

Reference:S2-PDGS-MPC-L2ADQRIssue:8Date:08/12/2018





Level 2A Data Quality Report

Ref. S2-PDGS-MPC-L2ADQR









elecnor













Authors Table

	Name	Company	Responsibility	Date	Signature
Written by	S. Clerc & MPC Team	ARGANS	Technical Manager	08/12/2018	SCIERC
Verified by	O. Devignot	CS	Quality Manager	08/12/2018	\mathcal{O}
Approved by	L. Pessiot	CS	Service Manager	08/12/2018	Lewent

















Table of contents

<u>1.</u> <u>SC</u>	OPE OF THE DOCUMENT	4		
1.1	Introduction	4		
1.2	Main points for this month	4		
<u>2. ME</u>	ASURED PRODUCT PERFORMANCES	5		
2.1	Performances Overview	5		
2.2	Performances	6		
2.2	Surface reflectance radiometry accuracy	6		
2.2	2.2 Water Vapour accuracy	8		
2.2	Aerosol Optical Depth accuracy	10		
2.2	2.4 Classification accuracy	13		
<u>3.</u> PR	OCESSING CHAIN STATUS	14		
3.1	Processing baseline	14		
3.1	1 Evolution	14		
3.1	2 Configuration and differences with Sen2cor Toolbox version	14		
3.2	Status of Processing Baselines and Known Processing Anoma	alies 14		
<u>4.</u> PR	ODUCT ANOMALIES	16		
4.1	Introduction	16		
4.2	Incorrect Tile ID metadata (#1)	16		
4.3	Incorrect No Data mask (#2)	16		
4.4 Encoding of Quality Bands (#3)16				
4.5 Terrain correction over clouds (#4)17				
4.6 Naming of quality masks files (#5)17				
<u>5.</u> PR	ODUCT FEATURES	18		
5.1	Scene classification			
5.2	Overlap between tiles19			













1. Scope of the Document

IGN

ThalesAlenia

AIRBUS

elecnor

GIN

ONERA

1.1 Introduction

This document provides the status of Sentinel-2 mission Level 2A products data quality. It refers to systematic production from processing baselines 02.07 and higher and complements the Data Quality Report for L1C products.

It documents the measured product performances, the status of Level 2A processing chain, and the list of known anomalies on the production.

Note that a reference article provides 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", RSE, 2017). More information about L2A performance validation can be found in G. Doxani et al., "Atmospheric Correction Inter-Comparison Exercise", Remote Sensing, 10 (352), pp 1-18. DOI: doi:10.3390/rs10020352 ISSN 2072-4292. Please note that a former version of Sen2Cor was used during this inter-comparison exercise (not 02.07) and performance have generally improved since then.

1.2 Main points for this month

- Evolution of L2A processing baseline PB 02.10 and 02.11
- Product features: known limitations of the scene classification algorithm and overlap between tiles



4/19



C TELESPAZIC

CS .

ACR



2.1 Performances Overview

The following overview table provides a summary of the Level 2A products data quality performances. Note that the performances reported in this issue of the L2A Data Quality Report have been measured with Sen2cor versions 2.4 and 2.5.3 (toolbox version), and may thus slightly differ from the performance of the current processing baseline.

Table 2-1: Summary of Sentinel-2 L2A products measured performances for mission key requirements.

Requirement	Description	Measured performance	
Surface reflectance accuracy	Uncertainty of Bottom-of- Atmosphere reflectance ρ shall be less than 0.05ρ _{reference} + 0.005	TBD	
Water Vapour accuracy	The difference ΔWV of retrieved Water vapour to reference from AERONET WV_{ref} shall be within $ \Delta WV \leq 0.1*WV_{ref}+0.2$	97% of retrieved Water vapour values are within requirement	
Aerosol Optical Depth accuracy	The difference ΔAOT of retrieved Aerosol optical thickness at 550 nm to reference from AERONET AOT _{ref} shall be within $ \Delta AOT \leq 0.1*AOT_{ref}+0.03$	39% of retrieved Aerosol optical thickness values at 550 nm are within requirement	
Classification accuracy	No requirement defined.	The overall accuracy is 98% for recognition of clear pixels over land and water	

Measured performances are detailed in the following sections.













2.2 Performances

2.2.1 Surface reflectance radiometry accuracy

Quantitative assessment of surface reflectance radiometric performance is currently only available for Sen2Cor version 2.4. AERONET-corrected surface reflectance data serve as a reference for this analysis. They are computed from the Sentinel-2 L1C data (TOA) using the aerosol properties obtained from AERONET in-situ measurements as input to the 6S radiation transport processor.

The analysis is based on the dataset defined for the Atmospheric Correction Inter-comparison Exercise (ACIX) (G. Doxani *et al.*, "Atmospheric Correction Inter-Comparison Exercise", Remote Sensing, 10 (352), pp 1-18. DOI: doi:10.3390/rs10020352 ISSN 2072-4292). Plots were generated for all Sentinel-2 bands showing the average accuracy, precision and uncertainty values (APU) over all images within the validation data set per surface reflectance bin. Accuracy value is equivalent to the mean bias, precision value is equivalent to the repeatability or variation around the mean bias and uncertainty is quadratic sum of Accuracy and Precision.

Average APU per band is shown in Figure 1, while Figure 2 shows the average APU per band relative to the average surface reflectance of the band. Both accuracy and uncertainty values show an increasing trend with wavelength (band number). Precision increases up to band 5 and then stays constant. Average accuracy value relative to average surface reflectance reference is below or near to 5% except for bands 5 and 12.

Note that better performance is expected from version Sen2Cor 2.5 onwards due to largely improved AOT retrieval.



AIRBUS

elecnor

ARGANS

gır











Figure 1: Average accuracy, precision, uncertainty (solid lines, left hand side scale) and surface reflectance reference (dashed line, right hand side scale) per band for Sen2Cor version 2.4 based on the ACIX-dataset.





AIRBUS

gm∕

elecnor



ACRI









2.2.2 Water Vapour accuracy

Quantitative assessment of water vapour retrieval accuracy is determined by direct comparison of Sen2Cor output averaged over 9 km x 9 km region of interest around Sun photometer with reference value from AERONET Sun photometer.

The analysis is based on the ACIX dataset excluding water sites (G. Doxani et al., "Atmospheric Correction Inter-Comparison Exercise", Remote Sensing, 10 (352), pp 1-18. DOI: doi:10.3390/rs10020352 ISSN 2072-4292).



Figure 3: Correlation plot of Sen2Cor WV retrieval at 20 m resolution over WV reference from AERONET on basis of the ACIX data set excluding water sites. The dashed line indicates x=y and the solid lines show the limits of accuracy requirement $|\Delta WV| \le 0.1*WV_{ref}+0.2$.



elecnor















Figure 4: Histogram plot of WV (at 20 m resolution) retrieval difference to the reference value from AERONET. The green dashed curve gives a normal distribution computed with accuracy as mean value and precision as standard deviation. The blue dashed curve represents a normal distribution around zero with uncertainty as standard deviation.

Table 2-2: Statistical numbers reporting on WV-validation for Sen2Cor2.5 on basis of the ACIX data set excluding water sites.

WV statistics				
Total no. of granules	66			
WV retrievals within requirement	97%			
R^2 (Coefficient of variation)	0.98			
r (Pearson's corr. coeff.)	0.99			
MA (Median Accuracy value)	0.16 cm			
MP (Median Precision value)	0.17 cm			
Uncertainty (U)	0.23 cm			
Max WV difference	1.00 cm			
95.4% Quantile	0.46 cm			
75% Quantile	0.21 cm			







elecnor









9/19



10/19

Water vapour retrieval is very accurate with correlations over 0.98 and with 97% of retrievals within the requirement. About 95% of water vapour retrievals are less than 0.46 cm different from reference and about 75% deviate less than 0.21 cm from reference.

2.2.3 Aerosol Optical Depth accuracy

Quantitative assessment of aerosol optical depth retrieval accuracy is determined by direct comparison of Sen2Cor output averaged over 9kmx9km region of interest around Sun photometer with reference value from AERONET Sun photometer. The analysis is based on the ACIX dataset excluding water sites (G. Doxani et al., "Atmospheric Correction Inter-Comparison Exercise", Remote Sensing, 10 (352), pp 1-18. DOI: doi:10.3390/rs10020352 ISSN 2072-4292).



Figure 5: Correlation plot of Sen2Cor AOT₅₅₀ retrieval at 20 m resolution over AOT₅₅₀ reference from AERONET on basis of the ACIX data set excluding water sites. Green triangles are AOT₅₅₀ retrieved with the DDValgorithm and orange triangles are AOT₅₅₀ resulting from the present fall-back solution (process with configured start VIS of 40 km). The dashed grey line indicates x=y and the solid grey lines show the limits of accuracy requirement $|\Delta AOT_{550}| \le 0.1*AOT_{550ref}+0.03$. (Inset: zoom on low AOT values).

AIRBUS

elecnor

ARGANS

gır















Figure 6: Histogram plots of AOT₅₅₀ (at 20 m resolution) retrieval difference to the reference value from AERONET. The blue dashed curves give normal distributions around zero with uncertainty as standard deviation. The upper plot shows results for the complete data set and the lower plot for the subset of images containing more than 5% DDV-pixels.



ACRI

ARGANS



gn∕

elecnor









11/19



Table 2-3: Statistical numbers reporting on AOT₅₅₀-validation for Sen2Cor 2.5 on basis of the ACIX data set excluding water sites. The DDV set is a subset of the complete data set limited to images which contain more than 5% DDV-pixels.

AOT statistics	Complete set	DDV set	
Total no. of granules	67	37	
Retrievals within requirement	39%	49%	
R^2 (Coefficient of variation)	0.27	0.47	
r (Pearson's correlation coeff.)	0.52	0.69	
MA (Median Accuracy value)	0.05	0.04	
MP (Median Precision value)	0.15	0.03	
U (Uncertainty)	0.17	0.06	
Max AOT ₅₅₀ difference	0.77	0.16	
95.4% Quantile	0.38	0.10	
75% Quantile	0.10	0.06	

Aerosol optical depth retrieval results are very different between the complete data set and the dataset limited to images with at least 5% of dense dark vegetation (DDV) pixels. The AOT-retrieval algorithm implemented in Sen2Cor requires DDV-pixels in the image. If there are not enough DDV-pixels present, then the processing is done with a fixed AOT leading to large AOT errors (Figure 5, Figure 6, Table 2-3).

Accuracy \pm precision and uncertainty values are 0.04 \pm 0.03 and 0.06 for the DDV subset (Table 2-3), which is a very good performance increase since Sen2Cor version 2.4. Accuracy \pm precision and uncertainty values for Sen2Cor version 2.4 are 0.11 \pm 0.07 and 0.14 for the DDV subset. About 95% of AOT retrievals with Sen2Cor 2.5 are less than 0.10 different from reference value. Nevertheless there are only about 50% of retrievals within requirement.

A processor evolution is in development to improve the results for arid regions where no DDV-pixels are present in the image.



ACR













2.2.4 Classification accuracy

Classification accuracy is evaluated by comparison of the Sen2Cor outputs with reference samples. The reference samples are generated by visual inspection and labelling of a validation data set, which was determined by stratified random sampling.

Current analysis of classification accuracy for Sen2Cor 2.5 using CCI data as auxiliary information is based on 2 images over test site Barrax in Spain. The average overall accuracy over both images is 98% for recognition of clear pixels over land and water and 99% for recognition of clouds. Detailed results for one of these images are shown in Table 2-4. Users (resp. producers) accuracy for recognition of clear pixels over land and water correspond to commission error of 0.09 (resp. omission error of 0.02). Users (resp. producers) accuracy for recognition of clouds corresponds to commission error of 0.01 (resp. omission error of 0.01).

Table 2-4: Classification accuracy for recognition of clear pixels and for detection of clouds for an example image over Barrax (Spain) acquired on 09.05.2017. "Clear pixels over land and water" aggregate the Sen2Cor classes vegetation, non-vegetated and water. "All clouds" aggregate Sen2Cor classes cloud_medium_probability, cloud_high_probability and thin cirrus.

Clear pixels over land and water					
	Land-Water	Others	Sum	users accuracy	
Land-Water	36297	3387	39684	0.915	
Others	937	100925	101862	0.991	
Sum	37234	104312	141546		
producers accuracy	0.975	0.968	OA	0.969	
All clouds					
	Clouds	Others	Sum	users accuracy	
Clouds	70310	851	71161	0.988	
Others	939	69446	70385	0.987	
	555	05110	,		
Sum	71249	70297	141546		



ACR

ARGANS

elecnor











3. Processing Chain Status

3.1 Processing baseline

3.1.1 Evolution

Since 26/03/2018, Level 2A products are produced systematically over Europe and distributed in the Sentinel Data Hub (product type "MSIL2A").

On 06/11/2018 processing baseline 02.10 was introduced to reflect an evolution of upstream Level 1C products (L1C baseline 02.07, see the L1C Data Quality Report for details). The main evolutions of the product will be:

- Accurate tile sensing time
- Improved detector footprint masks
- Improved image boundary
- Reduction of Across-Track correlated noise

Processing baseline 02.11 was deployed on 21/11/2018. This baseline corrects anomaly #4 (terrain correction over cloudy pixels). This correction will be available in a future public Sen2cor version (2.8.0).

3.1.2 Configuration and differences with Sen2cor Toolbox version

Baseline 02.11 uses Sen2cor defaults configuration parameters except:

- Terrain correction is activated,
- CCI AUX data is used to support scene classification.

Some differences can be found between L2A products generated by users with current Sen2cor Toolbox version and the products from the 02.11 baseline:

- The Digital Elevation Model (DEM) is different, which can impact terrain correction results,
- The JP2000 compression library is different, which leads to a slightly different size of the products and a different compression noise,
- Anomaly #4 is corrected in baseline 02.11, while this anomaly will be corrected in a future version of the toolbox version.

3.2 Status of Processing Baselines and Known Processing Anomalies

The following table provides the status of known L2A processing anomalies. Note that some L1C anomalies directly affect the quality of the L2A products. Users are invited to refer to the L1C Data Quality Report for a complete status.

AIRBUS

gn

elecnor











Reference:S2-PDGS-MPC-L2ADQRIssue:8Date:08/12/2018



Table 3-1: Anomaly and processing baseline summary.

	Baseline number	02.07	02.08	02.09	02.10	02.11
Anomaly ID	Deployment date	26/03/2018	23/05/2018	08/09/2018	06/11/2018	21/112018
	Anomaly title					
1	Wrong tile ID metadata	All products until 05/04/2018				
2	Incorrect No Data mask	Limited occurrences for pixels near the edge of the swath (Until 19/09/2018)				
3	Encoding of Quality Bands	Until 19/09/2018				
4	Terrain Correction over clouds	A few products				
5	Naming of quality mask files			A few products		















4. Product Anomalies

4.1 Introduction

This chapter describes anomalies observed on the L2A production.

4.2 Incorrect Tile ID metadata (#1)

This minor anomaly affects the L1C_TILE_ID field of the tile metadata. The processing baseline of the source L1C product is incorrectly reported as 02.07 instead of 02.06. The issue has been corrected on 05/04/2018.

4.3 Incorrect No Data mask (#2)

In the Scene Classification mask (SCL) some pixels near the edge of the swath may be incorrectly flagged as "water" instead of "No Data". The issue has been fixed and has been deployed on 19/09/2018.



Figure 7: Incorrect No Data Mask (anomaly #2). Left: pixels incorrectly flagged as water (blue) near the swath edge. Right: same image after correction.

4.4 Encoding of Quality Bands (#3)

elecnor

ARGANS

gır

In products from processing baselines 02.07 and 02.08, the quality bands are coded over 16 bits instead of 8 bits as specified in the Product Definition Document (PDD). This minor anomaly affects the following bands: SCL, CLD, SNW, PVI, TCI. The correction has been deployed on 19/09/2018.

















4.5 Terrain correction over clouds (#4)

This anomaly creates spurious topographic correction over cloudy pixels. Please note the impact of this anomaly is limited to the visual appearance of the images. Cloudy pixels are flagged in the scene classification mask and shall not be used for quantitative remote sensing.

Terrain correction has been de-activated for cloudy pixels with processing baseline 02.10.



Figure 8: Band B04, Tile 32TLP from orbit S2B 7098. Left: L1C image; Right: L2A image. The topography seems to be visible through the opaque clouds. (Anomaly #4)

4.6 Naming of quality masks files (#5)

This anomaly affects the naming of the quality mask files in the QI_DATA folder. The "long name" convention (e.g. S2A_OPER_MSK...) is used instead of the "short name" convention (MSK_DEFECT...). This anomaly has been found on L2A products of orbit S2B 8458. It is currently under investigation.



















5. Product features

5.1 Scene classification

The current scene classification algorithm has some known limitations:

- Over-detection of clouds over bright targets,
- Under-detection of semi-transparent clouds or cloud edges,
- Cloud pixels miss-classified as snow (shaded parts of the clouds),
- Dark areas miss-classified as cloud shadows. This can occur in particular when bright objects are incorrectly classified as clouds,
- Topographic shadows may be miss-classified as water,
- Open fires can be miss-classified as cirrus.

As mentioned in section 3.1, these problems have been significantly reduced starting with baseline 02.09.

Starting with baseline 02.10, terrain correction is no longer applied for pixels identified as cloudy. This can lead to visual artefacts at the edges of semi-transparent clouds, see figure below.



Figure 9: Visual artefacts at the edges of semi-transparent clouds.



elecnor













5.2 Overlap between tiles

The L2A products are processed at tile level and some differences can occur in the overlap area between adjacent tiles:

- The scene classification may be different for a few pixels
- The AOD and surface reflectances are generally different, although the difference should be small.

End of Document













