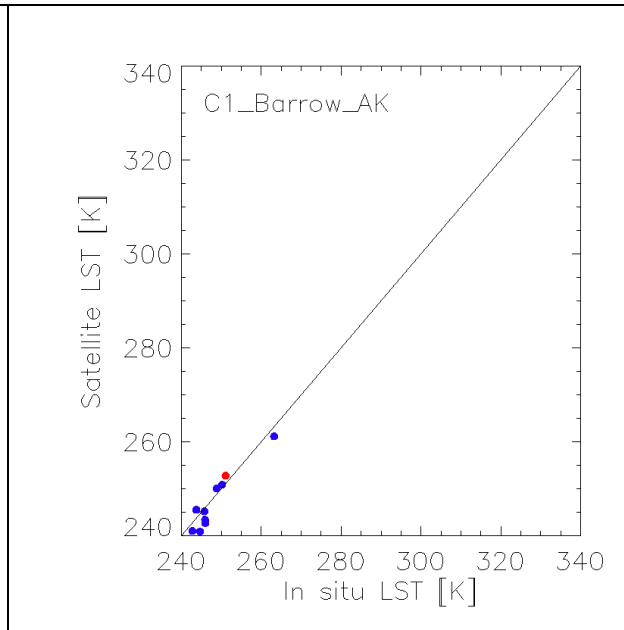
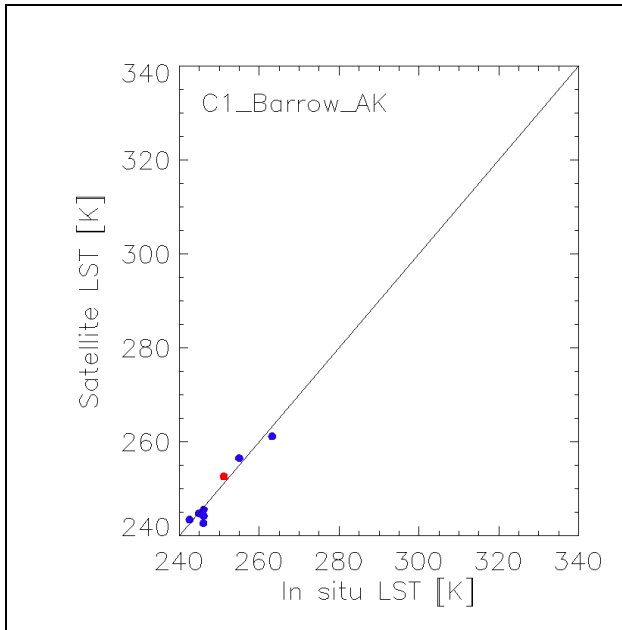
SLSTR-B

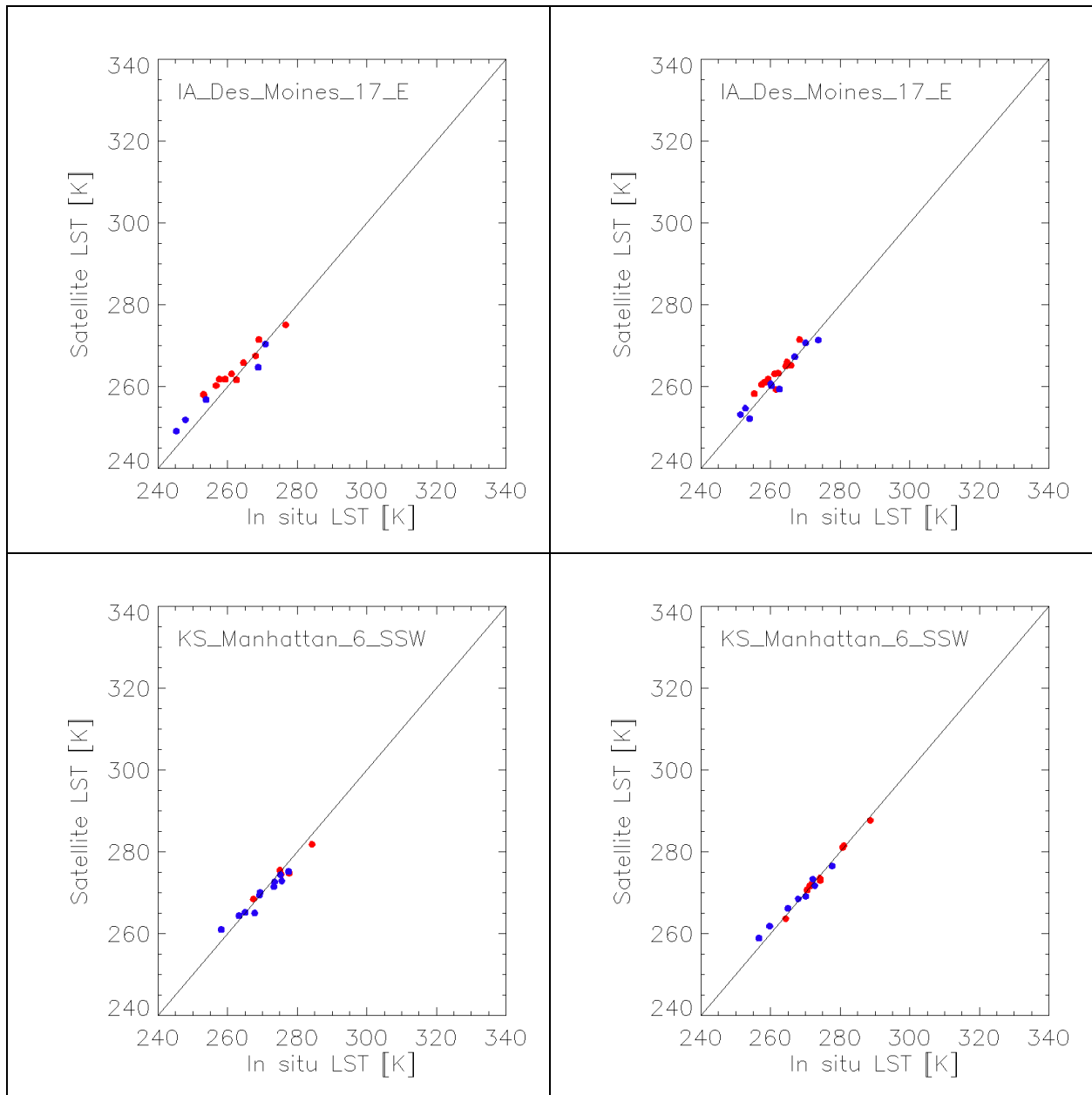












As with past months, cloud has reduced the number of matchups per station to single figures for most stations during day or night, with some missing statistics entirely. It is therefore challenging to determine robust statistics. Nonetheless, it can be seen that overall the matchups are in general close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

5.2 Category-C validation

Category-C validation uses inter-comparisons with similar LST products from other sources such as other satellite sensors, which give important quality information with respect to spatial patterns in LST deviations. Here we compare the SL_2_LST product from both SLSTR-A and SLSTR-B with the operational SEVIRI L2 product available from the LSA SAF. The results can be summarised:

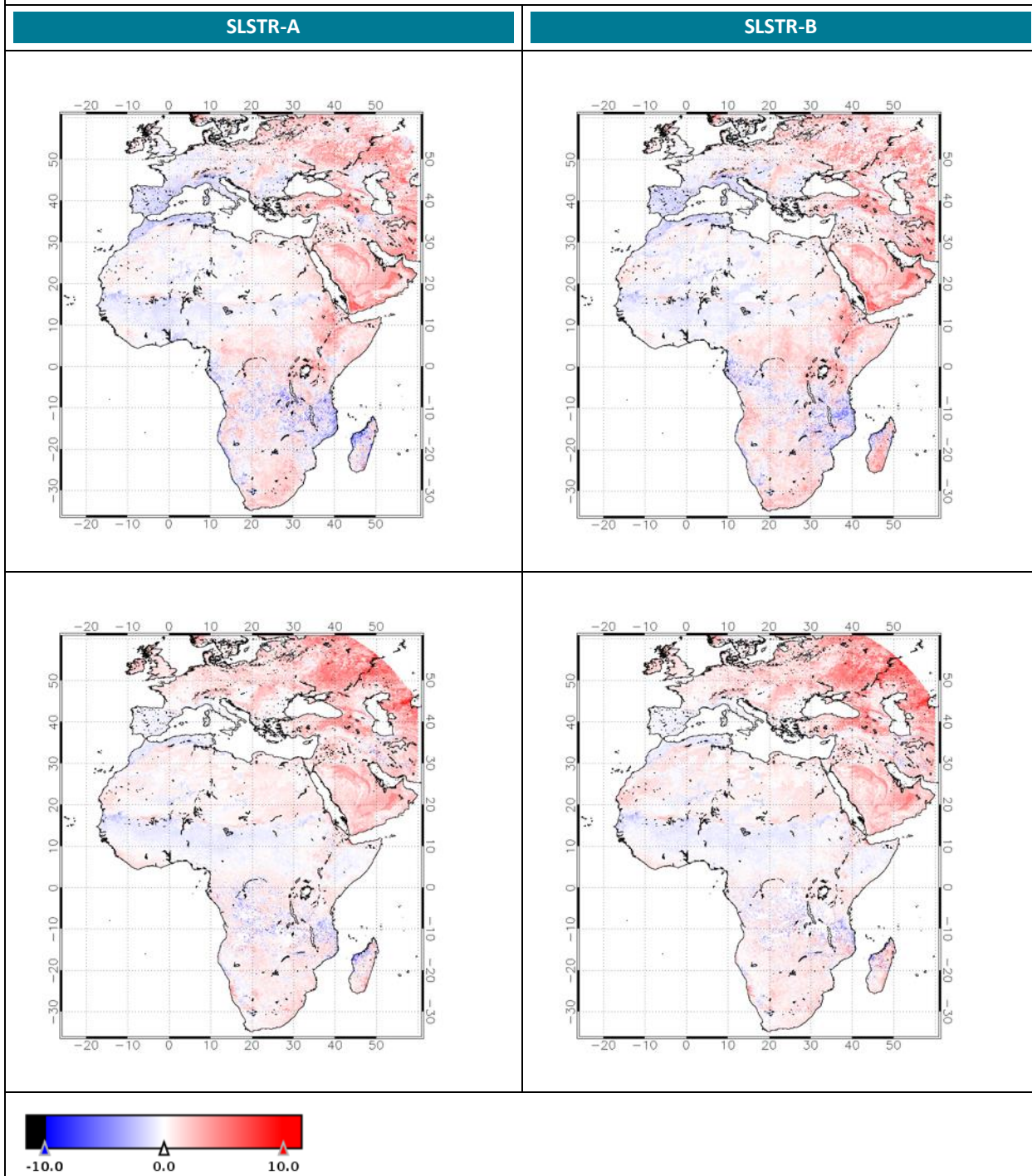
Continent	Median differences in K from the intercomparison of the SL_2_LST product with respect to the operational LSA SAF SEVIRI LST product for January 2022			
	SLSTR-A		SLSTR-B	
	Day	Night	Day	Night
Africa	0.3	0.3	0.4	0.3
Europe	1.1	1.9	1.1	1.9

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 and north-eastern Europe) are towards the edge of the SEVIRI disk and therefore represent large viewing angles. At these extreme viewing angles it is expected that SLSTR LST would be increasingly higher than SEVIRI LST. For both daytime and night-time the differences are mainly < 1K for Africa for both SLSTR-A and SLSTR-B. During daytime differences are over 1K for Europe as a result of increasing differences due to geometry as days get warmer. Differences are not the same as previous months 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

Intercomparison of the SL_2_LST product with respect to the operational LSA SAF SEVIRI LST product for January 2022 for SLSTR-A (left) and SLSTR-B (right). Daytime composites are in the top row and Night-time composites are in the bottom row

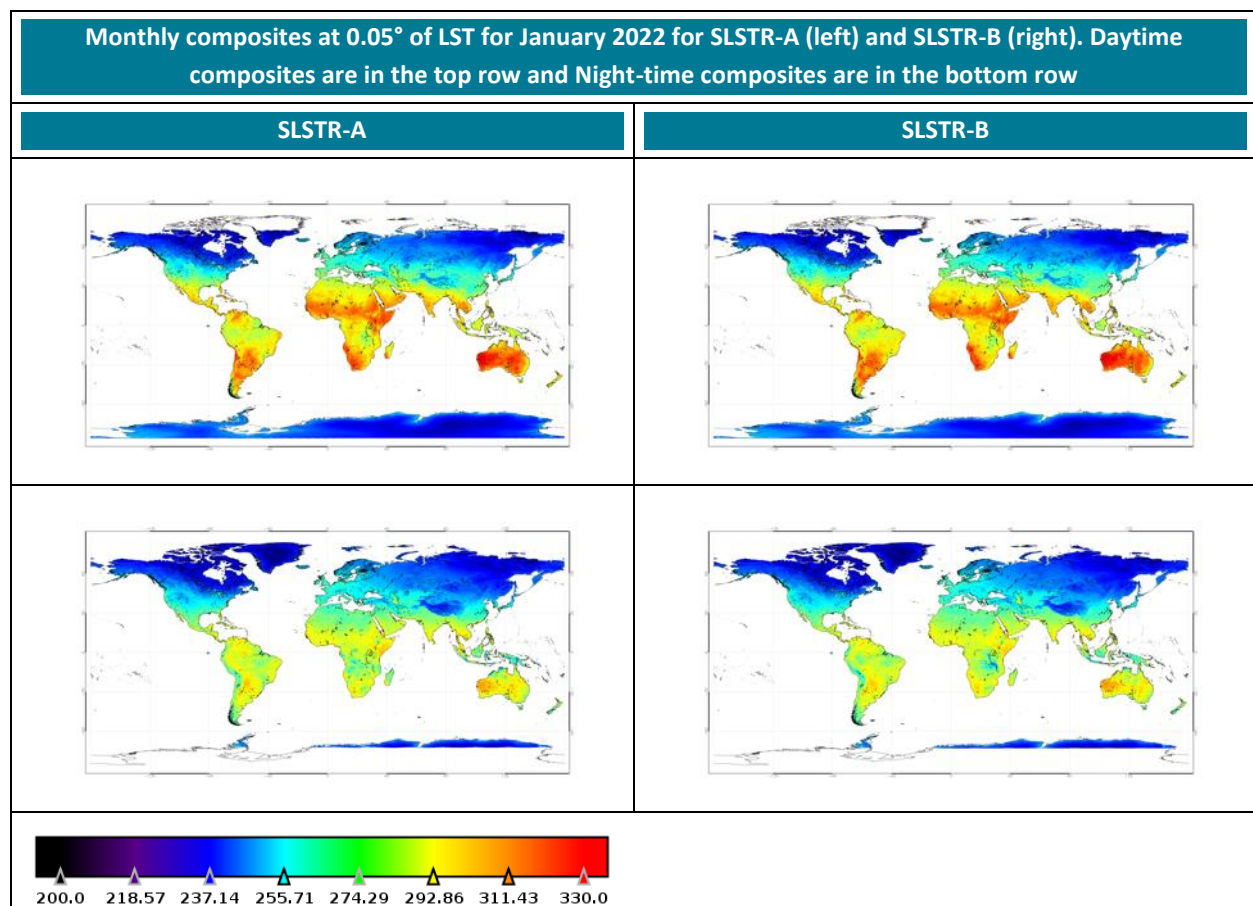


While some of these differences are > 1 K they are all within the corresponding uncertainty of SEVIRI at the pixel-scale (> 2 K), and so the **two products can be assessed as being consistent**. It should also be noted that there are no significant differences between the two products in terms of biome-dependency - the differences are consistent across biomes. An area of stronger differences is evident over the north-east Sahara which is being investigated. 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 months 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 months to identify whether an optimisation to the cloud coefficients should be considered for some biomes.

5.3 Level-3C Assessment

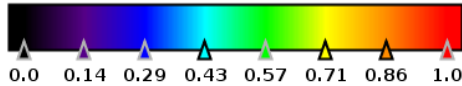
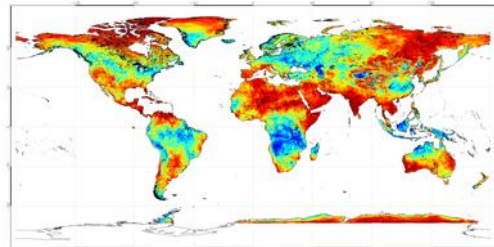
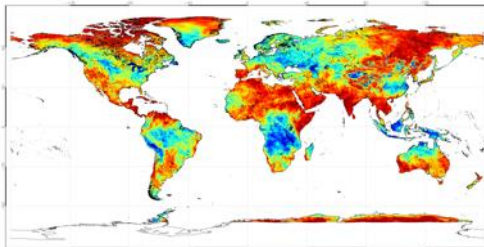
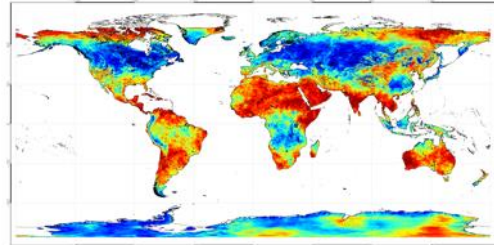
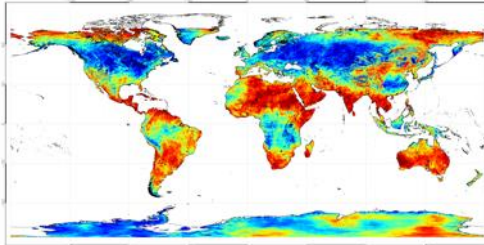
To better understand the global product and identify any gross issues Level-3 evaluation is also performed. Here we generate monthly daytime and night-time 0.05° composites of the LST field and corresponding sampling ratios. The sampling ratios are derived as $\text{clear_pixels} / (\text{clear_pixels}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



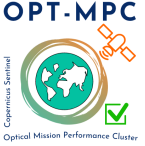
Monthly composites at 0.05° of sampling ratio for January 2022 for SLSTR-A (left) and SLSTR-B (right).
Daytime composites are in the top row and Night-time composites are in the bottom row

SLSTR-A

SLSTR-B



The LST fields indicate the SL_2_LST product is producing values in line with expectations for both SLSTR-A and SLSTR-B. There are no distinct issues or non-physical values evident. The sampling ratio is now closer to what would be expected across the globe following the implementation of the temporal interpolation for the probabilistic cloud mask on 15th January 2020. Cloud contamination appears to be low, although there appears to be some excessive cloud clearing in some regions and undermasking in other, indicating the cloud coefficients ADF will need tuning for both instruments now the issue regarding the temporal interpolation has been resolved. The update to the ADF has now been implemented as of 23rd October 2020.

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6 Level 2 FRP validation


Level 2 Fire Radiative Power products have been compared with respect to an independent operational reference product (MODIS Terra MOD14 FRP). In particular, to evaluate the performance of the night-time algorithm, an inter-comparison between the SLSTR NTC FRP (both from SLSTR-A and SLSTR-B) and the FRP retrieved from the similar MODIS MOD14 product was designed and conducted, giving important information on both spatial patterns of fire detection and FRP quantification. The inter-comparison procedure, initially based on previous work from M. Wooster and W. Xu on the FRP Prototype and on the evaluation of SEVIRI fire data, is divided into two main parts, the first one related to active fire (AF) pixel detection and omission and commission fire pixels, and the second to fire clusters. The SLSTR FRP NTC product (both SLSTR-A and SLSTR-B) has been released to the public on the 19th August 2020. The current processing baseline for SLSTR-A FRP products is v2.77 and for SLSTR-B is v1.55. The baseline was deployed in the Land processing centres on 14th June 2021 for SLSTR-A and for SLSTR-B. AF detection is initially performed using S7, and the FRP retrieval can then be performed in two ways: either using S7 when all active fire pixels in an identified active fire cluster remain unsaturated and F1 otherwise (the so called F1_OFF option), or always using F1 regardless of S7 saturation (the F1_ON option). At present, the algorithm is predominantly delivering active fire detections and FRP data from night-time (ascending node) S3A and S3B overpasses, as the S7 (middle infrared) channel saturates frequently over warm surfaces during day-time. The current configuration makes use of the F1_ON option for the processing.

6.1 FRP validation

The SLSTR FRP validation uses inter-comparisons with similar FRP products from other sources such as other satellite sensors, which give important quality information with respect to active fire detection and fire clusters characterisation. Here we compare the SL_2_FRP product from both SLSTR-A and SLSTR-B with the operational MODIS MOD14 FRP product (from MODIS Terra) available from the LAADS DAAC. It is important to note that the employed products have slightly different overpass times, implying that the two sensors do not observe fires in the exact same configuration nor with the same atmospheric conditions. Thus, for these reasons, and for the nature of the procedure delineated below, this inter-comparison should not be interpreted as a full validation exercise but rather as a check of the consistency of the FRP products derived from SLSTR with the ones from MODIS. The inter-comparison procedure is divided into two main parts. The first part is related to omission and commission fire pixels, i.e., fire pixels detected by MODIS without any SLSTR fire pixel in a 7x7 window around it (omissions), and fire pixels detected by SLSTR without any MODIS fire pixel in a 7x7 window around it (commissions). The second part is related to the characterisation of fire clusters, i.e., groups of one or more pixels spatially adjacent to each other and corresponding to a single fire. A description is given in the following.

Part 1, omission and commission fire pixels between SLSTR FRP and MODIS MOD14:

- ❖ Select areas of high fire activity during the relevant time period and fetch all the relative SL_2_FRP scenes (both SLSTR-A and SLSTR-B);
- ❖ Discard all scenes that do not contain active fire pixels;

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- ❖ Select and download matching MODIS MOD14 data with overpass time within ± 6 minutes of those of SLSTR and covering the same area of interest, and discard all scenes that do not have a matching MOD14 product;
- ❖ Restrict observations to a scan angle of $\pm 30^\circ$ or equivalent pixel area of 1.7 km^2 to avoid edge-of-swath data, and restrict to the common area of detection between the two products;
- ❖ Discard all scenes that do not contain active fire pixels after the restriction step;
- ❖ Re-project the MODIS pixels to the SLSTR Level 1b data grid. If multiple MODIS active fire pixels (AFP) are present in the same equivalent SLSTR grid cell, their combined FRP is used;
- ❖ Evaluate SLSTR FRP commission fire pixels, i.e., when there is a fire pixel in the SLSTR grid without any MOD14 fire pixel in a 7×7 window around it;
- ❖ Evaluate SLSTR FRP omission fire pixels, i.e., when there is a MOD14 fire pixel without any SLSTR fire pixel in a 7×7 window around it;
- ❖ Find and evaluate fire pixels detected by both sensors.

Part 2, Fire Cluster FRP comparison between SLSTR FRP and MODIS MOD14:

- ❖ Apply an atmospheric correction to MODIS FRP data, calculated using transmittance and water vapour content of the column above the fire pixel;
- ❖ Starting from the fire pixels detected by both sensors, find all the fire clusters detected by both SLSTR and MODIS, i.e., groups of one or more pixels spatially adjacent to each other and corresponding to a single fire; cases where a single SLSTR cluster corresponds to multiple MOD14 clusters and/or vice versa are merged together and the total FRP is used;
- ❖ Compute the total FRP for all active fire pixels in each fire cluster for MODIS and SLSTR data.
- ❖ Check for cloud/water/detection flags around each fire cluster that might affect the FRP value; if none is present, the cluster is flagged as well-detected;
- ❖ If necessary, check the SLSTR S7-S8 difference for possible issues and mismatches with the detected fire clusters;
- ❖ Generate statistics and analysis based on all the fire clusters detected by both MODIS and SLSTR.

Using the procedure delineated above, fire pixels from two areas of high fire activity between 1st September 2021 and 30th November 2021 were aggregated and compared. In particular, the two areas of interest are: South America, and the southern portion of Africa, see Figure 23. From around four thousand SLSTR scenes encompassing these areas, around 140 products which respected all the criteria delineated above were selected to perform this analysis. A summary of the results is reported in Table 7.

Table 7: Summary of the inter-comparison between SLSTR FRP and MODIS FRP.

Variable	Value
Number of commission AFP	12,901 (45% of Total SLSTR AFP)
Number of omission AFP	1,960 (6.8% of Total SLSTR AFP)
FRP of commission AFP (MW)	52,539
FRP of omission AFP (MW)	101,023
Number of SLSTR AFP detected by both sensors	15,714 (55% of Total SLSTR AFP)
Number of MOD14 AFP detected by both sensors	6,393 (76% of Total MOD14 AFP)
Total number of AFP detected by SLSTR	28,615
Total number of MOD14 AFP	8,353
Mean number of SLSTR AFP per cluster	5.6
Total SLSTR FRP within clusters (MW)	159,296
Mean SLSTR FRP per cluster (MW)	60.9
Median SLSTR FRP per cluster (MW)	22.4
Mean number of MOD14 AFP per cluster	2.1
Total MOD14 FRP within clusters (MW)	146,134
Mean MOD14 FRP per cluster (MW)	55.9
Median MOD14 FRP per cluster (MW)	15.6
Mean bias of FRP per cluster (MW)	5.0
Median of FRP scatter per cluster (MW)	4.8
Root-mean-square deviation of FRP per cluster	116
25-50-75 percentiles of SLSTR clusters FRP	8.6, 15.6, 36.7
25-50-75 percentiles of MOD14 clusters FRP	11.7, 22.4, 48.9

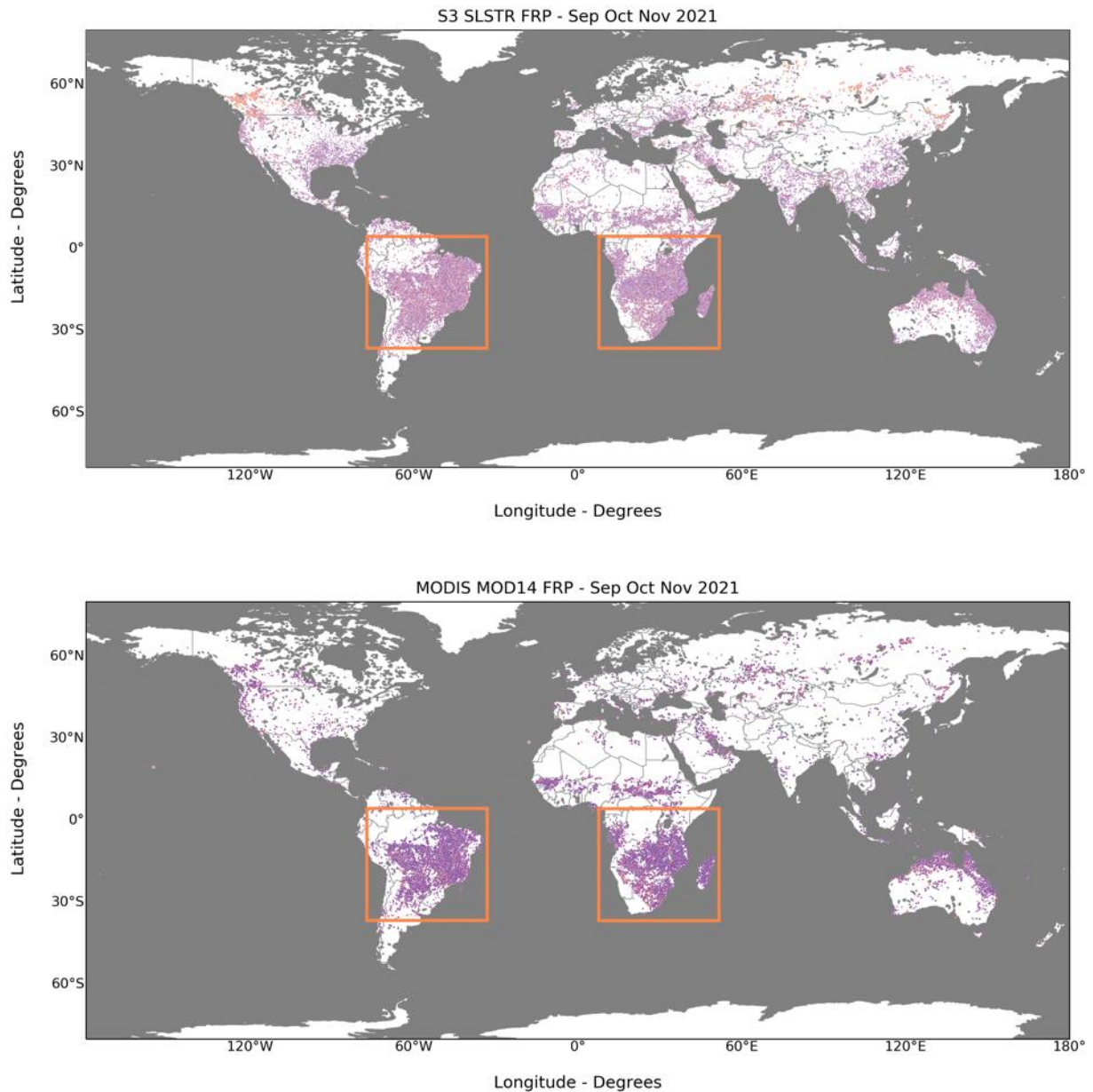
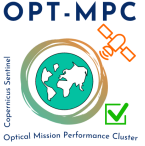


Figure 23: Areas of high fire activity selected for the inter-comparison. The basemap shows night-time fires detected by SLSTR (top) and MODIS (bottom) for the months of September, October, and November 2021

Overall, there is good agreement between SLSTR FRP and MODIS FRP, as can be seen in Table 7. The comparison shows that SLSTR detects in general more fire pixels than MODIS (28,615 vs 8,353), albeit many of them with very low FRP. Furthermore, there is a large number of commission fire pixels and a low number of omission fire pixels, 45% and 6.8%, of the total amount of SLSTR AFPs, respectively. Such pixels indicate fires that were detected only by one sensor, however, these are not necessarily incorrect/missed detections. It is important to highlight, in fact, that the two sensors observe the scenes at slightly different times (the MODIS product has to be within an interval of ± 6 minutes with respect to the SLSTR acquisition). This difference in time translates into different conditions of the observed fires and also of the cloud coverage. A fire could move, increase/decrease in extent and power, whereas clouds could cover different portions of the image. On the other hand, a fraction of these pixels may represent real

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fires that are undetected by MODIS but are detected by the SLSTR product - for example because of the use of the smaller pixel footprint F1 channel – or vice versa. For these reasons, the reported values should not be interpreted as full validation, but rather as indication of the consistency between the two sensors. A summary of results per dataset for omission, commission, and fire pixels detected by both sensors is visualised in Figure 24.

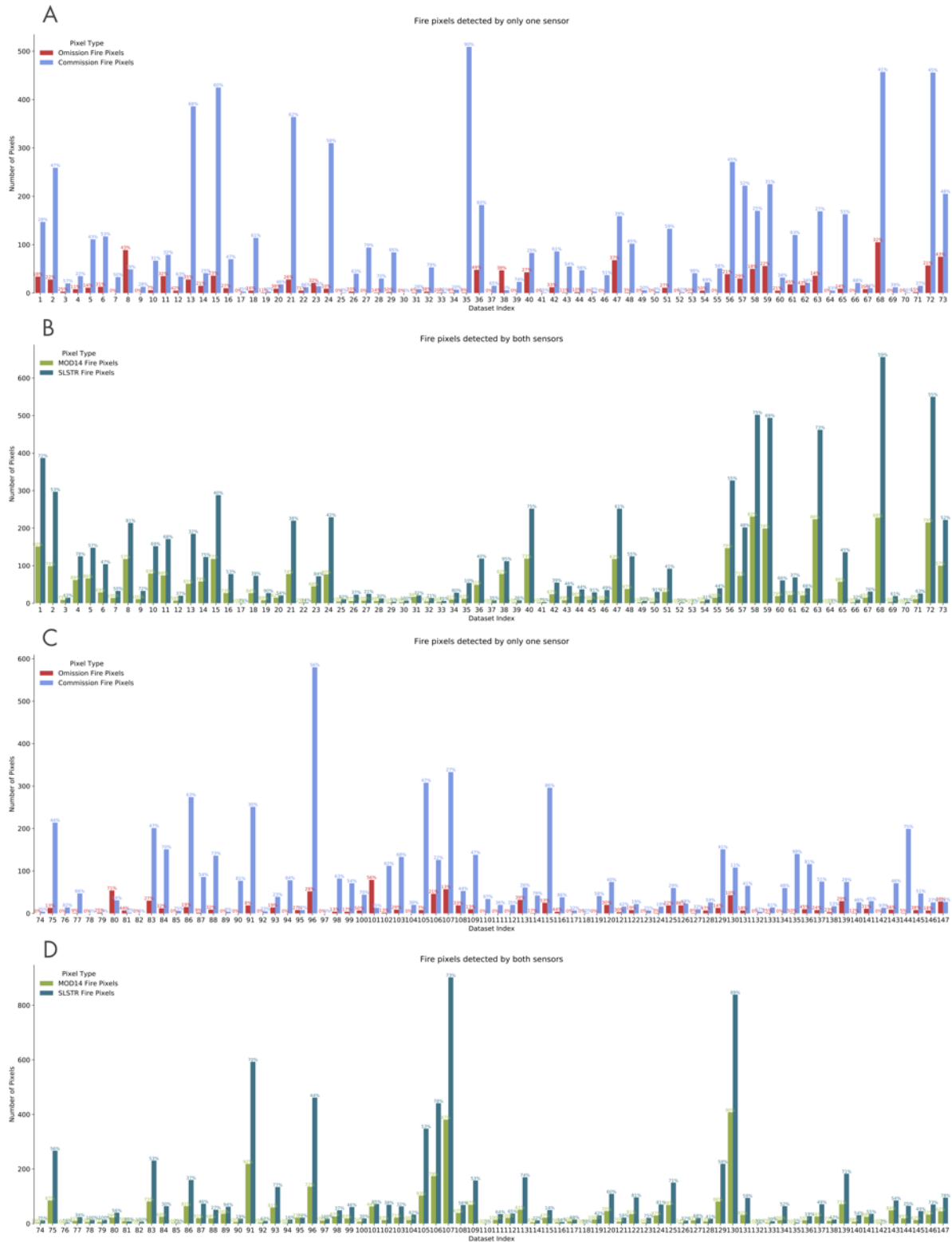


Figure 24: Amount of fire pixels detected only by one sensor (A and C) and by both sensors (B and D), per dataset. The percentages on top of each bar represent the proportion of pixels for that bar with respect to the total amount of fire pixel per dataset.

The distribution of FRP for fire clusters detected by both sensors is quite similar between SLSTR and MODIS (see Figure 25), even though MODIS exhibits a higher peak for low FRP values and SLSTR shows a higher curve for intermediate values. Similarly, the results of a robust regression between the FRP values given by the two sensors are close to the one-to-one line, as can be seen in Figure 26, and the fire clusters appear quite similar, albeit with a few outliers. Generally, SLSTR appears to detect more fire pixels than MODIS for the same fire clusters, many of them with very low FRP, and the total FRP of all clusters is higher for SLSTR (see Table 7), although this number is heavily affected by a few outliers with high FRPs. Contrary to the case of omission/commission fire pixels, the cluster analysis includes a step for checking the relevant flags associated with the fire detection, in particular those related to water or clouds in the background window around the fire cluster. Thus, results of the cluster analysis are more robust against differences in the atmospheric conditions or cloud masking algorithm. Nonetheless, the detections could still have been affected by the fact that the different sensors do not observe the fires exactly at the same time and are not perfectly equivalent. Hence, some fluctuations are expected.

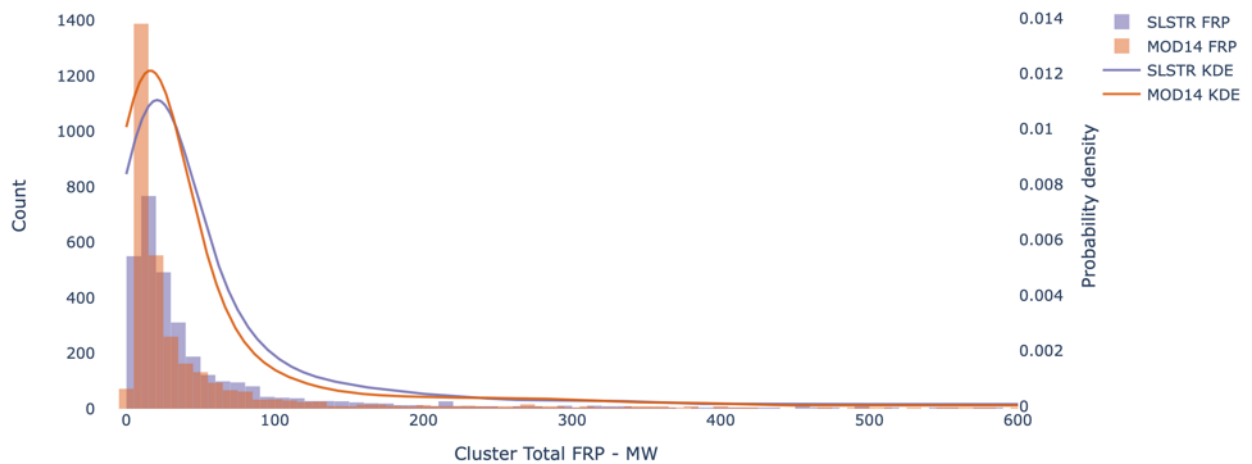


Figure 25: Distribution of the FRP for fire clusters detected by both sensors. The lines represent kernel density estimates (KDE) computed over the barplot.

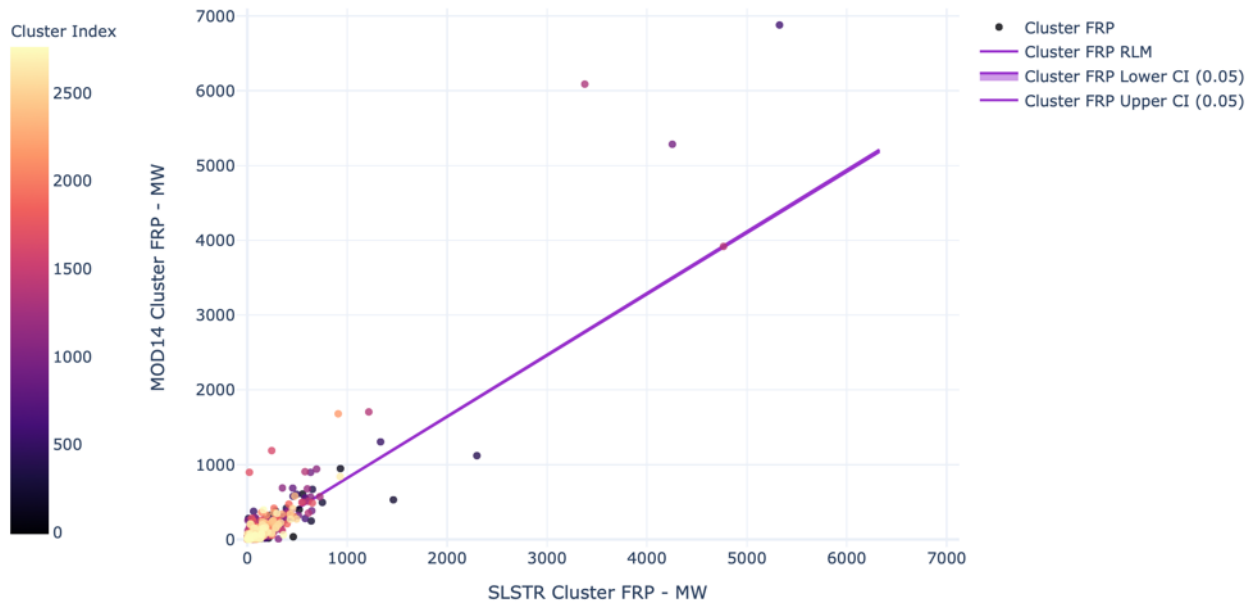



Figure 26: Scatterplot between the FRP of fire clusters detected by both sensors. SLSTR values are reported on the x-axis, whereas MODIS ones are on the y-axis. The regression line (with a shaded 0.05 confidence interval) is obtained with a robust linear method (RLM), which is less affected by outliers. The scatterpoints are color-coded according to their cluster number, so that they can be traced back to the original datasets.

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7 Events

7.1 SLSTR-A

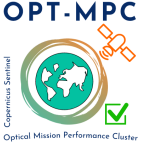
SLSTR-A was switched on and operating nominally during January 2022, with SUE scanning and autonomous switching between day and night modes, except for the following events:

- ❖ 4th January 2022, 09:01-09:03 – gaps in L2 products only due to error in PUG
- ❖ 7th January 2022, 00:04-00:17 – pointing errors due to collision avoidance manoeuvre
- ❖ 7th January 2022, 02:06-02:17 – pointing errors due to collision avoidance manoeuvre
- ❖ 10th January 2022, 23:11-23:19 – gap in L2 products only
- ❖ 18th January 2022, 07:49-08:40 – pointing errors and gaps due to OLCI lunar calibration manoeuvre
- ❖ 19th January 2022, 07:25-07:35 – pointing errors due to scheduled in-plane manoeuvre
- ❖ 27th January 2022, 09:05-09:07 – data gaps for NTC products due to bad frame numbers
- ❖ 27th January 2022, 17:07-17:12 – data gaps caused by radio frequency interference

7.2 SLSTR-B

SLSTR-B was switched on and operating nominally during January 2022, with SUE scanning and autonomous switching between day and night modes, except for the following events:

- ❖ 12th January 2022, 08:18-08:28 – pointing errors due to scheduled in-plane manoeuvre
- ❖ 12th January 2022, 08:25-08:35 – data gaps caused by radio frequency interference

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8 Appendix A

Other reports related to the Optical mission are:

- ❖ S3 OLCI Data Quality Report, January 2022 (ref. OMPC.ACR.DQR.03.01-2022)

All Data Quality Reports are available on the Sentinel-3 Technical Guide pages of the Sentinel Online website, at: <https://sentinel.esa.int>

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