S2 MPC

Data Quality Report

Ref. S2-PDGS-MPC-DQR

Authors Table

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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 prepared 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", submitted[1]).

[1] http://www.preprints.org/manuscript/201610.0078/v1

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.

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

The constant monitoring of the instrument line-of-sight has revealed a small evolution of the biases since Q3 2016. Consequently the geometric calibration has been updated on November 15th.

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, validation in progress
North-America	Input data collection in progress
South-America	Ready for processing
Asia	Processing in progress
Islands	Input data collection in progress

2.2.3 Absolute Geolocation

The geolocation performance has been assessed by measuring the error on a set of 931 ground control points (GCPs) on 137 products of baseline 02.04.

The latest performance estimation is 11 m at 95.5% (vs. requirement of 20 m for unrefined products), see figure below. The small degradation with respect to previous estimates is linked to a few outliers which have traced back to temporary Star Tracker outages.

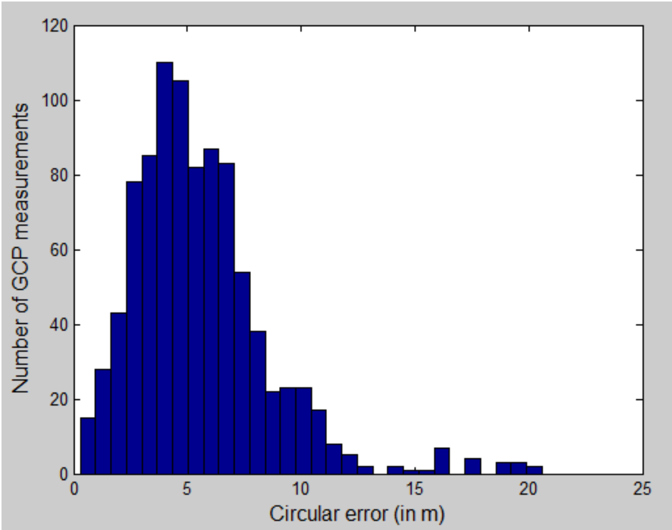

Figure 1: Histogram of the measured geolocation circular error. The typical performance is around 4 m, while the 95% confidence value is 10.8 m. A few outliers (>15 m) correspond to temporary outages of the Star Tracker.

A small bias was observed (visible on Figure 2 below) and led to a correction of the satellite geometrical model in November 15th. A few outliers where identified and have been explained by a temporary loss of performance of the navigation system. Otherwise, no significant trend in the performance is observed, as can be seen on Figure 2, right.

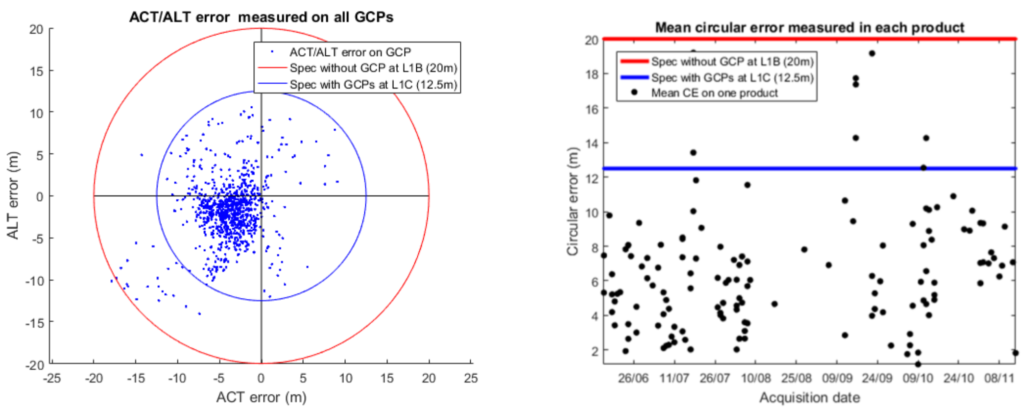

Figure 2: Geolocation performance assessment with processing baseline 02.04. Left: Point cloud of measured errors in Across-Track (ACT)/Along-Track (ALT) frame for each control points. Right: Timeline of measured circular errors for each product.

2.2.4 Multi-Spectral Registration

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

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

Bref/Bsec - Det	CE@99.73%	Bref/Bsec - Det	CE@99.73%
B04/B03-D01	0.237	B05/B11-D01	0.189
B04/B03-D02	0.214	B05/B11-D02	0.222
B04/B03-D03	0.202	B05/B11-D03	0.181
B04/B03-D04	0.165	B05/B11-D04	0.15
B04/B03-D05	0.182	B05/B11-D05	0.16
B04/B03-D06	0.168	B05/B11-D06	0.147
B04/B03-D07	0.203	B05/B11-D07	0.151
B04/B03-D08	0.162	B05/B11-D08	0.143
B04/B03-D09	0.146	B05/B11-D09	0.127
B04/B03-D10	0.145	B05/B11-D10	0.111
B04/B03-D11	0.135	B05/B11-D11	0.125
B04/B03-D12	0.122	B05/B11-D12	0.113
B11/B12-D01	0.259	B05/B12-D01	0.212
B11/B12-D02	0.292	B05/B12-D02	0.221
B11/B12-D03	0.218	B05/B12-D03	0.178
B11/B12-D04	0.155	B05/B12-D04	0.151
B11/B12-D05	0.182	B05/B12-D05	0.141
B11/B12-D06	0.133	B05/B12-D06	0.121
B11/B12-D07	0.109	B05/B12-D07	0.115
B11/B12-D08	0.121	B05/B12-D08	0.117
B11/B12-D09	0.107	B05/B12-D09	0.113
B11/B12-D10	0.084	B05/B12-D10	0.107
B11/B12-D11	0.114	B05/B12-D11	0.114
B11/B12-D12	0.091	B05/B12-D12	0.096

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. According to this methodology, the current performance is 1.2 pixel. Figure 3 shows the histogram of the distribution of multi-temporal registration errors, showing a peak at 0.3 pixels.

It is recalled that the objective is to meet the required 0.3 pixel performance (95.5% confidence level) with the activation of the geometric refinement using the GRI.

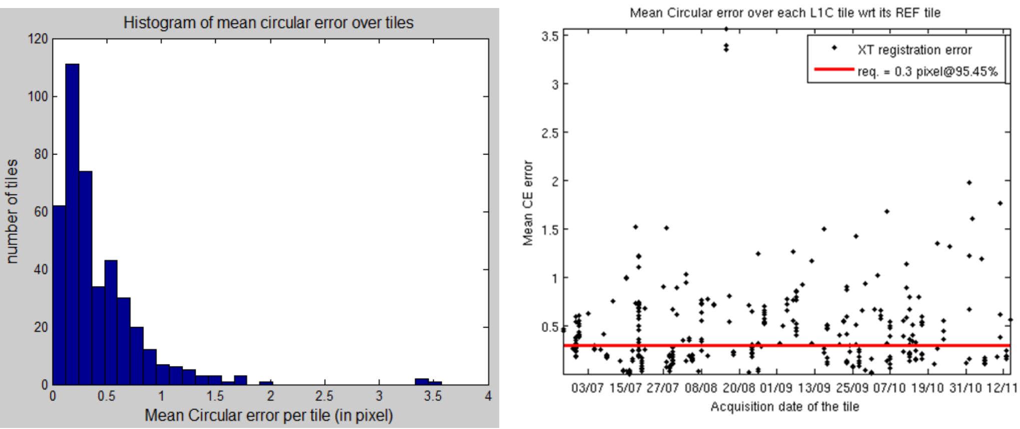

Figure 3: Histogram (left) and Time series (right) of the multi-temporal performance. The 0.3 pixel requirement will be applicable only after activation of the geometrical refinement. The current performance is 1.2 pixel at 95% confidence.

2.3 Radiometric Performance

2.3.1 Radiometric Calibration Status

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

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.
- Comparison with other sensors (Landsat OLI).

The first two methods indicate a radiometry slightly above the reference (typically 2.5%) for visible bands but still within requirements.

The results of the different methods are presented in the figure below. Results are provided for all bands, except B10 (water vapour absorption band) for which direct validation is not possible. All results are compatible with the 5% radiometric accuracy requirement. 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 (0_2 and water vapour).

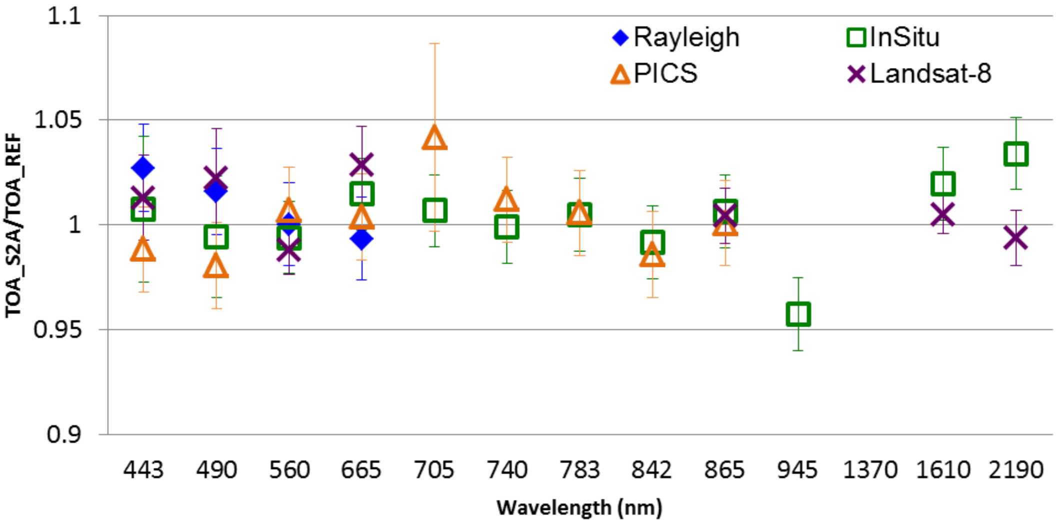

Figure 4: Comparison of radiometric accuracy for all spectral bands (except B10): ratio of S2A measurement on reference. Error bars indicate the method uncertainty.

Tabulated results for bands B01 to B8A presented below indicate the effectiveness and reliability of the on-board calibration method.

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

S2A/MSI	Wavelength (nm)	Gain Coefficient	Standard Deviation
B01	443	0.989	0.027
B02	490	0.983	0.025
B03	560	1.006	0.025
B04	665	1.001	0.017
B05	705	1.038	0.033
B06	740	1.010	0.021
B07	783	1.005	0.013
B08	842	0.983	0.029
B8A	865	1.000	0.011

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).

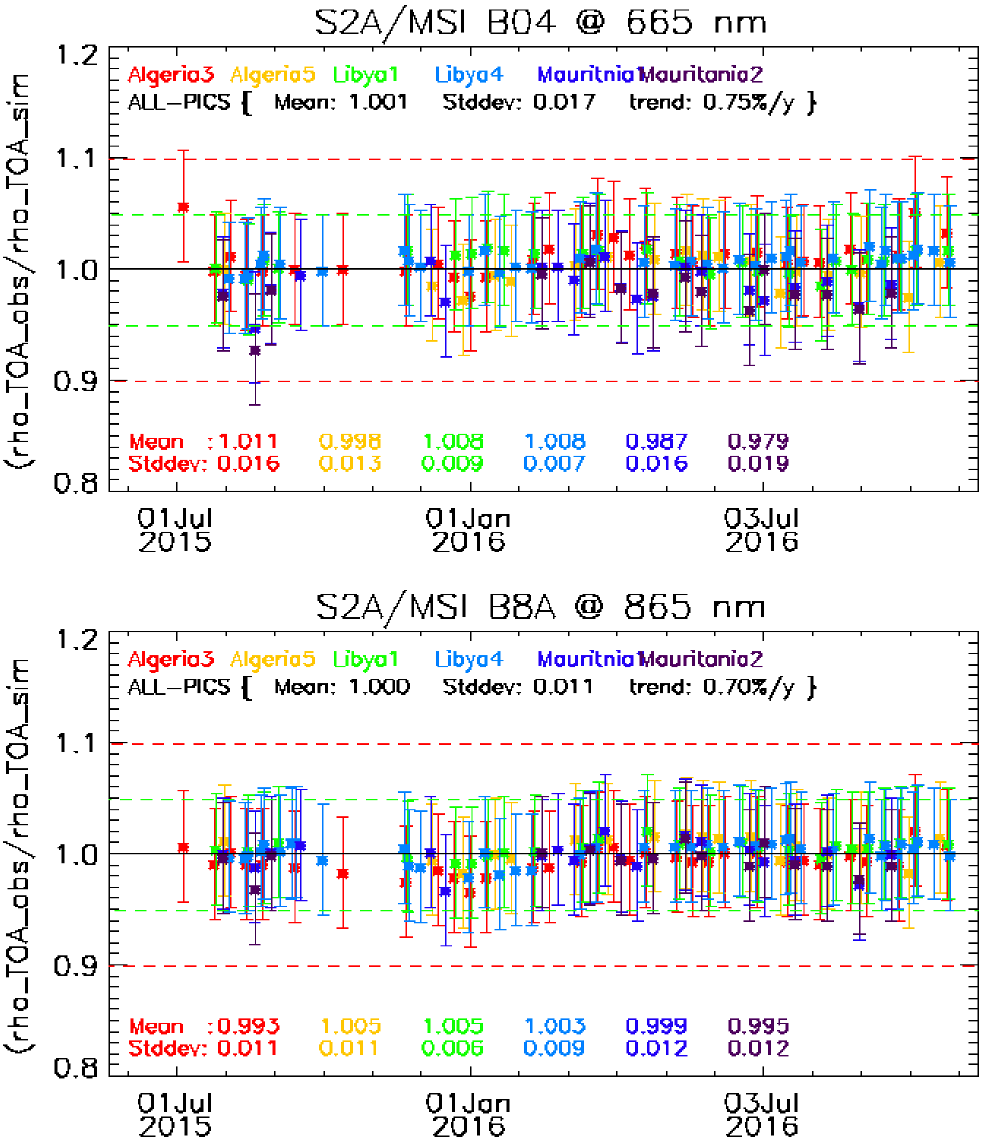

Figure 5: Time series of the ratio as observed reflectance over simulated from S2A/MSI for band B04 (665 nm, top) and band B08 (865 nm, bottom) over the 6 PICS Cal/Val-sites. Error bars indicate the method uncertainty.

2.3.3 Noise

The Signal-to-Noise Ratio (SNR) performances estimates have been slightly revised for 60 m bands to better take into account the effect of spatial binning. The performances remain excellent. The SNR is higher than 160 (worst-case for band B8A).

Table 2-4: Estimated SNR performance 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
Measured	1372	214	249	230	253	220	227	221	161	222	390	159	217
Requirement	129	154	168	142	117	89	105	174	72	114	50	100	100
Margin (%)	963	39	48	62	116	147	116	27	124	95	680	59	117

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

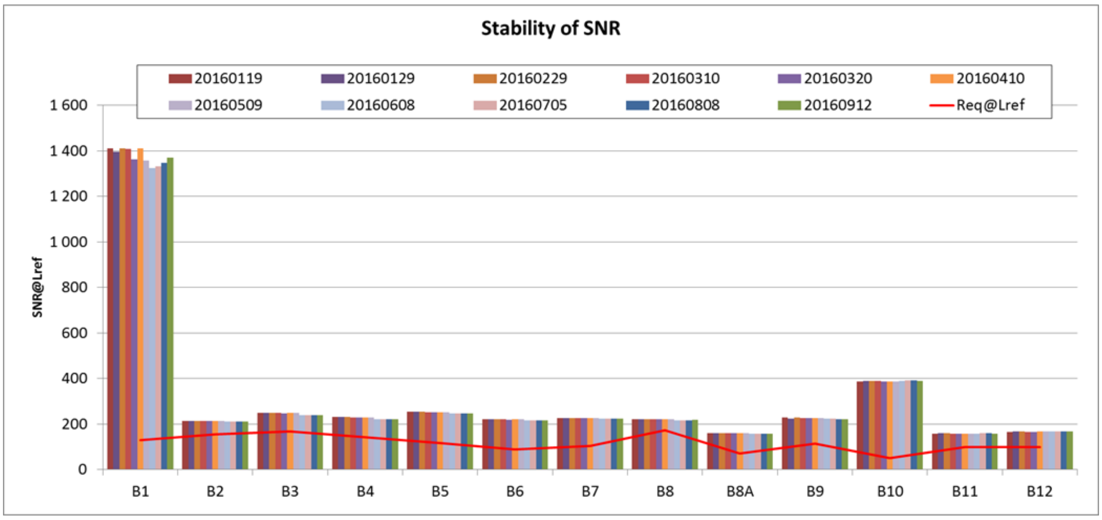

Figure 6: Evolution of the SNR performance since 19/01/2016.

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.

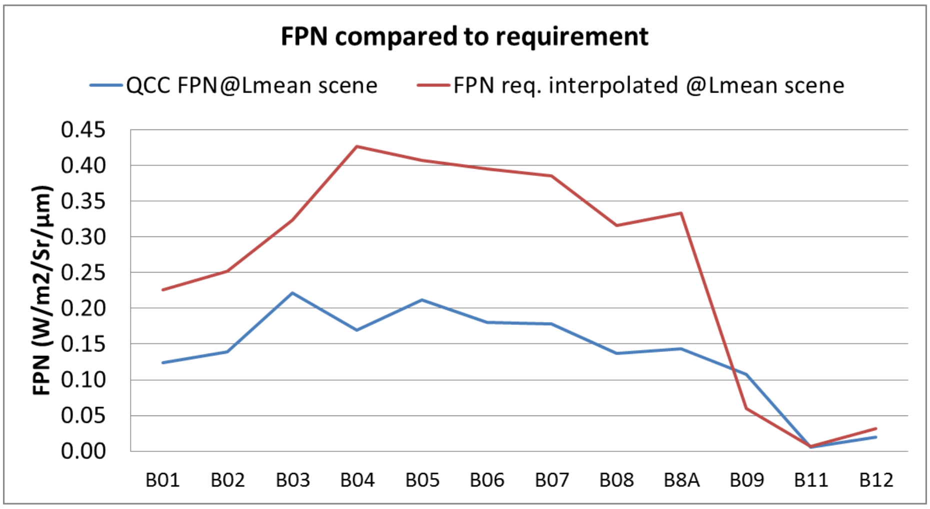

Figure 7: Measured Fixed Pattern Noise (residual error after equalization) on quasi-uniform scenes (blue curve), compared to requirement interpolated at scene radiance (red curve). The noise is better than requirements for VNIR bands and close to requirements for SWIR bands.

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-flight 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.

Table 2-5: MTF performance assessment.

Spectral Band	Measured ACT	Measured ALT	Requirement
B01	0.34±0.03	0.28±0.03	0.15 < MTF < 0.45
B02	0.25±0.06	0.27±0.06	0.15 < MTF < 0.30
B03	0.27±0.03	0.28±0.04	0.15 < MTF < 0.30
B04	0.25±0.04	0.23±0.03	0.15 < MTF < 0.30
B05	0.42±0.03	0.34±0.05	0.15 < MTF < 0.30
B06	0.35±0.12	0.33±0.05	0.15 < MTF < 0.30
B07	0.35±0.07	0.34±0.03	0.15 < MTF < 0.30
B08	0.26±0.11	0.25±0.06	0.15 < MTF < 0.30
B8A	0.36±0.06	0.31±0.04	0.15 < MTF < 0.30
B09	0.25±0.10	0.27±0.03	0.15 < MTF < 0.45
B11	0.20±0.04	0.24±0.04	0.15 < MTF < 0.30
B12	0.24±0.07	0.22±0.06	0.15 < MTF < 0.30

3. Processing Chain Status

3.1 Product Format

Since September 27th, user products are distributed in a "single tile" format.

On October 20th the definition of the product sensing start and stop time has been modified to avoid inconsistencies observed on some occasions. Currently the sensing start and stop time of a product are both equal to the datatake start time. In the future it is planned to introduce a more accurate sensing time for each individual tile.

On December 6th, 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.

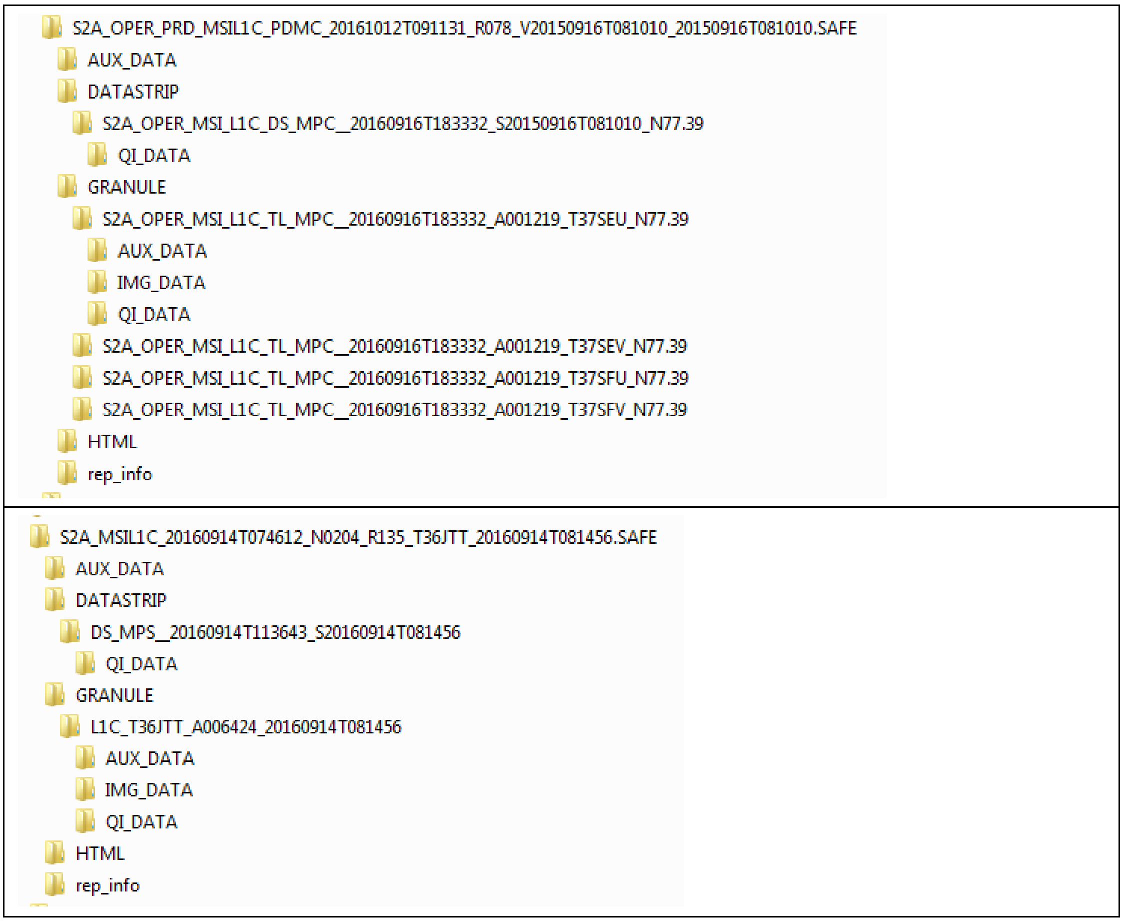

Figure 8: Product format overview. Top previous format (PSD issue 13), bottom: new format (PSD issue 14) for single-tile products.

The new products also contains an RGB "True Colour" image (TCI) in JPEG2000 format. The new xsd schemas[2] are available from ESA.

3.2 Status of Processing Baselines and Known Processing Anomalies

The table below summarizes 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.

<table>
<tr><th rowspan="3">Anomaly ID</th><th>Baseline number</th><th colspan="2">02.01</th><th>02.02</th><th>02.03</th><th colspan="2">02.04</th></tr>
<tr><th>Deployment date</th><th>27/01/2016</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></tr>
<tr><th>Anomaly title</th><th></th><th></th><th></th><th></th><th></th><th></th></tr>
<tr><td>4</td><td>Instrument Measurement Time MTD</td><td></td><td colspan="5">yes</td></tr>
<tr><td>5</td><td>Minimum Reflectance "0"</td><td>yes</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>6</td><td>Detector Footprint at Equator</td><td>yes</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>7</td><td>Missing Physical Gains MTD</td><td colspan="5">yes</td><td></td></tr>
<tr><td>11</td><td>Missing Viewing Angles MTD</td><td>yes, not systematic</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>12</td><td>Anomalous Pixels</td><td colspan="2">yes, few products impacted</td><td></td><td></td><td></td><td></td></tr>
<tr><td>15</td><td>Strong Misregistration</td><td></td><td></td><td></td><td>yes</td><td></td><td></td></tr>
<tr><td>16</td><td>Stretched 60 m bands</td><td colspan="3">A few orbits impacted</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></td><td>yes</td></tr>
</table>

3.3 Archive Reprocessing

A reprocessing campaign of images acquired during the commissioning period (from launch till 30/11/2015) is in progress.

Due to a major anomaly in the L0 archive of the reprocessing centre, many L1 products generated for the period between 04 July and 03 September 2015 with

[2] https://sentinels.copernicus.eu/documents/247904/685211/Sentinel-2-Product-Specifications-Document-XSD-schemas

baseline 02.01 and 02.02 are anomalous. This period is being reprocessed with processing baseline 02.04 and users are advised to only use products generated with this baseline.

Another series of issues at the reprocessing centre has led to the release of corrupted products from sensing period September 2015 (reprocessed between 13 and 26 October 2016). The affected products have been removed from the SciHub archive. Users are advised to check the discard of the corresponding products and look for newly reprocessed products in the future.

In addition, close inspection of reprocessed products led to discover new anomalies which had not be detected during commissioning. The related products have been removed from the archive and will not be reprocessed as they are not recoverable. These anomalies are:

- Misaligned detectors, spectral misregistration and black pixels in visible bands, affecting some products on S2A orbits 792, 847, 990, and 1043. These anomalies are generated by Instrument Source Packets lost during downlink.
- Important geolocation error affecting orbits 1296 to 1304. This problem arose when a dysfunction of one on-board GPS receiver occurred (corrected since then with a software patch).

Finally, some products from September 2015 affected by a minor on-board anomaly are now available in the archive. The anomaly affects only SWIR bands while visible bands are meeting quality standards. The anomaly (Id #9) is described in section 4.6 and the list of affected orbits is provided.

4. Product Anomalies

4.1 Introduction

This section describes all known product anomalies. Each anomaly is tagged with a code #N" allowing to link 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.

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 noise	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 MTD (#4)

Within the satellite ancillary metadata, the value of Instrument Measurement Time (IMT) is not represented correctly due to a formatting error.

4.3 Minimum Reflectance "0" (#5)

Valid pixels with zero reflectance could not be distinguished from "no data" pixels (coded with value 0). Zero reflectance pixels could be observed on the water vapour absorption band B10 or on SWIR band B12 over water surfaces.

It has been decided to truncate reflectance values to digital number 1 (i.e. reflectance 0.0001) to solve this issue, only "no data" pixels will be marked with value 0.

4.4 Detector Footprint at Equator (#6)

An error was found in the detector footprint gml file for tiles immediately North of the equator (systematic error). This error is corrected with baseline 02.01 after end of March 2016.

4.5 Missing Physical Gains MTD (#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.

4.6 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).

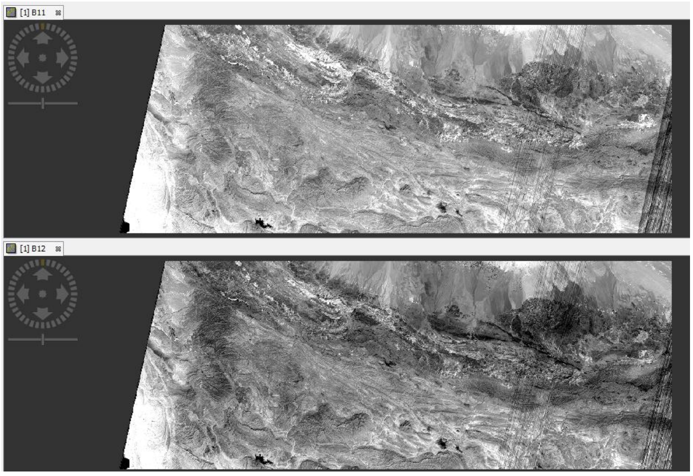

Figure 9: Striping of SWIR bands (anomaly #9). Top: B11, Bottom, B12.

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.

4.7 Striping of Visible Bands (#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 occurrence observed recently.

This type of behaviour is expected and traced in the product: the number of missing packets is reported in the datastrip metadata and the affected area is described in the technical quality masks (TECQA gml files).

The currently quality control policy is to remove from the archive products which present such large defects that they are no longer fit for purpose. This has been the case recently with several tiles on orbit 7201 (see figure below).

On the other hand, products with minor defects will be left in the archive.

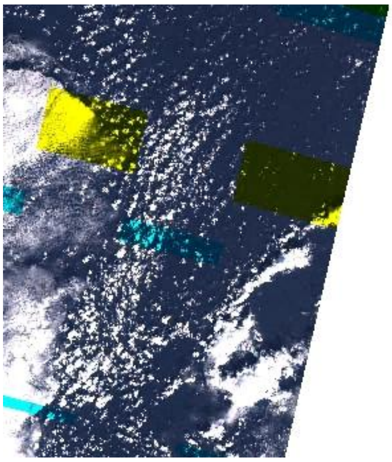

Figure 10: L1C product affected by a large number of missing packets (Anomaly #10).

4.8 Missing Viewing Angles MTD (#11)

For some products, the mean viewing angles in the tile metadata were missing for some bands in some products (not systematic). This anomaly is solved with baseline 02.01 after end of March 2016.

4.9 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.

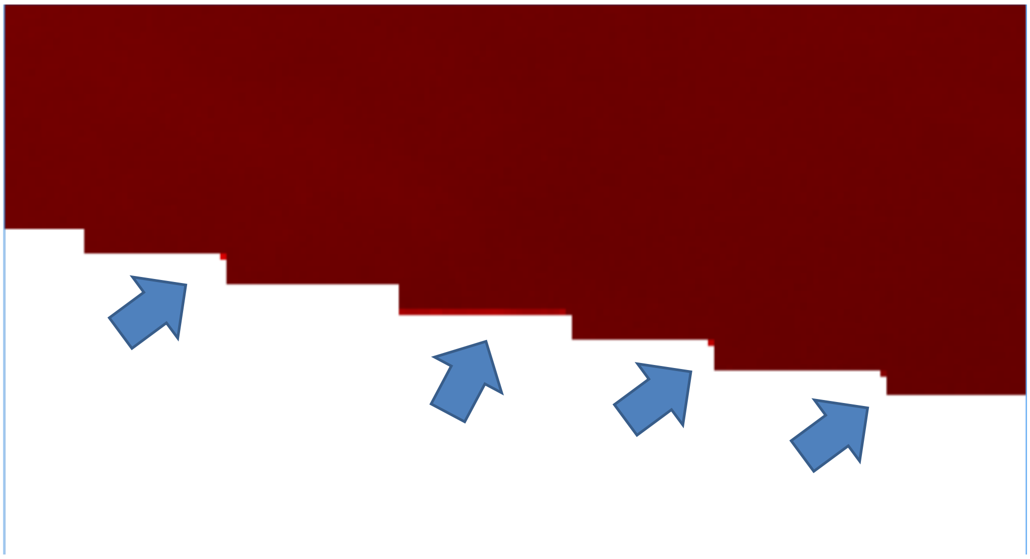

Figure 11: Anomalous pixels on band B4 (anomaly #12).

4.10 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.

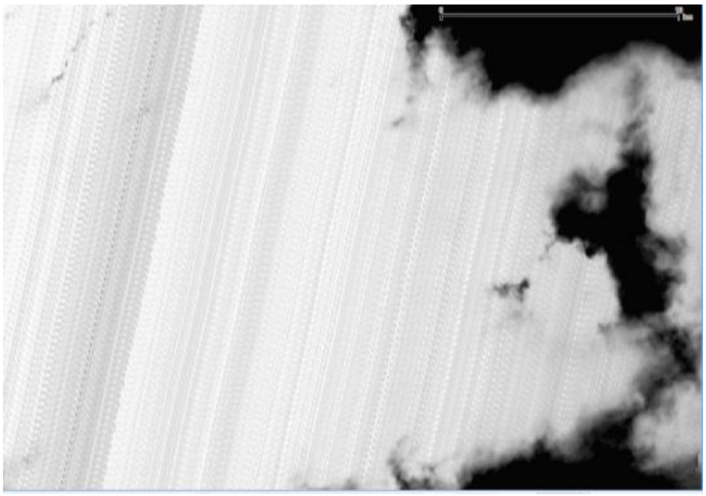

Figure 12: Along-track noise pattern on B10 images over bright clouds (#13).

4.11 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 April 3rd (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.

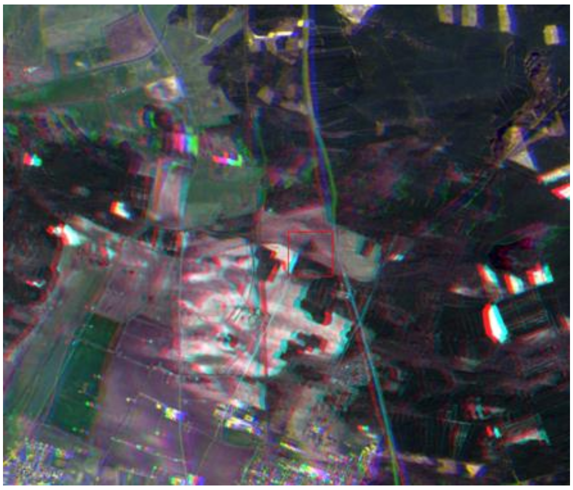

Figure 13: Spectral co-registration error (anomaly #14).

4.12 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.

4.13 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. This anomaly is currently under investigation.

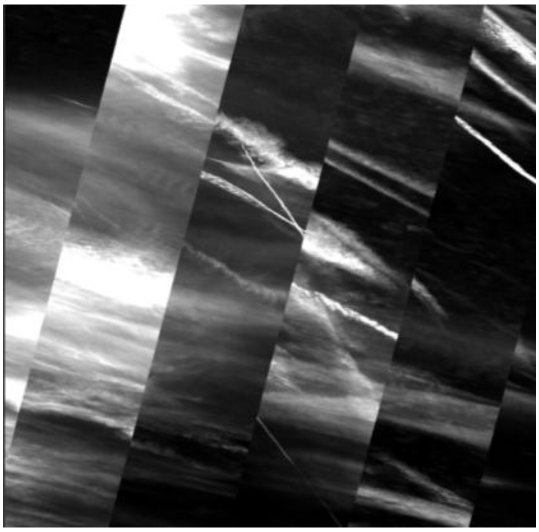

Figure 14: Stretching of 60 m bands (anomaly #16).

4.14 Misaligned detectors on band 1 (#17)

An anomaly on the receiving ground station occurred on 12th of July 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.

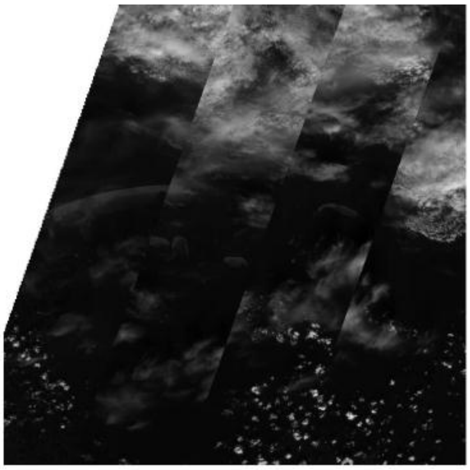

Figure 15: Detector misalignment on band B1 (anomaly #17).

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

4.15 Geolocation Error (#18)

This anomaly occurred while the satellite was performing a collision avoidance manoeuvre. 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.

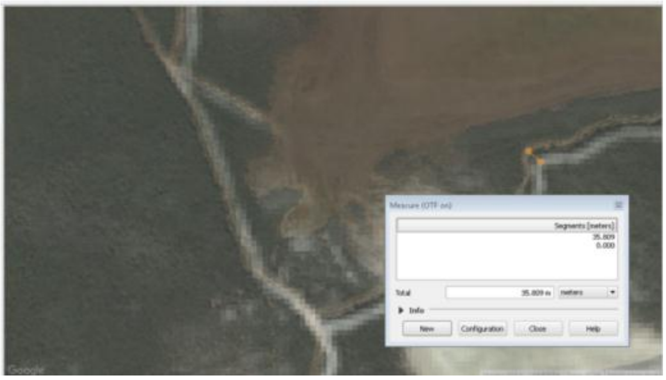

Figure 16: S2 image superimposed with reference map, showing a geolocation error of 35 m (anomaly #18).

4.16 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.

The update of the processing chain to correct this anomaly is under way.

5. Pixels Status

5.1 Defective and noisy pixels

In the following tables are listed all the identified defective and noisy pixels:

- Defective pixels which currently replaced by an interpolation of neighbouring pixels. Defective pixels are interpolated.
- Noisy pixels: pixels operational but with a high noise level. These pixels are being monitored and could be declared defective in the future.

Following the decontamination operation in July, the health status is being reassessed.

Table 5-1: Defective pixels on 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 Band 11.

Band B11			Current status & R2DEPI defective pixels	
Band	Detector	Pixel number (from 0)	Current status	Last updated
B11	2	471	Noisy	
B11	8	61	Noisy	
B11	8	999	Noisy	
B11	11	1271	Noisy	

Table 5-3: Defective pixels on band 12.

Band B12			Current status & R2DEPI defective pixels	
Band	Detector	Pixel number (from 0)	Current status	Last updated

B12	1	185	Noisy	
B12	1	213	Noisy	
B12	1	440	Defective	26/08/2015
B12	1	488	Noisy	
B12	1	592	Noisy	
B12	1	603	Noisy	
B12	1	703	Defective	06/11/2015
B12	1	727	Noisy	
B12	1	855	Noisy	
B12	1	1045	Noisy	
B12	3	1089	Noisy	
B12	4	25	Noisy	
B12	4	32	Noisy	
B12	4	73	Noisy	
B12	4	126	Noisy	
B12	4	444	Noisy	
B12	4	682	Noisy	
B12	4	716	Noisy	
B12	4	726	Noisy	
B12	4	799	Noisy	
B12	4	803	Noisy	
B12	4	806	Noisy	
B12	4	880	Noisy	
B12	4	1075	Noisy	
B12	4	1110	Noisy	
B12	4	1245	Noisy	
B12	5	303	Noisy	
B12	5	661	Noisy	
B12	5	1121	Noisy	
B12	5	1122	Noisy	
B12	6	90	Noisy	
B12	6	773	Noisy	
B12	8	805	Noisy	
B12	8	965	Noisy	
B12	9	176	Noisy	

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 5-4: Pixel affected by reset spike noise.

Band	Detector	Pixel number (from 0)	Current status
B02, B03, B04	1,3,5,7	35	Pixel Reset Noise
	1,3,5,7	489	Pixel Reset Noise
	1,3,5,7	781	Pixel Reset Noise
	1,3,5,7	961	Pixel Reset Noise
	1,3,5,7	1036	Pixel Reset Noise
	1,3,5,7	1177	Pixel Reset Noise
	1,3,5,7	1252	Pixel Reset Noise
	1,3,5,7	1724	Pixel Reset Noise
	1,3,5,7	1822	Pixel Reset Noise
B02, B03, B04	2,4,6,8	2556	Pixel Reset Noise
	2,4,6,8	2102	Pixel Reset Noise
	2,4,6,8	1810	Pixel Reset Noise
	2,4,6,8	1630	Pixel Reset Noise
	2,4,6,8	1555	Pixel Reset Noise
	2,4,6,8	1414	Pixel Reset Noise
	2,4,6,8	1339	Pixel Reset Noise
	2,4,6,8	867	Pixel Reset Noise
	2,4,6,8	769	Pixel Reset Noise
B08	1,3,5,7	35	Pixel Reset Noise
	2,4,6,8	2556	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).

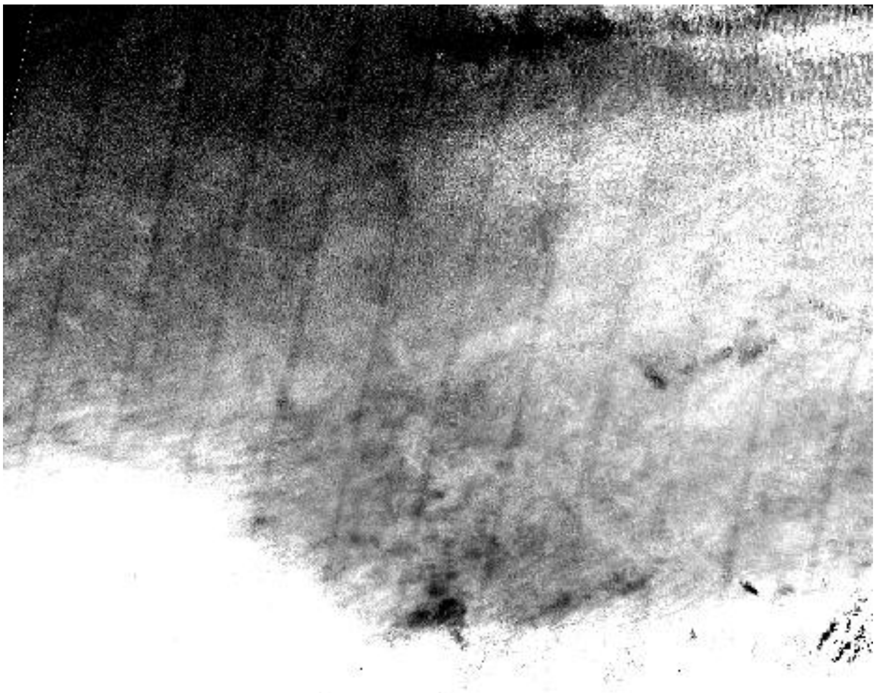

Figure 17: Along-track stripes resulting from spectral response non-uniformity (band B03).

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).

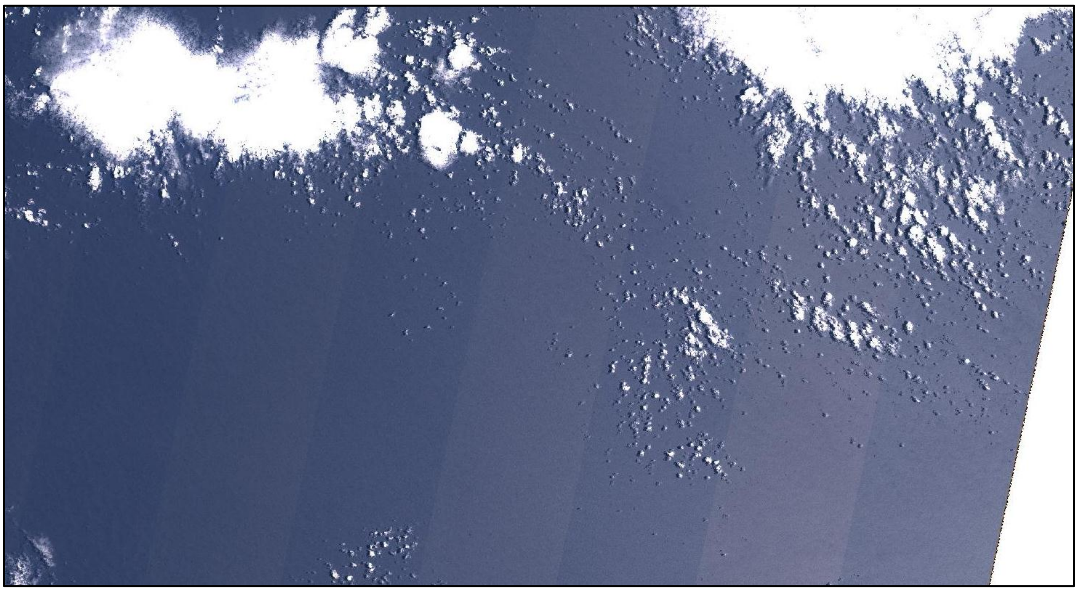

Figure 6-18: Stripe pattern over sea surface, due to the observation parallax effect between odd and even detectors.

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 19 below.

Figure 19: Spectral misregistration and detector misalignment for object at high altitude (plane and contrail). This feature is not an anomaly.

6.3 Across-Track noise

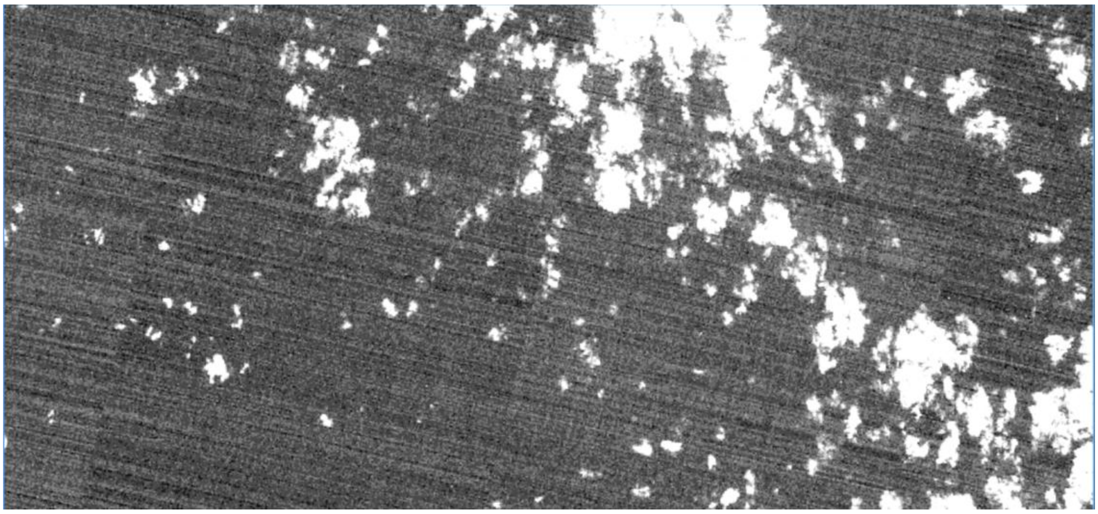

Figure 20: Across-Track intra-detector noise pattern

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.

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