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

S3 OLCI Cyclic Performance Report

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S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: iii

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S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: iv

Table of content

1	PROC	ESSING BASELINE VERSION	1
	1.1	Sentinel3-A	1
	1.2	Sentinel3-B	1
2	INSTR	UMENT MONITORING	2
	2.1	CCD temperatures	2
	2.1.1	OLCI-A	2
	2.1.2	OLCI-B	4
	2.2	Radiometric Calibration	6
	2.2.1		
	2.2.2	Instrument response and degradation modelling [OLCI-L1B-CV-250]	. 19
	2.2.3	Ageing of nominal diffuser [OLCI-L1B-CV-240]	. 38
	2.2.4	Updating of calibration ADF [OLCI-L1B-CV-260]	. 38
	2.2.5 Diffu	Radiometric Calibrations for sun azimuth angle dependency and Yaw Manoeuvres for Sol ser on-orbit re-characterization [OLCI-L1B-CV-270 and OLCI-L1B-CV-280]	
	2.3	Spectral Calibration [OLCI-L1B-CV-400]	. 39
	2.3.1	OLCI-A	. 39
	2.3.2	OLCI-B	. 41
	2.4	Signal to Noise assessment [OLCI-L1B-CV-620]	. 45
	2.4.1	SNR from Radiometric calibration data	. 45
	2.4.2	SNR from EO data	. 51
	2.5	Geometric Calibration/Validation	. 51
	2.5.1	OLCI-A	. 51
	2.5.2	OLCI-B	. 54
3	OLCI	EVEL 1 PRODUCT VALIDATION	58
	3.1	[OLCI-L1B-CV-300], [OLCI-L1B-CV-310] — Radiometric Validation	. 58
	3.1.1	S3ETRAC Service	. 58
	3.1.2	Radiometric validation with DIMITRI	. 61
	3.1.3	Radiometric validation with OSCAR	. 65
	3.2	[OLCI-L1B-CV-320] – Radiometric Validation with Level 3 products	. 67
	3.2.1	OLCI-A	. 67
	2 2 2	OLCLB	67



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: v

4	LEVEL 2	2 LAND PRODUCTS VALIDATION	68
	4.1 [0	DLCI-L2LRF-CV-300]	68
	4.1.1	Routine extractions	68
	4.1.2	Comparisons with MERIS MGVI and MTCI climatology	. 78
		DLCI-L2LRF-CV-410 & OLCI-L2LRF-CV-420] — Cloud Masking & Surface Classification for Lan	
5	LEVEL 2	2 WATER PRODUCTS VALIDATION	85
	5.1 [0	DLCI-L2-CV-210, OLCI-L2-CV-220] — Vicarious calibration of the NIR and VIS bands	85
	L2WLR-C	DLCI-L2WLR-CV-300, OLCI-L2WLR-CV-310, OLCI-L2WLR-CV-32, OLCI-L2WLR-CV-330, OLCI-V-340, OLCI-L2WLR-CV-350, OLCI-L2WLR-CV-360 and OLCI-L2WLR-CV-370] – Level 2 Wate eflectance product validation	
	_		
	5.2.2	OLCI-A	86
	5.2.3	OLCI-B	93
	5.3 [C	DLCI-L2WLR-CV-430] — Algorithm performance over spatial and temporal domains DLCI-L2WLR-CV-510 & 520] — Cloud Masking & Surface Classification for Water Products DLCI-L2WLR-CV530] Validation of Aerosol Product	99 99
	5.5.1	Aeronet comparisons with OLCI A	99
	5.5.2	Marine Aeronet comparisons with OLCI A	101
	5.5.3	Aeronet comparisons with OLCI B	102
	5.5.4	Summary	103
	5.5.5	References	103
	5.6 [0	DLCI-L2WLR-CV-380] Development of calibration, product and science algorithms	104
6	VALIDA	ATION OF INTEGRATED WATER VAPOUR OVER LAND & WATER	.105
	6.1 Ir	ntegrated water vapour above land	105
	6.1.1	Validation of OLCI A IWV using GNSS	105
	6.1.2	Validation of OLCI A IWV using passive microwave radiometer at ARM sites	107
	6.1.3	Validation of OLCI A IWV using GRUAN radiosonde observations	108
	6.1.4	Validation of OLCI A IWV using AERONET observations	109
	6.1.5	Validation of OLCI B IWV	110
	6.2 Ir	itegrated water vapour above water	111
	6.2.1	Quantitative validation using GNSS	111
	6.2.2	Validation by AFRONET IWV Retrievals – Ocean	112



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: vi

	6.3	Summary	. 113
(6.4	References	. 113
		EL 2 SYN PRODUCTS VALIDATION	
8	EVE	NTS	116
9	ΔΡΡ	FNDIX A	117



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: vii

List of Figures

Figure 1: long term monitoring of OLCI-A CCD temperatures using minimum value (top), time averaged values (middle), and maximum value (bottom) provided in the annotations of the Radiometric Calibration Level 1 products, for the shutter frames, all radiometric calibrations so far except the first one (absolute orbit 183) for which the instrument was not yet thermally stable
Figure 2: Same as Figure 1 for diffuser frames 3
Figure 3: long term monitoring of OLCI-B CCD temperatures using minimum value (top), time averaged values (middle), and maximum value (bottom) provided in the annotations of the Radiometric Calibration Level 1 products, for the Shutter frames, all radiometric calibrations so far except the first one (absolute orbit 167) for which the instrument was not yet thermally stable. —————4
Figure 4: same as Figure 3 for diffuser frames5
Figure 5: Sun azimuth angles during acquired OLCI-A Radiometric Calibrations (diffuser frame) on top of nominal yearly cycle (black curve). Diffuser 1 with diamonds, diffuser 2 with crosses, 2016 acquisitions in dark blue, 2017 in clear blue, 2018 in green, 2019 in light green, 2020 in orange and 2021 in red7 Figure 6: same as Figure 5 for OLCI-B (2018 in blue, 2019 in green, 2020 in yellow and 2021 in red)7
Figure 7: OLCI-A Sun geometry during radiometric Calibrations on top of characterization ones (diffuser frame)8
Figure 8: same as Figure 7 for OLCI-B8
Figure 9: Dark Offset table for band Oa06 with (red) and without (black) HEP filtering (Radiometric Calibration of 22 July 2017). The strong HEP event near pixel 400 has been detected and removed by the HEP filtering9
Figure 10: OLCI-A Dark Offset for band Oa1 (top) and Oa21 (bottom), all radiometric calibrations so far except the first one (orbit 183) for which the instrument was not thermally stable yet
Figure 11: map of OLCI-A periodic noise for the 5 cameras, for band Oa21. X-axis is detector number (East part, from 540 to 740, where the periodic noise occurs), Y-axis is the orbit number. Y-axis range is focused on the most recent 5000 orbits. The counts have been corrected from the West detectors mean value (not affected by periodic noise) in order to remove mean level gaps and consequently to have a better visualisation of the long term evolution of the periodic noise structure. At the beginning of the mission the periodic noise for band Oa21 had strong amplitude in camera 2, 3 and 5 compared to camera 1 and 4. However PN evolved through the mission and these discrepancies between cameras have been reduced. At the time of this Cyclic Report Camera 2 still shows a slightly higher PN than other cameras.
Figure 12: same as Figure 11 for smear band 12
Figure 13: OLCI-A Dark Current for band Oa1 (top) and Oa21 (bottom), all radiometric calibrations so far except the first one (orbit 183) for which the instrument was not thermally stable yet 13
Figure 14: left column: ACT mean on 400 first detectors of OLCI-A Dark Current coefficients for spectral band Oa01 (top) and Oa21 (bottom). Right column: same as left column but for Standard deviation instead of mean. We see an increase of the DC level as a function of time especially for band Oa21
Figure 15: OLCI-A Dark current increase rates with time (in counts per year) vs. band (left) and vs. band width (right)



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: viii

Figure 16: OLCI-B Dark Offset for band Oa1 (top) and Oa21 (bottom), all radiometric calibrations so far except the first one (orbit 167) for which the instrument was not thermally stable yet 15
Figure 17: OLCI-B map of periodic noise for the 5 cameras, for band Oa21. X-axis is detector number (East part, from 540 to 740, where the periodic noise occurs), Y-axis is the orbit number. The counts have been corrected from the West detectors mean value (not affected by periodic noise) in order to remove mean level gaps and consequently to have a better visualisation of the long term evolution of the periodic noise structure
Figure 18: same as Figure 17 for smear band 17
Figure 19: OLCI-B Dark Current for band Oa1 (top) and Oa21 (bottom), all radiometric calibrations so far except the first one (orbit 167) for which the instrument was not thermally stable yet
Figure 20: left column: ACT mean on 400 first detectors of OLCI-B Dark Current coefficients for spectral band Oa01 (top) and Oa21 (bottom). Right column: same as left column but for Standard deviation instead of mean. We see an increase of the DC level as a function of time especially for band Oa21
Figure 21: OLCI-B Dark Current increase rates with time (in counts per year) vs. band (left) and vs. band width (right)
Figure 22: OLCI-A Gain Coefficients for band Oa1 (top) and Oa21 (bottom), derived using the in-flight BRDF model. The dataset is made of all diffuser 1 radiometric calibrations since orbit 979 20
Figure 23: camera averaged gain relative evolution with respect to calibration of 25/04/2016 (change of OLCI channel settings), as a function of elapsed time since the beginning of the mission; one curve for each band (see colour code on plots), one plot for each module. The diffuser ageing has been taken into account
Figure 24: OLCI-B Gain Coefficients for band Oa1 (top) and Oa21 (bottom), derived using the in-flight BRDF model. The dataset is made of all diffuser 1 radiometric calibrations since orbit 758 22
Figure 25: OLCI-B camera averaged gain relative evolution with respect to first calibration after channel programming change (18/06/2018), as a function of elapsed time since the beginning of the mission; one curve for each band (see colour code on plots), one plot for each module. The diffuser ageing has been taken into account
Figure 26: RMS performance of the OLCI-A Gain Model of the current processing baseline as a function of orbit 24
Figure 27: RMS performance of the OLCI-A Gain Model of the previous Processing Baseline as a function of orbit 25
Figure 28: OLCI-A Camera-averaged instrument evolution since channel programming change (25/04/2016) and up to the most recent calibration (06/11/2021) versus wavelength 26
Figure 29: For the 5 cameras: OLCI-A Evolution model performance, as camera-average and standard deviation of ratio of Model over Data vs. wavelength, for each orbit of the test dataset, including 4 calibrations in extrapolation, with a colour code for each calibration from blue (oldest) to red (most recent)
Figure 30: OLCI-A evolution model performance, as ratio of Model over Data vs. pixels, all cameras side by side, over the whole current calibration dataset (since instrument programing update), including 4 calibrations in extrapolation, channels Oa1 to Oa6
Figure 31: same as Figure 30 for channels Oa7 to Oa14 29
Figure 32: same as Figure 30 for channels Oa15 to Oa21 30



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: ix

Figure 33: RMS performance of the OLCI-B Gain Model of the current processing baseline as a function of orbit.
Figure 34: RMS performance of the OLCI-B Gain Model of the previous processing baseline as a function of orbit (please note the different vertical scale with respect to Figure 33)
Figure 35: OLCI-B Camera-averaged instrument evolution since channel programming change (18/06/2018) and up to most recent calibration (24/11/2021) versus wavelength 33
Figure 36: For the 5 cameras: OLCI-B Evolution model performance, as camera-average and standard deviation of ratio of Model over Data vs. wavelength, for each orbit of the test dataset, including 10 calibrations in extrapolation, with a colour code for each calibration from blue (oldest) to red (most recent)
Figure 37: OLCI-B evolution model performance, as ratio of Model over Data vs. pixels, all cameras side by side, over the whole current calibration dataset (since instrument programming update), including 10 calibrations in extrapolation, channels Oa1 to Oa6
Figure 38: same as Figure 37 for channels Oa7 to Oa14 36
Figure 39: same as Figure 37 for channels Oa15 to Oa21 37
Figure 40: OLCI-A across track spectral calibration from all S02/S03 sequences since the beginning of the mission. Top plot is spectral line 1, middle plot is spectral line 2 and bottom plot spectral line 3. The nominal spectral calibration is plotted as a red horizontal dotted line and the on-ground spectra calibration as a red thick line
Figure 41: OLCI-A camera averaged spectral calibration evolution as a function of time since launch (all spectral S02/S03 calibrations since the beginning of the mission are included). The data are normalized with the first Spectral Calibration of the plot
Figure 42: OLCI-A camera averaged spectral calibration evolution as a function of orbit number from SOS calibrations since the 4th may 2016. The last calibration for SO9 is from 01 Nov 2021. For each camera, the spectral evolution corresponding derived from spectral lines at 485 nm, 656 nm, 770 nm and 854 nm have been averaged. The data are normalized with the first Spectral Calibration of the plot
Figure 43: OLCI-B across track spectral calibration from all S02/S03 sequences since the beginning of the mission. Top plot is spectral line 1, middle plot is spectral line 2 and bottom plot spectral line 3. The nominal spectral calibration is plotted as a red dotted line and the on-ground spectral calibration as a red thick line
Figure 44: OLCI-B camera averaged spectral calibration evolution as a function of time since launch (al spectral S02/S03 calibrations since the beginning of the mission are included). The data are normalized with the first Spectral Calibration
Figure 45: OLCI-B camera averaged spectral calibration evolution as a function of orbit number since launch from S09 calibrations since the beginning of the mission. The last calibration for S09 is from 11 Nov 2021. For each camera, the spectral evolution corresponding derived from spectral lines at 485 nm, 656 nm, 770 nm and 854 nm have been averaged. The data are normalized with the first Spectral Calibration
Figure 46: OLCI-A Signal to Noise ratio as a function of the spectral band for the 5 cameras. These results have been computed from radiometric calibration data. All calibrations except first one (orbit 183) are presents with the colours corresponding to the orbit number (see legend). The SNR is very stable with time: the curves for all orbits are almost superimposed. The dashed curve is the ESA requirement 45
Figure 47: long-term stability of the SNR estimates from Calibration data, example of channel Oa1, 46



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: x

have been computed from radiometric calibration data. All calibrations except first one (orbit 167) are presents with the colours corresponding to the orbit number (see legend). The SNR is very stable with time: the curves for all orbits are almost superimposed. The dashed curve is the ESA requirement 48
Figure 49: long-term stability of the OLCI-B SNR estimates from Calibration data, example of channel Oa1
Figure 50: overall OLCI-A georeferencing RMS performance time series (left) and number of validated control points corresponding to the performance time series (right) over the whole monitoring period 52
Figure 51: across-track (left) and along-track (right) OLCI-A georeferencing biases time series for Camera 1. Blue line is the average, black lines are average plus and minus 1 sigma 52
Figure 52: same as Figure 51 for Camera 2 52
Figure 53: same as Figure 51 for Camera 3 53
Figure 54: same as Figure 51 for Camera 4 53
Figure 55: same as Figure 51 for Camera 5 53
Figure 56: OLCI-A spatial across-track misregistration at each camera transition (left) and maximum amplitude of the across-track error within each camera (left) 54
Figure 57: OLCI-A spatial along-track misregistration at each camera transition (left) and maximum amplitude of the along-track error within each camera (left).
Figure 58: overall OLCI-B georeferencing RMS performance time series over the whole monitoring period (left) and corresponding number of validated control points (right) 55
Figure 59: across-track (left) and along-track (right) OLCI-B georeferencing biases time series for Camera 1 55
Figure 60: same as Figure 59 for Camera 2 55
Figure 61: same as Figure 59 for Camera 3 56
Figure 62: same as Figure 59 for Camera 4 56
Figure 63: same as Figure 59 for Camera 5 56
Figure 64: OLCI-B spatial across-track misregistration at each camera transition (left) and maximum amplitude of the across-track error within each camera (left).
Figure 65: OLCI-B spatial along-track misregistration at each camera transition (left) and maximum amplitude of the along-track error within each camera (left).
Figure 66: summary of S3ETRAC products generation for OLCI-A (number of OLCI-A L1 products Ingested blue — number of S3ETRAC extracted products generated, green — number of S3ETRAC runs without generation of output product (data not meeting selection requirements), yellow — number of runs ending in error, red, one plot per site type)
Figure 67: summary of S3ETRAC products generation for OLCI-B (number of OLCI-B L1 products Ingested, yellow – number of S3ETRAC extracted products generated, blue – number of S3ETRAC runs without generation of output product (data not meeting selection requirements), green – number of runs ending in error, red, one plot per site type).
Figure 68: Time-series of the elementary ratios (observed/simulated) signal from OLCI-A for (top to bottom) bands Oa03 and Oa18 respectively over January 2021-Present from the six PICS Cal/Val sites.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: xi

Dashed-green and orange lines indicate the 2% and 5% respectively. Error bars indicate the omethodology uncertainty	desert 62
Figure 69: Time-series of the elementary ratios (observed/simulated) signal from OLCI-B for (t bottom) bands Oa08 and Oa18 respectively over January 2021-Present from the six PICS Cal/Val Dashed-green and orange lines indicate the 2% and 5% respectively. Error bars indicate the methodology uncertainty	l sites. desert
Figure 70: The estimated gain values for OLCI-A and OLCI-B from Glint, Rayleigh and PICS method the past twelve months as a function of wavelength. We use the gain value of Oa8 from PICS-I method as reference gain for Glint method. Dashed-green and orange lines indicate the 2% ar respectively. Error bars indicate the method uncertainties	Desert nd 5%
Figure 71: Ratio of observed TOA reflectance to simulated one for (green-yellow) S2A/MSI, Aqua/MODIS, (blue) S3A/OLCI and (green) S3B/OLCI averaged over the six PICS test sites as a funct wavelength.	tion of
Figure 72: OSCAR Rayleigh S3A and S3B Calibration results as a function of wavelength for Nove 2021. The results are obtained with a new climatology derived from CMEMS OLCI monthly CHL pro	ducts.
Figure 73. OSCAR Rayleigh S3A and S3B Calibration results as a function of wavelength for Jan – Nove 2021. Average and standard deviation over all scenes currently (re)processed with the new climaters.	ology.
Figure 74: DeGeb time series over current report period	
Figure 75: ITCat time series over current report period	69
Figure 76: ITIsp time series over current report period	69
Figure 77: ITSro time series over current report period	70
Figure 78: ITTra time series over current report period	70
Figure 79: SPAli time series over current report period	71
Figure 80: UKNFo time series over current report period	71
Figure 81: USNe1 time series over current report period	72
Figure 82: USNe2 time series over current report period	72
Figure 83: USNe3 time series over current report period	73
Figure 84: DeGeb time series over current report period	73
Figure 85: ITCat time series over current report period	74
Figure 86: ITIsp time series over current report period	74
Figure 87: ITSro time series over current report period	75
Figure 88: ITTra time series over current report period	75
Figure 89: SPAli time series over current report period	76
Figure 90: UKNFo time series over current report period	76
Figure 91: USNe1 time series over current report period	77
Figure 92: USNe2 time series over current report period	77
Figure 93: USNe3 time series over current report period	78



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: xii

Figure 94: Time-series OGVI and OTCI and corresponding scatterplot of monthly mean for site BE-Brasschaat, Belgium, land cover Needle-leaved, evergreen. A and C represent S3A; B and D represent S3B.
Figure 95: Time-series OGVI and OTCI and corresponding scatterplot of monthly mean for site DE-Haininch, Deutschland, land cover Broadleaved, deciduous, closed. A and C represent S3A; B and D represent S3B
Figure 96: Time-series OGVI and OTCI and corresponding scatterplot of monthly mean for site FR-EstreesMons, France, land cover Cultivated and managed areas. A and C represent S3A; B and D represent S3B83
Figure 97: Comparison of OTCI-MTCI (a) and OGVI-MGVI (b). Points in the scatterplot represent the monthly mean of all available S3A and MERIS archive over 42 validation sites. Red and grey lines represent the modelled and 1:1 lines respectively. The scatterplots are updated to include extractions from current S3A cycle
Figure 98: Scatter plots of OLCI-A versus in situ radiometry (FR data). Processing Baseline prior to 3.00 (left), Collection 003 (right), Oa1 to Oa4 (400 to 490 nm)
Figure 99: Scatter plots of OLCI-A versus in situ radiometry (FR data). Processing Baseline prior to 3.00 (left), Collection 003 (right), Oa5 Oa6 Oa07 and Oa08 (510, 560, 620 and 665 nm)
Figure 100: AAOT time series over current report period 91
Figure 101: Galata time series over current report period 92
Figure 102: Scatter plots of OLCI-B versus in situ radiometry (FR data). Processing Baseline prior to Collection 3.00 (left), Collection 003 (right), Oa1 to Oa4 (400 to 490 nm) 94
Figure 103: Scatter plots of OLCI-B versus in situ radiometry (FR data). Processing Baseline prior to Collection 3.00 (left), Collection 003 (right), Oa5 to Oa8 (510 to 665 nm)95
Figure 104: AAOT time series over current report period 97
Figure 105: Casablanca Platform time series over current report period 98
Figure 106: Upper left: OLCI aerosol optical thickness at 865nm against Aeronet at 870nm, upper right: OLCIs Angstroem exponent at 865nm against the Aeronet Angstroem exponent at 865nm-440nm. Lower left: Temporal evolution of different quality measures of the optical thickness comparison (from top to bottom: systematic deviation factor, bias, root mean squared difference (with and without bias correction), explained variance (number in boxes are the numbers of matchups)). Lower right: positions of the used AERONET stations
Figure 107: Upper left: OLCI aerosol optical thickness at 865nm against maritime Aeronet at 870nm, upper right: OLCIs Angstroem exponent at 865nm against the maritime Aeronet Angstroem exponent at 865nm-440nm. Lower right: positions of the used cruises
Figure 108: Upper left: OLCI aerosol optical thickness at 865nm against Aeronet v3 L1.5 AOT at 870nm, upper right: OLCIs Angstroem exponent at 865nm against the Aeronet v3 L1.5 Angstroem exponent at 865nm-440nm. Lower: positions of the used AERONET stations
Figure 109: Upper left: Scatter plot of the IWV products, derived from OLCI A above land and from SUOMI NET GNSS measurements. Upper right: Histogram of the difference between OLCI and GNSS (blue: original OLCI, orange: bias corrected OLCI). Lower left: Temporal evolution of different quality measures (from top to bottom: systematic deviation factor, bias, root mean squared difference (with and without bias correction), explained variance (number in boxes are the numbers of matchups)). Lower right: Positions of the GNSS stations (grey: no valid matchup)



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: xiii

Figure 110: Upper left: Scatter plot of the IWV products, derived from OLCI A above land and from AMR MWR. Upper right: Histogram of the difference between OLCI and ARM (blue: original OLCI, orange: bias corrected OLCI). Lower left: Temporal evolution of different quality measures (from top to bottom: systematic deviation factor, bias, root mean squared difference (with and without bias correction), explained variance (number in boxes are the numbers of matchups)). Lower right: Position of ARM SGP.
Figure 111: Left: Scatter plot of the IWV products, derived from OLCI A above land and from GRUAN radiosonde measurements. Right: Histogram of the difference between OLCI and GRUAN (blue: original OLCI, orange: bias corrected OLCI)109
Figure 112: Upper left: Scatter plot of the IWV products, derived from OLCI A above land and from AERONET. Upper right: Histogram of the difference between OLCI and AERONET (blue: original OLCI, orange: bias corrected OLCI). Lower: Positions of the used AERONET stations (grey: no valid matchup).
Figure 113: Scatter plot of the IWV products, derived from OLCI B above land and from SUOMI NET GNSS measurements (upper left), from ARM MWR (upper right) and AERONET (lower)
Figure 114: Upper: Scatter plot of the IWV products, derived from OLCI (A left, B right) above ocean and from SUOMI NET GNSS measurements. Lower: Positions of the GNSS (A: left, B: right)
Figure 115: Upper: Scatter plot of the IWV products, derived from OLCI (A left, B right) above ocean and from Aeronet-OC v.3 L1.5 measurements. Lower: Positions of the used Aeronet match ups (A: left, B: right)113

List of Tables

Table 1: OLCI-A SNR figures as derived from Radiometric Calibration data. Figures are given for each camera (time average and standard deviation), and for the whole instrument. The requirement and its reference radiance level are recalled (in mW.sr ⁻¹ .m ⁻² .nm ⁻¹)
Table 2: OLCI-B SNR figures as derived from Radiometric Calibration data. Figures are given for each camera (time average and standard deviation), and for the whole instrument. The requirement and it reference radiance level are recalled (in mW.sr ⁻¹ .m ⁻² .nm ⁻¹)
Table 3: S3ETRAC Rayleigh Calibration sites 6!
Table 4. OSCAR Rayleigh calibration results for S3A and S3B (average and standard deviation over all acquisitions) over all scenes currently (re)processed with the new climatology and observed difference (in between OLCIA and OLCIB
Table 5: Validation sites analysed in report S3A 70/S3B 51. Land cover data from GLC2000 grouped according to the International Geosphere-Biosphere Programme (IGBP) designations.
Table 6: Comparison statistics between monthly S3A/B OLCI land products and MERIS archive data 80
Table 7: OLCI-A FR statistics over December 2017-15/02/2021 90
Table 8: OLCI-A FR statistics over mid-February 2021-present (Collection 003) 90
Table 9: OLCI-B FR statistics over the July 2017-16 February 2021 period
Table 10: OLCI-B FR statistics over mid-February 2021-present (Collection 003)90

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 1

1 Processing Baseline Version

1.1 Sentinel3-A

IPF	IPF / Processing Baseline version	Date of deployment
OL1	06.12 / 3.01 (OLL1002.21.00)	NRT: 18/11/2021 11:34 UTC NTC: 28/04/2021 07:15 UTC
OL2 LAND	06.14 / 2.66	NRT: 23/06/2020 08:00 UTC NTC: 23/06/2020 08:00 UTC
OL2 MAR	07.00 / 2.72M	NRT: 16/02/2021 08:35 UTC NTC: 15/02/2021 05:46 UTC
SY2	06.21 / 2.77	NTC: 14/06/2021 08:21 UTC
SY2_VGS	06.09 / 2.77	NTC: 14/06/2021 08:21 UTC

1.2 Sentinel3-B

IPF	IPF / Processing Baseline version	Date of deployment
OL1	06.12 / 3.01 (OLL1002.21.00)	NRT: 29/07/2021 08:30 UTC NTC: 29/07/2021 08:30 UTC
OL2 LAND	06.14 / 1.40	NRT: 23/06/2020 08:00 UTC NTC: 23/06/2020 08:00 UTC
OL2 MAR	07.00 / 2.72M	NRT: 16/02/2021 07:56 UTC NTC: 15/02/2021 06:47 UTC
SY2	06.21 / 1.55	NTC: 14/06/2021 08:21 UTC
SY2_VGS	06.09 / 1.55	NTC: 14/06/2021 08:21 UTC

SENTINEL 3 Mission Performance

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 2

2 Instrument monitoring

2.1 CCD temperatures

2.1.1 OLCI-A

The monitoring of the CCD temperatures is based on MPMF data extractions not yet operational. In the meantime, we monitor the CCD temperatures on the long-term using Radiometric Calibration Annotations (see Figure 1). Variations are very small (0.09 C peak-to-peak) and no trend can be identified. Data from current cycle (rightmost data points) do not show any specificity.

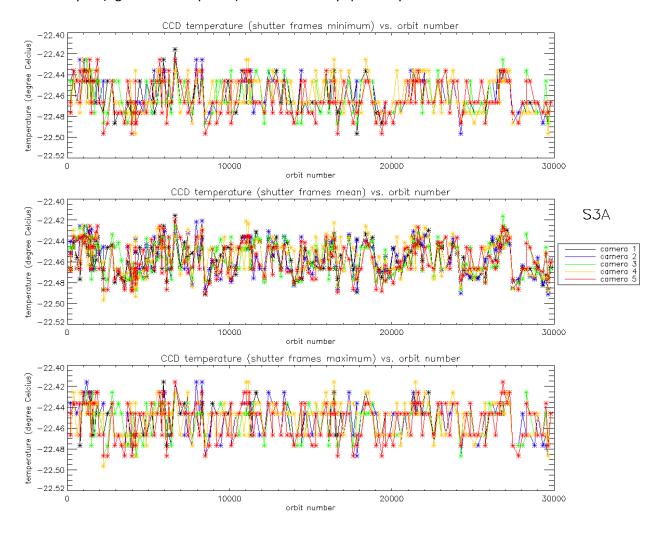


Figure 1: long term monitoring of OLCI-A CCD temperatures using minimum value (top), time averaged values (middle), and maximum value (bottom) provided in the annotations of the Radiometric Calibration Level 1 products, for the shutter frames, all radiometric calibrations so far except the first one (absolute orbit 183) for which the instrument was not yet thermally stable.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

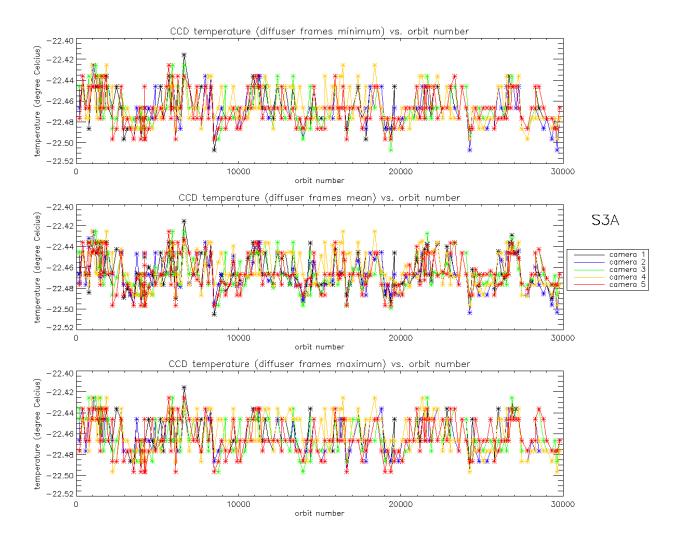


Figure 2: Same as Figure 1 for diffuser frames.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 4

2.1.2 OLCI-B

As for OLCI-A, the variations of CCD temperature are very small (0.08 C peak-to-peak) and no trend can be identified. Data from current cycle (rightmost data points) do not show any specificity.

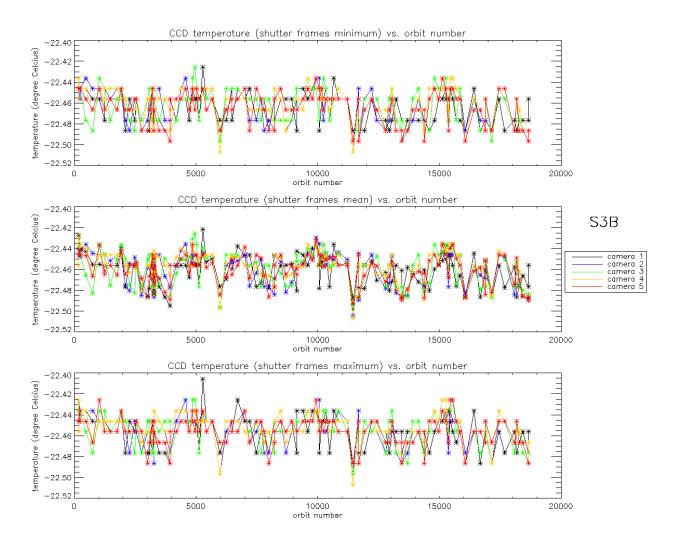


Figure 3: long term monitoring of OLCI-B CCD temperatures using minimum value (top), time averaged values (middle), and maximum value (bottom) provided in the annotations of the Radiometric Calibration Level 1 products, for the Shutter frames, all radiometric calibrations so far except the first one (absolute orbit 167) for which the instrument was not yet thermally stable.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

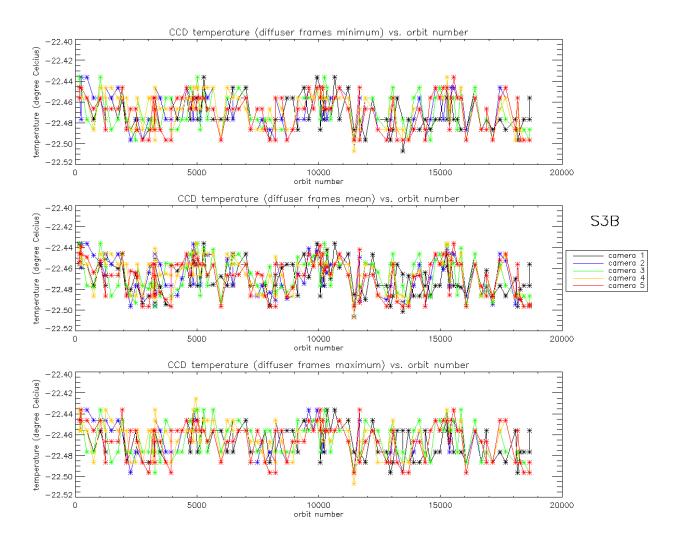


Figure 4: same as Figure 3 for diffuser frames.

SENTINEL 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 6

2.2 Radiometric Calibration

For OLCI-A, one Radiometric Calibration sequence has been acquired during Cycle 078:

S01 sequence (diffuser 1) on 06/11/2021 14:12 to 14:14 (absolute orbit 29799)

For OLCI-B, three Radiometric Calibration sequences have been acquired during Cycle 059:

- S01 sequence (diffuser 1) on 08/11/2021 10:59 to 11:01 (absolute orbit 18432)
- S01 sequence (diffuser 1) on 24/11/2021 07:24 to 07:26 (absolute orbit 18658)
- S05 sequence (diffuser 2) on 24/11/2021 09:05 to 09:07 (absolute orbit 18659)

The acquired Sun azimuth angles are presented on Figure 5 for OLCI-A and Figure 6 for OLCI-B, on top of the nominal values without Yaw Manoeuvre (i.e. with nominal Yaw Steering control of the satellite).

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

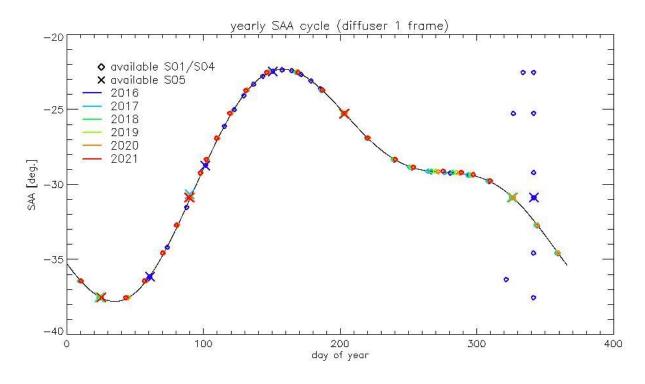


Figure 5: Sun azimuth angles during acquired OLCI-A Radiometric Calibrations (diffuser frame) on top of nominal yearly cycle (black curve). Diffuser 1 with diamonds, diffuser 2 with crosses, 2016 acquisitions in dark blue, 2017 in clear blue, 2018 in green, 2019 in light green, 2020 in orange and 2021 in red.

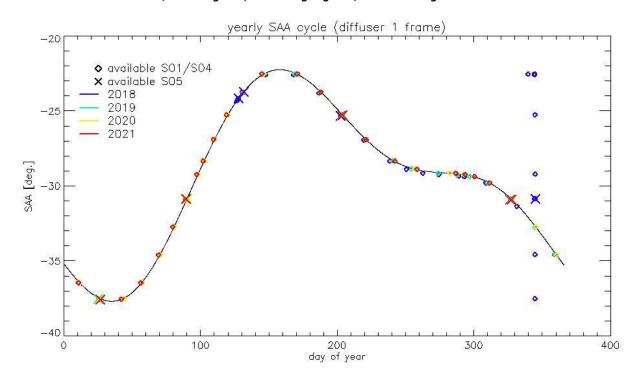


Figure 6: same as Figure 5 for OLCI-B (2018 in blue, 2019 in green, 2020 in yellow and 2021 in red).



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 8

Sun Zenith Angles as a function of Sun Azimuth Angles are presented in Figure 7 for OLCI-A and Figure 8 for OLCI-B.

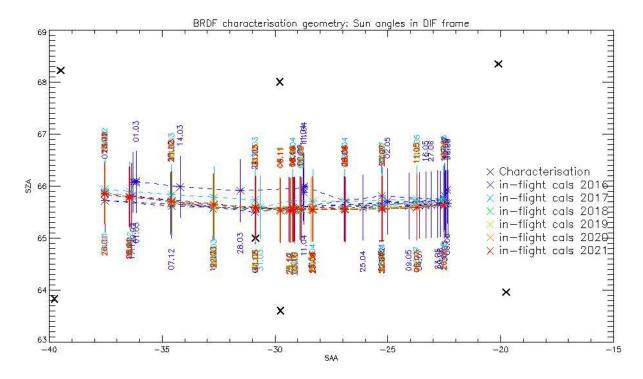


Figure 7: OLCI-A Sun geometry during radiometric Calibrations on top of characterization ones (diffuser frame)

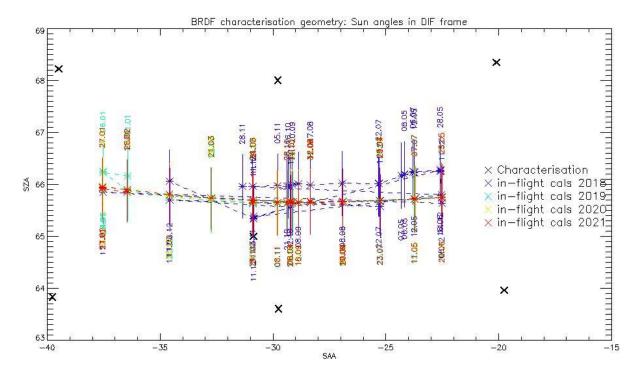


Figure 8: same as Figure 7 for OLCI-B

Mission Performance

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 9

2.2.1 Dark Offsets [OLCI-L1B-CV-230]

Note about the High Energy Particles:

The filtering of High Energy Particle (HEP) events from radiometric calibration data has been implemented (for shutter frames only) in a post processor, allowing generating Dark Offset and Dark Current tables computed on filtered data. The post-processor starts from IPF intermediate data (corrected counts), applies the HEP detection and filtering and finally computes the Dark Offset and Dark Current tables the same way as IPF. An example of the impact of HEP filtering is given in Figure 9.

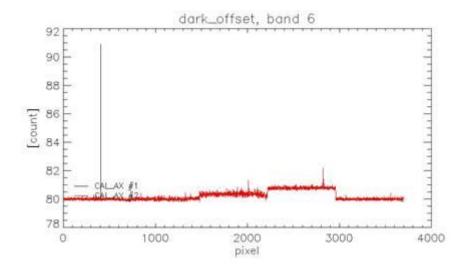


Figure 9: Dark Offset table for band Oa06 with (red) and without (black) HEP filtering (Radiometric Calibration of 22 July 2017). The strong HEP event near pixel 400 has been detected and removed by the HEP filtering.

All results presented below in this section have been obtained using the HEP filtered Dark Offset and Dark Current tables.

SEATINGE, 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 10

2.2.1.2 OLCI-A

Dark offsets

Dark offsets are continuously affected by the global offset induced by the Periodic Noise on the OCL convergence. Current Cycle calibrations are affected the same way as others. The amplitude of the shift varies with band and camera from virtually nothing (e.g. camera 2, band 0a1) to up to 5 counts (Oa21, camera 3). The Periodic Noise itself comes on top of the global shift with its known signature: high frequency oscillations with a rapid damp. This effect remains more or less stable with time in terms of amplitude, frequency and decay length, but its phase varies with time, introducing the global offset mentioned above.

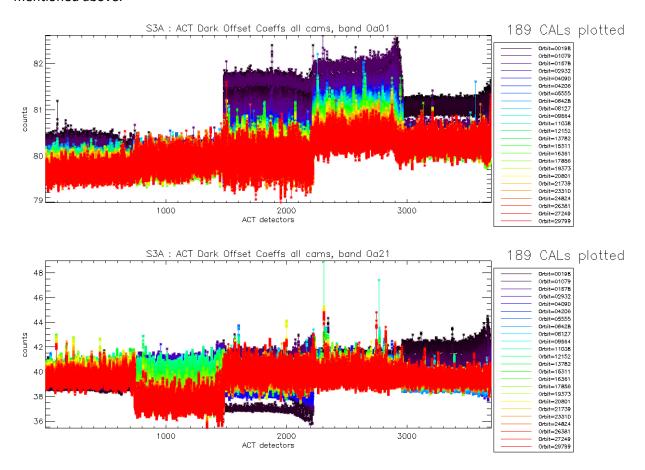


Figure 10: OLCI-A Dark Offset for band Oa1 (top) and Oa21 (bottom), all radiometric calibrations so far except the first one (orbit 183) for which the instrument was not thermally stable yet.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

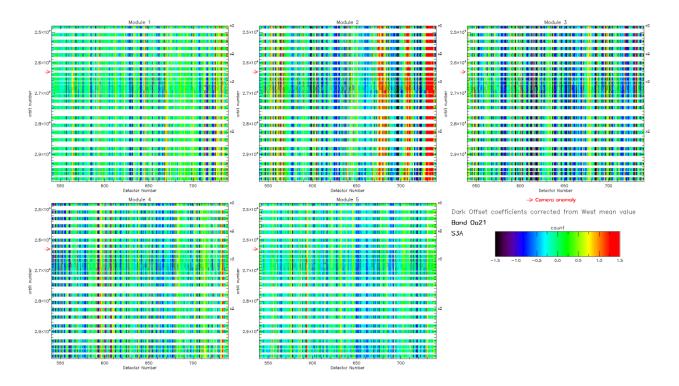


Figure 11: map of OLCI-A periodic noise for the 5 cameras, for band Oa21. X-axis is detector number (East part, from 540 to 740, where the periodic noise occurs), Y-axis is the orbit number. Y-axis range is focused on the most recent 5000 orbits. The counts have been corrected from the West detectors mean value (not affected by periodic noise) in order to remove mean level gaps and consequently to have a better visualisation of the long term evolution of the periodic noise structure. At the beginning of the mission the periodic noise for band Oa21 had strong amplitude in camera 2, 3 and 5 compared to camera 1 and 4. However PN evolved through the



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 12

mission and these discrepancies between cameras have been reduced. At the time of this Cyclic Report Camera 2 still shows a slightly higher PN than other cameras.

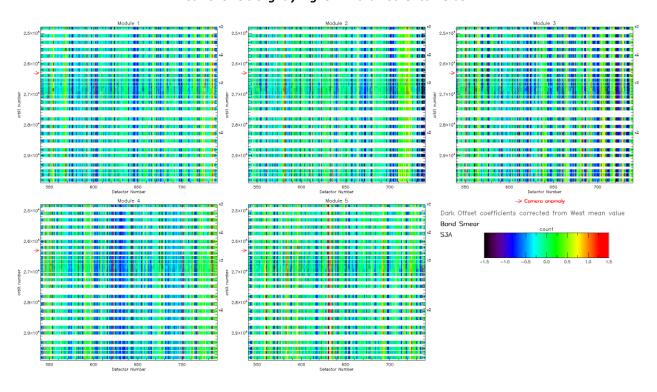


Figure 12: same as Figure 11 for smear band.

Figure 11 and Figure 12 show the so-called 'map of periodic noise' in the 5 cameras, for respectively band 21 and smear band. These maps have been computed from the dark offsets after removal of the mean level of the WEST detectors (not impacted by PN) in order to remove mean level gaps from one CAL to the other and consequently to highlight the shape of the PN. Maps are focused on the last 200 EAST detectors where PN occurs and on a time range covering only the last 5000 orbits in order to better visualize the CALs of the current cycle.

Figure 11 and Figure 12 show that at this stage of the mission the PN is very stable in all cameras. There is no special behaviour noticed during the reporting period.

Dark Currents

Dark Currents (Figure 13) are not affected by the global offset of the Dark Offsets, thanks to the clamping to the average blind pixels value. However, the oscillations of Periodic Noise remain visible. There is no significant evolution of this parameter during the current cycle except the small regular increase (almost linear), for all detectors, since the beginning of the mission (see Figure 14).

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

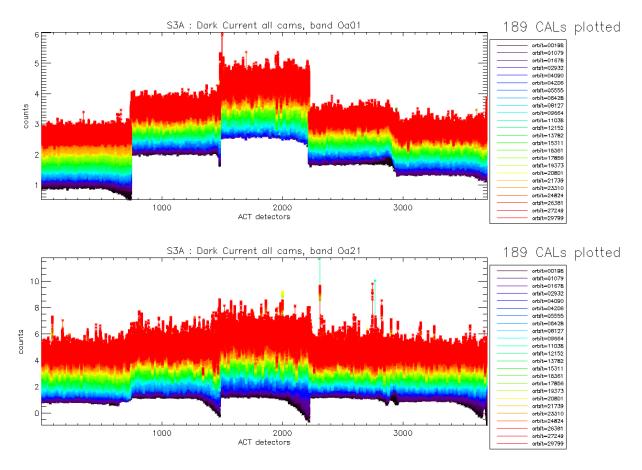


Figure 13: OLCI-A Dark Current for band Oa1 (top) and Oa21 (bottom), all radiometric calibrations so far except the first one (orbit 183) for which the instrument was not thermally stable yet.

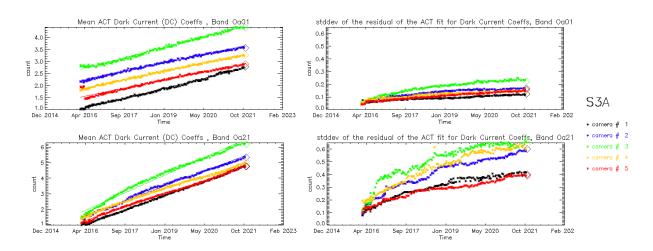


Figure 14: left column: ACT mean on 400 first detectors of OLCI-A Dark Current coefficients for spectral band Oa01 (top) and Oa21 (bottom). Right column: same as left column but for Standard deviation instead of mean.

We see an increase of the DC level as a function of time especially for band Oa21.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 14

A possible explanation of the regular increase of DC could be the increase of the number of hot pixels which is more important in Oa21 because this band is made of more CCD lines than band Oa01 and thus receives more cosmic rays impacts. It is known that cosmic rays degrade the structure of the CCD, generating more and more hot pixels at long term scales. Indeed, when computing the time slopes of the spatially averaged Dark Current as a function of band, i.e. the slopes of curves in left plots of Figure 14, one can see that Oa21 is by far the most affected, followed by the smear band (Figure 15, left); when plotting these slopes against total band width (in CCD rows, regardless of the number of micro-bands), the correlation between the slope values and the width becomes clear (Figure 15, right).

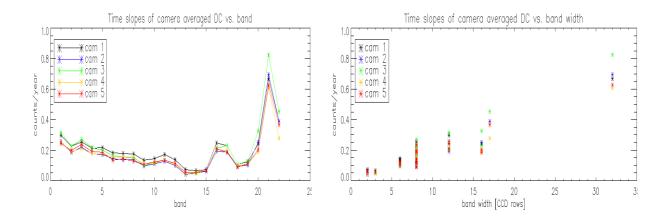


Figure 15: OLCI-A Dark current increase rates with time (in counts per year) vs. band (left) and vs. band width (right)

2.2.1.3 OLCI-B

Dark Offsets

Dark offsets for OLCI-B show a similar behaviour than for OLCI-A: mean level gaps between different orbits, induced by the presence of a pseudo periodic noise on the east edge of the cameras with a drifting phase.

Evolution of OLCI-B Dark Offset coefficients for band Oa01 and Oa21 are represented in Figure 16.

The periodic noise maps are shown for band Oa21 and smear band respectively in Figure 17 and Figure 18. As it happened for OLCI-A after a few thousands of orbits, the strong periodic noise phase and amplitude drift, present at the very beginning of the mission is now showing a clear stabilization.

Despite this overall stabilization, small evolutions are still noticeable in some bands/camera, like for example camera 1 in band Oa21 (upper left map in Figure 17) or in camera 1 band smear (upper left map in Figure 18).

Globally, OLCI-B PN is slightly less stabilized than OLCI-A PN.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

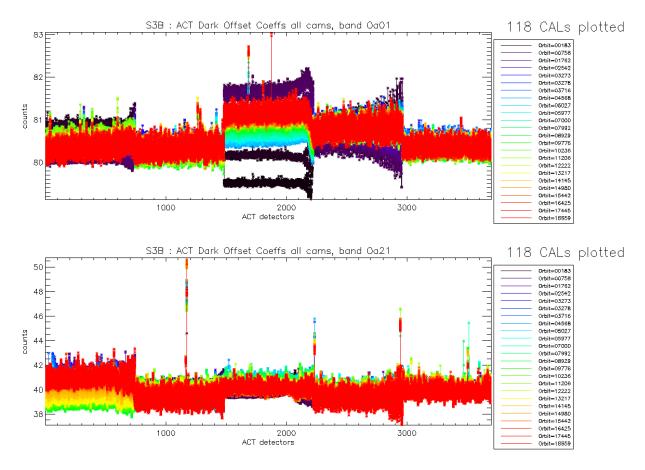


Figure 16: OLCI-B Dark Offset for band Oa1 (top) and Oa21 (bottom), all radiometric calibrations so far except the first one (orbit 167) for which the instrument was not thermally stable yet.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

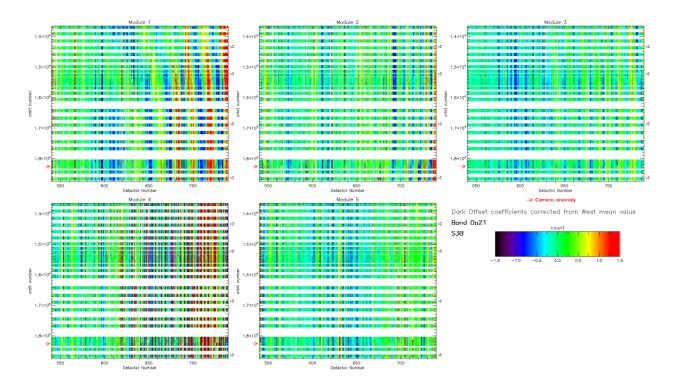


Figure 17: OLCI-B map of periodic noise for the 5 cameras, for band Oa21. X-axis is detector number (East part, from 540 to 740, where the periodic noise occurs), Y-axis is the orbit number. The counts have been corrected from the West detectors mean value (not affected by periodic noise) in order to remove mean level gaps and consequently to have a better visualisation of the long term evolution of the periodic noise structure.

Sentinel 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 17

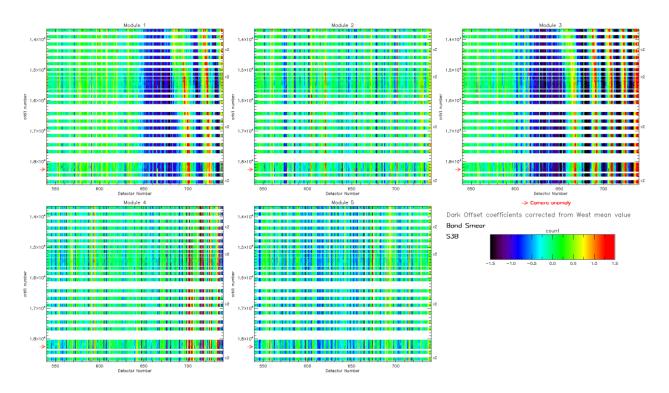


Figure 18: same as Figure 17 for smear band.

Dark Currents

As for OLCI-A there is no significant evolution of the Dark Current coefficients (Figure 19) during the current cycle except the small regular increase (almost linear), for all detectors, since the beginning of the mission (see Figure 20) probably due to an increase of hot pixels (see Figure 21).

SENTINEL 3 Mission Performance

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

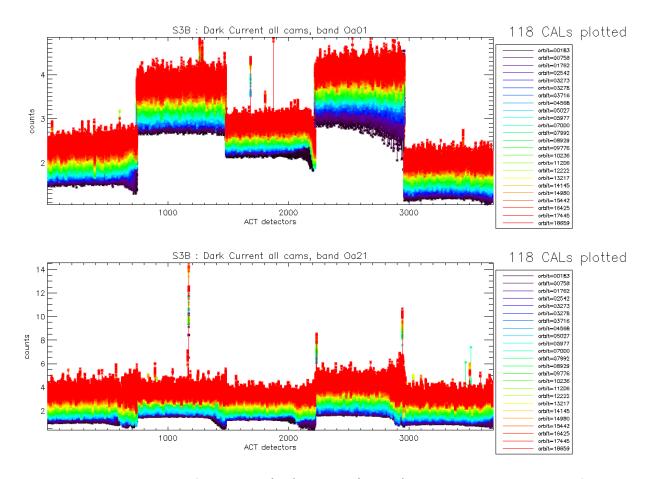


Figure 19: OLCI-B Dark Current for band Oa1 (top) and Oa21 (bottom), all radiometric calibrations so far except the first one (orbit 167) for which the instrument was not thermally stable yet.

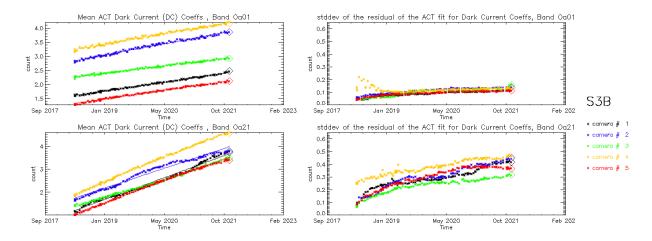


Figure 20: left column: ACT mean on 400 first detectors of OLCI-B Dark Current coefficients for spectral band Oa01 (top) and Oa21 (bottom). Right column: same as left column but for Standard deviation instead of mean.

We see an increase of the DC level as a function of time especially for band Oa21.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 19

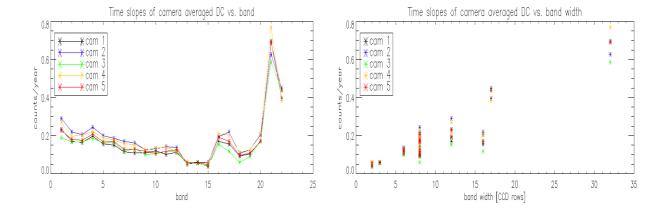


Figure 21: OLCI-B Dark Current increase rates with time (in counts per year) vs. band (left) and vs. band width (right)

2.2.2 Instrument response and degradation modelling [OLCI-L1B-CV-250]

2.2.2.1 Instrument response monitoring

2.2.2.1.1 OLCI-A

Figure 22 shows the gain coefficients of every pixel for two OLCI-A channels, Oa1 (400 nm) and Oa21 (1020 nm), highlighting the significant evolution of the instrument response since early mission.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 20

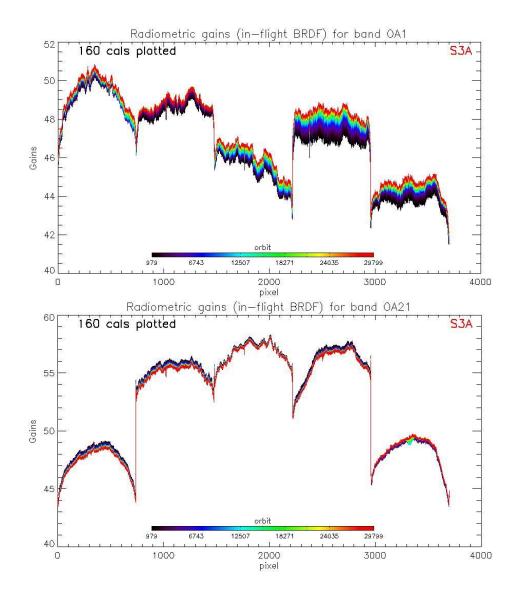


Figure 22: OLCI-A Gain Coefficients for band Oa1 (top) and Oa21 (bottom), derived using the in-flight BRDF model. The dataset is made of all diffuser 1 radiometric calibrations since orbit 979.

Figure 23 displays a summary of the time evolution of the cross-track average of the gains (in-flight BRDF, taking into account the diffuser ageing), for each module, relative to a given reference calibration (the 25/04/2016, change of OLCI channel settings). It shows that, if a significant evolution occurred during the early mission, the trends tend in general to stabilize, with some exceptions (e.g. band 1 of camera 1 and 4, bands 2 & 3 of camera 5).

SENTINGL 3 Mission Performance Contre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

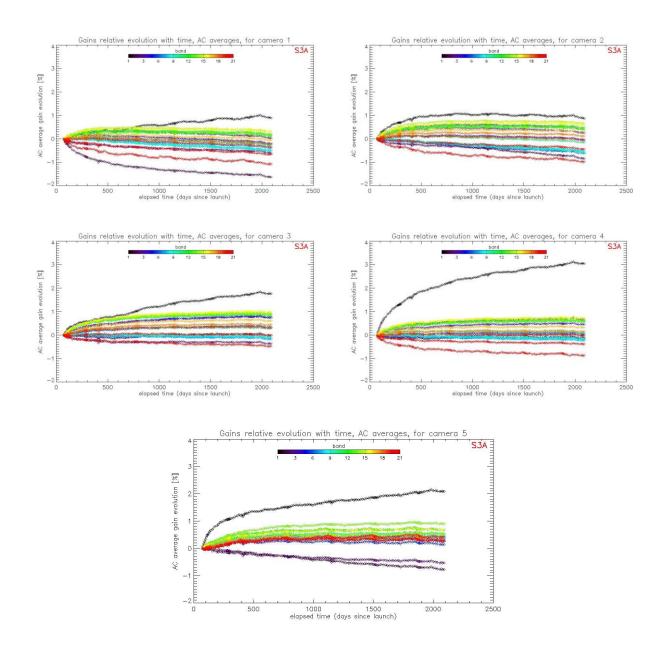


Figure 23: camera averaged gain relative evolution with respect to calibration of 25/04/2016 (change of OLCI channel settings), as a function of elapsed time since the beginning of the mission; one curve for each band (see colour code on plots), one plot for each module. The diffuser ageing has been taken into account.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 22

2.2.2.1.2 OLCI-B

Figure 24 shows the gain coefficients of every pixel for two OLCI-B channels, Oa1 (400 nm) and Oa21 (1020 nm), highlighting the significant evolution of the instrument response since early mission.

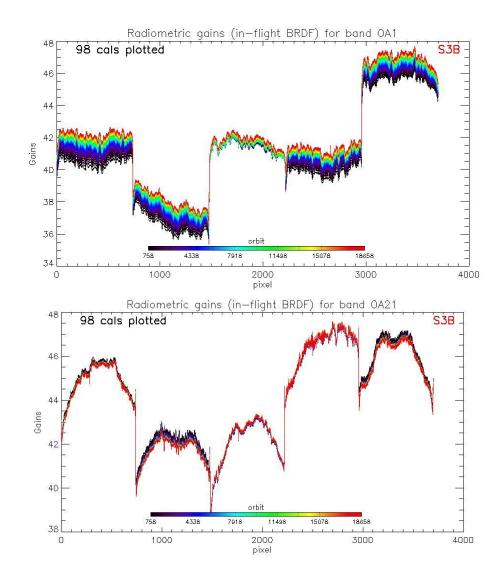


Figure 24: OLCI-B Gain Coefficients for band Oa1 (top) and Oa21 (bottom), derived using the in-flight BRDF model. The dataset is made of all diffuser 1 radiometric calibrations since orbit 758.

Figure 25 displays a summary of the time evolution of the cross-track average of the gains (in-flight BRDF, taking into account diffuser ageing), for each module, relative to a given reference calibration (first calibration after channel programming change: 18/06/2018). It shows that, if a significant evolution occurred during the early mission, the trends tend to stabilize. The large amount of points near elapsed time = 220 days is due to the yaw manoeuvre campaign.

SENTING. 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

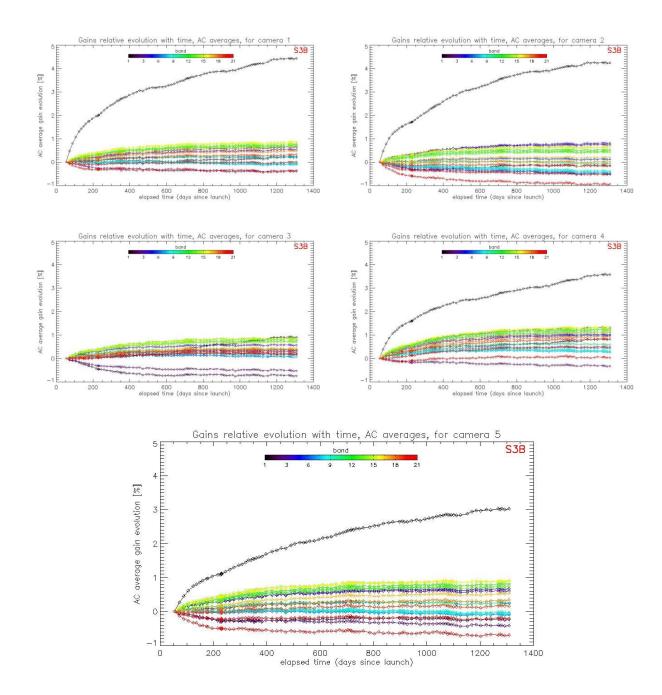


Figure 25: OLCI-B camera averaged gain relative evolution with respect to first calibration after channel programming change (18/06/2018), as a function of elapsed time since the beginning of the mission; one curve for each band (see colour code on plots), one plot for each module. The diffuser ageing has been taken into account.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 24

2.2.2.2 Instrument evolution modelling

2.2.2.2.1 OLCI-A

The OLCI-A Radiometric Model has been refreshed and put in operations at PDGS the 18/11/2021 (Processing Baseline 3.01). The model has been derived on the basis of a more recent Radiometric Calibration dataset (from 25/01/2018 to 03/10/2021). It includes the correction of the diffuser ageing for the six bluest bands (Oa1 to Oa6) for which it is clearly measurable. The model performance over the complete dataset (including the 4 calibrations in extrapolation over about 2 months) remains better than 0.085% for all bands except Oa01 first CAL (<0.09%) when averaged over the whole field of view (Figure 26) even though a drift is visible for all bands with respect to the most recent data. The previous model, trained on a Radiometric Dataset limited to 08/08/2020, shows clearly a more pronounced drift of the model with respect to most recent data (Figure 27). Comparison of the two figures shows the improvement brought by the updated Model over almost all the mission. Performance shown on Figure 26 adopts, as for OLCI-B, the multiple model approach, i.e. different models (three for OLCI-A since PB, three for OLCI-B since PB 1.57) are used to cover the whole mission (red dashed line on Figure 26), each model being fitted on a partial dataset (green dashed line on Figure 26) whose coverage is optimised to provide best performance.

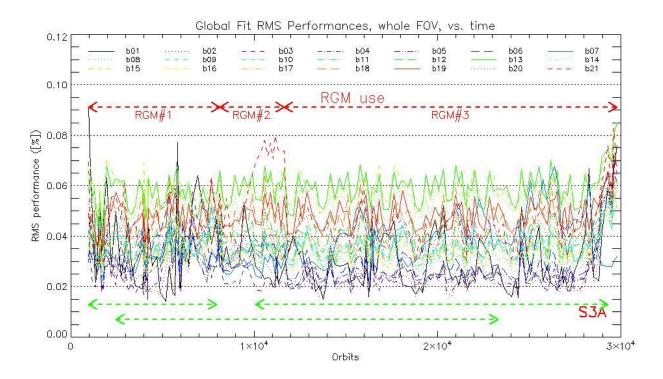


Figure 26: RMS performance of the OLCI-A Gain Model of the current processing baseline as a function of orbit.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 25

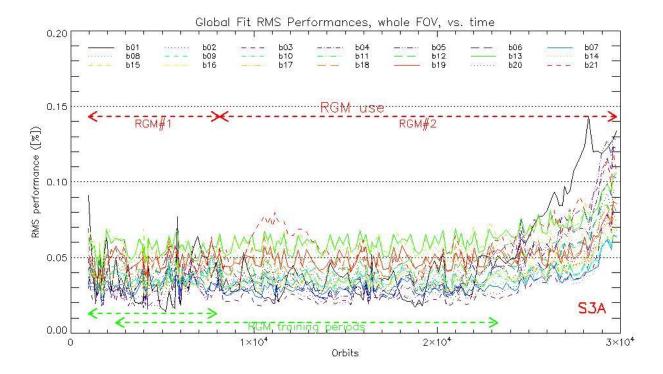


Figure 27: RMS performance of the OLCI-A Gain Model of the previous Processing Baseline as a function of orbit.

The overall instrument evolution since channel programming change (25/04/2016) is shown on Figure 28.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 26

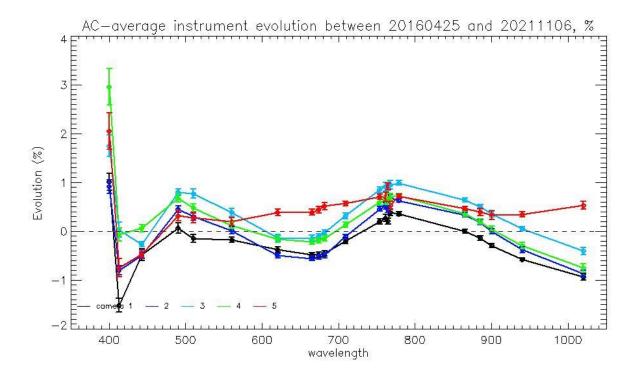


Figure 28: OLCI-A Camera-averaged instrument evolution since channel programming change (25/04/2016) and up to the most recent calibration (06/11/2021) versus wavelength.

The overall per camera performance, as a function of wavelength, and at each orbit is shown on Figure 29 as the average and standard deviation of the model over data ratio.

Finally, Figure 30 to Figure 32 show the detail of the model performance, with across-track plots of the model over data ratios at each orbit, one plot for each channel.

Comparisons of Figure 30 to Figure 32 with their counterparts in Report of Cycle 62 clearly demonstrate the improvement brought by the new model whatever the level of detail.

Mission Performance Contre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

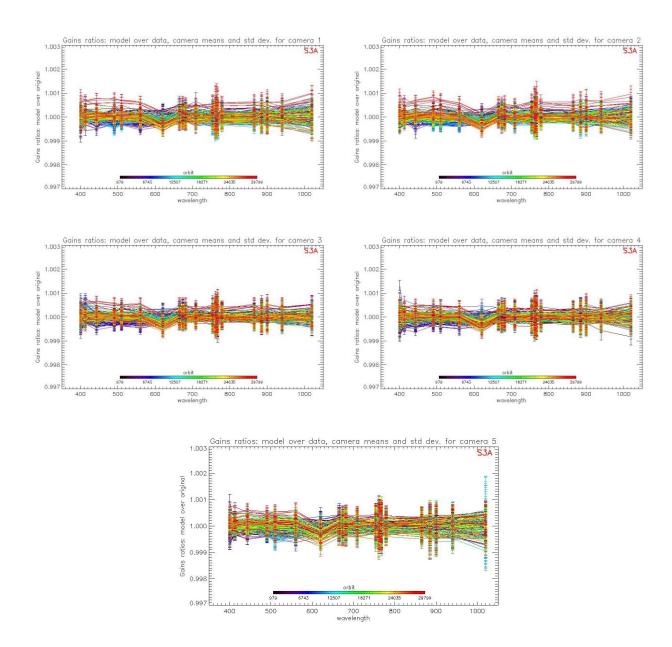


Figure 29: For the 5 cameras: OLCI-A Evolution model performance, as camera-average and standard deviation of ratio of Model over Data vs. wavelength, for each orbit of the test dataset, including 4 calibrations in extrapolation, with a colour code for each calibration from blue (oldest) to red (most recent).

Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

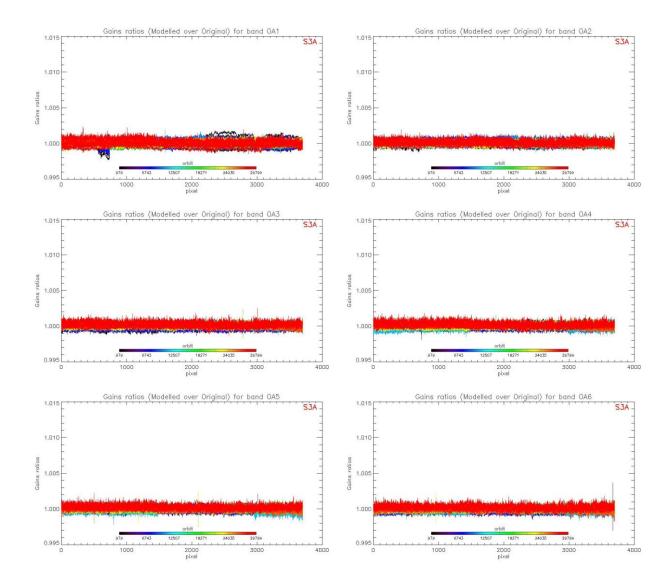


Figure 30: OLCI-A evolution model performance, as ratio of Model over Data vs. pixels, all cameras side by side, over the whole current calibration dataset (since instrument programing update), including 4 calibrations in extrapolation, channels Oa1 to Oa6.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

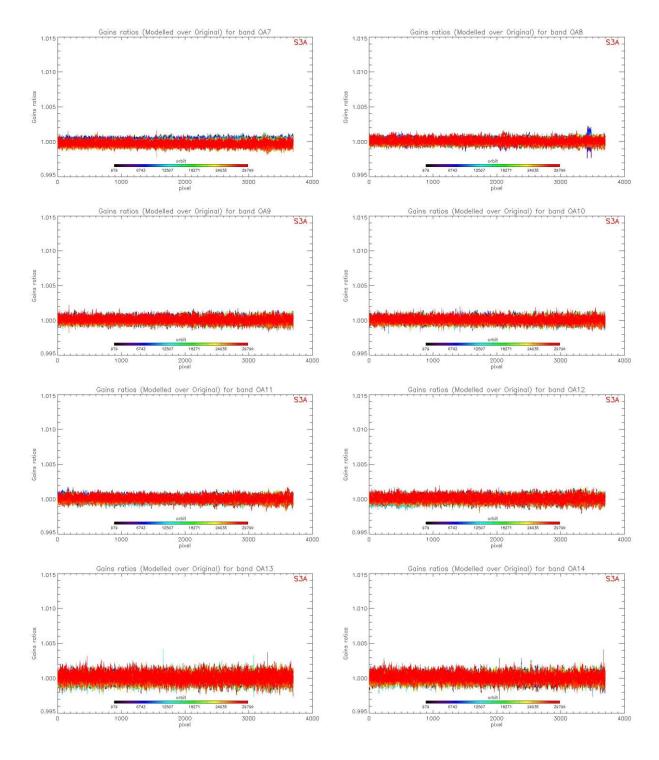


Figure 31: same as Figure 30 for channels Oa7 to Oa14.

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Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

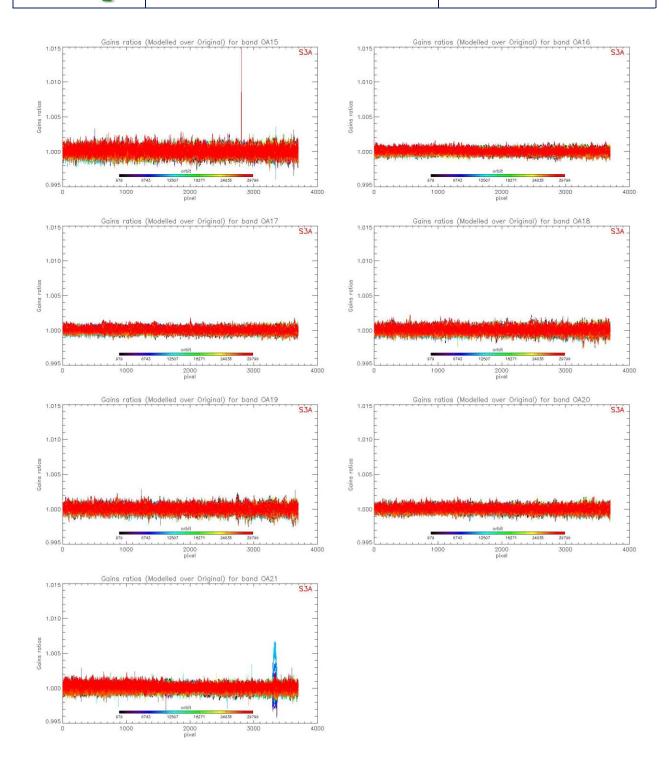


Figure 32: same as Figure 30 for channels Oa15 to Oa21.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 31

2.2.2.2. OLCI-B

Instrument response and degradation modelling for OLCI-B, including the use of the in-flight BRDF model (based on 11th December 2018 Yaw Manoeuvres), has been refreshed and deployed at PDGS on 18/11/2021 (Processing Baseline 3.01). The model has been derived on the basis of an extended Radiometric Calibration dataset (from 18/06/2019 to 16/09/2021), and most of all a revised Ageing model. It includes the correction of the diffuser ageing for the five bluest bands (Oa1 to Oa5) for which it is clearly measurable. The model performance over the complete dataset (including the single calibration in extrapolation about 1 week after the PB update) is illustrated in Figure 33. It remains better than 0.07% when averaged over the whole field of view for all band except Oa01 (< 0.09%). The previous model, trained on a Radiometric Dataset limited to 09/08/2020, shows a strong drift of the model with respect to most recent data, especially for band Oa01 (Figure 34). Comparison of the two figures shows the improvement brought by the updated Model over all the mission.

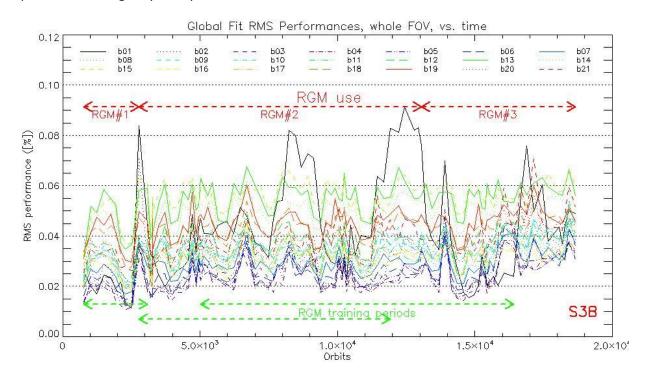


Figure 33: RMS performance of the OLCI-B Gain Model of the current processing baseline as a function of orbit.

Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

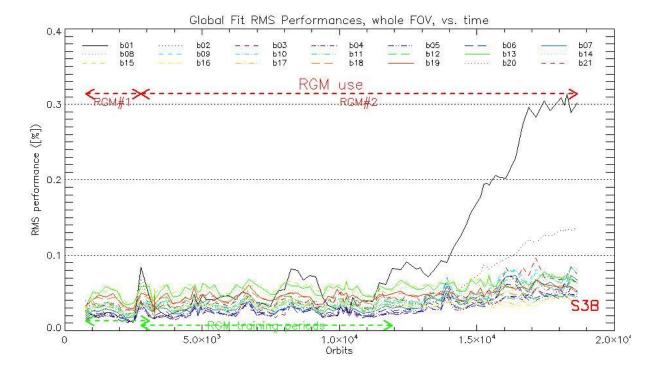


Figure 34: RMS performance of the OLCI-B Gain Model of the previous processing baseline as a function of orbit (please note the different vertical scale with respect to Figure 33).

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 33

The overall instrument evolution since channel programming change (18/06/2018) is shown on Figure 35.

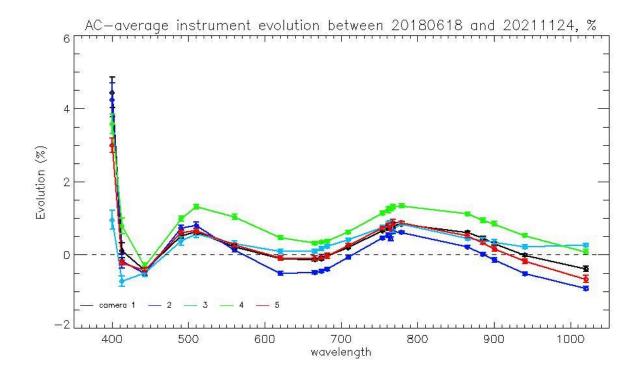


Figure 35: OLCI-B Camera-averaged instrument evolution since channel programming change (18/06/2018) and up to most recent calibration (24/11/2021) versus wavelength.

The overall per camera performance, as a function of wavelength, and at each orbit is shown on Figure 36 as the average and standard deviation of the model over data ratio.

Finally, Figure 37 to Figure 39 show the detail of the model performance, with across-track plots of the model over data ratios at each orbit, one plot for each channel.

Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

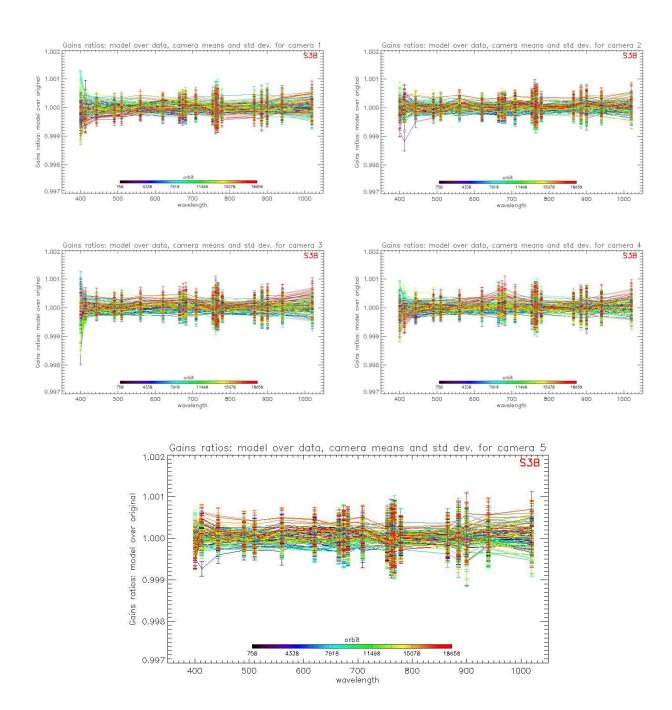


Figure 36: For the 5 cameras: OLCI-B Evolution model performance, as camera-average and standard deviation of ratio of Model over Data vs. wavelength, for each orbit of the test dataset, including 10 calibrations in extrapolation, with a colour code for each calibration from blue (oldest) to red (most recent).

Sentinel 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

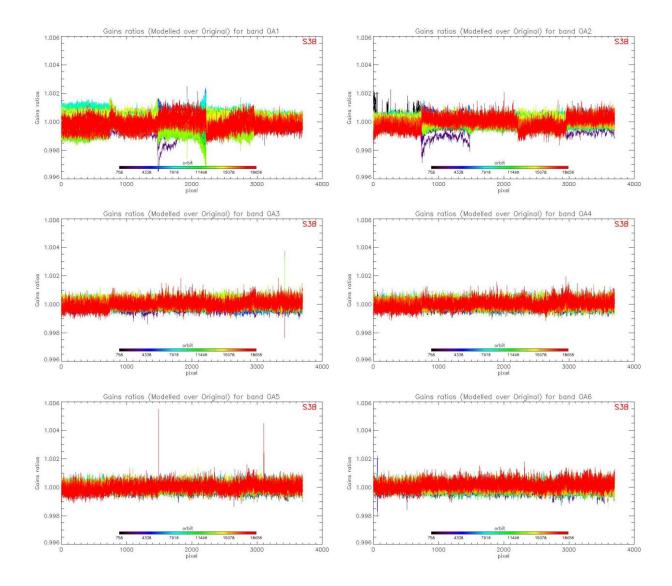


Figure 37: OLCI-B evolution model performance, as ratio of Model over Data vs. pixels, all cameras side by side, over the whole current calibration dataset (since instrument programming update), including 10 calibrations in extrapolation, channels Oa1 to Oa6.

Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

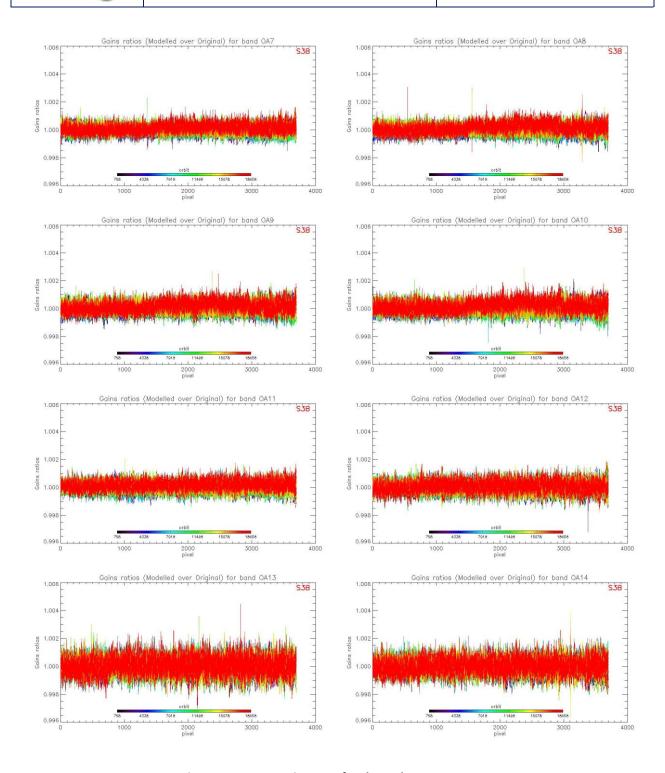


Figure 38: same as Figure 37 for channels Oa7 to Oa14.

Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

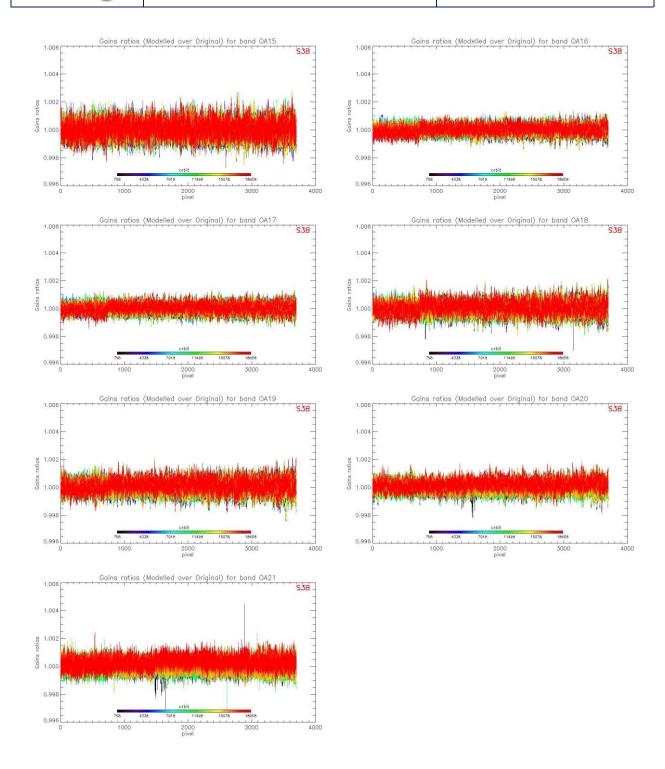


Figure 39: same as Figure 37 for channels Oa15 to Oa21.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 38

2.2.3 Ageing of nominal diffuser [OLCI-L1B-CV-240]

2.2.3.1 OLCI-A

There has been no sequence S05 (reference diffuser) for OLCI-A during acquisition cycle 078.

Consequently, the last ageing results, presented in CPR #74/#55 (S3A/S3B), stay valid.

2.2.3.2 OLCI-B

There has been one calibration sequence S05 (reference diffuser) for OLCI-B during acquisition Cycle 059:

S05 sequence (diffuser 2) on 24/11/2021 09:05 to 09:07 (absolute orbit 18659)

With associated S01 in order to compute ageing:

S01 sequence (diffuser 1) on 24/11/2021 07:24 to 07:26 (absolute orbit 18658)

Since a S05/S01 sequence has been measured on 23 November 2021 for OLCI-A, which belongs to the next OLCI-A cycle (#79), the ageing results for OLCI-B will be presented in the next CPR (#79/#60 S3A/S3B) at the same time as the OLCI-A ageing results.

The last ageing results, presented in CPR #74/#55 (S3A/S3B), stay valid.

2.2.4 Updating of calibration ADF [OLCI-L1B-CV-260]

2.2.4.1.1 OLCI-A

No CAL_AX ADF has been delivered to PDGS during the report period for OLCI-A.

2.2.4.1.2 OLCI-B

No CAL_AX ADF has been delivered to PDGS during the report period for OLCI-B.

2.2.5 Radiometric Calibrations for sun azimuth angle dependency and Yaw Manoeuvres for Solar Diffuser on-orbit re-characterization [OLCI-L1B-CV-270 and OLCI-L1B-CV-280]

2.2.5.1.1 OLCI-A

This activity has not evolved during cycle 078 and results presented in Cycle 15 report are still valid.

2.2.5.1.2 OLCI-B

Activity has started for S3B-OLCI. The SAA domain explored is now increased by the acquisitions from the Yaw Manoeuvres and analysis becomes meaningful. Analysis is on-going.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 39

2.3 Spectral Calibration [OLCI-L1B-CV-400]

2.3.1 OLCI-A

There has been one SO2+SO3 Spectral Calibration for OLCI-A in the reporting period:

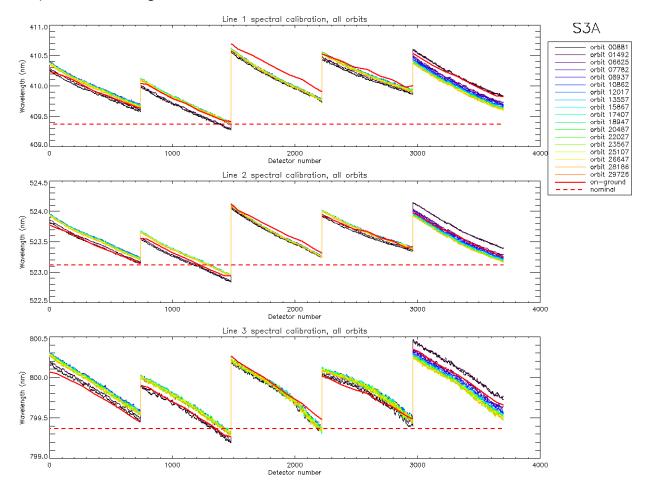
- \$ S02 sequence (diffuser 1) on 01/11/2021 11:20 to 11:21 (absolute orbit 29726)
- So3 sequence (Erbium doped diffuser) on 01/11/2021 13:01 to 13:02 (absolute orbit 29727)

and one Spectral calibration S09:

\$ S09 sequence on 01/11/2021 09:04:51 to 09:04:57 (absolute orbit 29725)

The S02/S03 data have been processed and analysed to assess OLCI-A spectral long-term evolution. The absolute results are presented in Figure 40 while its long term evolution is presented Figure 41.

The processing of the S09 calibration sequence (spectral calibration using O_2 absorption and Fraunhofer lines) is illustrated in Figure 42.



Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Figure 40: OLCI-A across track spectral calibration from all S02/S03 sequences since the beginning of the mission.

Top plot is spectral line 1, middle plot is spectral line 2 and bottom plot spectral line 3. The nominal spectral calibration is plotted as a red horizontal dotted line and the on-ground spectral calibration as a red thick line.

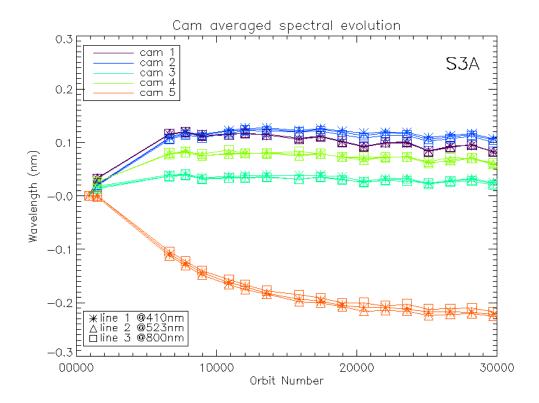


Figure 41: OLCI-A camera averaged spectral calibration evolution as a function of time since launch (all spectral S02/S03 calibrations since the beginning of the mission are included). The data are normalized with the first Spectral Calibration of the plot.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 41

S09 spectral calibration evolution

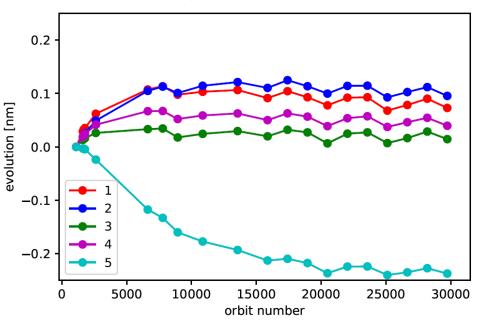


Figure 42: OLCI-A camera averaged spectral calibration evolution as a function of orbit number from S09 calibrations since the 4th may 2016. The last calibration for S09 is from 01 Nov 2021. For each camera, the spectral evolution corresponding derived from spectral lines at 485 nm, 656 nm, 770 nm and 854 nm have been averaged. The data are normalized with the first Spectral Calibration of the plot.

We see that the long term evolution of the spectral calibration obtained with sequence S09 (Figure 42) is in rather good agreement with the one obtained with sequence S02/S03 (Figure 41). Indeed, for camera 1, 2, 3 and 4, we observe for the two methods a positive trend of the spectral calibration at the beginning of the mission, which is now rather stabilized, and for camera 5, an obvious negative trend since almost the beginning of the mission which is also stabilizing but more progressively. In all cases, the spectral calibration drift since the beginning of the mission is smaller than ≈0.23 nm and the change with respect to the values included in the Auxiliary Data files is less than 0.1 nm. However, camera 5 still evolves but with a slower rate; only further monitoring will allow to assess the need for an evolution of the Auxiliary Parameters impacted by the instrument spectral model, reflecting the current or future state of the instrument

2.3.2 OLCI-B

There has been one SO2+SO3 Spectral Calibration for OLCI-B in the reporting period:

- \$ S02 sequence (diffuser 1) on 11/11/2021 11:22 to 11:24 (absolute orbit 18475)
- S03 sequence (Erbium doped diffuser) on 11/11/2021 13:03 to 13:05 (absolute orbit 18476)

and one Spectral calibration S09:

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 42

\$ S09 sequence on 11/11/2021 09:06:38 to 09:06:44 (absolute orbit 18474)

The SO2/SO3 data have been processed and analysed to assess OLCI-B spectral long-term evolution. The absolute results are presented in Figure 43 while its long term evolution is presented on Figure 44. The processing of the SO9 calibration sequence (spectral calibration using O2 absorption and Fraunhofer lines) is now available and presented in Figure 45.

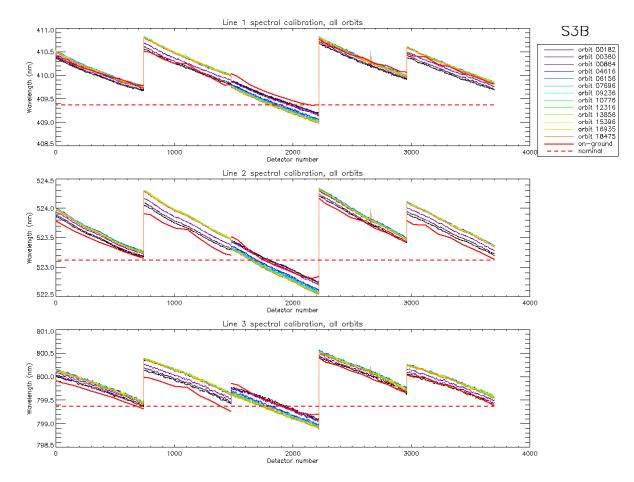


Figure 43: OLCI-B across track spectral calibration from all S02/S03 sequences since the beginning of the mission.

Top plot is spectral line 1, middle plot is spectral line 2 and bottom plot spectral line 3. The nominal spectral calibration is plotted as a red dotted line and the on-ground spectral calibration as a red thick line.

Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

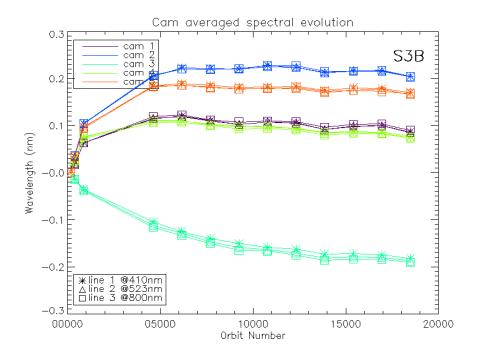


Figure 44: OLCI-B camera averaged spectral calibration evolution as a function of time since launch (all spectral S02/S03 calibrations since the beginning of the mission are included). The data are normalized with the first Spectral Calibration.

SENTINEL 3 Mission

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 44

S09 spectral calibration evolution

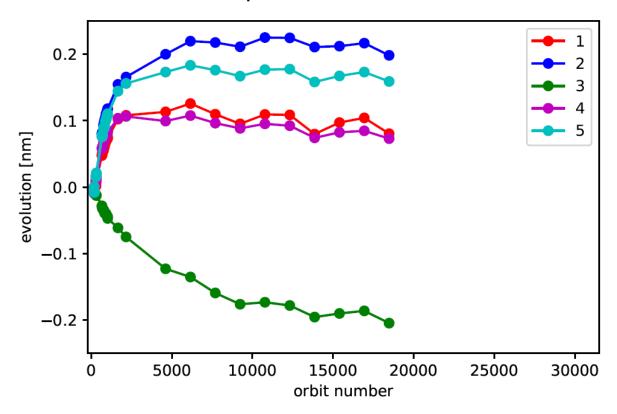


Figure 45: OLCI-B camera averaged spectral calibration evolution as a function of orbit number since launch from S09 calibrations since the beginning of the mission. The last calibration for S09 is from 11 Nov 2021. For each camera, the spectral evolution corresponding derived from spectral lines at 485 nm, 656 nm, 770 nm and 854 nm have been averaged. The data are normalized with the first Spectral Calibration.

Figure 43 to Figure 45 show that:

- As for OLCI-A camera 5, the wavelength calibration drift of OLCI-B camera 3 goes in the opposite direction than for the other cameras.
- It seems than the quick drift of the early mission has stabilized especially for camera 1, 2, 4 and 5.
 The stabilization for camera 3 is now also clearly visible even though it took more time to stabilize than for other camera.
- The results obtained with the S02/S03 method and the one obtained with the S09 method are rather similar.

The spectral calibration drift is smaller than ≈0.23 nm for all cases.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 45

2.4 Signal to Noise assessment [OLCI-L1B-CV-620]

2.4.1 SNR from Radiometric calibration data

2.4.1.1 OLCI-A

SNR computed for all calibration data (S01, S04 and S05 sequences) as a function of band number is presented in Figure 46.

SNR computed for all calibration data as a function of orbit number for band Oa01 (the less stable band) is presented in Figure 47.

There is no significant evolution of this parameter during the current cycle and the ESA requirement is fulfilled for all bands.

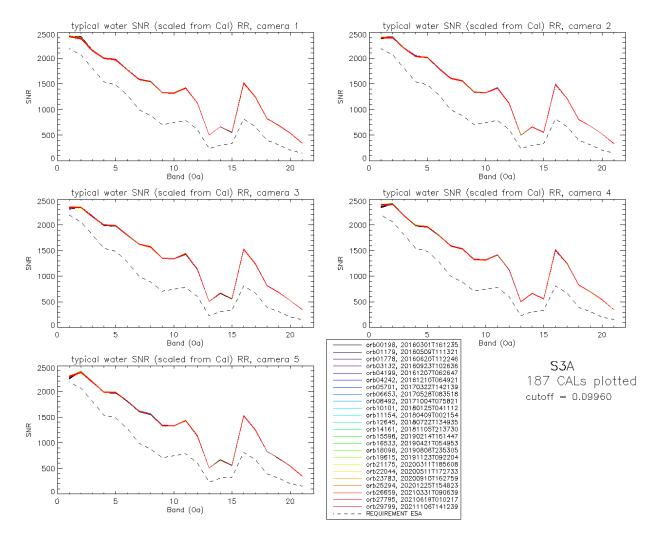


Figure 46: OLCI-A Signal to Noise ratio as a function of the spectral band for the 5 cameras. These results have been computed from radiometric calibration data. All calibrations except first one (orbit 183) are presents with

Mission Performance Gentre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 46

the colours corresponding to the orbit number (see legend). The SNR is very stable with time: the curves for all orbits are almost superimposed. The dashed curve is the ESA requirement.

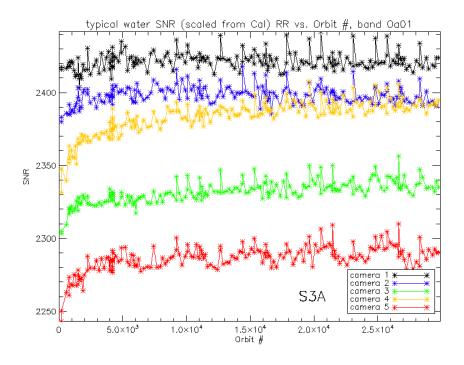


Figure 47: long-term stability of the SNR estimates from Calibration data, example of channel Oa1.

The mission averaged SNR figures are provided in Table 1 below, together with their radiance reference level. According to the OLCI SNR requirements, these figures are valid at these radiance levels and at Reduced Resolution (RR, 1.2 km). They can be scaled to other radiance levels assuming shot noise (CCD sensor noise) is the dominating term, i.e. radiometric noise can be considered Gaussian with its standard deviation varying as the square root of the signal; in other words: $SNR(L) = SNR(L_{ref}) \cdot \sqrt{\frac{L}{L_{ref}}}$. Following the same assumption, values at Full Resolution (300m) can be derived from RR ones as 4 times smaller.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Table 1: OLCI-A SNR figures as derived from Radiometric Calibration data. Figures are given for each camera (time average and standard deviation), and for the whole instrument. The requirement and its reference radiance level are recalled (in mW.sr⁻¹.m⁻².nm⁻¹).

	L_{ref}	SNR	C1		C2		C3		C4		C5		All	
nm	LU	RQT	avg	std	avg	std	avg	std	avg	std	avg	std	avg	std
400.000	63.0	2188	2421	6.2	2398	6.2	2331	7.7	2383	11.9	2286	9.1	2364	6.9
412.000	74.1	2061	2388	9.3	2404	6.7	2339	4.9	2401	4.9	2380	9.1	2382	5.5
442.000	65.6	1811	2158	5.9	2196	6.0	2163	4.9	2185	4.1	2194	5.7	2179	4.0
490.000	51.2	1541	2000	4.6	2036	4.9	1998	4.1	1984	4.4	1988	4.6	2001	3.2
510.000	44.4	1488	1979	5.4	2014	5.0	1985	4.5	1967	4.4	1985	4.3	1986	3.5
560.000	31.5	1280	1775	4.6	1802	4.2	1803	4.6	1794	3.8	1818	3.3	1799	3.0
620.000	21.1	997	1591	4.1	1608	4.3	1624	3.2	1593	3.2	1615	3.5	1606	2.6
665.000	16.4	883	1546	4.2	1557	4.4	1566	3.9	1533	3.6	1561	3.7	1553	3.0
674.000	15.7	707	1328	3.4	1337	3.7	1350	2.8	1323	3.2	1342	3.5	1336	2.5
681.000	15.1	745	1319	3.6	1326	3.1	1338	2.7	1314	2.5	1333	3.4	1326	2.1
709.000	12.7	785	1420	4.2	1420	4.1	1435	3.3	1414	3.5	1431	3.1	1424	2.7
754.000	10.3	605	1127	3.1	1121	2.8	1136	3.2	1125	2.5	1139	2.7	1130	2.2
761.000	6.1	232	502	1.1	498	1.1	505	1.2	501	1.1	508	1.4	503	0.8
764.000	7.1	305	663	1.6	658	1.6	668	2.0	661	1.5	670	2.1	664	1.3
768.000	7.6	330	558	1.4	554	1.3	563	1.3	557	1.3	564	1.3	559	1.0
779.000	9.2	812	1516	4.7	1498	4.6	1526	5.2	1512	4.9	1526	5.0	1516	4.1
865.000	6.2	666	1244	3.6	1213	3.5	1239	3.8	1246	3.5	1250	2.8	1238	2.8
885.000	6.0	395	823	1.7	801	1.6	814	1.9	824	1.4	831	1.6	819	1.1
900.000	4.7	308	691	1.6	673	1.3	683	1.6	693	1.5	698	1.5	688	1.0
940.000	2.4	203	534	1.2	522	1.2	525	0.9	539	1.1	542	1.3	532	0.7
1020.000	3.9	152	345	0.9	337	0.8	348	0.7	345	0.8	351	0.8	345	0.5



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 48

2.4.1.2 OLCI-B

SNR computed for all OLCI-B calibration data (S01, S04 (but not the dark-only S04) and S05 sequences) as a function of band number is presented in Figure 48.

SNR computed for all OLCI-B calibration data as a function of orbit number for band Oa01 (the less stable band) is presented in Figure 49.

As for OLCI-A the SNR is very stable in time. There is no significant evolution of this parameter during the current cycle and the ESA requirement is fulfilled for all bands.

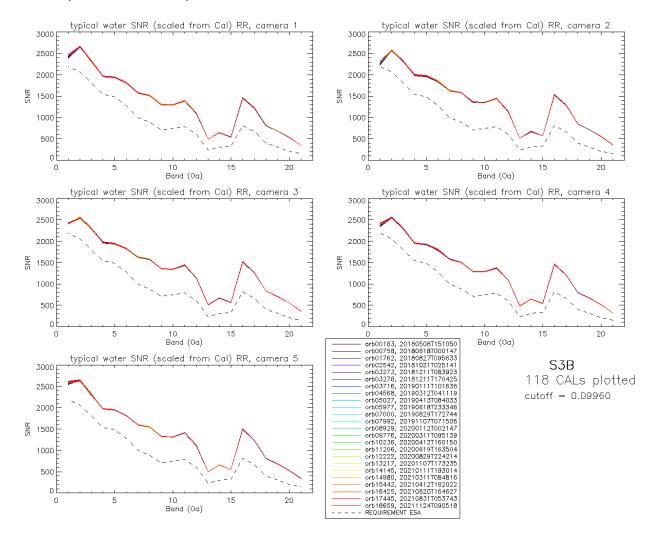


Figure 48: OLCI-B Signal to Noise ratio as a function of the spectral band for the 5 cameras. These results have been computed from radiometric calibration data. All calibrations except first one (orbit 167) are presents with the colours corresponding to the orbit number (see legend). The SNR is very stable with time: the curves for all orbits are almost superimposed. The dashed curve is the ESA requirement.

Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

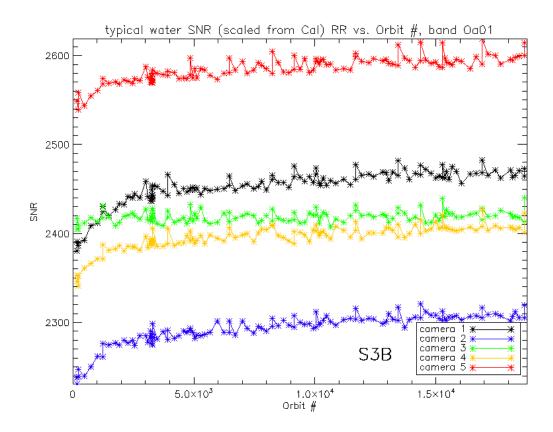


Figure 49: long-term stability of the OLCI-B SNR estimates from Calibration data, example of channel Oa1.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Table 2: OLCI-B SNR figures as derived from Radiometric Calibration data. Figures are given for each camera (time average and standard deviation), and for the whole instrument. The requirement and its reference radiance level are recalled (in mW.sr⁻¹.m⁻².nm⁻¹).

	•	CNID	I		co co					/-	OF.		A II	
	L _{ref}	SNR	C1		C2		C3		C4		C5		All	
nm	LU	RQT	avg	std	avg	std	avg	std	avg	std	avg	std	avg	std
400.000	63.0	2188	2453	19.4	2293	17.1	2418	6.3	2396	13.9	2584	14.0	2429	13.1
412.000	74.1	2061	2655	6.7	2569	5.9	2545	8.3	2550	5.9	2638	7.2	2591	5.1
442.000	65.6	1811	2324	6.3	2317	5.9	2300	6.3	2303	6.7	2309	6.4	2311	5.3
490.000	51.2	1541	1966	4.7	1989	5.6	1971	4.9	1952	4.6	1979	4.5	1972	3.7
510.000	44.4	1488	1939	4.8	1967	5.7	1943	5.0	1924	5.1	1951	4.8	1945	4.0
560.000	31.5	1280	1813	4.8	1848	5.2	1829	4.5	1804	5.0	1817	4.1	1822	3.7
620.000	21.1	997	1573	4.3	1626	4.7	1625	3.7	1576	3.7	1601	3.2	1600	2.9
665.000	16.4	883	1513	4.1	1579	3.9	1573	3.8	1501	3.1	1546	3.8	1543	2.8
674.000	15.7	707	1301	3.8	1358	3.5	1353	3.3	1292	2.6	1328	3.0	1326	2.3
681.000	15.1	745	1293	3.6	1347	3.2	1343	2.9	1285	2.8	1316	2.8	1317	2.1
709.000	12.7	785	1390	4.1	1447	4.2	1443	4.1	1373	2.9	1412	3.8	1413	3.0
754.000	10.3	605	1096	3.8	1143	3.7	1142	3.5	1089	2.8	1116	3.3	1117	2.9
761.000	6.1	232	487	1.2	509	1.2	508	1.4	485	1.2	497	1.4	498	1.0
764.000	7.1	305	643	1.6	672	2.0	672	1.9	641	1.7	657	1.8	657	1.5
768.000	7.6	330	541	1.5	568	1.5	564	1.4	541	1.4	554	1.6	554	1.1
779.000	9.2	812	1467	4.2	1535	4.7	1527	5.4	1467	4.1	1506	4.5	1500	3.9
865.000	6.2	666	1221	3.6	1287	3.7	1258	3.6	1205	3.7	1238	2.9	1242	2.8
885.000	6.0	395	808	2.3	847	1.9	834	2.0	799	1.7	814	2.1	820	1.5
900.000	4.7	308	679	1.5	714	2.0	704	1.7	670	1.6	683	1.5	690	1.2
940.000	2.4	203	527	1.3	549	1.5	551	1.3	510	1.2	522	1.3	532	0.9
1020.000	3.9	152	336	0.8	358	1.2	358	0.8	318	0.8	338	1.0	342	0.6



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 51

2.4.2 SNR from EO data

2.4.2.1 OLCI-A

There has been no update on SNR assessment from EO data during the cycle. Last figures (cycle 9) are considered valid.

2.4.2.2 OLCI-B

The SNR assessment from EO data has not been applied to OLCI-B considering a) that SNR estimates from RC data have been proved more reliable for OLCI-A and b) that it requires a significant amount of human and machine resources that can be more efficiently used for other tasks.

2.5 Geometric Calibration/Validation

2.5.1 OLCI-A

OLCI-A georeferencing performance is compliant since the introduction of MPC Geometric Calibration, put in production on the 14th of March 2018. It has however significantly improved after its last full revision of GCMs (Geometric Calibration Models, or platform to instrument alignment quaternions) and IPPVMs (Instrument Pixels Pointing Vectors) both derived using the GeoCal Tool and put in production on 30/07/2019.

The following figures (Figure 50 to Figure 55) show time series of the overall RMS performance (requirement criterion) and of the across-track and along-track biases for each camera. New plots (Figure 56 and Figure 57) introduce monitoring of the performance homogeneity within the field of view: georeferencing errors in each direction at camera transitions (difference between last pixel of camera N and first pixel of camera N+1) and within a given camera (maximum bias minus minimum inside each camera). The performance improvement since the 30/07/2019 is significant on most figures: the global RMS value decreases form around 0.35 to about 0.2 (Figure 50), the across-track biases decrease significantly for all cameras (Figure 51 to Figure 55), the along-track bias reduces for at least camera 3 (Figure 53) and the field of view homogeneity improves drastically (Figure 56 and Figure 57, but also reduction of the dispersion – distance between the ± 1 sigma lines – in Figure 51 to Figure 55).



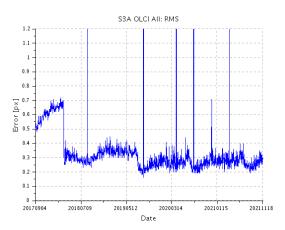
S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021



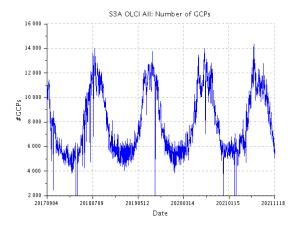
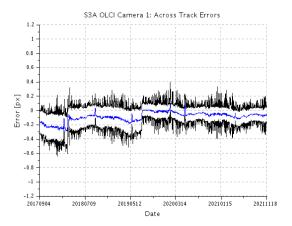


Figure 50: overall OLCI-A georeferencing RMS performance time series (left) and number of validated control points corresponding to the performance time series (right) over the whole monitoring period



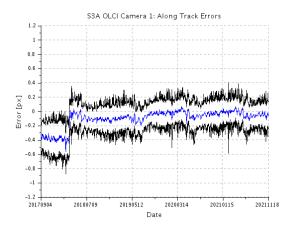
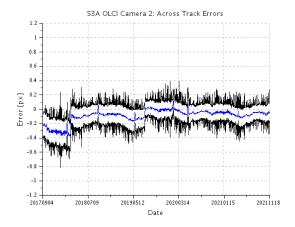


Figure 51: across-track (left) and along-track (right) OLCI-A georeferencing biases time series for Camera 1. Blue line is the average, black lines are average plus and minus 1 sigma.



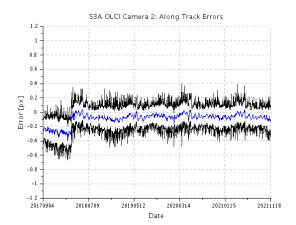


Figure 52: same as Figure 51 for Camera 2.

Sentinel-3 MPC

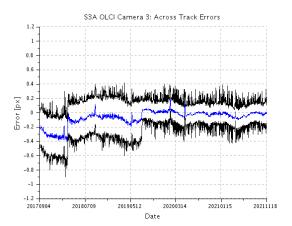
S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 - S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021



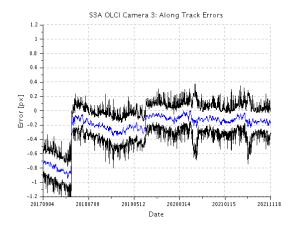
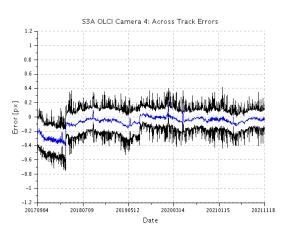


Figure 53: same as Figure 51 for Camera 3.



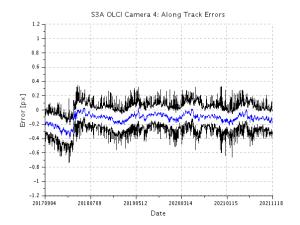
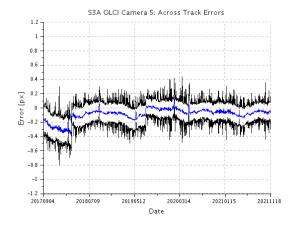


Figure 54: same as Figure 51 for Camera 4.



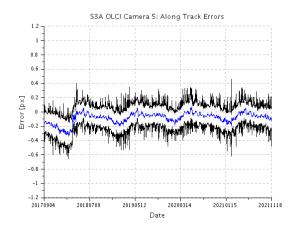


Figure 55: same as Figure 51 for Camera 5.



S3 OLCI Cyclic Performance Report

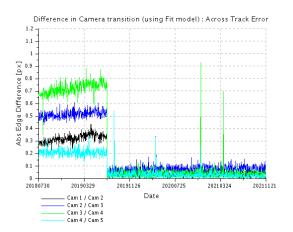
S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 54



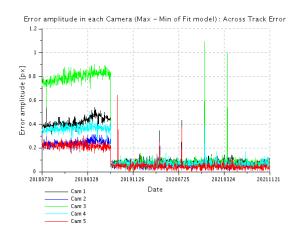
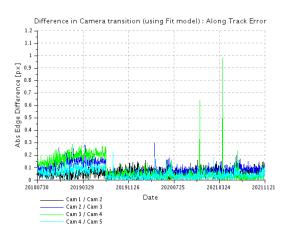


Figure 56: OLCI-A spatial across-track misregistration at each camera transition (left) and maximum amplitude of the across-track error within each camera (left).



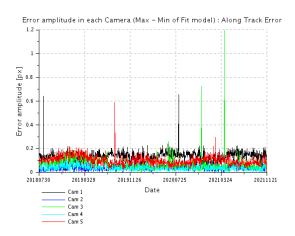


Figure 57: OLCI-A spatial along-track misregistration at each camera transition (left) and maximum amplitude of the along-track error within each camera (left).

2.5.2 OLCI-B

Georeferencing performance of OLCI-B improved significantly with the fourth geometric calibration introduced the 30/07/2019. However, the instrument pointing is still evolving, in particular for camera 2 (Figure 64) and a new geometric calibration has been done and introduced in the processing chain on the 16th of April 2020. Its impact is significant on the along-track biases of all cameras (Figure 59 to Figure 63), but also on the continuity at camera interfaces (Figure 64, left) and on intra-camera homogeneity (Figure 64, right). Since then, further adjustments to the geometric calibration have been introduced, mainly to correct the along-track drifts. The most recent was put in production on 29/07/2021and its effect can be seen e.g. on left graphs of Figure 60, Figure 61 and Figure 63 (across-track biases of cameras 2, 3 & 5).



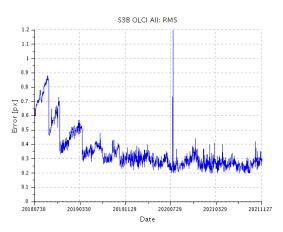
S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021



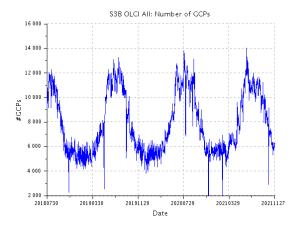
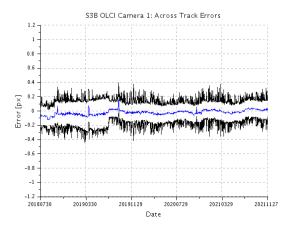


Figure 58: overall OLCI-B georeferencing RMS performance time series over the whole monitoring period (left) and corresponding number of validated control points (right)



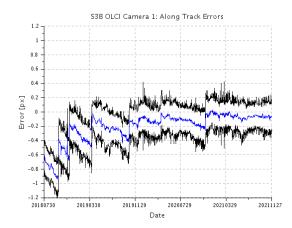
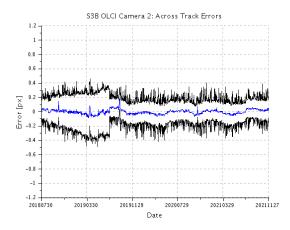


Figure 59: across-track (left) and along-track (right) OLCI-B georeferencing biases time series for Camera 1.



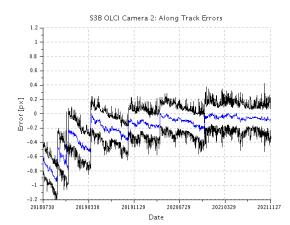


Figure 60: same as Figure 59 for Camera 2.

Sentinel-3 MPC

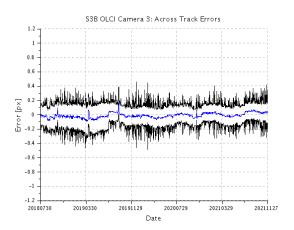
S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 - S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021



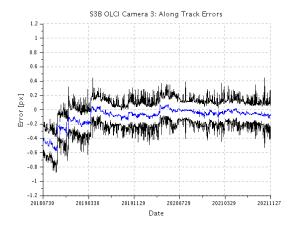
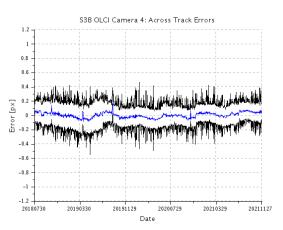


Figure 61: same as Figure 59 for Camera 3.



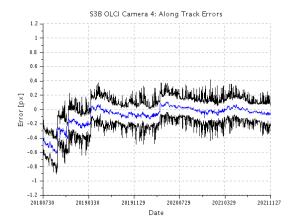
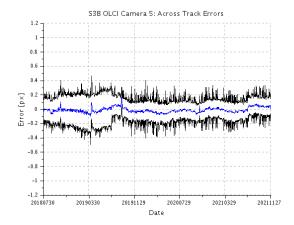


Figure 62: same as Figure 59 for Camera 4.



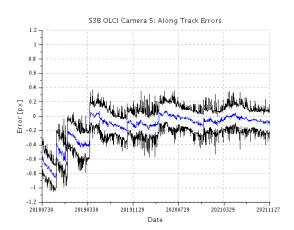


Figure 63: same as Figure 59 for Camera 5.

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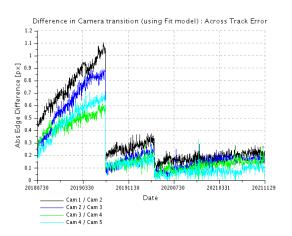
S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021



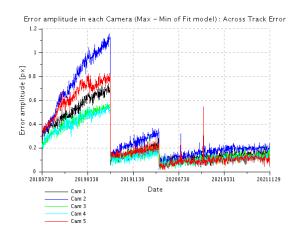
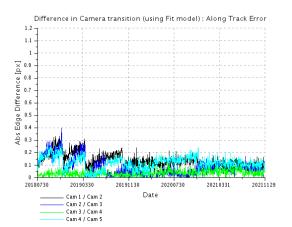


Figure 64: OLCI-B spatial across-track misregistration at each camera transition (left) and maximum amplitude of the across-track error within each camera (left).



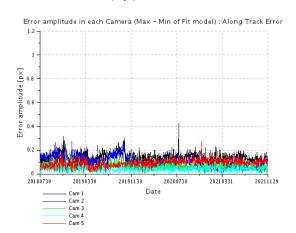


Figure 65: OLCI-B spatial along-track misregistration at each camera transition (left) and maximum amplitude of the along-track error within each camera (left).



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 58

3 OLCI Level 1 Product validation

3.1 [OLCI-L1B-CV-300], [OLCI-L1B-CV-310] - Radiometric Validation

3.1.1 S3ETRAC Service

Activities done

The S3ETRAC service extracts OLCI L1 RR and SLSTR L1 RBT data and computes associated statistics over 49 sites corresponding to different surface types (desert, snow, ocean maximizing Rayleigh signal, ocean maximizing sunglint scattering and deep convective clouds). The S3ETRAC products are used for the assessment and monitoring of the L1 radiometry (optical channels) by the ESLs.

All details about the S3ETRAC/OLCI and S3ETRAC/SLSTR statistics are provided on the S3ETRAC website http://s3etrac.acri.fr/index.php?action=generalstatistics.

- Number of OLCI products processed by the S3ETRAC service
- Statistics per type of target (DESERT, SNOW, RAYLEIGH, SUNGLINT and DCC)
- Statistics per sites
- Statistics on the number of records

For illustration, we provide below statistics on the number of S3ETRAC/OLCI records generated per type of targets (DESERT, SNOW, RAYLEIGH, SUNGLINT and DCC) for both OLCI-A (Figure 66) and OLCI-B (Figure 67).

Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

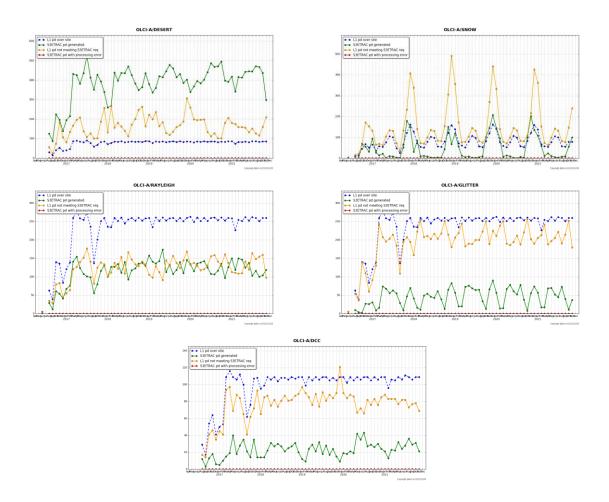


Figure 66: summary of S3ETRAC products generation for OLCI-A

(number of OLCI-A L1 products Ingested, blue – number of S3ETRAC extracted products generated, green – number of S3ETRAC runs without generation of output product (data not meeting selection requirements), yellow – number of runs ending in error, red, one plot per site type).

SENTINEL 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

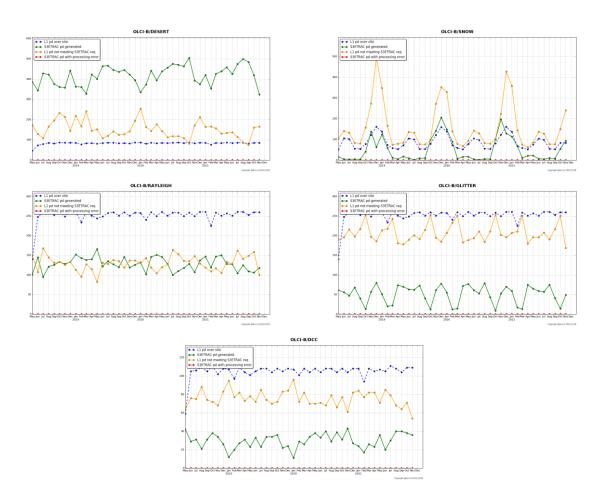


Figure 67: summary of S3ETRAC products generation for OLCI-B

(number of OLCI-B L1 products Ingested, yellow – number of S3ETRAC extracted products generated, blue – number of S3ETRAC runs without generation of output product (data not meeting selection requirements), green – number of runs ending in error, red, one plot per site type).

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 61

3.1.2 Radiometric validation with DIMITRI

Highlights

OLCI-A and OLCI-B L1B radiometry verification as follow:

- The verification is performed over Desert and Ocean-sites until the 21st of November 2021.
- All results from OLCI-A and OLCI-B over Rayleigh, Glint and PICS are consistent with the previous cycle over the used CalVal sites.
- Good stability of both sensors OLCI-A and OLCI-B could be observed, nevertheless the timeseries average shows higher reflectance from OLCI-A.
- Bands with high gaseous absorption are excluded.

Verification and Validation over PICS

- The ingestion of all the available L1B-LN1-NT products from OLCI-A and OLCI-B over the 6 desert CalVal-sites (Algeria 3 & 5, Libya 1 & 4 and Mauritania 1 & 2) has been performed until the 21st of November 2021.
- 2. The results are consistent over all the six used PICS sites (Figure 68 and Figure 69). Both sensors show a good stability over the analysed period.
- 3. The temporal average over the period **January 2021 Present** of the elementary ratios (observed reflectance to the simulated one) for **OLCI-A** shows gain values between 2-4% over all the VNIR bands (Figure 70). Unlikely, the temporal average over the same period of the elementary ratios for **OLCI-B** shows gain values within 2% (mission requirements) over the VNIR spectral range (Figure 70). The spectral bands with significant absorption from water vapor and O₂ (Oa11, Oa13, Oa14, Oa15 and Oa20) are excluded.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

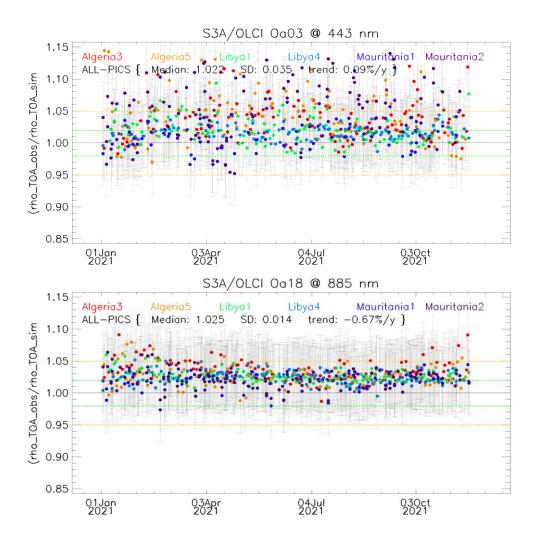


Figure 68: Time-series of the elementary ratios (observed/simulated) signal from OLCI-A for (top to bottom) bands Oa03 and Oa18 respectively over January 2021-Present from the six PICS Cal/Val sites. Dashed-green and orange lines indicate the 2% and 5% respectively. Error bars indicate the desert methodology uncertainty.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 63

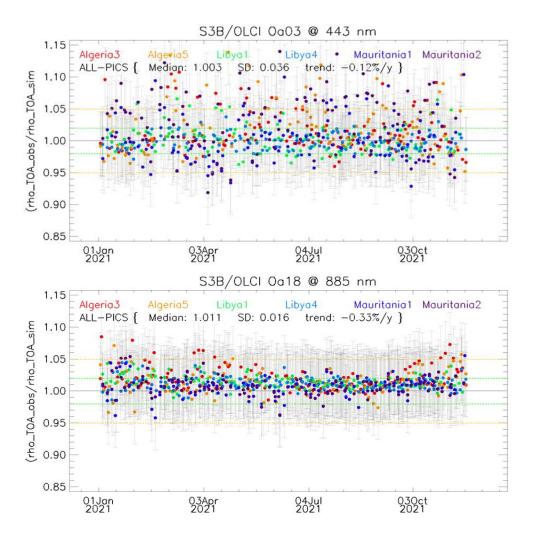


Figure 69: Time-series of the elementary ratios (observed/simulated) signal from OLCI-B for (top to bottom) bands Oa08 and Oa18 respectively over January 2021-Present from the six PICS Cal/Val sites. Dashed-green and orange lines indicate the 2% and 5% respectively. Error bars indicate the desert methodology uncertainty.

Validation over Rayleigh

Rayleigh method has been performed from the available mini-files over the **last 12 months** for OLCI-A and OLCI-B. The results were produced with the configuration (ROI-AVERAGE). The gain coefficients of OLCI-A are consistent with the previous results. Bands Oa01-Oa05 display biases values between 3%-5% while bands Oa06-Oa09 exhibit biases between about 2%, just within the mission requirement (Figure 70). The gain coefficients of OLCI-B are lower than OLCI-A ones, where bands Oa01-Oa05 display biases values about 2-5%, when bands Oa6-Oa9 exhibit biases around the 2% mission requirement (Figure 70).

Validation over Glint and synthesis

Glint calibration method with the configuration (ROI-PIXEL) has been performed over the **last 12 months** for OLCI-A and OLCI-B. The outcome of this analysis shows a good consistency with the desert and Rayleigh



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 64

outputs over the NIR spectral range Oa06-Oa09 for both sensors. Glint results from OLCI-A show that the NIR bands are within the 2% (mission requirements), except Oa21 which shows higher biases more than ~5% for both sensors (see Figure 70). Again, the glint gain from OLCI-B looks slightly lower than OLCI-A one.

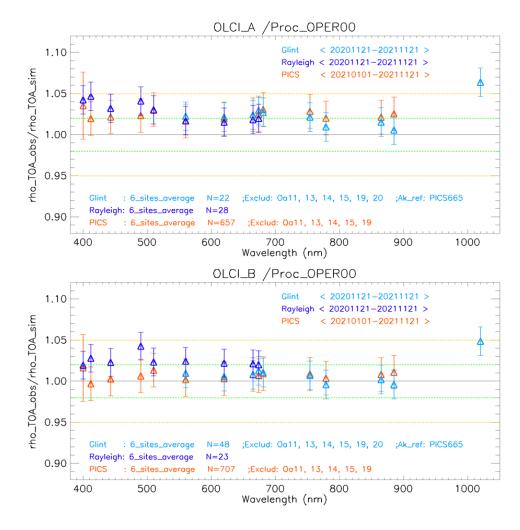


Figure 70: The estimated gain values for OLCI-A and OLCI-B from Glint, Rayleigh and PICS methods over the past twelve months as a function of wavelength. We use the gain value of Oa8 from PICS-Desert method as reference gain for Glint method. Dashed-green and orange lines indicate the 2% and 5% respectively. Error bars indicate the method uncertainties.

Cross-mission Intercomparison over PICS:

X-mission Intercomparison with MODIS-A MSI-A and MSI-B has been performed until October 2021.

Figure 71 shows the estimated gain over different time-series for different sensors over PICS. The spectral bands with significant absorption from water vapor and O2 are excluded. OLCI-A seems to have higher gain wrt the other sensors, and about 1-2% higher gain wrt to OLCI-B over VNIR spectral range.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 65

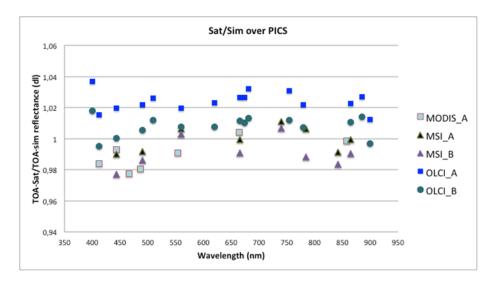


Figure 71: Ratio of observed TOA reflectance to simulated one for (green-yellow) S2A/MSI, (red) Aqua/MODIS, (blue) S3A/OLCI and (green) S3B/OLCI averaged over the six PICS test sites as a function of wavelength.

3.1.3 Radiometric validation with OSCAR

OSCAR Rayleigh results

The OSCAR Rayleigh have been applied to the S3A and S3B S3ETRAC data from the 6 oceanic calibration sites (Table 3) using a new chlorophyll climatology which has been derived from the CMEMS OLCI monthly CHL products from considering the years 2017, 2018 and 2019.

Table 3: S3ETRAC Rayleigh Calibration sites

, , ,												
Site Name	Ocean	North Latitude	South Latitude	East Longitude	West Longitude							
PacSE	South-East of Pacific	-20.7	-44.9	-89	-130.2							
PacNW	North-West of Pacific	22.7	10	165.6	139.5							
PacN	North of Pacific	23.5	15	200.6	179.4							
AtlN	North of Atlantic	27	17	-44.2	-62.5							
AtIS	South of Atlantic	-9.9	-19.9	-11	-32.3							
IndS	South of Indian	-21.2	-29.9	100.1	89.5							

In Figure 72 the average OSCAR OLCI-A and OLCI-B Rayleigh results are given for November 2021 (only partially processed). In Figure 73 and Table 4 the average of all scenes currently (re)processed with this new climatology is given. The (re)processing was done on the S3ETRAC scenes from all months of 2019 and 2020, and Jan – Nov. 2021.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

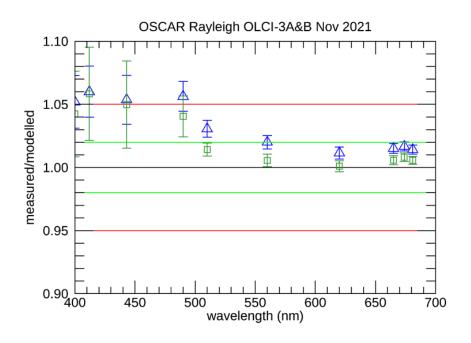


Figure 72: OSCAR Rayleigh S3A and S3B Calibration results as a function of wavelength for November 2021. The results are obtained with a new climatology derived from CMEMS OLCI monthly CHL products.

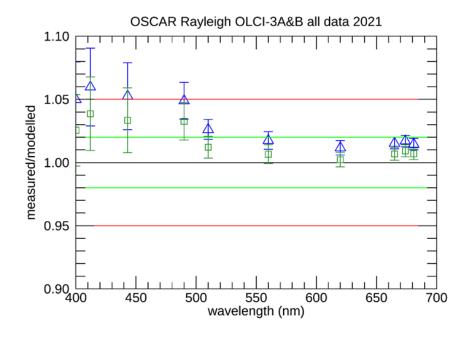


Figure 73. OSCAR Rayleigh S3A and S3B Calibration results as a function of wavelength for Jan – November 2021.

Average and standard deviation over all scenes currently (re)processed with the new climatology.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 67

Table 4. OSCAR Rayleigh calibration results for S3A and S3B (average and standard deviation over all acquisitions) over all scenes currently (re)processed with the new climatology and observed difference (in %) between OLCIA and OLCIB

OLCI	Wavelength	Oscar Rayle	eigh OLCIA	Oscar Rayl	% difference OLCIA and	
band	(nm)	avg	stdev	avg	stdev	OLCIB
Oa01	400	1.050	0.030	1.026	0.028	2.32%
Oa02	412	1.060	0.031	1.039	0.029	1.98%
Oa03	443	1.053	0.027	1.033	0.025	1.82%
Oa04	490	1.049	0.015	1.033	0.015	1.54%
Oa05	510	1.026	0.008	1.012	0.009	1.37%
Oa06	560	1.017	0.007	1.007	0.007	1.07%
Oa07	620	1.012	0.006	1.002	0.006	0.92%
Oa08	665	1.015	0.005	1.007	0.005	0.83%
Oa09	674	1.017	0.004	1.009	0.005	0.76%
Oa10	681	1.015	0.004	1.007	0.005	0.75%
Oa11	709	0.998	0.008	0.993	0.008	0.45%
Oa12	754	1.009	0.001	1.008	0.002	0.13%

3.2 [OLCI-L1B-CV-320] - Radiometric Validation with Level 3 products

3.2.1 OLCI-A

There has been no new result during the cycle. Last figures (cycle 20) are considered valid.

3.2.2 OLCI-B

This activity has not started for OLCI-B.

SENTINEL 3 Mission Performance

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 68

4 Level 2 Land products validation

4.1 [OLCI-L2LRF-CV-300]

4.1.1 Routine extractions

- The focus for this time period has been on the rolling archive Non Time Critical (NT) data until the 3rd of December 2021. More data available for statistical analysis as a concatenation procedure for all available data in the MERMAID processing has been implemented.
- Concatenated time series of OLCI Global Vegetation Index and OLCI Terrestrial Chlorophyll Index have been regenerated on the current rolling archive availability including previous extractions since June 2016 and April 2018 for S3A and S3B respectively.

4.1.1.1 OLCI-A

Figure 74 to Figure 83 below present the Core Land Sites OLCI-A time series over the current period.

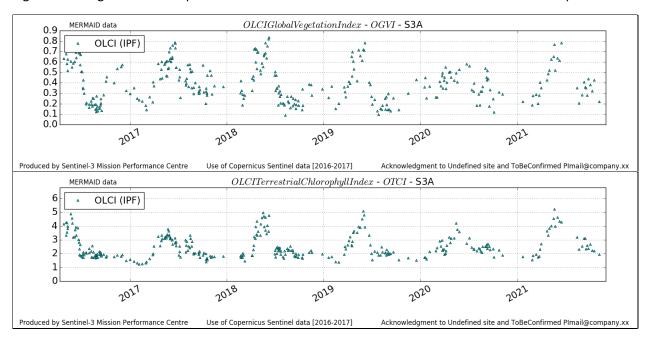


Figure 74: DeGeb time series over current report period

SENTINEL 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

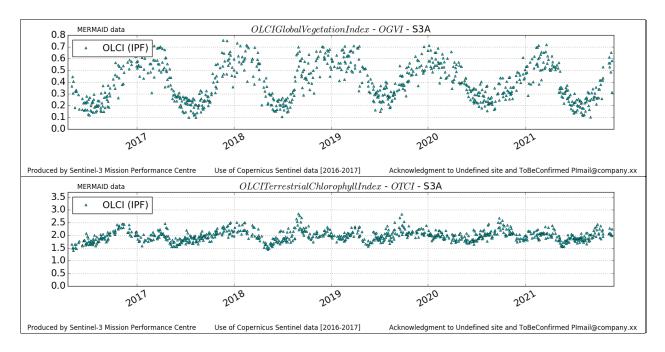


Figure 75: ITCat time series over current report period

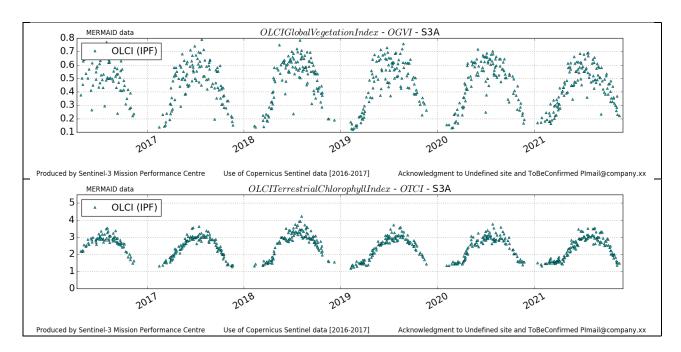


Figure 76: ITIsp time series over current report period

SEMINEL 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 - S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

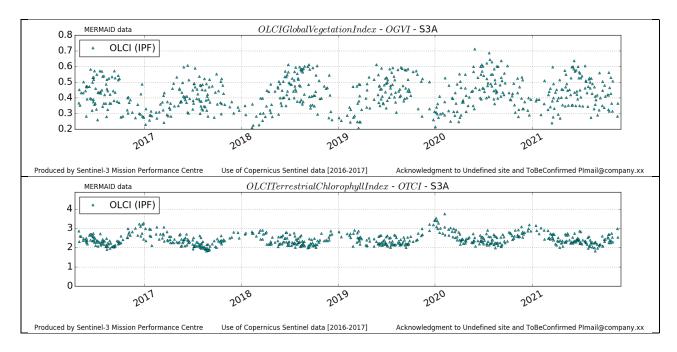


Figure 77: ITSro time series over current report period

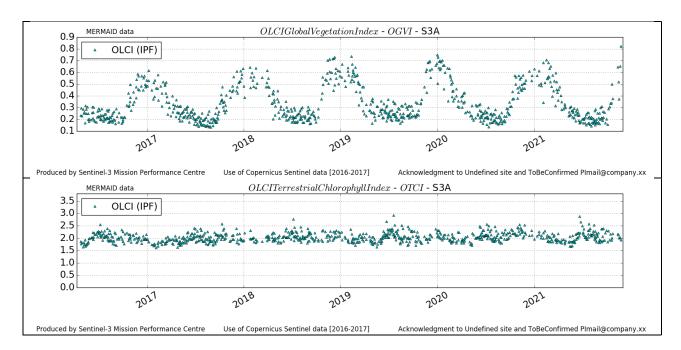


Figure 78: ITTra time series over current report period

SEMINEL 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 - S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

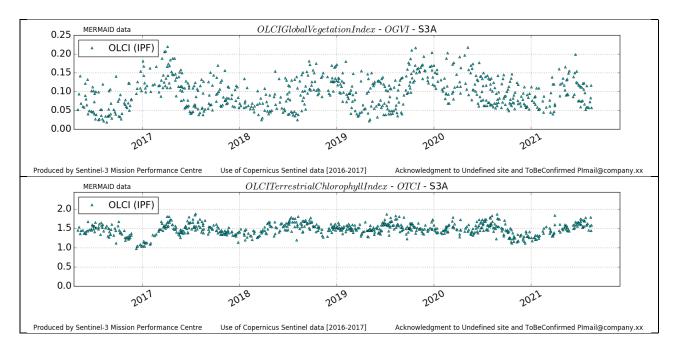


Figure 79: SPAli time series over current report period

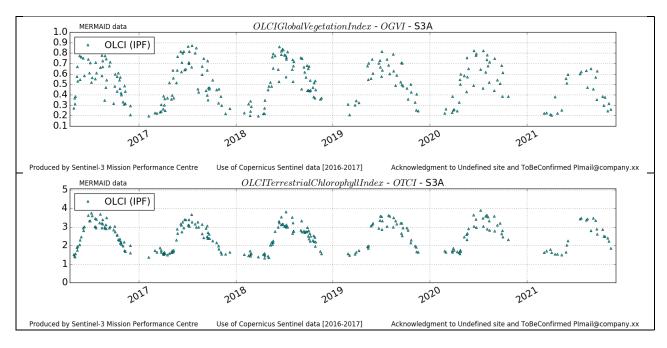


Figure 80: UKNFo time series over current report period

Mission Performance

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

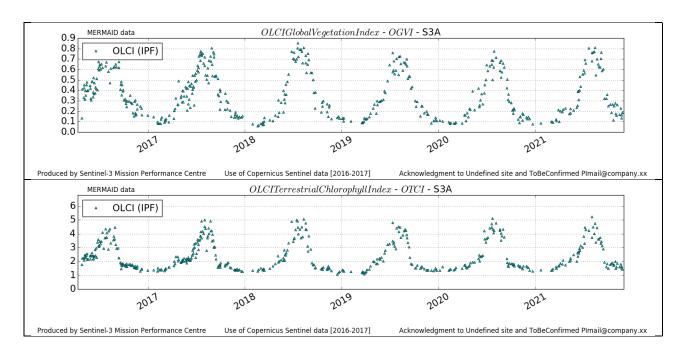


Figure 81: USNe1 time series over current report period

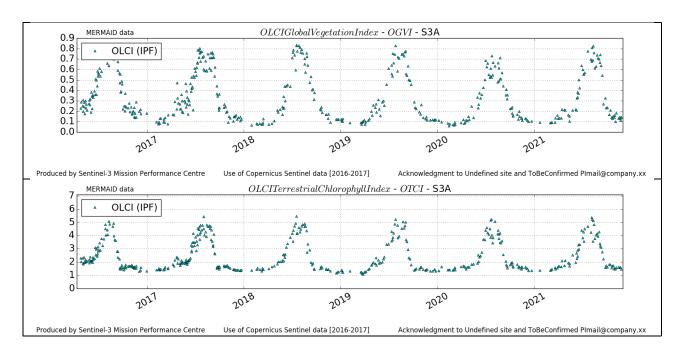


Figure 82: USNe2 time series over current report period

SENTINEL 3

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 73

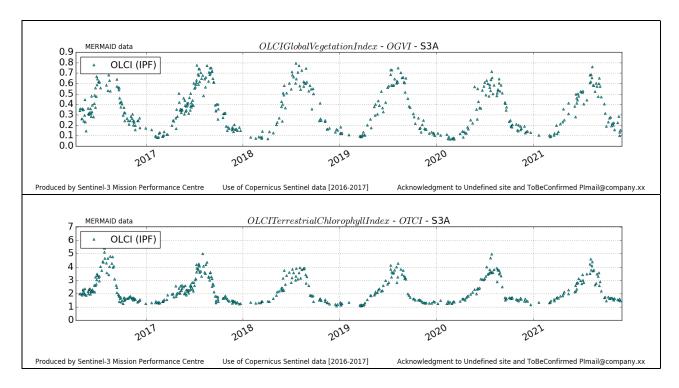


Figure 83: USNe3 time series over current report period

4.1.1.2 OLCI-B

Figure 84 to Figure 93 below present the Core Land Sites OLCI-B time series over the current period.

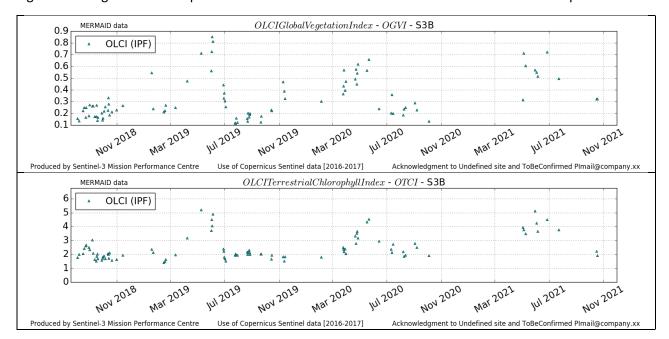


Figure 84: DeGeb time series over current report period

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 - S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

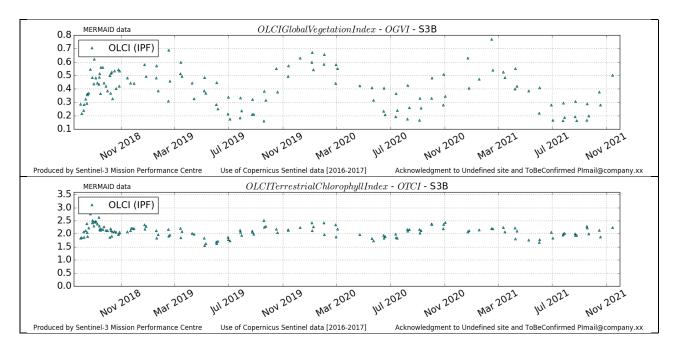


Figure 85: ITCat time series over current report period

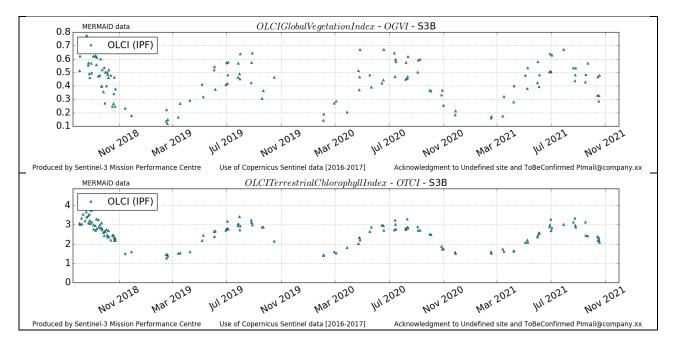


Figure 86: ITIsp time series over current report period

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 - S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

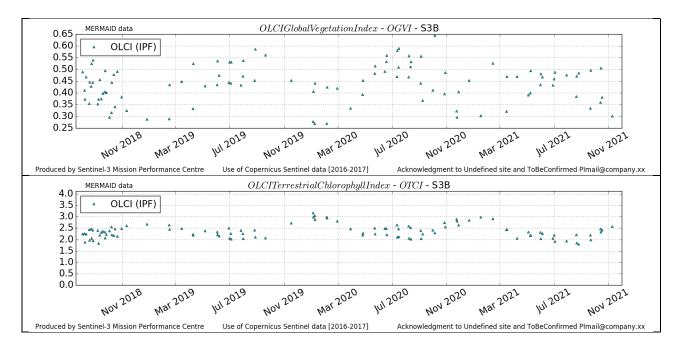


Figure 87: ITSro time series over current report period

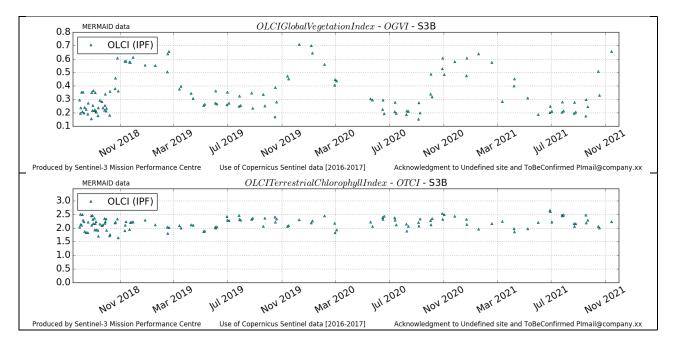


Figure 88: ITTra time series over current report period

Sentinel 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

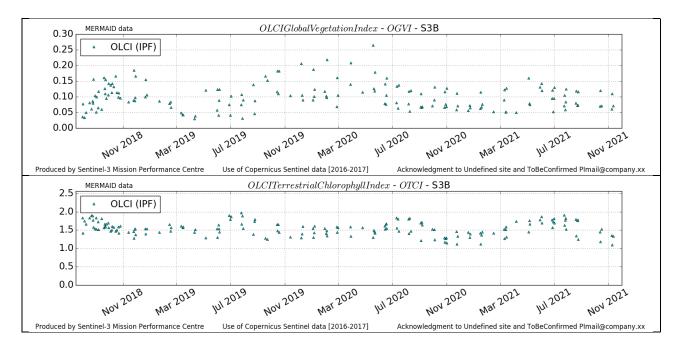


Figure 89: SPAli time series over current report period

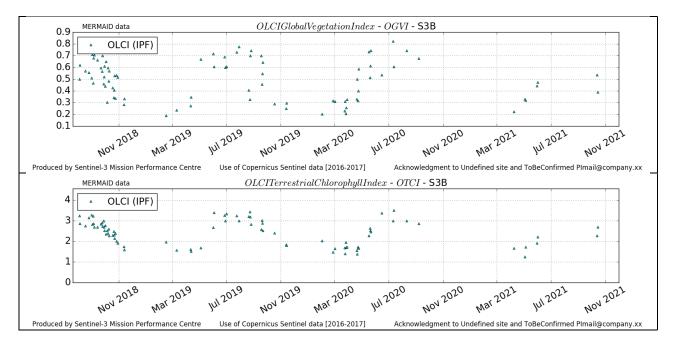


Figure 90: UKNFo time series over current report period

SENTINEL 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

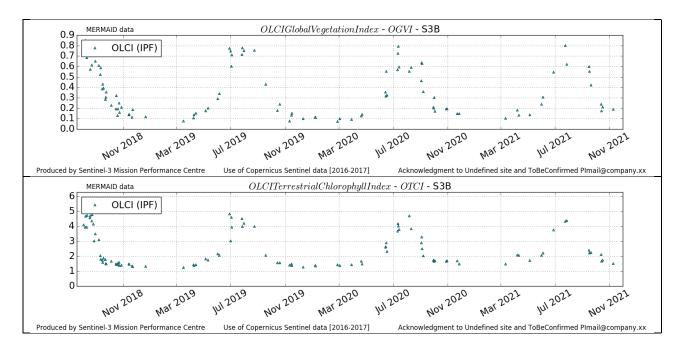


Figure 91: USNe1 time series over current report period

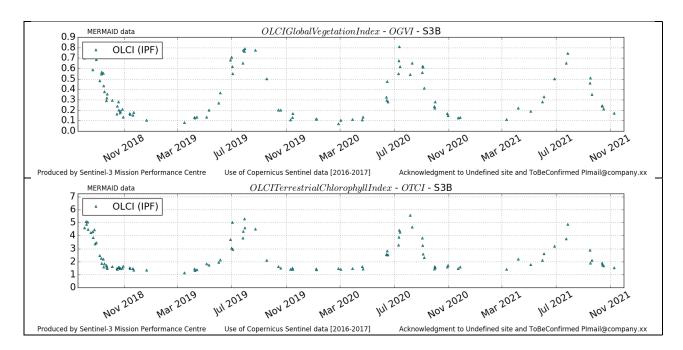


Figure 92: USNe2 time series over current report period

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 78

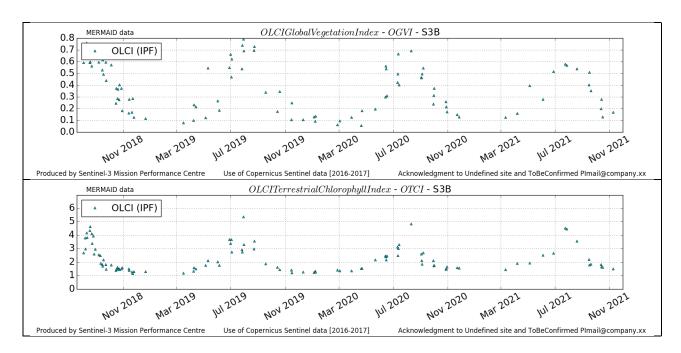


Figure 93: USNe3 time series over current report period

4.1.2 Comparisons with MERIS MGVI and MTCI climatology

This report presents the comparison between MERIS and OLCI land products between the 5^{th} November 2021 and the 3^{rd} December 2021. The comparison is conducted using 3x3 pixel extractions over 42 established validation sites. The sites are distributed across a range of latitudes and include representative land cover types (Table 5). Statistical measures of the comparison between MERIS and OLCI products are presented in Table 6. In general, there is good agreement between the land products with strong R^2 values and biases around 0. There are similar seasonal trajectories and timings shown in the extractions from both products at the following sites reviewed in this monthly report: BE-Brasschaat, DE-Haininch and FR-EstreesMons (Figure 94 to Figure 96). The monthly mean extractions from all sites is shown in Figure 97. OTCI from S3A shows a strong agreement with the MERIS archive, $R^2 = 0.93$, NRMSD < 0.08 with a low bias, -0.02. OGVI similarly shows a strong agreement with the MERIS archive, $R^2 = 0.93$, NRMSD < 0.16 with a slightly higher bias of 0.06.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Table 5: Validation sites analysed in report S3A 70/S3B 51. Land cover data from GLC2000 grouped according to the International Geosphere-Biosphere Programme (IGBP) designations.

Acronym	Country	Network	Lat Lo	
AU-Cape-Tribulation	Australia	TERN-SuperSites, OzFlux	-16.106	145.378 EBF
AU-Cumberland	Australia	TERN-SuperSites, AusCover/OzFlux	-33.615	150.723 EBF
AU-Great-Western	Australia	TERN-SuperSites, AusCover/OzFlux	-30.192	120.654 DBF
AU-Litchfield	Australia	TERN-SuperSites, AusCover/OzFlux	-13.18	130.79 EBF
AU-Robson-Creek	Australia	TERN-SuperSites, AusCover/OzFlux	-17.117	145.63 EBF
AU-Rushworth	Australia	TERN-AusCover	-36.753	144.966 DBF
AU-Tumbarumba	Australia	TERN-SuperSites, AusCover/OzFlux	-35.657	148.152 EBF
AU-Warra-Tall	Australia	TERN-SuperSites, AusCover/OzFlux	-43.095	146.654 EBF
AU-Watts-Creek	Australia	TERN-AusCover	-37.689	145.685 EBF
AU-Wombat	Australia	TERN-SuperSites, AusCover/OzFlux	-37.422	144.094 EBF
BE-Brasschaat	Belgium	ICOS	51.308	4.52 ENF
BE-Vielsalm	Belgium	ICOS	50.305	5.998 ENF
BR-Mata-Seca	Brazil	ENVIRONET	-14.88	-43.973 non-forest
CA-Mer-Bleue	Canada	National Capitol Comission	45.4	-75.493 non-forest
CR-Santa-Rosa	Costa Rica	ENVIRONET	10.842	-85.616 EBF
CZ-Bili-Kriz	Czechia	ICOS	49.502	18.537 ENF
DE-Haininch	Deutschland	ICOS Associated	51.079	10.453 DBF
DE-Hones-Holz	Deutschland	ICOS	52.085	11.222 DBF
DE-Selhausen	Deutschland	ICOS	50.866	6.447 cultivated
DE-Tharandt	Deutschland	ICOS	50.964	13.567 ENF
FR-Aurade	France	ICOS	43.55	1.106 cultivated
FR-Estrees-Mons	France	ICOS Associated	49.872	3.021 cultivated
FR-Guayaflux	France	ICOS Associated	5.279	-52.925 EBF
FR-Hesse	France	ICOS	48.674	7.065 DBF
FR-Montiers	France	ICOS	48.538	5.312 DBF
FR-Puechabon	France	ICOS	43.741	3.596 ENF
IT-Casterporziano2	Italy	ICOS	41.704267	12.357293 DBF
IT-Collelongo	Italy	EFDC	41.849	13.588 DBF
IT-Lison	Italy	ICOS	45.74	12.75 cultivated
NE-Loobos	Netherlands	ICOS Associated	52.166	5.744 ENF
SE-Dahra	Senegal	KIT / UC	15.4	-15.43 cultivated
UK-Wytham-Woods	United Kingdom	ForestGeo - NPL	51.774	-1.338 DBF
US-Bartlett	United States	NEON, AERONET	44.064	-71.287 DBF
US-Central-Plains	United States	NEON, AERONET	40.816	-104.746 non-forest
US-Harvard	United States	NEON, AERONET	42.537	-72.173 DBF
US-Moab-Site	United States	NEON, AERONET	38.248	-109.388 non-forest
US-Mountain-Lake	United States	NEON, AERONET	37.378	-80.525 DBF
US-Oak-Rige	United States	NEON, AERONET	35.964	-84.283 DBF
US-Ordway-Swisher	United States	NEON, AERONET	29.689	-81.993 ENF
US-Smithsonian	United States	NEON, AERONET	38.893	-78.14 DBF
US-Steigerwarldt	United States	NEON	45.509	-89.586 DBF
US-Talladega	United States	NEON, AERONET	32.95	-87.393 ENF

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Table 6: Comparison statistics between monthly S3A/B OLCI land products and MERIS archive data.

					S3A									S3B			
Site Acronym		ОТ	CI vs MTC	1		OG\	VI vs MGV	/1			ОТО	CI vs MTC	ı		OGV	/I vs MGV	1
	n	R2	NRMSD	Bias	n	R2	NRMSD	Bias	r	n	R2	NRMSD	Bias	n	R2	NRMSD	Bias
AU-Calperum	12	0.45	0.04	0.09	12	0.9	0.08	-0.01	1	12	0.15	0.05	0.03	12	0.73	0.16	0
AU-Cape-Tribulation	12	0.8	0.04	-0.09	12	0.24	0.04	0.15	1	12	0.74	0.04	-0.17	12	0.08	0.1	0.16
AU-Cumberland	12	0.57	0.04	-0.05	12	0.55	0.07	0.07	1	12	0.5	0.04	0.02	12	0.63	0.1	0.08
AU-Great-Western	12	0.97	0.02	0.11	12	0.93	0	0.04	1	12	0.95	0.02	0.11	12	0.73	0.1	0.02
AU-Robson-Creek	12	0.91	0.03	-0.03	12	0.87	0.07	0.1	1	12	0.83	0.05	-0.16	12	0.84	0.07	0.12
AU-Rushworth	12	0.84	0.04	0.14	12	0.35	0.08	0.09	1	12	0.81	0.04	0.02	12	0.39	0.12	0.06
AU-Tumbarumba	12	0.88	0.05	0.31	12	0.62	0.06	0.09	1	12	0.77	0.04	0.13	12	0.16	0.13	0.01
AU-Warra-Tall	12	0.68	0.06	-0.08	12	0.3	0.21	0.04		9	0.7	0.05	-0.3	9	0.24	0.28	0.01
AU-Watts-Creek	12	0.67	0.05	0.03	12	0.44	0.08	0.09	1	12	0.72	0.05	-0.02	12	0.23	0.11	0.08
AU-Wombat	12	0.91	0.03	0.11	12	0.34	0.05	0.08	1	12	0.88	0.03	-0.02	12	0.01	0.08	0.04
BE-Brasschaat	11	0.99	0.03	-0.04	11	0.97	0.08	0.06	1	10	0.97	0.04	-0.09	10	0.93	0.08	0.02
BE-Vielsalm	11	0.89	0.05	0.06	11	0.98	0.06	0.1	1	10	0.91	0.04	0.01	10	0.92	0.11	0.12
CA-Mer-Bleue	10	0.97	0.04	0	10	0.97	0.06	0.03	1	10	0.94	0.05	-0.01	10	0.97	0.08	0.01
CZ-Bili-Kriz	12	0.81	0.05	0.09	12	0.93	0.1	0.07		9	0.91	0.04	-0.1	9	0.82	0.13	0.06
DE-Haininch	10	0.99	0.07	-0.04	10	0.98	0.08	0.05		9	0.97	0.09	-0.04	9	0.97	0.1	0.1
DE-Hones-Holz	10	0.99	0.04	0.1	10	1	0.02	0.05	1	10	0.97	0.08	-0.11	10	0.94	0.12	0.01
DE-Selhausen	12	0.88	0.09	-0.03	12	0.53	0.18	0.06	1	12	0.83	0.1	-0.13	12	0.31	0.27	0.02
DE-Tharandt	11	0.97	0.05	-0.02	11	0.97	0.09	0.09	1	10	0.98	0.04	-0.21	10	0.97	0.09	0.09
FR-Aurade	12	0.83	0.1	0.07	12	0.81	0.19	0.14	1	11	0.88	0.08	0.03	11	0.86	0.16	0.08
FR-Estrees-Mons	12	0.94	0.07	0.01	12	0.88	0.11	0.06	1	11	0.87	0.12	0.14	11	0.87	0.11	0.04
FR-Guayaflux	12	0.78	0.03	-0.14	12	0.46	0.07	0.16	1	12	0.68	0.04	-0.22	12	0.07	0.17	0.19
FR-Hesse	12	0.99	0.04	0.04	12	0.98	0.06	0.06	1	11	0.96	0.07	0.03	11	0.86	0.17	0.08
FR-Montiers	12	0.99	0.03	-0.13	12	0.99	0.06	0.05	1	12	0.96	0.08	-0.15	12	0.95	0.13	0.07
FR-Puechabon	12	0.85	0.03	-0.04	12	0.93	0.06	0.09	1	12	0.89	0.04	0.08	12	0.93	0.06	0.06
IT-Casterporziano2	12	0.95	0.02	-0.13	12	0.88	0.03	0.06	1	12	0.91	0.04	-0.05	12	0.65	0.05	0.03
IT-Collelongo	12	0.98	0.06	0	12	0.98	0.08	0.02	1	12	0.94	0.12	0.05	12	0.92	0.16	0.03
IT-Lison	12	0.98	0.03	-0.05	12	0.97	0.07	0.08	1	12	0.93	0.06	-0.06	12	0.91	0.1	0.08
NE-Loobos	12	0.72	0.07	0.08	12	0.89	0.1	0.05	1	12	0.61	0.07	0.05	12	0.88	0.1	0.03
UK-Wytham-Woods	12	0.97	0.05	0.07	12	0.96	0.07	0.1	1	11	0.94	0.07	-0.06	11	0.86	0.16	0.07
US-Bartlett	12	0.98	0.03	-0.03	12	0.98	0.1	0.06	1	12	0.89	0.08	-0.05	12	0.95	0.12	0.04
US-Central-Plains	12	0.76	0.03	-0.02	12	0.91	0.1	0.01	1	11	0.74	0.03	-0.03	11	0.8	0.21	0
US-Harvard	12	0.99	0.03	-0.14	12	0.97	0.09	0.04	1	12	0.97	0.05	-0.24	12	0.93	0.14	0.01
US-Jornada	10	0.77	0.04	0.02	10	0.91	0.2	0.01		8	0.82	0.04	0.07	8	0.35	0.4	0.01
US-Moab-Site	12	0.69	0.03	0.05	12	0.11	0.22	0.01	1	11	0.88	0.02	0.02	11	0.04	0.43	0.04
US-Mountain-Lake	12	0.99	0.05	-0.21	12	0.99	0.05	0.03	1	11	0.96	0.07	-0.41	11	1	0.05	0
US-Oak-Rige	12	1	0.03	-0.05	12	0.98	0.07	0.05	1	12	0.98	0.05	-0.07	12	0.99	0.05	0.05
US-Smithsonian	11	0.98	0.05	-0.16	11	0.99	0.05	0.04		9	0.99	0.06	-0.22	9	0.97	0.09	0.01
US-Steigerwarldt	12	0.95	0.06	-0.02	12	0.99	0.08	0	1	10	0.95	0.06	-0.06	10	0.99	0.05	0.01
US-Talladega	12	0.98	0.02	-0.13	12	0.98	0.05	0.07	1	12	0.91	0.05	-0.19	12	0.93	0.1	0.06

Sentinel 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

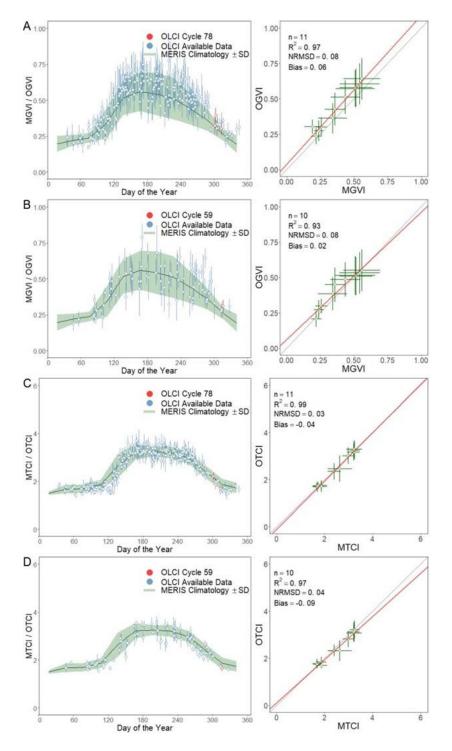


Figure 94: Time-series OGVI and OTCI and corresponding scatterplot of monthly mean for site BE-Brasschaat, Belgium, land cover Needle-leaved, evergreen. A and C represent S3A; B and D represent S3B.

SENTINEL 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

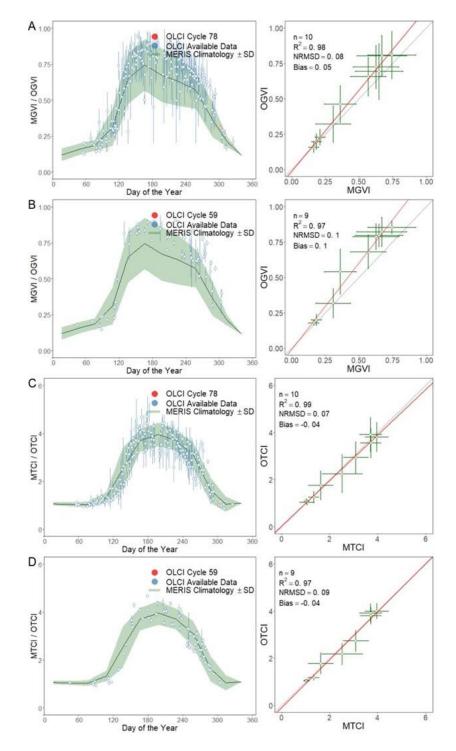


Figure 95: Time-series OGVI and OTCI and corresponding scatterplot of monthly mean for site DE-Haininch, Deutschland, land cover Broadleaved, deciduous, closed. A and C represent S3A; B and D represent S3B.

SEMBLE 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

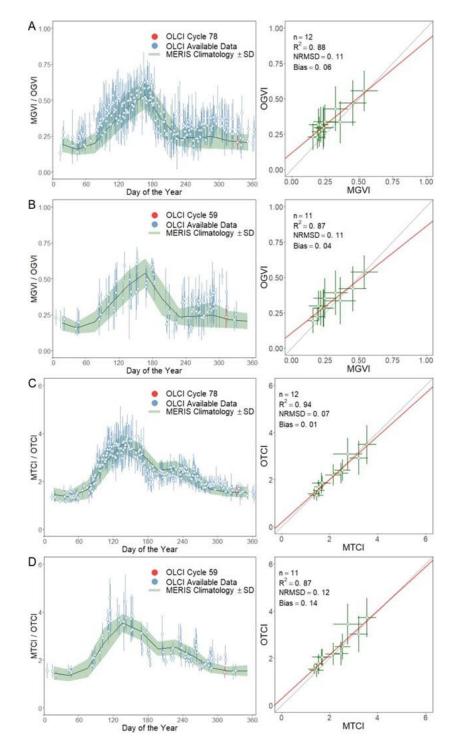


Figure 96: Time-series OGVI and OTCI and corresponding scatterplot of monthly mean for site FR-EstreesMons, France, land cover Cultivated and managed areas. A and C represent S3A; B and D represent S3B.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 84

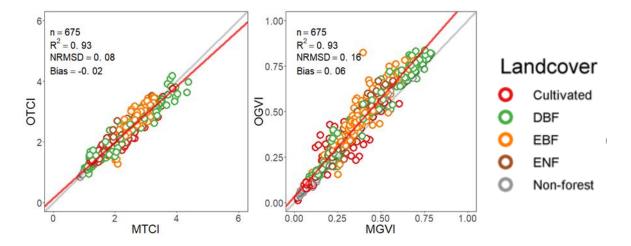


Figure 97: Comparison of OTCI-MTCI (a) and OGVI-MGVI (b). Points in the scatterplot represent the monthly mean of all available S3A and MERIS archive over 42 validation sites. Red and grey lines represent the modelled and 1:1 lines respectively. The scatterplots are updated to include extractions from current S3A cycle.

4.2 [OLCI-L2LRF-CV-410 & OLCI-L2LRF-CV-420] — Cloud Masking & Surface Classification for Land Products

There has been no new result during the cycle. Last figures (cycle 075-A/055-B) are considered valid. Routine monitoring activities have been continued.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 85

5 Level 2 Water products validation

5.1 [OLCI-L2-CV-210, OLCI-L2-CV-220] – Vicarious calibration of the NIR and VIS bands

Results are not further discussed here as SVC is now implemented directly by EUMETSAT.

5.2 [OLCI-L2WLR-CV-300, OLCI-L2WLR-CV-310, OLCI-L2WLR-CV-32, OLCI-L2WLR-CV-330, OLCI-L2WLR-CV-340, OLCI-L2WLR-CV-350, OLCI-L2WLR-CV-360 and OLCI-L2WLR-CV-370] — Level 2 Water-leaving Reflectance product validation.

5.2.1 Acknowledgements

S3-MPC acknowledges all PIs mentioned below and their respective institutions for their valuable contribution to the validation of OLCI L2 water products with a special emphasis on AERONET-OC PIs for their unique contribution to NRT data validation and a special mention to Giuseppe Zibordi maintaining and providing data over 5 ground stations. AERONET-OC is indeed from far the largest contributor of Fiducial Reference Measurements for routine quantitative data validation.

AERONET-OC

- AAOT, Galata, Gloria, GDT, HLH, Irbe Lighthouse: Giuseppe Zibordi, Joint Research Centre of the European Commission
- leodo, Socheongcho: Young-Je Park & Hak-Yeol You, Korean Institute of Ocean Science and Technology & Korea Hydrographic and Oceanographic Administration
- LISCO: Sam Ahmed, Alex Gilerson, City College of New York
- MVCO: Hui Feng and Heidi Sosik, Ocean Process Analysis Laboratory (OPAL), Woods Hole Oceanographic Institution
- Thornton: Dimitry Van der Zande, RBINS/OD Nature
- Lucinda: Thomas Schroeder, Integrated Marine Observing System, IMOS
- USC_SEAPRISM: Burton Jones and Curtiss Davis, University Southern California | USC, Oregon State University
- WaveCIS: Alan Weidemann, Bill Gibson, Robert Arnone, University of Southern MS, Coastal Studies Inst – LSU, Naval Research Laboratory
- Ariake tower: Joji Ishizaka, Kohei Arai, Nagoya University & Saga University
- Blyth NOAH: Rodney Forster, University of Hull, UK
- Casablanca platform: Giuseppe Zibordi, Marco Talone, Joint Research Centre of the European Commission



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 86

- Grizzly bay, Lake Okeechobee, South Greenbay: NimaPahlevan, NASA
- Lake Erie: Tim Moore, Steve Ruberg, Menghua Wang, University of New Hampshire & NOAA

BOUSSOLE

 David Antoine, Enzo Vellucci (Curtin University, Perth & Laboratoire d'Oceanographie de Villefranche, CNRS)

MOBY

Kenneth Voss & Carol Johnson (University of Miami & NIST)

SLGO

 Simon Belanger, Thomas Jaegler & Peter Galbraith (Arctus, Inc & Department of fisheries and Ocean Canada)

AWI

Astrid Bracher (Alfred-Wegener-Institut)

IMOS

Thomas Schroeder (Integrated Marine Observing System, IMOS)

BSH

Holger Klein (Bundesamt für Seeschifffahrt und Hydrographie, BSH)

Proval

Edouard Leymarie (Laboratoire d'Oceanographie de Villefranche, CNRS)

5.2.2 OLCI-A

Activities done

- The focus for this time period has been on the rolling archive Non Time Critical (NT) data until the 6th of December 2021.
- Since 16 February 2021, EUMETSAT has released a new L2 Ocean Colour processor in Sentinel-3 OLCI operations. L2 operational Ocean Colour data now belong to Collection 3, OL_L2M.003.00. Collection-3 introduces major changes in Level-2 Ocean Colour processing. The goal of the changes is to achieve accuracy and consistency between OLCI-A and -B and to introduce several algorithm improvements:
 - System Vicarious Calibration gains are updated in OLCI-A and OLCI-B.
 - Revised Bright Pixel Correction, new Chlorophyll Index algorithm, and updated whitecap correction are introduced in the open water processing chain.
 - New Neural Network v.2 (NNv.2) is introduced in the complex water processing chain.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 87

- New and updated flags are available, together with a new flag recommendation for users.
- The full Collection 002 time series period is here after compared to the new processing baseline PB3.00 covering 16 February 2021 to present.
- All extractions and statistics have been regenerated on the current rolling archive availability including all the extraction since July 2017. The available matchups therefore represent over almost three years of operation.
 - At best 891 and 895 matchups at 490 and 560nm respectively are useful for Collection 002 time period. OLCl's performances remain nominal.
 - At best 195 and 228 matchups at 490 and 560nm respectively are useful for Collection 003 time period. OLCI's performances remain nominal.

Overall Water-leaving Reflectance performance

Scatter plots and Performance Statistics

Figure 98 and Figure 99 below present the scatterplots and statistics of OLCI FR versus in situ reflectance. Two time periods are considered:

- The Collection 002 period from launch of the Sentinel 3 A in April 2016 to the 15th of February 2021
- Collection 003 introduced 16/02/2021.

Table 7 below summarises the statistics over the overall Collection 002 dataset (July 2017-16 February 2021) and Table 8 for data processed with Collection 003 only (16/02/2021 on). The whole time series statistics are almost within the requirements (5% accuracy in the blue/green bands) — as demonstrated by the RPD values within ±5%, with the noticeable exception of 400 and 412 nm over 10%, very similar to those of the Reprocessing period that was used to derive SVC gains. Performances over the Collection 003 period appear significantly lower but still require consolidation.

SENTINEL 3 Mission Performance

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

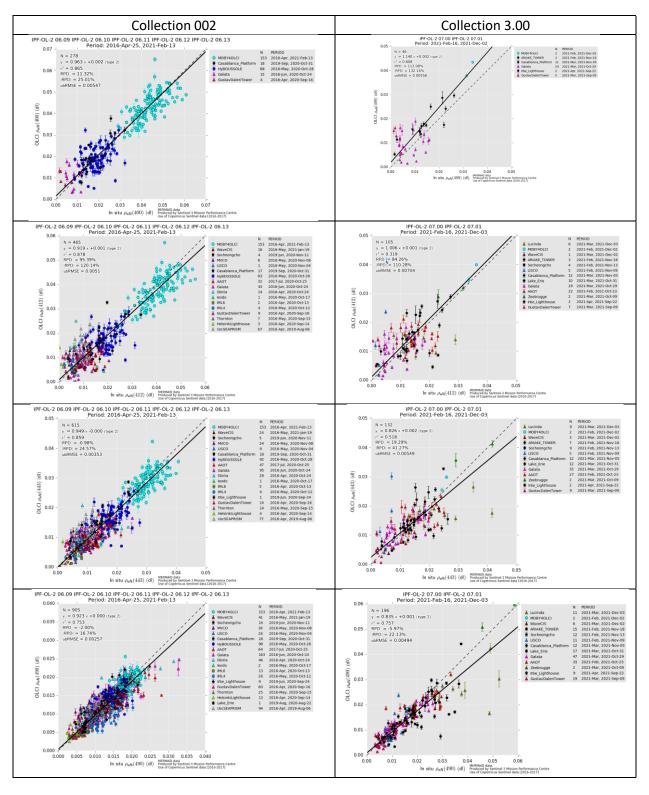


Figure 98: Scatter plots of OLCI-A versus in situ radiometry (FR data). Processing Baseline prior to 3.00 (left), Collection 003 (right), Oa1 to Oa4 (400 to 490 nm)

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

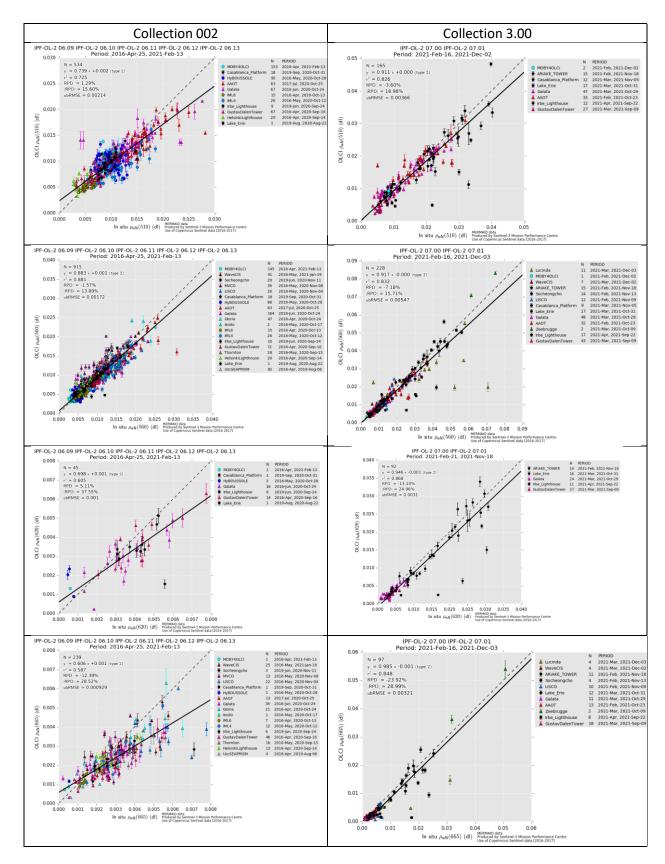


Figure 99: Scatter plots of OLCI-A versus in situ radiometry (FR data). Processing Baseline prior to 3.00 (left), Collection 003 (right), Oa5 Oa6 Oa07 and Oa08 (510, 560, 620 and 665 nm).

SENTINEL 3 Mission Performance Control

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 90

Table 7: OLCI-A FR statistics over December 2017-15/02/2021.

lambda	N	RPD	RPD	MAD	RMSE	slope	intercept	r2	
400	278	11.32%	25.01%	0.0004	0.0055	0.9634	0.0015	(0.87
412	461	95.36%	120.33%	-0.0009	0.0052	0.9218	0.0008	(0.88
443	610	-1.43%	24.23%	-0.0010	0.0036	0.9517	-0.0002	(0.86
490	891	-2.34%	16.61%	-0.0006	0.0026	0.9251	0.0003	(0.75
510	534	1.29%	15.60%	-0.0004	0.0022	0.7391	0.0024	(0.72
560	895	-1.72%	13.78%	-0.0005	0.0018	0.8805	0.0006	(0.89
620	45	5.11%	37.55%	-0.0005	0.0011	0.6977	0.0006	(0.60
665	236	-12.10%	28.43%	-0.0006	0.0011	0.6201	0.0005	(0.60

Table 8: OLCI-A FR statistics over mid-February 2021-present (Collection 003).

lambda	N	RPD RPD N		MAD	RMSE	slope	intercept	r2	
400	46	112.08%	132.14%	0.0034	0.0065	1.1401	0.0019		0.61
412	104	84.69%	110.96%	0.0012	0.0072	1.0059	0.0011		0.32
443	131	19.26%	41.40%	0.0000	0.0055	0.8258	0.0024		0.52
490	195	-6.75%	21.49%	-0.0019	0.0052	0.8369	0.0008		0.76
510	164	-5.11%	17.61%	-0.0012	0.0037	0.9152	0.0001		0.84
560	228	-7.18%	15.71%	-0.0017	0.0057	0.9171	-0.0003		0.83
620	92	-13.10%	24.96%	-0.0013	0.0034	0.9456	-0.0008		0.87
665	97	-23.92%	28.99%	-0.0016	0.0036	0.9846	-0.0015		0.85

Time series

Figure 100 and Figure 101 below present AAOT and Galata in situ and OLCI time series over the June 2017-present period, including Collection 003 introduced 16/02/2021.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

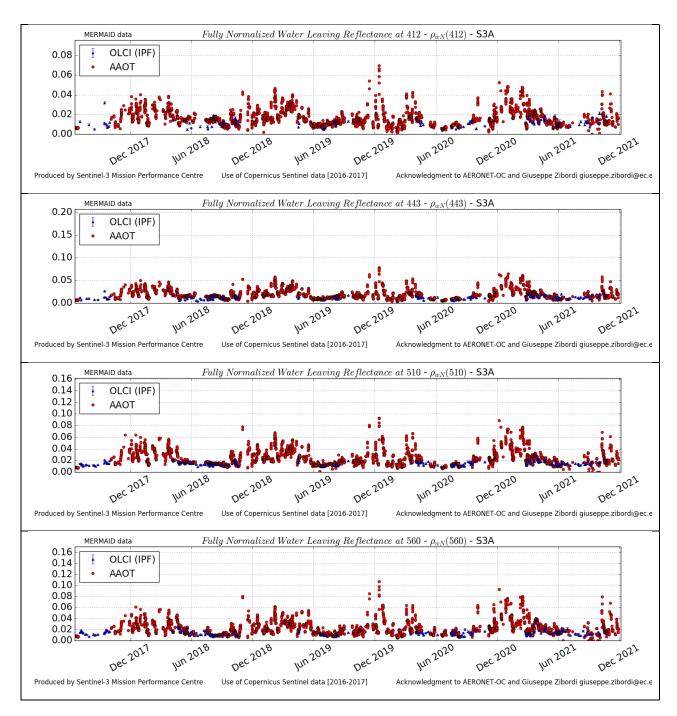


Figure 100: AAOT time series over current report period

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 - S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

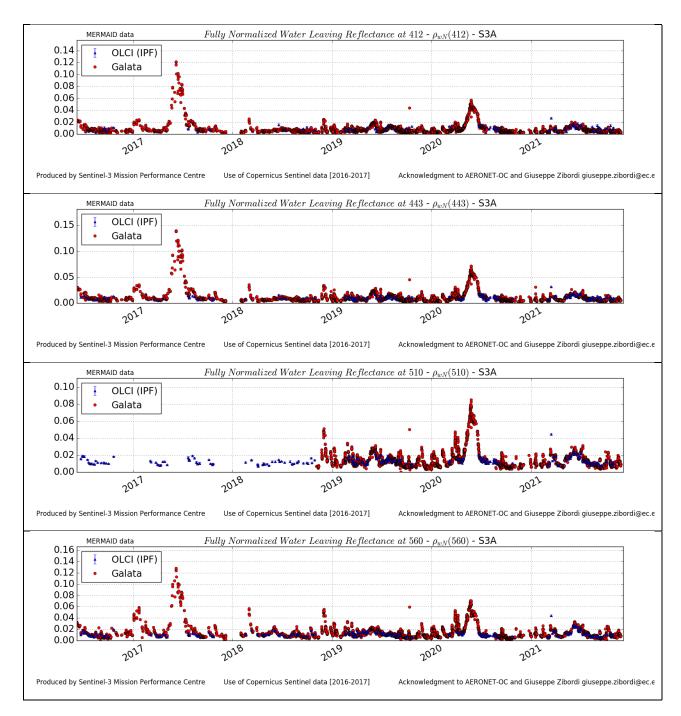


Figure 101: Galata time series over current report period



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 93

5.2.3 OLCI-B

Activities done

- The focus for this time period has been on the rolling archive Non Time Critical (NT) data until the 6th of December 2021.
- Since 16 February 2021, EUMETSAT has released a new L2 Ocean Colour processor in Sentinel-3 OLCI operations. L2 operational Ocean Colour data now belong to Collection 3, OL_L2M.003.00. Collection-3 introduces major changes in Level-2 Ocean Colour processing. The goal of the changes is to achieve accuracy and consistency between OLCI-A and -B and to introduce several algorithm improvements:
 - System Vicarious Calibration gains are updated in OLCI-A and OLCI-B.
 - Revised Bright Pixel Correction, new Chlorophyll Index algorithm, and updated whitecap correction are introduced in the open water processing chain.
 - New Neural Network v.2 (NNv.2) is introduced in the complex water processing chain.
 - New and updated flags are available, together with a new flag recommendation for users.
- All extractions and statistics have been regenerated on the current rolling archive availability including all the extraction since February 2019.
 - At best 237 and 261 matchups at 490 and 560nm respectively are useful for Collection 002.
 - At best 158 and 197 matchups at 490 and 560 nm respectively are useful for Collection 003.

*

It must be noted that OLCI-B has SVC adjustment only since 16/02/2021.

Overall Water-leaving Reflectance performance

Scatter plots and Performance Statistics

Figure 102 and Figure 103 below presents the scatterplots and statistics of OLCI-B FR versus in situ reflectance.

Two time periods are considered:

- The Collection 002 period from beginning of the mission to the 15th of February 2021,
- Collection 003, introduced 16/02/2021.

Table 9 below summarises the statistics over the whole reporting period while Table 10 present the same figures restricted to Collection 003.

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

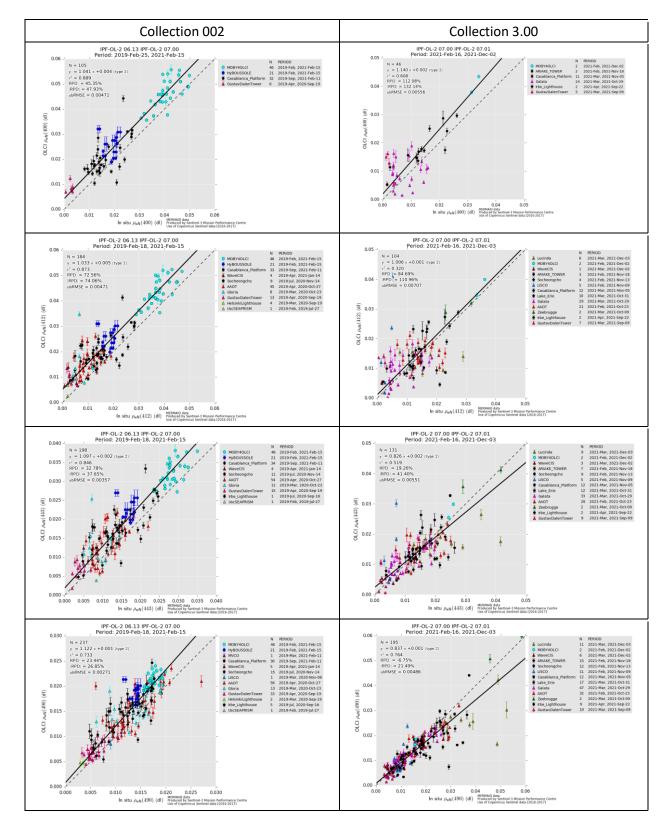


Figure 102: Scatter plots of OLCI-B versus in situ radiometry (FR data). Processing Baseline prior to Collection 3.00 (left), Collection 003 (right), Oa1 to Oa4 (400 to 490 nm)

SENTINEL 3 Mission Performance

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

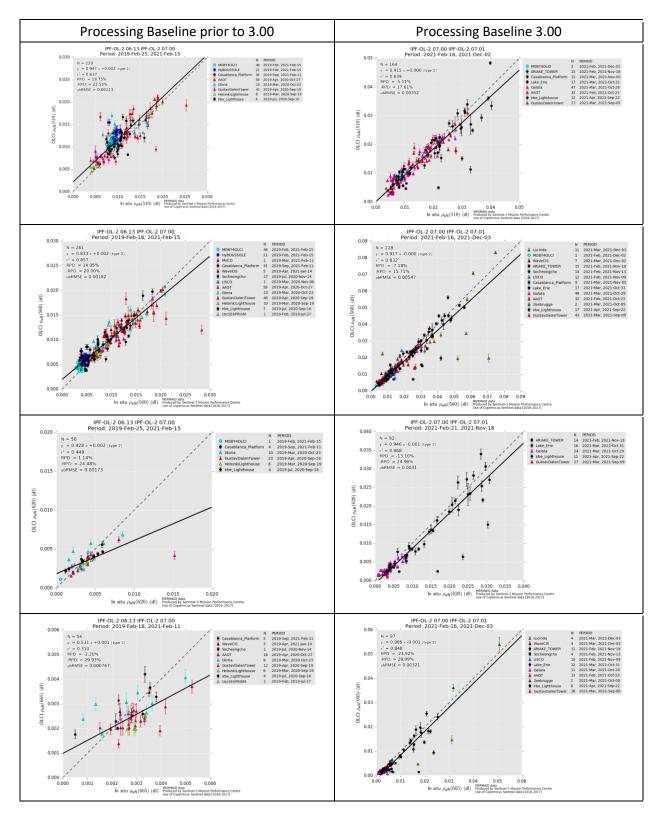


Figure 103: Scatter plots of OLCI-B versus in situ radiometry (FR data). Processing Baseline prior to Collection 3.00 (left), Collection 003 (right), Oa5 to Oa8 (510 to 665 nm)

SENTINEL 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 96

Table 9: OLCI-B FR statistics over the July 2017-16 February 2021 period.

lambda	N	RPD	RPD	MAD	RMSE	slope	intercept	r2	
400	105	45.35%	47.93%	0.0053	0.0071	1.0409	0.0042		0.89
412	184	72.56%	74.06%	0.0057	0.0074	1.0327	0.0052		0.87
443	198	32.78%	37.65%	0.0034	0.0049	1.0969	0.0019		0.85
490	237	23.44%	26.85%	0.0024	0.0036	1.1217	0.0008		0.73
510	229	19.75%	23.53%	0.0016	0.0027	0.9471	0.0021		0.64
560	261	14.05%	20.00%	0.0005	0.0019	0.8334	0.0019		0.86
620	50	1.14%	24.48%	-0.0004	0.0018	0.4277	0.0018		0.45
665	54	-2.20%	29.93%	-0.0004	0.0009	0.5313	0.0010		0.31

It is recalled that that OLCI-B had no SVC adjustment over this period.

Table 10: OLCI-B FR statistics over mid-February 2021-present (Collection 003).

					, ,	<u> </u>			
lambda	N	RPD	RPD	MAD	RMSE	slope	intercept	r2	
400	27	103.75%	112.10%	0.0046	0.0074	1.2831	0.0007		0.79
412	74	83.91%	99.34%	0.0019	0.0060	1.0460	0.0012		0.63
443	101	24.50%	45.27%	0.0002	0.0054	1.0216	-0.0001		0.63
490	158	-4.13%	25.75%	-0.0018	0.0069	0.9045	-0.0002		0.64
510	131	-2.82%	21.04%	-0.0013	0.0060	0.8647	0.0009		0.70
560	197	-3.35%	17.15%	-0.0010	0.0051	0.9994	-0.0010		0.86
620	72	-15.51%	25.93%	-0.0020	0.0069	0.7397	0.0007		0.57
665	95	-16.26%	34.30%	-0.0017	0.0057	0.8292	-0.0004		0.61

Time series

Figure 104 and Figure 105 below present AAOT and Casablanca Platform in situ and OLCI-B time series over the current period.

Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 97

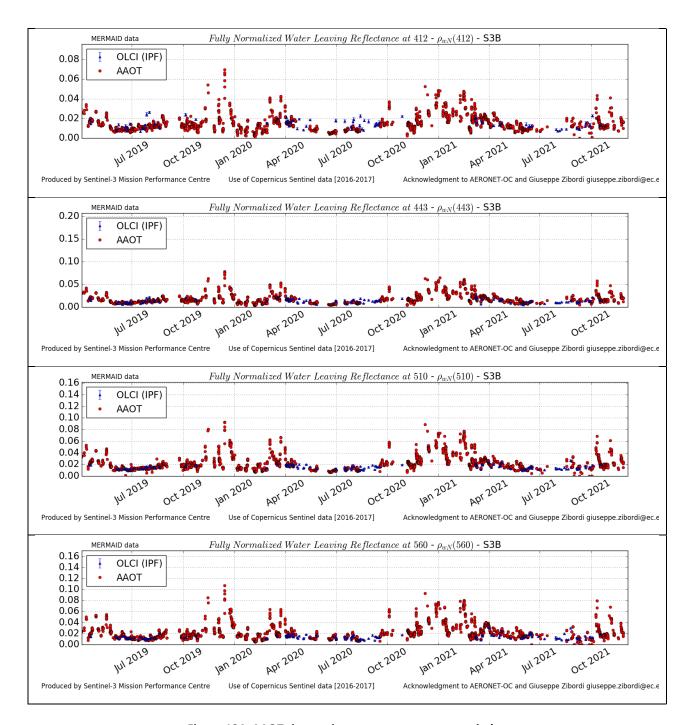


Figure 104: AAOT time series over current report period

Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 98

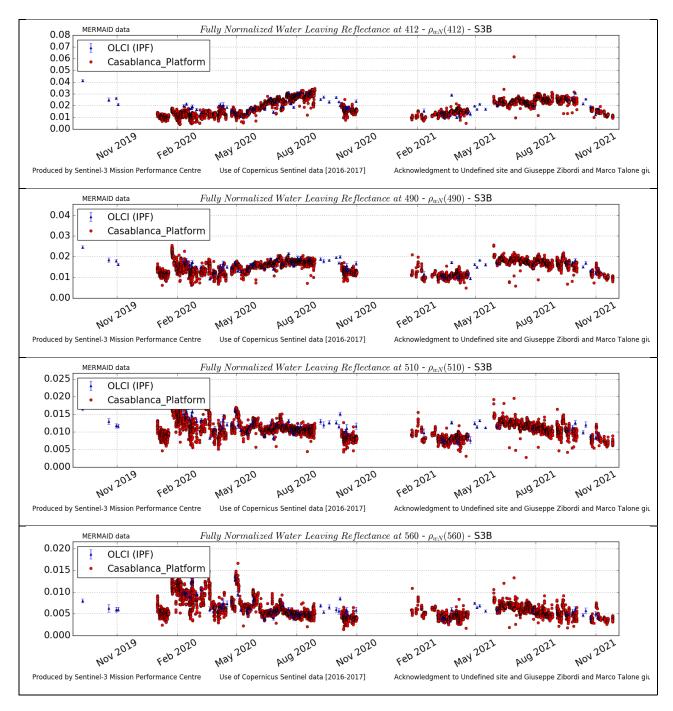


Figure 105: Casablanca Platform time series over current report period



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 99

5.3 [OLCI-L2WLR-CV-430] – Algorithm performance over spatial and temporal domains

There has been no new result during the cycle. Last figures (cycle 27) are considered valid.

5.4 [OLCI-L2WLR-CV-510 & 520] – Cloud Masking & Surface Classification for Water Products

There has been no new result during the cycle. Last figures (cycle 075-A/055-B) are considered valid.

Routine monitoring activities have been continued.

5.5 [OLCI-L2WLR-CV530] Validation of Aerosol Product

All OLCI-L2 ocean product types have been validated: full resolution and reduced resolution (*wrr, wfr*); near real time and non time critical (*NR, NT*). The ocean colour products from OLCI A and B have been taken from EUMETSAT's CODA (Copernicus Online Data Access, https://coda.eumetsat.int/#/home) or reprocessed OLCI A CODAREP (https://codarep.eumetsat.int/#/home) websites. Although the following quantitative comparisons are restricted to *full resolution non time critical*, the found results are valid for all product types.

To validate OLCI's Aerosol product (aerosol optical thickness and Angstroem coefficient at 865nm), we continuously compare it with data from AERONET (Holben et al 1998), AERONET-OC (Zibordi et al 2009) and MARITIME AERONET (Smirnow et al 2009). This is an ongoing process, where co-located data are collected and analysed, we are using AERONET V3 data. It comes in two different quality levels: L1.5 and L2. We are using level 1.5 since it allows much more matchups than L2. It takes up to one year until AERONET level 2 data is released, but a period longer than one year is not covered by the rolling archive of CODA. However, the *direct sun* retrievals (optical thickness and related diagnostics) are the same for both levels.

5.5.1 Aeronet comparisons with OLCI A

208000 OLCI A scenes within the period of June 2016 to November 2021 have been analysed so far. For a matchup, the temporal distance between the satellite overpass and the AERONET acquisition was less than 60 minutes. Only OLCI measurements are used for the validation which are cloud-free (according to the standard cloud flags: *cloud, cloud margin and cloud ambiguous*) in an area of about 10x10 km² around the AERONET acquisition. Further, all recommended flags from *Sentinel-3 OLCI Marine User Handbook* (EUM/OPS-SEN3/MAN/17/907205) have been applied. Eventually, to reduce the influence of undetected (sub pixel or sub visual) clouds, only matchups have been used, where the standard deviation of the aerosol optical thickness within the 10x10 km² area was less than 0.2. Due to the fact, that most of the AERONET stations are on land, the number of matchups reduced to 1040 only. The results are summarised in Figure 106. It becomes apparent, that:



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 100

- There is a highly linear relation between the AERONET and OLCI aerosol optical thickness, the explained variance is 0.76.
- The optical thickness of OLCI A is systematically overestimated by 20% 50%, the majority of the cases is at around 32%.
- This leads to a systematic bias of 0.04.
- If the systematic overestimation is corrected, the RMSD decreases from 0.05 do 0.03.
- There is only a weak $(r^2 = 0.2)$ linear relation for the Angstroem exponent.
- The majority of AERONET has an Angstroem of 1.6, whereas OLCI gives 1.4, thus OLCI underestimates the spectral extinction by 0.2.

All investigated quality measures show no significant temporal evolution.

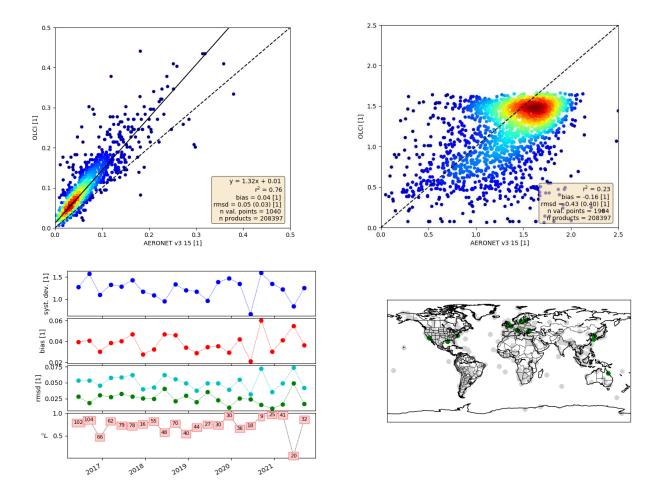


Figure 106: Upper left: OLCI aerosol optical thickness at 865nm against Aeronet at 870nm, upper right: OLCIs Angstroem exponent at 865nm against the Aeronet Angstroem exponent at 865nm-440nm. Lower left: Temporal evolution of different quality measures of the optical thickness comparison (from top to bottom: systematic

SENTINEL 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 101

deviation factor, bias, root mean squared difference (with and without bias correction), explained variance (number in boxes are the numbers of matchups)). Lower right: positions of the used AERONET stations.

5.5.2 Marine Aeronet comparisons with OLCI A

2300 OLCI A scenes within the period of June 2016 to September 2021 have been analysed so far. For a matchup, the temporal distance between the satellite overpass and the AERONET acquisition was less than 60 minutes. Since, the maritime AERONET L2 is expensively quality controlled, it is published with a delay of up to 1 year, thus the latest data is from late Summer 2021. Only OLCI measurements are used for the validation which are cloud-free (according to the standard cloud flags: *cloud, cloud margin and cloud ambiguous*) in an area of about 10x10 km² around the AERONET acquisition. Further, all recommended flags from *Sentinel-3 OLCI Marine User Handbook* (EUM/OPS-SEN3/MAN/17/907205) have been applied. Eventually, to reduce the influence of undetected (sub pixel or sub visual) clouds, only matchups have been used, where the standard deviation of the aerosol optical thickness within the 10x10 km² area was less than 0.2. After this rigid filtering only 64 leftovers remain. The results are summarized in Figure 107:

- There is a highly linear relation between the AERONET and OLCI AOT, the explained variance is 0.74.
- The data shows a systematic underestimation of 20%, contrary for the AERONET comparison. This is probably a sampling effect due to few points with high AOT.
- There is no linear relation for the Angstroem exponent.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 102

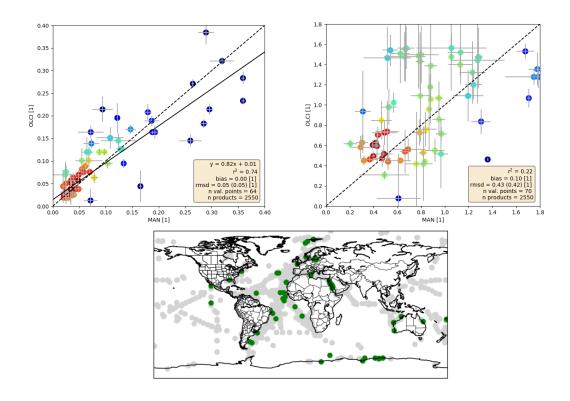


Figure 107: Upper left: OLCI aerosol optical thickness at 865nm against maritime Aeronet at 870nm, upper right: OLCIs Angstroem exponent at 865nm against the maritime Aeronet Angstroem exponent at 865nm-440nm.

Lower right: positions of the used cruises.

5.5.3 Aeronet comparisons with OLCI B

109500 OLCI B scenes within the period of June 2018 to November 2021 have been analysed. The criteria for a matchup are identic to the ones for OLCI A: the temporal distance between the satellite overpass and the AERONET acquisition was less than 60 minutes, only measurements are used for the validation which are cloud-free (according to the standard cloud flags: *cloud, cloud margin and cloud ambiguous*) in an area of about 10x10 km² around the AERONET acquisition. Further, all recommended flags from *Sentinel-3 OLCI Marine User Handbook* (EUM/OPS-SEN3/MAN/17/907205) have been applied. To reduce the influence of undetected (sub pixel or sub visual) clouds, only matchups have been used, where the standard deviation of the aerosol optical thickness within the 10x10 km² area was less than 0.2. Eventually the number of matchups reduced to 60 only. The results are summarised in Figure 108. It becomes apparent, that OLCI B behaves like OLCI A:

- There is a highly linear relation between the AERONET and OLCI AOT. The explained variance is 0.80.
- Similar to OLCI A, OLCI B is systematically overestimated, but the amount is smaller: 25% instead of 35%.
- The pattern of the Angstroem comparison is as for OLCI A; a weak relation, the majority around 1.4 and a systematic underestimate of OLCI by 0.3.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 103

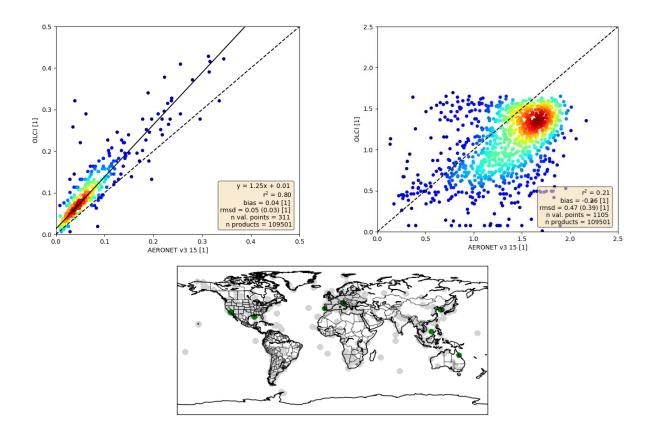


Figure 108: Upper left: OLCI aerosol optical thickness at 865nm against Aeronet v3 L1.5 AOT at 870nm, upper right: OLCIs Angstroem exponent at 865nm against the Aeronet v3 L1.5 Angstroem exponent at 865nm-440nm.

Lower: positions of the used AERONET stations.

5.5.4 Summary

The validation of OLCI aerosols products shows a high agreement for the aerosol optical thickness ($rmsd \sim 0.02$); if a systematic overestimation of around 32% is corrected. The Angstroem exponent agrees hardly (r^2 =0.2), but the order of magnitude (1.6) is almost met (bias =-0.2). A validation of OLCI B using AERONET level 1.5 data, shows the same pattern as for OLCI A but a smaller systematic overestimation (25%). The number of matchups with maritime AERONET and OLCI-A is still low, but the results are different. There is no systematic overestimation for low optical thickness and higher cases seem to be underestimated. Further on, the Angstroem exponent shows a completely different behaviour. It does not agglomerate around 1.5. Instead, it varies between 0.4 and 1.8 for the satellite retrievals and the ground truth, likewise. The explained variance is still low (r^2 =0.22).

5.5.5 References

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SENTINEL 3 Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 104

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5.6 [OLCI-L2WLR-CV-380] Development of calibration, product and science algorithms

Improvement of alternative atmospheric correction

There has been no new result during the cycle. Last figures (cycle 075-A/055-B) are considered valid.

Routine monitoring activities have been continued.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 105

6 Validation of Integrated Water Vapour over Land & Water

The OLCI L2 IWV processor distinguishes between ocean and land surfaces, and works very differently above the respective surfaces. The algorithm above water shows some serious flaws and is therefore not further investigated. A new version is under development, that will be integrated into an atmospheric branch. However, despite of a small systematic overestimation, the water vapour above land works very well and stable, and it is a good indicator for a system monitoring.

OLCI's IWV above land surface is validated using the following ground truth data:

- 1. Global GNSS data, with a focus to north America (SUOMI NET, Ware et al. 2000)
- 2. Microwave radiometer measurements at the *Atmospheric Radiation Measurement* (ARM) *Climate Research Facility* of the US Department of Energy (Turner et al. 2003, Turner et al. 2007).
- 3. GRUAN radiosonde observations IWV (Immler et al 2010, Bodeker 2015)
- 4. AERONET (Holben et al 1998), using atmospheric transmission measurements at 0.9μm

All L2 product types have been validated: full resolution and reduced resolution, near real time and non time critical, Ocean Colour (*wrr*, *wfr*) and Land Colour (*Irr*, *Ifr*). The found results for all product types are identical, as expected, since the used processor is the same. The following quantitative comparisons are hence restricted to *wrr NT* (Ocean Colour Product, reduced resolution, non time critical). Since the ocean colour product and the land colour product provide water vapour above land and water surfaces, the comparison is comprehensive. OLCI A data partly belong to reprocessed data if processed before Nov/2017. The ocean colour products from OLCI A have been taken from Eumetsats rolling archive CODA (Copernicus Online Data Access, https://coda.eumetsat.int/#/home) or reprocessed OLCI A CODAREP (https://codarep.eumetsat.int/#/home) websites. All OLCI B data is from Eumetsats CODA.

6.1 Integrated water vapour above land

6.1.1 Validation of OLCI A IWV using GNSS

576,000 potential matchups within the period of June 2016 to November 2021 have been analysed yet. The scenes cover high and low elevations, however, the majority of the used SUOMI-NET ground stations are in North and Central America. Only OLCI measurements are taken for the validation which are above land and are cloud-free in an area of about 10x10 km² around the GNSS stations. For the cloud detection, the standard L2 cloud-mask has been applied (including the cloud ambiguous and cloud margin flags). The comparison of OLCI and GNSS shows a very high agreement (Figure 109). The correlation between both quantities is 0.98 The root-mean-squared-difference is 2.1 kg/m². The systematic overestimation by OLCI is 12%. The bias corrected *rmsd* is 1.3 kg/m². Interesting is the strong seasonal pattern of the bias. It is also partly visible in the systematic overestimation swinging between 7 and 12%. This clearly belongs to the seasonality of water vapour in North Amerika, with lower (better) values during winter. This could be

SENTINEL 3 Mission Performance

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 106

an artefact of the retrieval inherent spectral extrapolation of the surface reflectance from window bands to the absorption band.

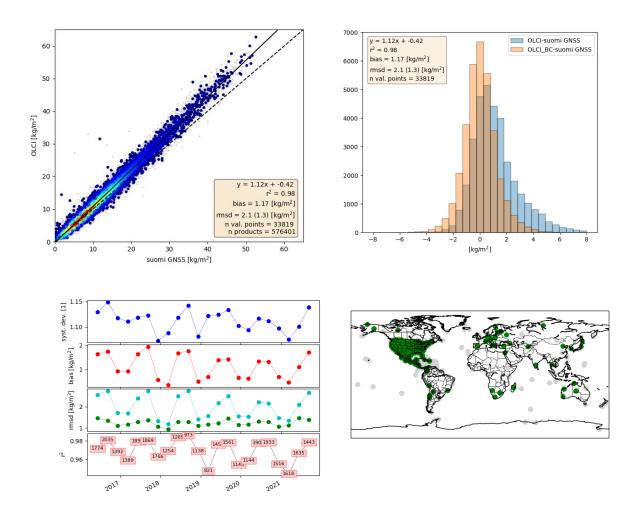


Figure 109: Upper left: Scatter plot of the IWV products, derived from OLCI A above land and from SUOMI NET GNSS measurements. Upper right: Histogram of the difference between OLCI and GNSS (blue: original OLCI, orange: bias corrected OLCI). Lower left: Temporal evolution of different quality measures (from top to bottom: systematic deviation factor, bias, root mean squared difference (with and without bias correction), explained



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 107

variance (number in boxes are the numbers of matchups)). Lower right: Positions of the GNSS stations (grey: no valid matchup)

6.1.2 Validation of OLCI A IWV using passive microwave radiometer at ARM sites

Microwave radiometer measurements at the *Atmospheric Radiation Measurement* (ARM) *Climate Research Facility* of the US Department of Energy provides the ground truth with the highest accuracy (0.6 kg/m²). Currently 3 ARM sites are operated continuously, only the SGP (southern great planes) site provided cloud free measurements. 3700 potential matchups within the period of June 2016 to November 2021 have been analysed yet. Only OLCI measurements are taken for the validation which are above land and are cloud-free in an area of about 10x10 km² around SGP.

Apparently the dissemination of one file type (sgpmwrret1liljclouC1.s1) has been discontinued. Instead we used at beginning of 2001 a precursor product (sgpmwrret1liljclouC1.c1), that already contains all necessary data, but not stringently filtered for glitches (e.g. rain on MWR window or thermal anomalies). Unfortunately, this has been discontinued in 2021 too. So, we switched to a different product: sgpmwrlosC1.b1. The mwrret (microwave physical retrieval) and mwrlos (microwave line of sight retrieval) are based on the same measurements and physical properties of the atmosphere. Mwrret uses an variational approach with a full radiative transfer optimization, whereas mwrlos is based on seasonally adapted regression parameter. Both retrievals provide ground truth with a high precision (0.6 kg/m² and 0.8 kg/m²). To guarantee temporal stability we reprocessed the full time series of OLCI A and B.

For the cloud detection, the standard L2 cloud-mask has been applied (including the cloud ambiguous and cloud margin flags), resulting in 206 valid matchups. The comparison shows a very high agreement (Figure 110Figure 109). The correlation between both quantities is 0.99. The root-mean-squared-difference is 1.4 kg/m². The systematic overestimation by OLCI is 9%. The bias corrected *rmsd* is 0.9 kg/m², close to the uncertainty of the MWR. The investigation of the temporal evolution shows the same seasonal pattern as the GNSS comparisons, again belonging to the same seasonality of water vapour in North Amerika.

S3 OLCI Cyclic Performance Report S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 108

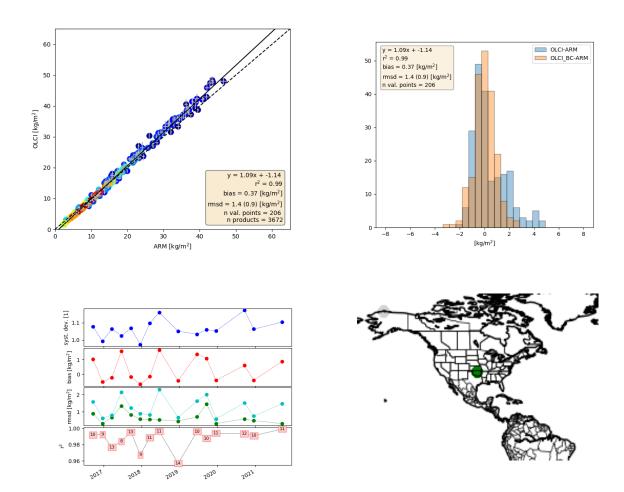


Figure 110: Upper left: Scatter plot of the IWV products, derived from OLCI A above land and from AMR MWR.

Upper right: Histogram of the difference between OLCI and ARM (blue: original OLCI, orange: bias corrected OLCI). Lower left: Temporal evolution of different quality measures (from top to bottom: systematic deviation factor, bias, root mean squared difference (with and without bias correction), explained variance (number in boxes are the numbers of matchups)). Lower right: Position of ARM SGP.

6.1.3 Validation of OLCI A IWV using GRUAN radiosonde observations

Radiosonde observations of temperature, humidity and pressure allow a direct integration of water vapour. The emphasis of GRUAN is to provide long-term, highly accurate measurements of the atmospheric profile. This is achieved by a very rigid quality control and uncertainty quantification. From the 3300 potential matchups within the period of June 2016 to January 2021, only OLCI measurements are taken for the validation which are above land and are cloud-free in an area of about 10x10 km² around the radiosonde launch place. For the cloud detection, the standard L2 cloud-mask has been applied (including the cloud ambiguous and cloud margin flags). Eventually only 39 valid matchups could be used.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

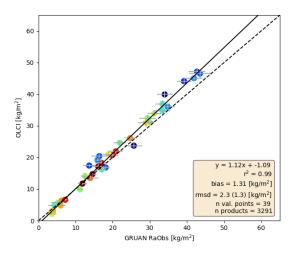
Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 109

This number is less than the number of valid matchups for the ARM site, since radiosondes launches are rare. That is why the time constraints have been relaxed to 6h. Still, the comparison shows a very high agreement (Figure 111). The correlation between both quantities is 0.99. The root-mean-squared-difference is 2.4 kg/m². The systematic overestimation by OLCI is 12%. The bias corrected *rmsd* is 1.3 kg/m². The number of valid matchups is currently too low to investigate a temporal evolution.



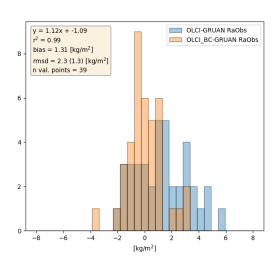


Figure 111: Left: Scatter plot of the IWV products, derived from OLCI A above land and from GRUAN radiosonde measurements. Right: Histogram of the difference between OLCI and GRUAN (blue: original OLCI, orange: bias corrected OLCI).

6.1.4 Validation of OLCI A IWV using AERONET observations

AERONET observations, regardless not primary made for water vapour, allow the direct estimation of the total column of water vapour by measuring the extinction of the direct solar irradiance at 900 nm. The used operational algorithm is quite simple and eventually relies on a logarithmic fit (incl. quadratic corrections). We are using AERONET for the IWV comparison, since AERONET data are better globally distributed, than ARM and SUOMINET, and are more frequent than GRUAN. In contrast to earlier investigations we use AERONET V3 level 1.5. It is not stringently quality controlled, but the retrieval algorithm is exactly the same as for level 2 and it is published without delay. This allows much more matchups with data from the 1 yr. rolling archive CODA.

Only OLCI measurements are used for the validation which are cloud-free (according to the standard cloud flags: *cloud, cloud margin and cloud ambiguous*) in an area of about 10x10 km² around the AERONET acquisition. From the 208000 potential matchups within the period of June 2016 to November 2021, 38500 valid matchups could be used. (Figure 112). The correlation between both quantities is 0.96. The root-mean-squared-difference is 3.7 kg/m². The systematic overestimation by OLCI is 19%. The bias



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 110

corrected *rmsd* is 1.8 kg/m². The systematic deviation between OLCI and AERONET of 19% is significantly larger than the one found for GNSS, ARM and GRUAN (~10%). We think that this stems from a dry bias of AERONET and accordingly deficits in the operational algorithm, but we have not investigated it deeper.

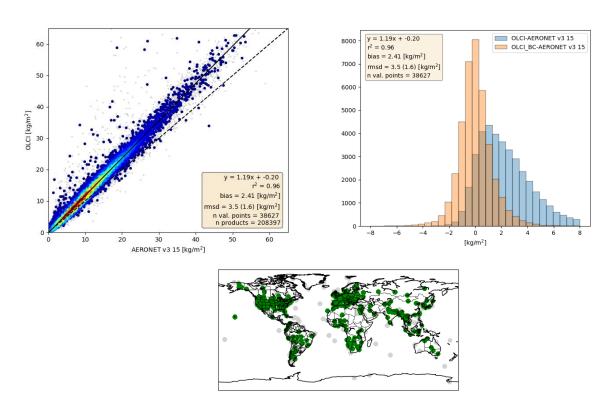


Figure 112: Upper left: Scatter plot of the IWV products, derived from OLCI A above land and from AERONET.

Upper right: Histogram of the difference between OLCI and AERONET (blue: original OLCI, orange: bias corrected OLCI). Lower: Positions of the used AERONET stations (grey: no valid matchup).

6.1.5 Validation of OLCI B IWV

Within the period of June 2018 to November 2021 several 100000 scenes have been analysed yet. 17800 of them are valid for SUOMI-NET CONUS ground stations in North and Central America, 97 for ARM MWR and 20500 for AERONET.

As for OLCI A, only measurements are taken for the validation which are above land and are cloud-free in an area of about 10x10 km² around the corresponding stations. For the cloud detection, the standard L2 cloud-mask has been applied (including the cloud ambiguous and cloud margin flags). The comparison of OLCI B shows almost identical results as for OLCI A (Figure 113).

SENTINEL 3 Mission Performance

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 111

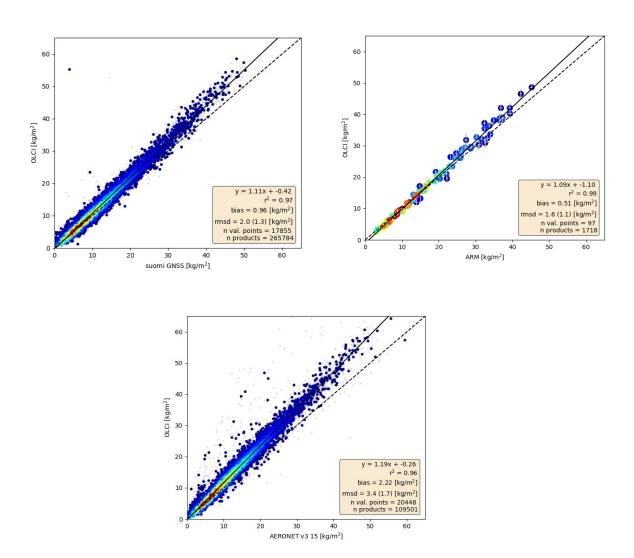


Figure 113: Scatter plot of the IWV products, derived from OLCI B above land and from SUOMI NET GNSS measurements (upper left), from ARM MWR (upper right) and AERONET (lower)

6.2 Integrated water vapour above water

6.2.1 Quantitative validation using GNSS

OLCIs IWV above water surfaces has been quantitatively validated via global GNSS measurements too, however with few additional assumptions:

- Since the GNSS stations are usually not directly above water, the closest water pixel (within 1km) is used for the satellite measurement.
- No height correction has been applied to account for the potentially elevated GNSS station.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 112

For OLCI-A, 70 matchups remain after filtering (Figure 114). They show a large bias 10 kg/m² and a large scatter (>6 kg/m²). For OLCI-B the number of valid matchups is smaller (32), but all indications point to similar systematic deviations and retrieval noise. This is in accordance with the visual inspection.

y=1,23x + 5,51 y=1,23x + 5,51 ibs = 9,49 [kg/m²] msd = 11,9 (5,8) [kg/m²] n products = 547386 0 0 10 20 30 40 50 60 10 20 30 40 50 60

Figure 114: Upper: Scatter plot of the IWV products, derived from OLCI (A left, B right) above ocean and from SUOMI NET GNSS measurements. Lower: Positions of the GNSS (A: left, B: right).

6.2.2 Validation by AERONET IWV Retrievals - Ocean

OLCIs IWV above water surfaces has been quantitatively validated via global AERONET-OC measurements. All filters are as for land matchups. The remaining 2300 (OLCI-A) and 1200 (OLCI-B) matchups show a large bias of about 9 kg/ m^2 , a large scatter (>6 kg/ m^2) and a systematic overestimation of about 20% (Figure 115). This is in accordance with the visual inspection and with the GNNS matchups (Figure 114) over oceans.



S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 113

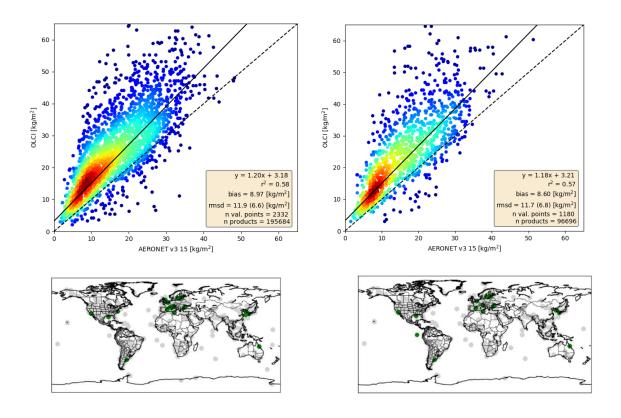


Figure 115: Upper: Scatter plot of the IWV products, derived from OLCI (A left, B right) above ocean and from Aeronet-OC v.3 L1.5 measurements. Lower: Positions of the used Aeronet match ups (A: left, B: right).

6.3 Summary

The validation exercise of the OLCI A IWV over land product using 4 different sources of ground truth showed consistently, that the product is of high quality (bias corrected root mean squared distance of down to 1.5 -0.8 kg/m²). However, there is a systematic overestimation of 9% to 13%. An equivalent validation of OLCI B shows the same results, no systematic differences between OLCI a and B have been found. The validation with Suominet shows seasonal patterns of the overestimation with better values during winter seasons.

Retrievals above ocean show an overestimation in transition zones between glint and off glint. This is a clear deficit of the description of the scattering-absorption interaction. Further the IWV has a large wet bias over ocean.

6.4 References

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S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 114

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Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 115

7 Level 2 SYN products validation

There has been no new result during the cycle. Most recent performance figures can be found in the S3MPC OPT Annual Performance Report - Year 2020 (S3MPC.ACR.APR.007, issue 1.0, 26/02/2021), available on-line at:

https://sentinels.copernicus.eu/web/sentinel/user-guides/sentinel-3-olci/document-library.

SENTINEL 3 Mission

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 116

8 Events

For OLCI-A, one Radiometric Calibration sequence has been acquired during Cycle 078:

\$ S01 sequence (diffuser 1) on 06/11/2021 14:12 to 14:14 (absolute orbit 29799)

For OLCI-B, three Radiometric Calibration sequences have been acquired during Cycle 059:

- S01 sequence (diffuser 1) on 08/11/2021 10:59 to 11:01 (absolute orbit 18432)
- S01 sequence (diffuser 1) on 24/11/2021 07:24 to 07:26 (absolute orbit 18658)
- S05 sequence (diffuser 2) on 24/11/2021 09:05 to 09:07 (absolute orbit 18659)

There has been one SO2+SO3 Spectral Calibration for OLCI-A in the reporting period:

- S02 sequence (diffuser 1) on 01/11/2021 11:20 to 11:21 (absolute orbit 29726)
- So3 sequence (Erbium doped diffuser) on 01/11/2021 13:01 to 13:02 (absolute orbit 29727)

and one Spectral calibration S09:

So sequence on 01/11/2021 09:04:51 to 09:04:57 (absolute orbit 29725)

There has been one SO2+SO3 Spectral Calibration for OLCI-B in the reporting period:

- S02 sequence (diffuser 1) on 11/11/2021 11:22 to 11:24 (absolute orbit 18475)
- \$ S03 sequence (Erbium doped diffuser) on 11/11/2021 13:03 to 13:05 (absolute orbit 18476)

and one Spectral calibration S09:

So sequence on 11/11/2021 09:06:38 to 09:06:44 (absolute orbit 18474)

Mission Performance Centre

Sentinel-3 MPC

S3 OLCI Cyclic Performance Report

S3A Cycle No. 078 – S3B Cycle No. 059

Ref.: S3MPC.ACR.PR.01-078-059

Issue: 1.0

Date: 07/12/2021

Page: 117

9 Appendix A

Other reports related to the Optical mission are:

❖ S3 SLSTR Cyclic Performance Report, S3A Cycle No. 078, S3B Cycle No. 059 (ref. S3MPC.RAL.PR.02-078-059)

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

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