S2 MPC

Data Quality Report

Ref. S2-PDGS-MPC-DQR

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1. Scope of the Document

This document provides the status of Sentinel-2 mission products data quality.

It documents measured product performance vs. specifications, observed anomalies and known issues, the list of defective pixels, processing chain improvements associated to each Processing Baseline, and an outlook on product evolution.

Note that a reference article has been published[1] to provide an in-depth presentation of Sentinel-2 Calibration and Validation methods and results after one year in operation (F. Gascon *et al.*, "Copernicus Sentinel-2 Calibration and Products Validation Status").

[1] http://www.mdpi.com/2072-4292/9/6/584/pdf

2. Measured Product Performances

2.1 Performances Overview

The following overview table provides a summary of the Level-1C products data quality performances measured on products in Processing Baselines 02.01 and higher, for a set of key mission requirements.

Similar performances are observed for S2A and S2B. However as the S2B mission is at an early stage, performances are expected to be less stable in time.

Table 2-1: Summary of Sentinel-2 L1C products measured performances for mission key requirements.

Requirement	Description	Measured performance
Absolute geolocation (without ground control points)	The geo-location uncertainty shall be better than 20 m at 2σ confidence level (without Ground Control Points).	< 11 m at 95.5% confidence (baseline 02.04)
Multi-spectral registration	The inter-channel spatial co-registration of any two spectral bands shall be better than 0.30 of the coarser achieved spatial sampling distance of these two bands at 3σ confidence level.	< 0.3 pixel at 99.7% confidence
Absolute radiometric uncertainty	The absolute radiometric uncertainty shall be better than 5 % (goal 3%).	B1 to B12, excl. B10: < 5%±2%
SNR	The Signal-to-Noise Ratio (SNR) shall be higher than specified values (see Table 2-4 in this document)	All bands compliant with > 27% margin

Measured performances are detailed in the following sections.

2.2 Geometric Performance

2.2.1 Geometric Calibration Status

2.2.1.1 S2A

An improvement of the yaw angle bias correction has been performed on May, 30th 2016. Before this date, a relatively large along-track bias can be observed between different repeat orbits in the overlap region at the edges of the swath. The multi-temporal co-registration performance reported in this document is computed for products acquired after this date.

An update of the geometric calibration is planned in the coming months to avoid reoccurrence of anomaly #18 on S2A. The latter anomaly originated by an imperfect alignment of the back-up Star Tracker (STR3).

2.2.1.2 S2B

The attitude reference bias of S2B is still evolving as a result of post-launch effect. This evolution must be compensated by regular updates of the geometric calibration. Next update is planned for end of August 2017.

2.2.2 Geometric Refinement and Global Reference Image (GRI)

The L1C processing chain implements a geometric refinement step which aims at improving the repetitiveness of the image geolocation, in order to reach the multi-temporal geolocation requirement (< 0.3 pixel at 95%). The refinement step will be activated upon completion of the GRI and the final validation of the refining algorithm. At that point the processing baseline will be updated (major version change) and the archive will be reprocessed.

The GRI is a set of Level 1B images (in sensor frame) covering the whole globe with highly accurate geolocation information obtained through a spatio-triangulation algorithm using reference Ground Control Points. The images use the reference band (B04) and are mostly (but not entirely) cloud-free. The GRI is an internal database used only for processing and not for dissemination. In particular, the GRI is not meant to be a cloud-free mosaic of the globe. Once the geometric refinement is activated, all images will have essentially the same geolocation accuracy.

The elaboration of the GRI is currently on-going. Continental sub-blocks are first built, processed and validated individually. In a second step, the sub-blocks (Europe, Africa and Asia on one hand, North and South America on the other hand) will be consolidated to improve the consistency at the boundary of the sub-blocks. The elaboration status is presented in the table below:

GRI sub-block	Status
Europe	Ready and Validated
North-Africa/Middle-East	Ready and Validated
Australia	Ready and Validated
South-Africa	Ready and Validated
North-America	Ready and Validated
South-America	Ready and Validated
Asia	Ready and Validated
Islands	Ready for delivery

2.2.3 Absolute Geolocation

Absolute geolocation is constantly monitored for S2A and S2B. As mentioned in section 2.2.1, the attitude reference of S2B is not yet stabilized and the geolocation performance cannot be reported at this stage. A first performance estimate will be provided for the next issue of the DQR.

For S2A, the latest estimation (on 148 products since 15/11/2016) is better than 10.28 m at 95.5% (vs. requirement of 20 m for unrefined products), see figure below. This is compatible with the current best estimate of the long term mission performance without refining (10.5 m).

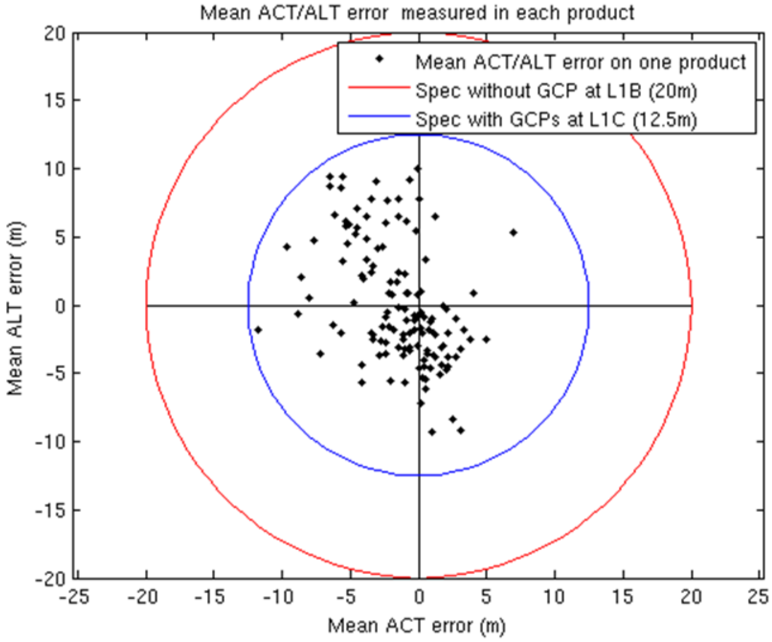


Figure 1: S2 A Geolocation performance measured on 148 products since 15/11/2106 (for all Ground Control Points in Across-Track/Along-Track frame).

Recent investigations have highlighted a latitude-dependence of the geolocation performance of Sentinel 2 images. This effect is particularly visible on the along-track component: images are shifted to the South in the Northern hemisphere and toward the North in the Southern hemisphere. The amplitude of the bias is of the order of 5 meters, which is compatible with the mission absolute geolocation requirements. This effect will be corrected with the introduction of the geometric refinement.

2.2.4 Multi-Spectral Registration

The co-registration requirement (< 0.3 pixel at 99.7% confidence) is met for all measured band couples.

S2A			
Bsec/Bref	B04	B05	B11
B02	0.168		
B03	0.209		
B06		0.139	
B07		0.152	
B08	0.165		
B8A		0.157	
B11		0.185	
B12		0.166	0.203

S2B			
Bsec/Bref	B04	B05	B11
B02	0.130		
B03	0.115		
B06		0.071	
B07		0.097	
B08	0.181		
B8A		0.176	
B09			
B11		0.163	
B12		0.149	0.150

Table 2-2: Multi-Spectral co-registration performance (per band couple and detector number) for S2A (top) and S2B (bottom). Requirement is 0.3 pixel.

2.2.5 Multi-Temporal Registration

The multi-temporal registration error for one tile is estimated as the mean measured error for all control points of the tile. Then the global performance is taken as the 95.5% percentile of the value for all tiles measured on the reference band (B04). According to this methodology, the current performance is 12 m. Figure 3 shows the histogram of the distribution of multi-temporal registration errors, showing a peak at 3 m.

It is recalled that the objective is to meet the required 3 m performance (95.5% confidence level) with the activation of the geometric refinement using the GRI.

Performance for S2B will be reported in the next issue of the DQR.

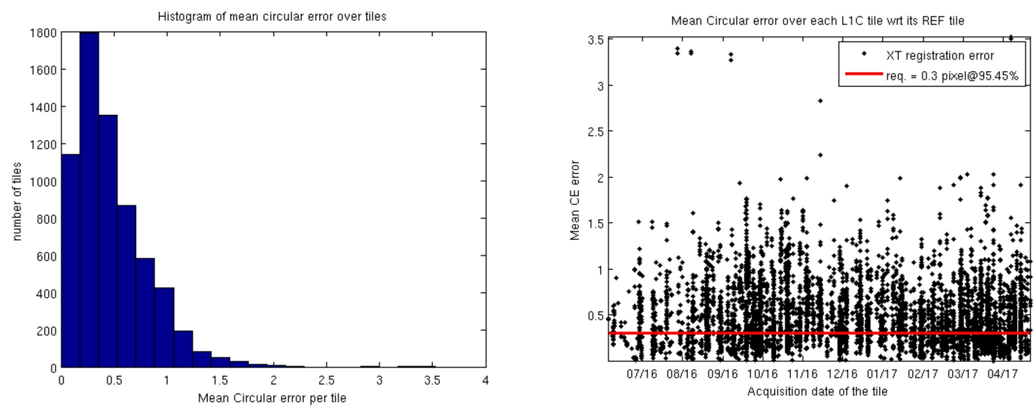


Figure 2: Histogram (left) and Time series (right) of the multi-temporal performance for S2A. The 3 m requirement will be applicable only after activation of the geometrical refinement.
The current performance is 12 m at 95% confidence.

2.3 Radiometric Performance

2.3.1 Radiometric Calibration Status

2.3.1.1 S2A

Radiometric calibrations are performed routinely at the beginning of each month. Decontamination operations are scheduled every 6 months (January and July).

Decontamination has been performed on July 8th 2017. A new post-decontamination calibration is being processed. In the necessary processing time interval (a few days), the data radiometric accuracy will be somewhat degraded, especially for SWIR bands (a few %).

2.3.1.2 S2B

Radiometric calibration is currently performed every 2 weeks and will be reduced to once per month after summer 2017. The decontamination frequency will depend on the observed evolution of the SWIR band radiometry.

2.3.2 Radiometric Uncertainty

Radiometric validation has been performed using several methods:

- “Rayleigh” method: measurement of the Rayleigh atmospheric backscattering over deep ocean sites.
- Comparison with in-situ data.
- Measurement over well characterized, temporally stable desert areas (Pseudo-Invariant Calibration Sites or PICS).
- Comparison with other sensors (Landsat-8 OLI).

The results are presented in the figures below for S2A for all methods and for S2B for the PICS method only. Results over S2A are provided for all bands, except B10 (water vapour absorption band) for which direct validation is not possible, while results over S2B are provided for VNIR only. All results are compatible with the 5% (3%) radiometric accuracy requirement (Goal) respectively. Results for band B05 and B09 (705 and 945 nm in the figure below) are less reliable because of the significant impact of gaseous absorption (O_2 and water vapour).

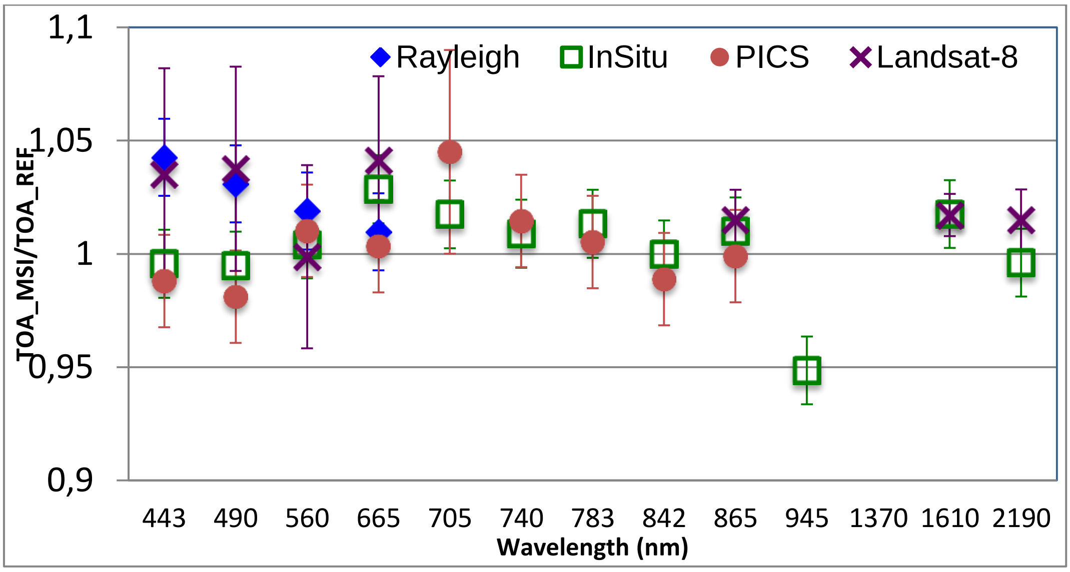


Figure 3: Comparison of radiometric accuracy for all spectral bands (except B10): ratio of S2A measurement on reference. Error bars indicate the method uncertainty.

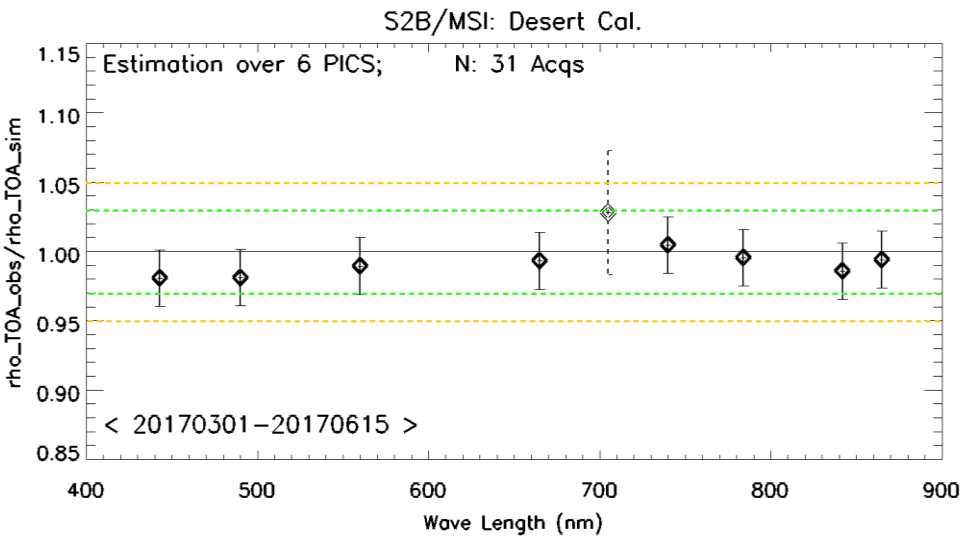


Figure 4: Radiometric accuracy estimation for S2B using the PICS method for bands B01 to B8A. Ratio of S2B measurement on reference. Errors bars indicate the method uncertainty.

Tabulated results for bands B01 to B8A presented below indicate the effectiveness and reliability of the on-board calibration method. Similar results will be presented for S2B when sufficient data has been processed.

Table 2-3: Best estimate of S2A calibration gains from validation.

S2A/MSI	Wavelength (nm)	Gain Coefficient	Standard Deviation
B01	443	1.015	0.028
B02	490	1.011	0.028
B03	560	1.008	0.009
B04	665	1.020	0.017
B05	705	1.031	0.020
B06	740	1.011	0.004
B07	783	1.009	0.006
B08	842	0.994	0.008
B8A	865	1.008	0.008
B11	1610	1.017	0.003
B12	2190	1.005	0.013

Time series of measurements are also produced to monitor the evolution in time of the radiometric response, in particular to detect a possible degradation of the diffuser. The current assessment is compatible with the specified stability requirement for all visible and NIR bands (< 1% per year).

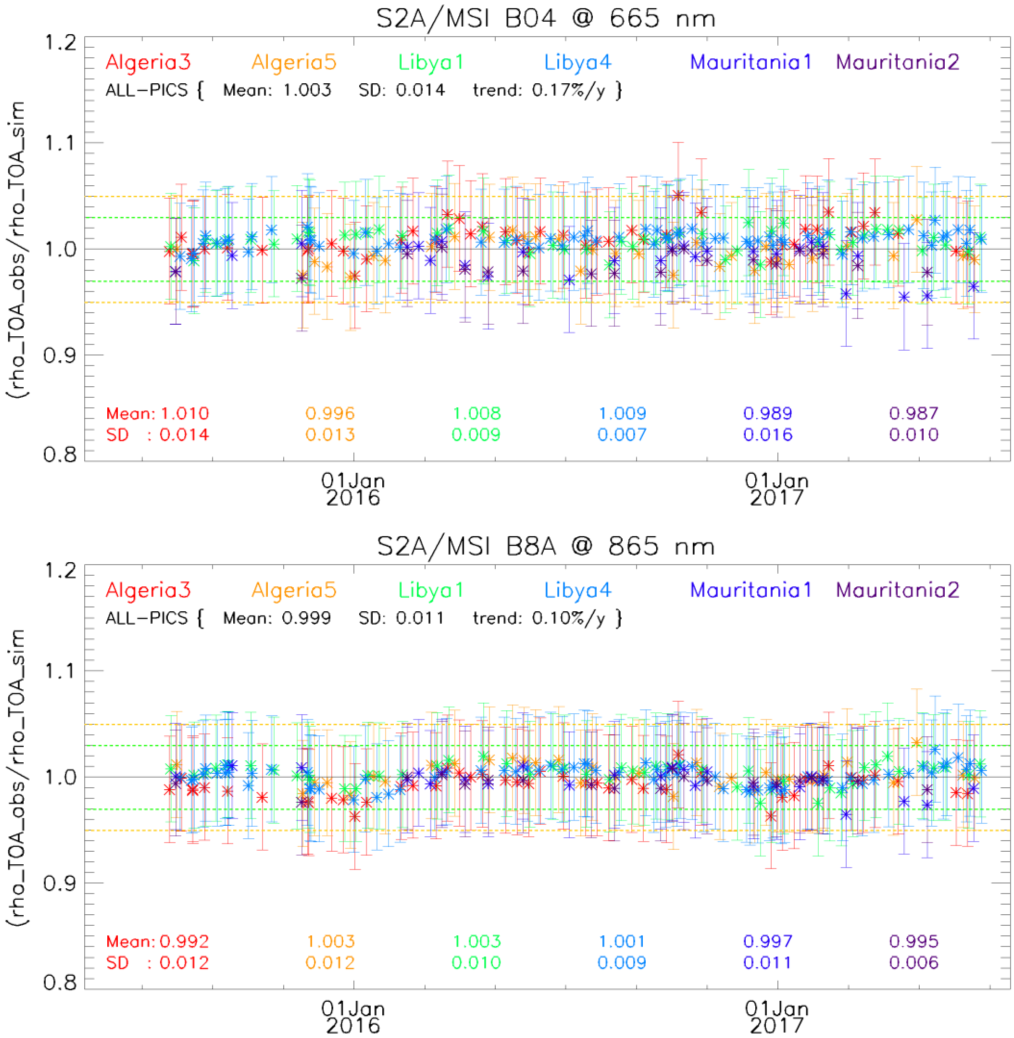


Figure 5: Time series of the ratio as observed reflectance over simulated from S2A/MSI for band B04 (665 nm, top) and band B08 (865 nm, bottom) over the 6 PICS Cal/Val-sites. Error bars indicate the method uncertainty.

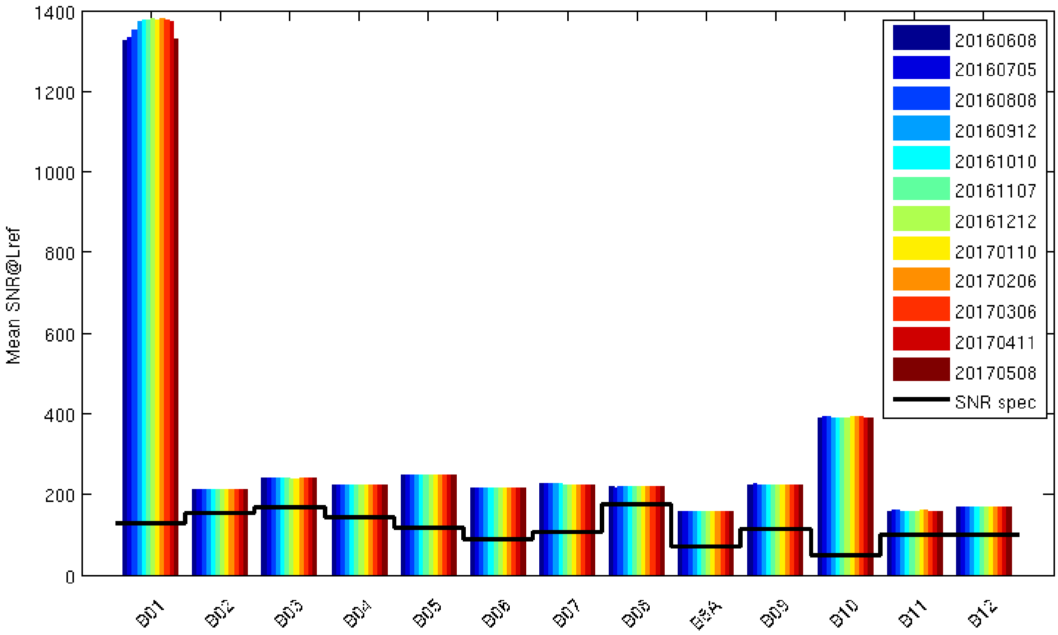
2.3.3 Noise

The SNR for both S2A and S2B is exceeding requirements (worst-case >160 for band B8A).

Table 2-4: Estimated SNR performance for S2A and S2B at reference radiance.

Spectral Band	B1	B2	B3	B4	B5	B6	B7	B8	B8A	B9	B10	B11	B12
Ref. radiance [W/m²/sr/µm]	129	128	128	108	74.5	68	67	103	52.5	9	6	4	1.5
S2A	1374	211	239	222	247	216	224	218	158	223	390	159	167
S2B	1369	213	242	231	249	224	232	230	170	245	404	169	167
Requirement	129	154	168	142	117	89	105	174	72	114	50	100	100
Margin (%)	963	37	42	57	111	143	113	25	119	95	678	58	67

As seen in the figure below, the noise characteristics are very stable over time.



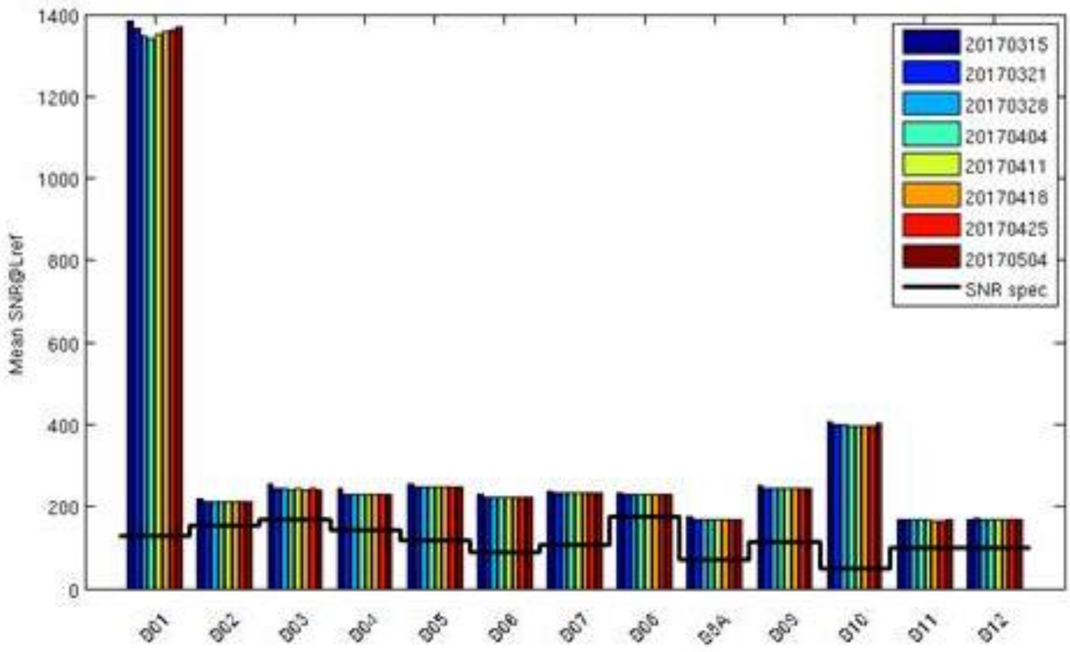
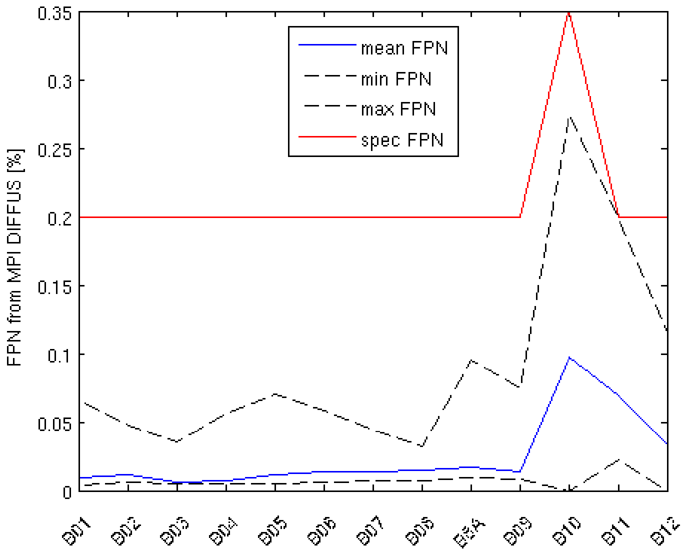
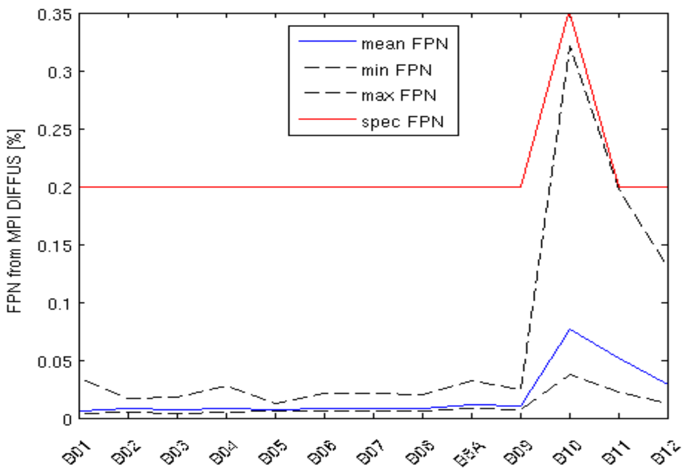


Figure 6: Evolution of the SNR performance for S2A since 08/06/2016 (top) and S2B since 15/03/2017 (bottom)

Another aspect of the image noise is the so-called Fixed Pattern Noise: this is the residual pixel radiometric error after equalization. The Fixed Pattern Noise is estimated on quasi-uniform ground scenes. The following figure compares the estimated Fixed Pattern Noise with respect to the requirement extrapolated at the radiance of the scene. The methodology overestimates the noise due to the contribution of the scene noise. However the measured FPN is largely better than requirement for VNIR bands. The performance is less good on SWIR bands, which reflects in part the impact of atmospheric signal noise for those bands and in part the relatively faster evolution of the response of SWIR pixels between two calibration operations. Note that diffuser lifetime considerations limit the calibration operations to once per month.



S2A



S2B

Figure 7: Fixed Pattern Noise (residual error after equalization) measured on diffuser images for S2A (top) and S2B (bottom). Blue curve: mean FPN, red: maximum specified value. Dashed: best- and worst-case pixels.
The noise is better than requirements for VNIR bands and close to requirements for SWIR bands.

2.3.4 Modulation Transfer Function

The Modulation Transfer Function (MTF) has been estimated by analysing images with sharp edges for all bands (except B10 for which in-orbit assessment is difficult).

Globally, see Table 2-5, the across track values measured in flight are lower than those expected from ground measurements. The MTF is above the maximum value requirement for B5, B6, B7 and B8A for the across track direction. For the along track direction, the requirement is generally met (marginally in some cases). Note that only the minimum value requirement has a direct impact on image quality. This requirement is satisfied for all bands.

The performance for S2B will be reported in future issues of the DQR. Preliminary results indicate similar or better performance than S2A.

Table 2-5: S2A MTF performance assessment.

Spectral Band	Measured ACT	Measured ALT	Requirement
B01	0.34±0.03	0.28±0.03	0.15 < MTF
B02	0.25±0.06	0.27±0.06	0.15 < MTF
B03	0.27±0.03	0.28±0.04	0.15 < MTF
B04	0.25±0.04	0.23±0.03	0.15 < MTF
B05	0.42±0.03	0.34±0.05	0.15 < MTF
B06	0.35±0.12	0.33±0.05	0.15 < MTF
B07	0.35±0.07	0.34±0.03	0.15 < MTF
B08	0.26±0.11	0.25±0.06	0.15 < MTF
B8A	0.36±0.06	0.31±0.04	0.15 < MTF
B09	0.25±0.10	0.27±0.03	0.15 < MTF
B11	0.20±0.04	0.24±0.04	0.15 < MTF
B12	0.24±0.07	0.22±0.06	0.15 < MTF

3. Processing Chain Status

3.1 Product Format

On December 6th 2016, a new naming convention has been introduced (Product Specification Document version 14). The new convention leads to shorter product paths with less redundancy of information. See below for an illustration of the new naming convention.

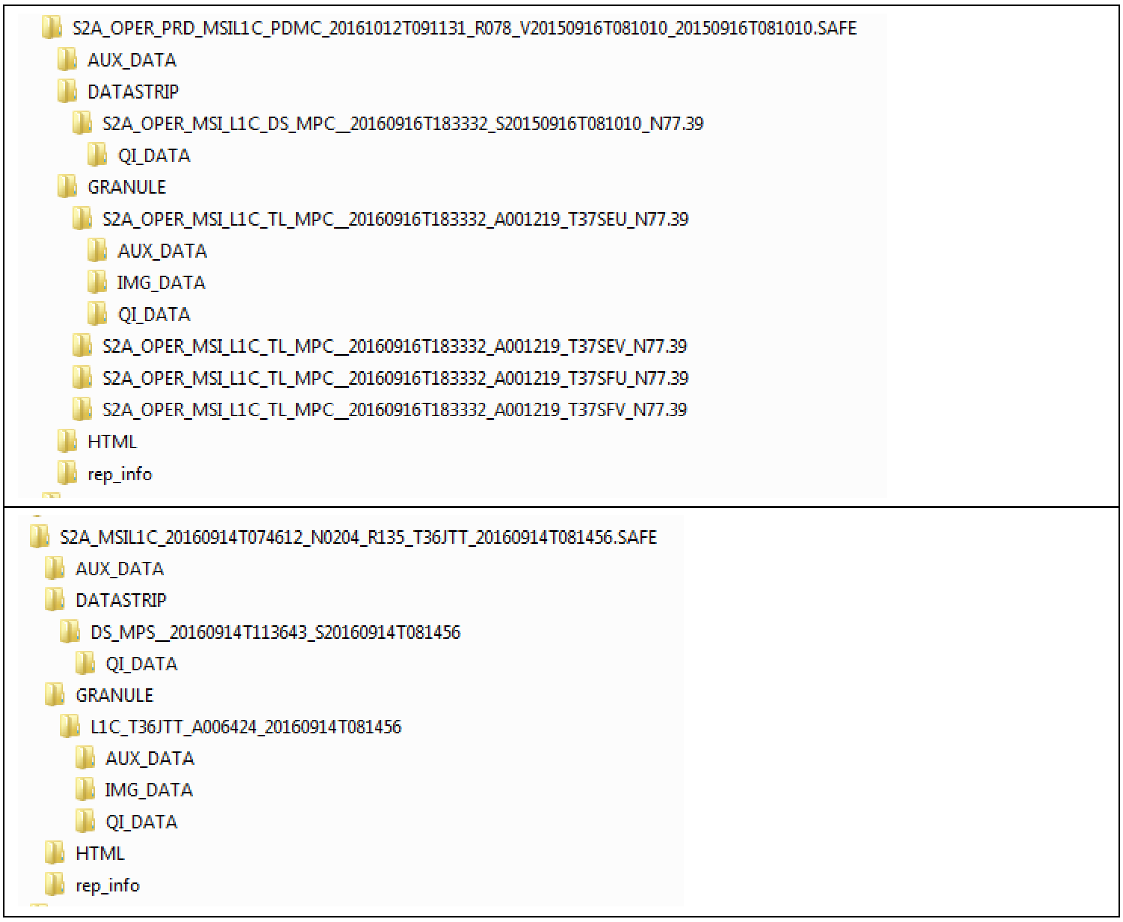


Figure 8: Product format overview. Top previous format (PSD issue 13), bottom: new format (PSD issue 14) for single-tile products.

As with the previous convention, two dates are included in the name of the SAFE product. However the meaning of these dates has changed:

- In the previous convention the first date referred to the product creation date and the second one to the sensing date
- In the compact naming convention, the first date is the sensing date while the second date is the "product discriminator", a reference date also based on the sensing date. The product discriminator date can be in some cases earlier or later than the sensing date.

Note that processing date can be still found in the datastrip metadata xml file.

The new products also contain an RGB "True Colour" image (TCI) in JPEG2000 format. The TCI image is created from the B02 (Blue), B03 (Green) and B04 (Red) bands, rescaled between 0 and 255 digital counts, with the following parameters:

- 0 digital count: No Data value
- 1 digital count: minimum reflectance level
- 255 digital counts: saturation level at reflectance 0.2

A new processing baseline is currently under validation. This new baseline will support the introduction of the European Data Relay Satellite (EDRS) for the Sentinel-2 mission. This additional downlink capacity will allow reaching an optimal revisit time worldwide (10 days revisit for 1 satellite). The new processing baseline will bring some minor changes in the product metadata. In addition, some processing anomalies will be fixed.

3.2 Status of Processing Baselines and Known Processing Anomalies

A new processing baseline 02.05 was introduced on 27/04/2017. This new baseline corrects anomalies #4, #23 and #24.

The table below summarizes recent evolutions of the evolutions of the processing baseline and the known processing anomalies affecting the production. The dates mentioned in the table refer to the product creation date.

Table 3-1: Summary of identified processing anomalies and associated processing baselines. Red: systematic anomaly. Orange: random anomaly affecting only a few products

<table>
<tr><th rowspan="3">Anomaly ID</th><th>Baseline number</th><th>02.01</th><th>02.02</th><th>02.03</th><th colspan="3">02.04</th><th>02.05</th></tr>
<tr><th>Deployment date</th><th>31/03/2016</th><th>03/05/2016</th><th>09/06/2016</th><th>15/06/2016</th><th>03/08/2016</th><th>26/01/2017</th><th>27/04/2017</th></tr>
<tr><th>Anomaly title</th><th></th><th></th><th></th><th></th><th></th><th></th><th></th></tr>
<tr><td>4</td><td>Instrument Measurement Time metadata</td><td colspan="6" style="background:#e6b8b7"></td><td></td></tr>
<tr><td>7</td><td>Missing Physical Gains metadata</td><td colspan="4" style="background:#e6b8b7"></td><td></td><td></td><td></td></tr>
<tr><td>12</td><td>Anomalous Pixels</td><td style="background:#fcd5b4"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>15</td><td>Strong Misregistration</td><td></td><td></td><td style="background:#e6b8b7"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>16</td><td>Stretched 60 m bands</td><td style="background:#fcd5b4">Orbit 4427</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>19</td><td>Wrong footprint on antemeridiem</td><td></td><td></td><td></td><td></td><td style="background:#e6b8b7"></td><td></td><td></td></tr>
<tr><td>23</td><td>Degraded AUX files</td><td colspan="6" style="background:#e6b8b7"></td><td></td></tr>
<tr><td>24</td><td>Imprecise technical quality mask</td><td></td><td></td><td></td><td></td><td colspan="2" style="background:#e6b8b7"></td><td></td></tr>
<tr><td>25</td><td>Geolocation error on orbit 7174</td><td></td><td></td><td></td><td></td><td style="background:#fcd5b4">orbit 7174</td><td></td><td></td></tr>
<tr><td>26</td><td>Incomplete manifest</td><td colspan="7" style="background:#e6b8b7">Until 18/05/2017</td></tr>
<tr><td>27</td><td>Incorrect footprint and missing metadata</td><td></td><td></td><td></td><td></td><td style="background:#e6b8b7"></td><td></td><td></td></tr>
</table>

Anomaly ID	Baseline number	02.01	02.02	02.03	02.04			02.05
	Deployment date	31/03/2016	03/05/2016	09/06/2016	15/06/2016	03/08/2016	26/01/2017	27/04/2017
	Anomaly title							
29	Incorrect cloud MTD						2 products found	
30	Corrupted metadata						50SQA 20/30/2017	
32	Missing viewing angles at ante-meridiem							
33	Missing bands							A few products
34	Missing ECMWF files							A few products

3.3 Archive Reprocessing

A reprocessing campaign of images acquired during the commissioning period (from launch till 30/11/2015) has been completed. Another reprocessing has been started on products with baseline 02.00, originally affected with a wrong tile numbering. The new products will be created with baseline 02.04, multi-tile format.

The following products from the reprocessing campaign are defective:

- Products from orbits 1296 to 1304 processed on October 2016 (large geolocation error due to a GPS anomaly)
- Orbits 2171, 2195, 2216 (large geolocation error)
- Orbit 1147 (too dark)

Finally a minor anomaly affects some products from September 2015 (see anomaly #9 in the next chapter). SWIR bands are strongly degraded. However VISNIR bands are meeting quality standards, so these products will remain available in the future.

3.4 Level 2A production

Since 02/05/2017, Sentinel 2 Level 2A products (atmospherically corrected) are available from the Sentinel data hub. This production is provided in the frame of pre-operational pilot project and is based on Sen2Cor 2.3.1. PlanetDEM Digital Elevation Model (DEM) is used, while cirrus and Bidirectional Reflectance Distribution Function (BRDF) corrections are deactivated.

Products are available for Europe with sensing date after 28/03/2017.

3.5 EDRS production

In the coming weeks, the European Data Relay System will be introduced to increase the data downlink capacity for the Sentinel 2 constellation. Thanks to the EDRS, a revisit time of 10 days (for one satellite) will be ensured globally. A new processing baseline will be introduced (02.06) to support this extension.

4. Product Anomalies

4.1 Introduction

This section describes all known product anomalies. Each anomaly is tagged with a code #N" allowing linking it to a given Processing Baseline through Table 3-1.

The table below provides the status of anomalies which are not related to processing and can therefore not be corrected through reprocessing. It complements Table 3-1 above.

Anomalies affecting obsolete products (baseline 02.00) are no longer described in this report.

Table 4-1: Anomalies not related to processing.

Anomaly ID	Anomaly title	Criticality	Unit	Affected products	Product status
9	Striping of SWIR bands	Minor	S2A	A few orbits, not systematic	Available
10	Striping of Visible bands	Major	S2A	A few orbits, not systematic	Removed from archive
13	B10 saturation	Minor	S2A	Products with high reflectances	Available
14	Geolocation error	Major	S2A	Orbits 3218, 4080 and 4081	Removed from archive
17	Misaligned detectors on band 1	Minor	S2A	A few orbits impacted (beginning of the datastrip)	Available
18	Geolocation Error	Minor	S2A	Orbits 6003 to 6011	Available

4.2 Instrument Measurement Time metadata (#4)

Within the satellite ancillary metadata, the value of Instrument Measurement Time (IMT) is not represented correctly due to a formatting error. This anomaly is corrected with product baseline 02.05.

4.3 Missing Physical Gains metadata (#7)

Band 12 is missing in the “physical gains” metadata of the user product. However the full list of physical gains is present in the metadata at granule level. This error was corrected early August 2016 and recent products are not anymore affected.

4.4 Striping of SWIR Bands (#9)

This anomaly is characterized by along-track stripes on some detectors of SWIR band images (see image below). Other detectors are also misaligned (along-track shift).

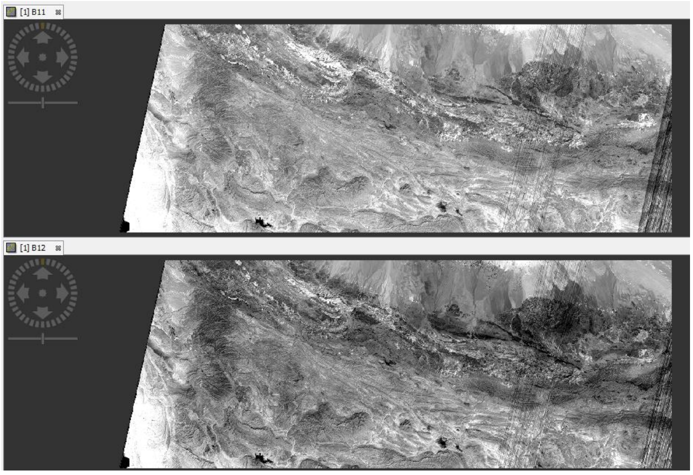


Figure 9: Striping of SWIR bands (anomaly #9). Top: B11, Bottom, B12.

This anomaly occurred during commissioning as a result of an incorrect instrument configuration. Users are advised to use only VISNIR bands for the corresponding orbits.

1118	1205	1302	1404
1143	1218	1308	
1146	1227	1314	
1151	1234	1319	
1156	1244	1326	
1159	1246	1329	
1171	1251	1337	
1175	1256	1342	
1186	1261	1343	
	1272	1348	
	1274	1391	
	1298	1394	

Table 4-2: List of orbits affected by anomaly #9.

4.5 Striping due to lost source packets (#10)

Data downlink issue sometimes lead to missing instrument source packets. This results in missing or corrupted pixels in L1C image, typically affecting only odd or even detectors and some spectral bands. The figure below presents an example of product affected by missing packets.

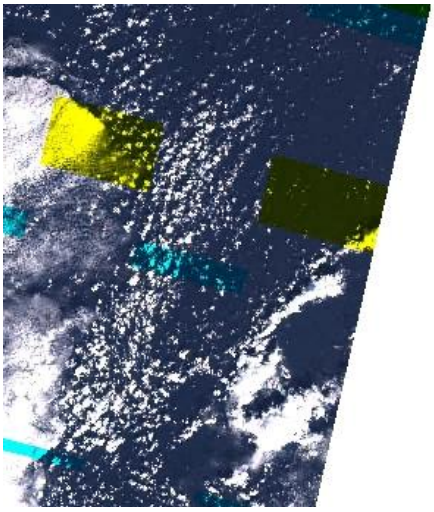


Figure 10: L1C product affected by a large number of missing packets. This type of feature is not considered as an anomaly and will not lead to removal of affected products.

Under the current quality control policy, this effect is not considered as an anomaly. Products affected by missing packets will remain in the archive.

This type of behaviour is expected and traced in the product:

- a technical quality check is performed at datastrip level and reported in the End User product metadata in case of failure;
- the number of missing packets is reported in the datastrip metadata;
- the affected area is described in the technical quality masks (TECQA gml files).

4.6 Anomalous Pixels (#12)

This anomaly is characterized by anomalous pixel values at the boundary of a datastrip. This anomaly has been corrected with baseline 02.02.

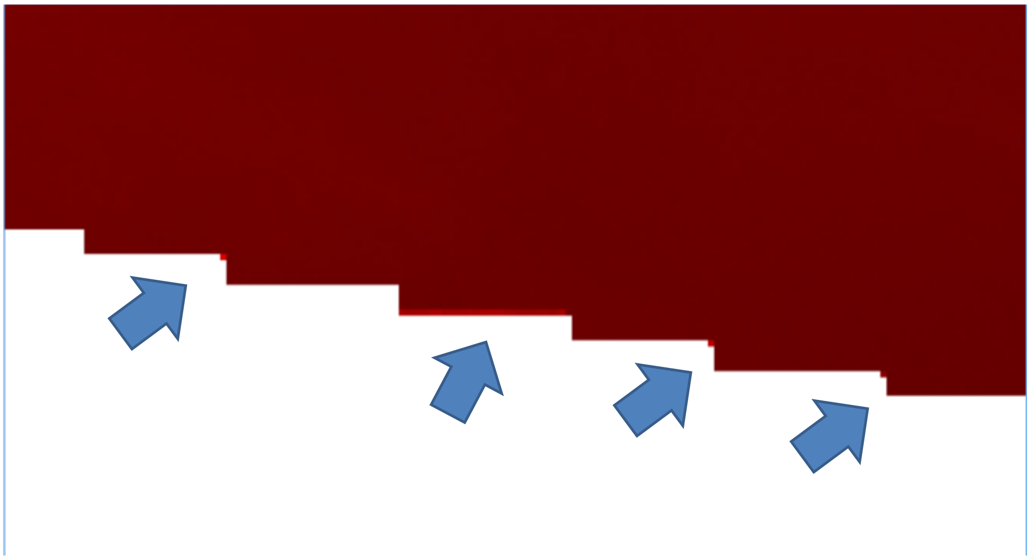


Figure 11: Anomalous pixels on band B4 (anomaly #12).

4.7 Saturation noise on Band 10 Images (#13)

This feature is characterized by noise patterns on bright images. It has now been identified as generated by saturation of the detector. This effect is not an anomaly in itself, however the saturation is currently not correctly reported in the image quality masks. A modification of the processor is in progress to solve this issue.

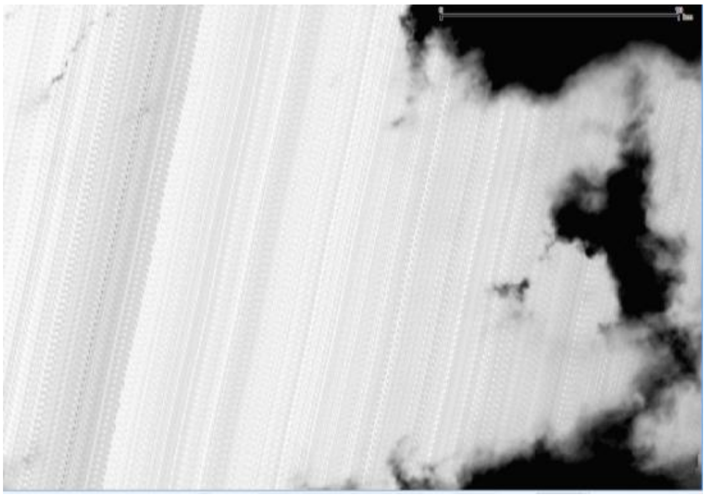


Figure 12: Along-track noise pattern on B10 images over bright clouds (#13).

4.8 Geolocation and Co-registration Error (#14)

A major anomaly has led to a strong and temporary geolocation and spectral registration errors. The anomaly occurred on February 3rd (orbit 3218) and 3rd of April 2016 (orbits 4080, 4081 and 4082). This anomaly has been correctly identified by the automatic on-line quality control and the degraded geometric performance is reported in the product metadata (geometric quality check status is "FAILED"). After identification of the anomaly, the defective products have been removed from the public archive.

The root cause of this anomaly has been identified. Missing data from attitude control telemetry is at the origin of the anomaly. An optimization of the management of the on-board telemetry has been implemented since and should avoid any re-occurrence.

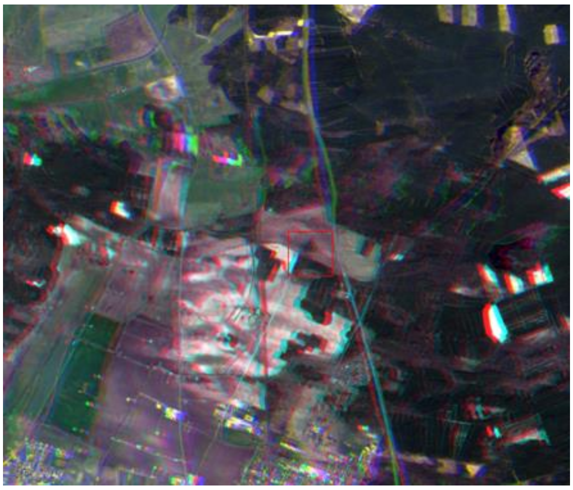


Figure 13: Spectral co-registration error (anomaly #14).

4.9 Strong Misregistration (#15)

Processing Baseline 02.03 deployed on 09/06/2016 was affected by an anomaly due to an incorrect configuration of the processing centres. This anomaly results in a strong spectral misregistration. This issue was rapidly identified, defective products have removed from the archive and subsequently reprocessed with baseline 02.02. After correction of the configuration error, baseline 02.04 was deployed on 15/06/2016.

4.10 Stretching of 60 m Bands (#16)

This anomaly is characterized by an incorrect appearance of the 60 m bands: images are stretched across-track and discontinuities are visible between detector boundaries. A few occurrences have been observed, and none since 27/04/2016.

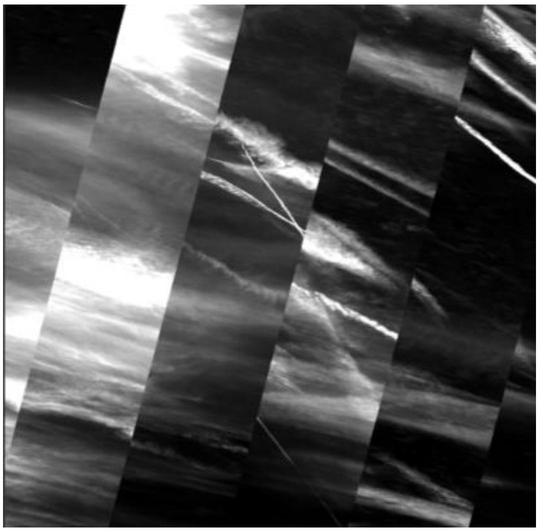


Figure 14: Stretching of 60 m bands (anomaly #16).

4.11 Misaligned detectors on band 1 (#17)

An anomaly on the receiving ground station occurred on 12th of July 2016 and led to corrupted products for a few orbits (5509 to 5525). The anomaly affects only band 1 and is limited the first products for the datastrips (Northern part). It is characterized by a misalignment of the odd and even detectors, as illustrated in the figure below.

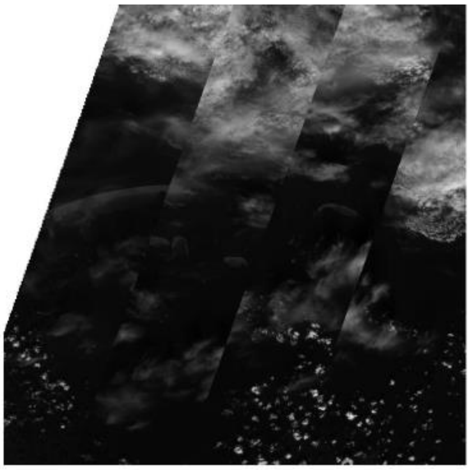


Figure 15: Detector misalignment on band B1 (anomaly #17).

A possible correction of this anomaly by an ad-hoc reprocessing is under study.

4.12 Geolocation Error (#18)

This anomaly occurred while the satellite was performing a collision avoidance manoeuvre on 16th August 2016. One Star Tracker was temporarily blinded by the Sun, which led to a degradation of the attitude estimation. As a result, the geolocation of the products acquired during this period (orbits 6003 to 6011) is affected by a variable geolocation error of up to 100 meters.

The anomaly seems related to the handling of the redundant Star Tracker in the attitude estimation system. Further analysis is on-going and possible remediation is investigated.

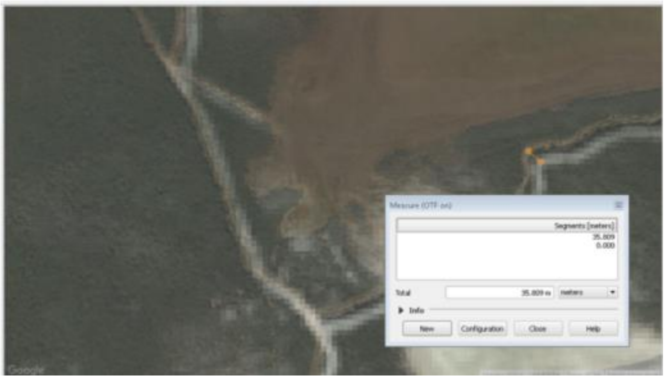


Figure 16: S2 image superimposed with reference map, showing a geolocation error of 35 m (anomaly #18).

4.13 Product footprint on the ante-meridiem (#19)

With the introduction of single tile products in October 2016, an issue has been identified in the product footprint for tiles crossing the ante-meridiem (180° longitude). The footprint should be composed of two rectangles in (above -180° and below +180°). Instead, only the second rectangle is present.

This anomaly has been fixed on 26/01/2017.

4.14 Degraded AUX files (#23)

This anomaly affects the ECMWF auxiliary files, for some specific tiles. The files are truncated and contain aberrant values. This anomaly is fixed with production baseline 02.05.

4.15 Imprecise technical quality mask (#24)

Since October 2016, technical quality masks (TECQA) are reporting instance of lost data packets (see anomaly #10). However it has been found that the masks are not perfectly accurate (see figure below). This anomaly is corrected with production baseline 02.05.

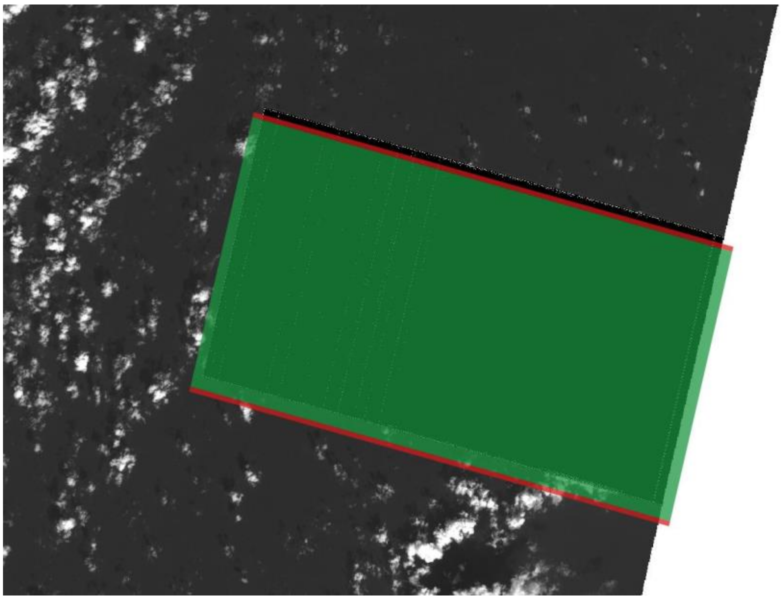


Figure 17: Technical Quality masks (green: lost packets, red: degraded packets) overlayed over an affected imaged. A small gap exists between the mask and the affected area (anomaly #21).

4.16 Geolocation error on orbit 7174 (#25)

A geolocation error of more than 100 m has been observed on the first datastrip of orbit 7174 (acquired 05/11/2016). A reprocessing is planned for this datastrip to correct this anomaly.

4.17 Incomplete manifest (#26)

In products generated before 18/05/2017, the meteorology Auxiliary files are missing from the file listing in the manifest.safe.

4.18 Inaccurate footprint and incomplete metadata (#27)

This anomaly occurred on January 20th 2017 following a change in the user product generation chain, and was solved on January 26th 2017. The anomaly affected the diffusion of products on the SciHub, and as a result few products affected by this anomaly have been disseminated. The characteristics of this anomaly are:

- Coarse precision of product footprint (1/3°)
- Missing Datastrip Identifier and granule Identifier attributes.

4.19 Incorrect cloud coverage metadata (#29)

Two products have been found affected by this anomaly. The products have very small data coverage and are completely cloudy. The cloud mask is accurate but the cloud coverage metadata is reported as zero. The affected products are 30UXB on 11/02/2017 and 50KQL on 12/04/2017.

Analysis is on-going to understand the root cause of this anomaly.

4.20 Corrupted metadata (#30)

The product for tile 50SQA generated on 20/03/2017 has several metadata with an incorrect "0" value (quantification value, spectral irradiances). Correction is under way. No other product has been found with this anomaly so far.

4.21 Missing viewing angles metadata (#32)

Viewing angles metadata (part of L1C granule metadata) are systematically missing for tiles of UTM zone 01 crossing the ante-meridiem. This anomaly is currently being analysed.

4.22 Missing spectral bands (#33)

Some recent products have been found with one or several spectral band images missing. Since 08/07/2017, the dissemination of defective products is blocked, while a remediation is in progress.

4.23 Missing ECMWF auxiliary files (#34)

In some cases, the meteorology auxiliary files (ECMWF data) are missing in the products. The root cause has been identified and the correction is in progress.

5. Pixels Status

5.1 Defective pixels

5.1.1 S2A

In the following tables are listed all the identified defective pixels which are currently replaced by an interpolation of neighbouring pixels. The health status has been verified after the last decontamination operation in January.

Table 5-1: Defective pixels on S2A Band 10.

Band B10			Current status & R2DEPI defective pixels	
Band	Detector	Pixel number (from 0)	Current status	Last updated
B10	4	1104	Defective	16/11/2015
B10	10	879	Defective	23/06/2015
B10	10	1174	Defective	23/06/2015

Table 5-2: Defective pixels on S2A Band 11.

Band B11			Current status & R2DEPI defective pixels	
Band	Detector	Pixel number (from 0)	Current status	Last updated
B11	**D11**	**24**	Defective	26/08/2015

Table 5-3: Defective pixels on S2A band 12.

Band B12			Current status & R2DEPI defective pixels	
Band	Detector	Pixel number (from 0)	Current status	Last updated
B12	1	440	Defective	26/08/2015
B12	1	703	Defective	06/11/2015

5.1.2 S2B

Table 5-4: Defective pixels on S2A band 12.

Band B12			Current status & R2DEPI defective pixels	
Band	Detector	Pixel number (from 0)	Current status	Last updated
B12	D3	1132	Defective	30/05/2017

5.2 Reset Spike pixels

During the MSI design phase, it has been identified that a few pixels of the 10 m bands are affected by an electronic cross-talk during detector read-out. This results in errors which can reach a few digital counts, depending on the observed scene.

We provide below the list of affected pixels.

Table 5-5: S2A Pixel affected by reset spike noise.

Band	pixel number		Current status
	Odd detector number	Even detector number	
B02, B03, B04	35	2556	Pixel Reset Noise
	489	2102	Pixel Reset Noise
	781	1810	Pixel Reset Noise
	961	1630	Pixel Reset Noise
	1036	1555	Pixel Reset Noise
	1177	1414	Pixel Reset Noise
	1252	1339	Pixel Reset Noise
	1724	867	Pixel Reset Noise
	1822	769	Pixel Reset Noise
B08	35	2556	Pixel Reset Noise

Table 5-6: S2B Pixel affected by reset spike noise.

Band	Pixel number		Current status
	Odd detector number	Even detector number	
B2	618	1973	Pixel Reset Noise
	619	1972	Pixel Reset Noise
	715	1876	Pixel Reset Noise
	895	1696	Pixel Reset Noise
	1047	1544	Pixel Reset Noise
	1539	1052	Pixel Reset Noise
	1596	995	Pixel Reset Noise
	1612	979	Pixel Reset Noise
	1669	922	Pixel Reset Noise
B3,B4	187	2404	Pixel Reset Noise
	619	1972	Pixel Reset Noise
	715	1876	Pixel Reset Noise
	895	1696	Pixel Reset Noise
	1047	1544	Pixel Reset Noise
	1539	1052	Pixel Reset Noise
	1596	995	Pixel Reset Noise
	1612	979	Pixel Reset Noise
	1669	922	Pixel Reset Noise
B5	1243	52	Pixel Reset Noise
B7	1273	22	Pixel Reset Noise
B8	87	2504	Pixel Reset Noise

6. Product Features

6.1 Spectral Response Non-uniformity

In this section we report on a known feature of Sentinel 2 products created by the spectral response non-uniformity. This feature has been anticipated since the design phase and is compliant with mission specification.

This feature is characterized by along-track soft-edged darker or brighter stripes near the detector boundaries, as shown on the figure below. Indeed, the spectral response is slightly different at the edges of the detectors, especially for bands B03 and B05. When the spectrum of the scene has strong gradient over the spectral bandwidth of the detector, a difference in the measured radiometry can be observed (up to 2% in worst-cases).

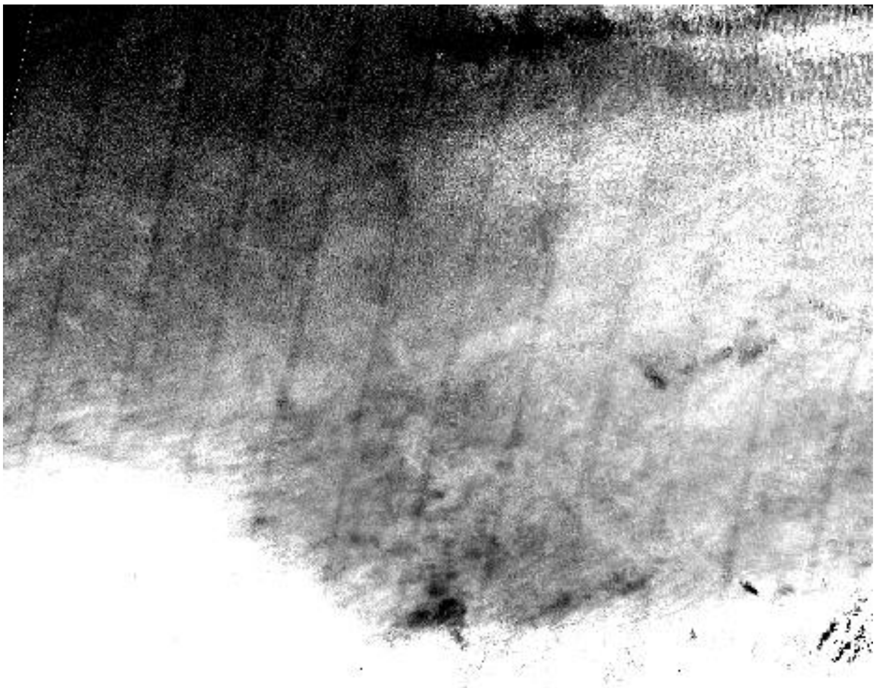


Figure 18: Along-track stripes resulting from spectral response non-uniformity (band B03).

6.2 Parallax effects

In this section we report on parallax effects created by the staggered configuration of the focal plane. Indeed the instrument swath is covered by 12 individual detectors assembled in a staggered manner. Because of this configuration, odd and even detectors do not see the ground under the same viewing angles. This can create visible effects on some images, as detailed in the next subsections.

6.2.1 Surface reflectance effects

Because the viewing angles are not the same for even and odd detectors, differences in measured radiometry can be observed on non-Lambertian surfaces. This is especially visible on Sun glint over sea surfaces (see Figure below).

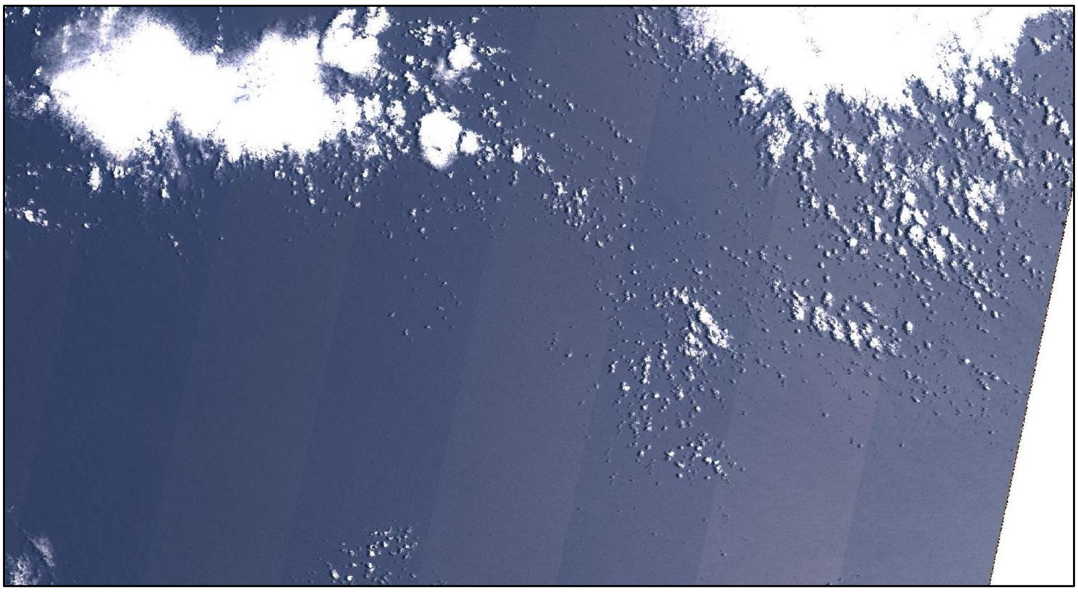


Figure 6-19: Stripe pattern over sea surface, due to the observation parallax effect between odd and even detectors.

6.2.2 Misregistration of High Altitude Objects

The processing algorithm ensures the coregistration of images acquired by all spectral bands and the detectors for features at ground level. Objects at a higher altitude like planes and clouds cannot be properly coregistered. As already reported in the first issue of the Data Quality Report, this effect leads to spectral misregistration (“rainbow” effect) and discontinuities between detectors.

Both effects can be seen in Figure 20 below.

Figure 20: Spectral misregistration and detector misalignment for object at high altitude (plane and contrail). This feature is not an anomaly.

6.3 Across-Track noise

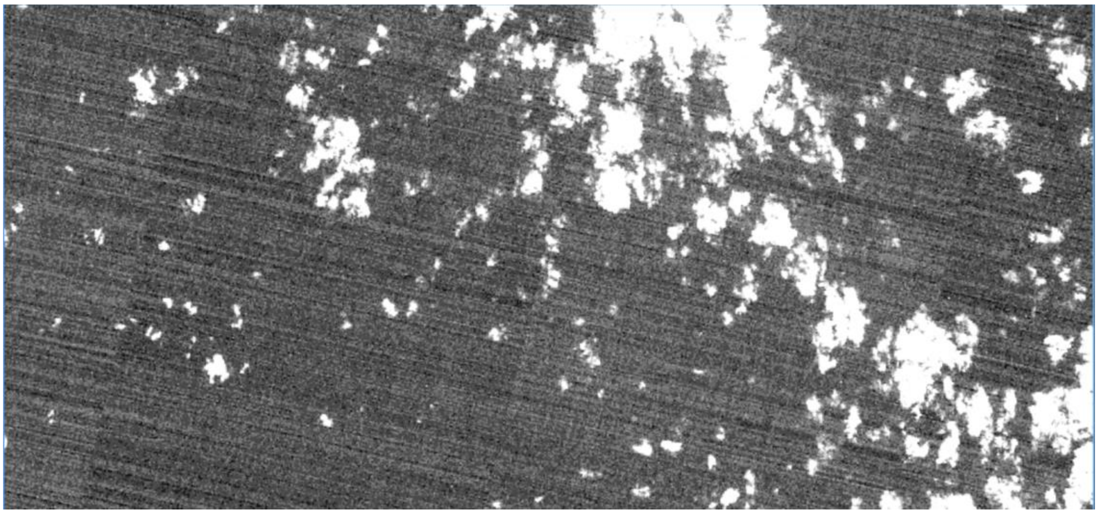


Figure 21: Across-Track intra-detector noise pattern

This feature can be observed in very dark images (typically on B10 or B12 over the sea). It is characterized by across-track lines covering a whole detector. The typical range of this noise pattern is a few digital counts, and therefore within the requirements of the mission.

This phenomenon is induced by the compression noise on "blind" pixels used for dark signal correction. A solution to filter out this noise has been identified and its operational implementation is currently under study.

End of document