S3-A SLSTR Cyclic Performance Report

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

**Title:** S3-A SLSTR Cyclic Performance Report

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**Disclaimer**
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### Changes Log

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(left); Gobabeb, Namibia (centre); Kalahari-Heimat, Namibia (right). [Results courtesy of Maria Martin through the GlobTemperature Project]

Figure 16: Validation of the SL_2_LST product over the mid-July to mid-November reprocessed period at the seven Gold Standard in situ stations of the SURFRAD network plus a Gold Standard station from the ARM network: Bondville, Illinois (top-left); Desert Rock, Nevada (top-centre); Fort Peck, Montana (top-right); Goodwin Creek, Mississippi (middle-left); Penn State University, Pennsylvania (middle-centre); Sioux Fall, South Dakota (middle-right); Table Mountain, Colorado (bottom-left); and Southern Great Plains, Oklahoma (bottom-centre).

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Table 4: NEDT for cycles 015-026 averaged over all detectors for both Earth views towards the –YBB (cold).

Table 5: SLSTR drifter match-up statistics for Cycle 26.
### 1 Processing Baseline Version

<table>
<thead>
<tr>
<th>IPF</th>
<th>IPF / Processing Baseline version</th>
<th>Date of deployment</th>
</tr>
</thead>
</table>
| SL1 | 06.14 / 2.17                     | CGS: 05/07/2017 13:15 UTC (NRT)  
PAC: 05/07/2017 12:34 UTC (NTC) |
| SL2 | 06.12 / 2.17                     | CGS: 05/07/2017 13:16 UTC (NRT)  
PAC: 05/07/2017 12:42 UTC (NTC) |
2 Instrument monitoring

2.1 Instrument temperatures

- Instrument temperatures were stable and consistent with expected values following the decontamination phase which was performed towards the end of Cycle 20 (see Figure 1).

- Figure 2, Figure 4 and Figure 5 show the orbital average blackbody, baffle and OME temperatures during cycle 26. The temperatures were stable (on top of a daily variation cycle). Longer term analysis also shows a yearly variation, with temperatures rising as the Earth approaches perihelion at the beginning of January. Cycle 26 falls at this yearly peak with +YBB temperatures around 304 K (see Figure 3 and Table 3). Figure 2 shows that gradients across the blackbody baseplate are stable and within their expected range (±20mK).

[Figure 1: Detector temperatures for each channel from 1st March 2016. Discontinuities occur for the infrared channels where the FPA was heated for decontamination or following an anomaly. The vertical dashed lines indicate the start and end of each cycle. Each dot represents the average temperature in one orbit.]
Figure 2: Blackbody temperature and baseplate gradient trends during cycle 26. The vertical dashed lines indicate the start and end of the cycle. Each dot represents the average temperature in one orbit. Note that the gaps are in the stream of data from the MPC used for monitoring, and are not due to any problem.

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Figure 5: Opto-Mechanical Enclosure (OME) temperature trends for cycle 26 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.
2.2 Scanner performance

Scanner performance in cycle 26 has been consistent with previous operations and within required limits.

![Graphs showing scanner performance](image)

*Figure 6: Scanner and flip jitter for cycle 26, showing mean, stddev and max/min position per orbit compared to the expected one for the nadir view.*
Figure 7: Scanner and flip jitter for cycle 26, showing mean, stddev and max/min position per orbit compared to the expected one for the oblique view.
2.3 Detector noise levels

2.3.1 VIS and SWIR channel signal-to-noise

The VIS and SWIR channel noise in cycle 26 was stable and consistent with previous operations - the signal-to-noise ratio of the measured VISCAL signal over the mission so far is plotted in Figure 8. Table 1 and Table 2 give the average signal-to-noise in each cycle (excluding the anomaly/decontamination period in Cycle 20). Note that this averages over the significant detector-detector dispersion for the SWIR channels that is shown in Figure 8.

Table 1: Average reflectance factor, and signal-to-noise ratio of the measured VISCAL signal for cycles 015-026, averaged over all detectors for the nadir view.

<table>
<thead>
<tr>
<th>Average Reflectance Factor</th>
<th>Cycle 015</th>
<th>Cycle 016</th>
<th>Cycle 017</th>
<th>Cycle 018</th>
<th>Cycle 019</th>
<th>Cycle 020</th>
<th>Cycle 021</th>
<th>Cycle 022</th>
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<tr>
<td>S1</td>
<td>0.187</td>
<td>224</td>
<td>233</td>
<td>231</td>
<td>230</td>
<td>230</td>
<td>232</td>
<td>230</td>
<td>234</td>
<td>235</td>
<td>234</td>
<td>278</td>
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<tr>
<td>S2</td>
<td>0.194</td>
<td>230</td>
<td>236</td>
<td>232</td>
<td>231</td>
<td>235</td>
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<tr>
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<td>S4</td>
<td>0.191</td>
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<td>136</td>
<td>139</td>
<td>140</td>
<td>142</td>
<td>141</td>
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<tr>
<td>S5</td>
<td>0.193</td>
<td>233</td>
<td>235</td>
<td>236</td>
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<td>232</td>
<td>229</td>
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<td>S6</td>
<td>0.175</td>
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<td>146</td>
<td>145</td>
<td>146</td>
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</table>

Table 2: Average reflectance factor, and signal-to-noise ratio of the measured VISCAL signal for cycles 015-026, averaged over all detectors for the oblique view.

<table>
<thead>
<tr>
<th>Average Reflectance Factor</th>
<th>Cycle 015</th>
<th>Cycle 016</th>
<th>Cycle 017</th>
<th>Cycle 018</th>
<th>Cycle 019</th>
<th>Cycle 020</th>
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<th>Cycle 025</th>
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<tbody>
<tr>
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<td>0.166</td>
<td>236</td>
<td>243</td>
<td>247</td>
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<td>S2</td>
<td>0.170</td>
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<td>S3</td>
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<td>S5</td>
<td>0.166</td>
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Note that there may be very small differences in the average signal-to-noise values in Table 1 and Table 2 for recent cycles compared to previous Cyclic Reports because additional products may have been received from the MPC since those reports were published.
Figure 8: VIS and SWIR channel signal-to-noise of the measured VISCAL signal in each orbit. Different colours indicate different detectors.
2.3.2 TIR channel NEDT

The thermal channel NEDT values in cycle 26 are consistent with previous operations and within the requirements. NEDT values for each cycle, averaged over all detectors and both Earth views, are shown in Table 3 and Table 4.

Figure 9: NEDT trend for the thermal channels in cycle 26. 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>
<thead>
<tr>
<th>Table 3: NEDT for cycles 015-026 averaged over all detectors for both Earth views towards the +YBB (hot).</th>
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<tr>
<td>+YBB temp (K)</td>
</tr>
<tr>
<td>S7</td>
</tr>
<tr>
<td>S8</td>
</tr>
<tr>
<td>S9</td>
</tr>
<tr>
<td>F1</td>
</tr>
<tr>
<td>F2</td>
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<td>NEDT (mK)</td>
</tr>
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<table>
<thead>
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<th>Table 4: NEDT for cycles 015-026 averaged over all detectors for both Earth views towards the –YBB (cold).</th>
</tr>
</thead>
<tbody>
<tr>
<td>-YBB temp (K)</td>
</tr>
<tr>
<td>S7</td>
</tr>
<tr>
<td>S9</td>
</tr>
<tr>
<td>F1</td>
</tr>
<tr>
<td>F2</td>
</tr>
<tr>
<td>NEDT (mK)</td>
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</table>

Note that there may be very small differences in the average NEDT values in Table 3 and Table 4 for recent cycles compared to previous Cyclic Reports because additional products may have been received from the MPC since those reports were published.
2.4 Calibration factors

2.4.1 VIS and SWIR VISCAL signal response

Signals from the VISCAL source for the VIS channels show oscillations due to the build up of ice on the optical path within the FPA. Decontamination must be carried out periodically in order to warm up the FPA and remove the ice. The latest decontamination cycle was successfully performed at the end of Cycle 20. The VISCAL signal has behaved as expected following the decontamination.

![Figure 10: VISCAL signal trend for VIS channels (nadir view).](image-url)
Figure 11: VISCAL signal trend for SWIR channels (nadir view).
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. Results from the GeoCal Tool are currently being analysed and will be presented in future cyclic reports.

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

Analysis of S3ETRAC results for SLSTR radiometric validation is ongoing and will be presented in future cyclic reports.
### 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 Level-3 image. Figure 12 shows an example Level-3 image for the visible channels from 3rd January 2018 (daytime only).

*Figure 12: Daytime Level-3 image for visible channels on 3rd January 2018.*
4 Level 2 SST validation

Level 2 WCT SSTs have been validated using CMEMS *in situ* data for Cycle 26. Match-ups between SLSTR and *in situ* data are provided by the EUMESAT OSI-SAF.

4.1 Dependence on latitude, TCWV, Satellite ZA and date

- The dependence of the difference between SLSTR $SST_{skin}$ and drifting buoy $SST_{depth}$ for Cycle 26 is shown in Figure 13. No adjustments have been made for difference in depth or time between the satellite and *in situ* measurements. SLSTR SSTs are extracted from the SL_2_WCT files. Daytime 2-channel (S8 and S9) results are shown in red, night time 2-channel results are shown in blue and night time 3-channel results are shown in green. Solid lines indicate dual-view retrievals, dashed lines indicate nadir-only retrievals. Bold lines indicate statistically significant (95% confidence) results.

*Figure 13: Dependence of median and robust standard deviation of match-ups between SLSTR $SST_{skin}$ and drifting buoy $SST_{depth}$ for Cycle 26 as a function of latitude, total column water vapour (TCWV), satellite zenith angle and date. The data gaps throughout the cycle are due to delays in match-up production.*
4.2 Spatial distribution of match-ups

- The spatial distribution of SLSTR/drifter match-ups for Cycle 26 is shown in Figure 14. No adjustments have been made for difference in depth or time between the satellite and in situ measurements.

---

*Figure 14: Spatial distribution of match-ups between SLSTR SST<sub>skin</sub> and drifting buoy SST<sub>depth</sub> for Cycle 26.*
4.3 Match-ups statistics

Match-ups statistics (median and robust standard deviation, RSD) of SLSTR/drifter match-ups for Cycle 26 are shown in Table 5. No adjustments have been made for difference in depth or time between the satellite and in situ measurements and so at night time (in the absence of diurnal warming) an offset of around -0.17 K is expected. The RSD values indicate SLSTR is providing SSTs mostly within its target accuracy (0.3 K).

<table>
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<tr>
<th>Retrieval</th>
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<th>Median (K)</th>
<th>RSD (K)</th>
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<td>-0.05</td>
<td>0.31</td>
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<tr>
<td>D2 day</td>
<td>1451</td>
<td>-0.09</td>
<td>0.24</td>
</tr>
<tr>
<td>N2 night</td>
<td>3651</td>
<td>-0.17</td>
<td>0.34</td>
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<tr>
<td>N3 night</td>
<td>3651</td>
<td>-0.15</td>
<td>0.21</td>
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<tr>
<td>D2 night</td>
<td>1398</td>
<td>-0.13</td>
<td>0.27</td>
</tr>
<tr>
<td>D3 night</td>
<td>1398</td>
<td>-0.15</td>
<td>0.24</td>
</tr>
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</table>

Table 5: SLSTR drifter match-up statistics for Cycle 26.
5 Level 2 LST validation

Level 2 Land Surface Temperature products have been validated against in situ observations (Category-A validation), and intercompared (Category-C validation) with respect to three independent reference products from the ESA DUE GlobTemperature Project (MODIS, GOES, and SEVIRI).

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. The results can be summarised as follows (see Figure 15 and Figure 16):

- Average absolute accuracy (vs. Gold Standard):
  - Daytime: 0.81K
  - Night-time: 1.07K

  This daytime accuracy meets the mission requirement of < 1K. The night-time accuracy is very close to this mission requirement. This also is in line with the GCOS climate requirements of 1 K accuracy.

- Average precision (vs. Gold Standard):
  - Daytime: 0.72K
  - Night-time: 1.21K

  While there is no Sentinel-3 mission requirement for precision, the daytime precision meets the GCOS climate requirement of 1K. The night-time accuracy is also very close to this climate requirement.

![Figure 15: Validation of the SL_2_LST product over the mid-July to mid-November reprocessed period at three Gold Standard in situ stations managed by the Karlsruhe Institute of Technology: Evora, Portugal (left); Gobabeb, Namibia (centre); Kalahari-Heimat, Namibia (right). [Results courtesy of Maria Martin through the GlobTemperature Project]](image-url)
Figure 16: Validation of the SL_2_LST product over the mid-July to mid-November reprocessed period at the seven Gold Standard in situ stations of the SURFRAD network plus a Gold Standard station from the ARM network: Bondville, Illinois (top-left); Desert Rock, Nevada (top-centre); Fort Peck, Montana (top-right); Goodwin Creek, Mississippi (middle-left); Penn State University, Pennsylvania (middle-centre); Sioux Fall, South Dakota (middle-right); Table Mountain, Colorado (bottom-left); and Southern Great Plains, Oklahoma (bottom-centre).
5.2 Category-C validation

Category-C validation uses inter-comparisons with similar LST products from other sources such as AATSR, AVHRR, MODIS, SEVIRI, and VIIRS, which give important quality information with respect to spatial patterns in LST deviations. The results can be summarised as follows:

- **Daytime intercomparison differences are:** ~1K vs. GOES__LST_2 over North America; ~1K vs. SEVIR_LST_2 over Europe; and < 1K vs. MOGSV_LST_2 on a Global basis.

- **Night-time intercomparison differences are:** <1K vs. GOES__LST_2 over North America; <1K vs. SEVIR_LST_2 over Europe; and < 1K vs. MOGSV_LST_2 on a Global basis.

- **Differences with respect to biomes tend to be larger during the day for surfaces with more heterogeneity and/or higher solar insolation. With respect to SLSTR zenith viewing angle differences are larger in the day on the left side of the SLSTR swath in the along-track direction.**
6 Events

SLSTR was switched on and operating nominally during the cycle, with SUE scanning and autonomous switching between day and night modes.

However, there was an issue with the Svalbard antenna on 1\textsuperscript{st} January 2018, which caused a gap in the data received. This affects Level-1 and Level-2 product granules between 03:27 and 05:23, which show missing data (see Figure 17).

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{figure17.png}
\caption{The quicklook image for the granule observed between 03:27 and 03:30 on 1\textsuperscript{st} January 2018, showing the start of the missing data.}
\end{figure}
7 Appendix A

Other reports related to the Optical mission are:

- S3-A OLCI Cyclic Performance Report, Cycle No. 026 (ref. S3MPC.ACR.PR.01-026)

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