Technical Note on Quality Assessment of GCOM-C Land and Ocean Products

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AMENDMENT RECORD SHEET

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1.0	06 JUL 2022	Finalised version

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1. INTRODUCTION

This document is a Quality Assessment (**QA**) report for the Second Generation GLobal Imager (**SGLI**) land and ocean products of the Japanese Space Agency's (**JAXA**) Global Change Observation Mission for Climate (GCOM-**C**).

This QA report includes an Earthnet Data Assessment Pilot (**EDAP**) maturity matrix assessment and series of product checks, using a sample of the GCOM-C products retrieved through JAXA's online portal.

1.1 Reference Documents

The following is a list of documents with a direct bearing on the content of this report. Where referenced in the text, these are identified as RD.n, where 'n' is the number in the list below:

[RD.1] Task 4 Atmospheric Assessment: EDAP.REP.006_1.1 - GCOM_C Quality Assessment Report.

[RD.2] EDAP Mission Quality Assessment Guidelines, Issue 1.2, 19 July 2019.

[RD.3] GCOM-C website https://global.jaxa.jp/projects/sat/gcom_c/

[RD.4] GCOM-C "SHIKISAI" Data Users Handbook, First Edition, December 2018 https://gportal.jaxa.jp/gpr/assets/mng_upload/GCOM-C/GCOM-C_SHIKISAI_Data_Users_Handbook_en.pdf

[RD.5] GCOM-C/SGLI Land Atmospheric Correction Algorithm, v2.000, March 2020 https://suzaku.eorc.jaxa.jp/GCOM_C/data/ATBD/ver2/V2ATBD_T1A_BRDF_Murakami.pdf

[RD.6] Bouvet, M.; Thome, K.; Berthelot, B.; Bialek, A.; Czapla-Myers, J.; Fox, N.P.; Goryl, P.; Henry, P.; Ma, L.; Marcq, S.; Meygret, A.; Wenny, B.N.; Woolliams, E.R. RadCalNet: A Radiometric Calibration Network for Earth Observing Imagers Operating in the Visible to Shortwave Infrared Spectral Range. Remote Sens. 2019, 11, 2401, https://doi.org/10.3390/rs11202401

[RD.7] JAXA G-Portal, Accessed August 2020: https://gportal.jaxa.jp/gpr/

[RD.8] GCOM-C post-launch calibration (updated in Dec. 2019) https://suzaku.eorc.jaxa.jp/GCOM_C/data/prelaunch/index_cal.html

[RD.9] Version 2 Cryosphere Products https://suzaku.eorc.jaxa.jp/GCOM_C/data/files/V2_Cryosphere_en.pdf

[RD.10] The 2020 data collection – changes, improvements and quality, Version 1.0, 07 March 2020.

[RD.11] CEOS, RadCalNet Quick Start Guide. Accessed August 2020: https://www.radcalnet.org/resources/RadCalNetQuickstartGuide_20180702.pdf

[RD.12] EDAP TN on Quality Assessment for Dove-R, v1.0, May 2020

[RD.13] GCOM-C Version 2 update https://suzaku.eorc.jaxa.jp/GCOM_C/data/update/ver2_std_update.html

[RD.14] GCOM-C Version 2 reprocessing status https://shikisai.jaxa.jp/status_v2_en.html

[RD.15] Version 2 Land Products https://suzaku.eorc.jaxa.jp/GCOM_C/data/files/V2_Land_en.pdf

[RD.16] Atmospheric Correction Algorithm for Ocean Color, Version 2, July 2020 https://suzaku.eorc.jaxa.jp/GCOM_C/data/ATBD/ver2/V2ATBD_O2AB_NWLR_Toratani_r3.pdf

[RD.17] BOUSSOLE vicarious calibration site http://www.obs-vlfr.fr/Boussole/html/calibration/vicarious_d.php

[RD.18] Version 2 Ocean Products https://suzaku.eorc.jaxa.jp/GCOM_C/data/files/V2_Ocean_en.pdf

1.2 Glossary

The following acronyms and abbreviations have been used in this Report.

AC	Atmospheric Correction
ATBD	Algorithm Theoretical Basis Document
BOA	Bottom-Of-Atmosphere
CEOS	Committee on Earth Observation Satellites
EDAP	Earthnet Data Assessment Pilot
EGRIP	East Greenland Ice Core Project
GCOM-C	Global Change Observation Mission for Climate
L2	Level 2
NIR	Near-InfraRed
NPL	National Physical Laboratory
NWLR	Normalised Water-Leaving Radiance
PAR	Photosynthetically Active Radiation
PUG	Product User Guide
QA	Quality Assessment
RD	Reference Document
RSRF	atmospherically corrected reflectance
SGLI	Second Generation GLobal Imager
SNR	Signal-To-Noise Ratio
SWIR	short wavelength infrared channel
Tb	brightness temperatures
TIR	Thermal InfraRed
TOA	Top-Of-Atmosphere
UV	Ultra Violet

2. EXECUTIVE SUMMARY

The aim has been to generate a complimentary assessment for marine and terrestrial applications, focused on the SGLI Level 2 (**L2**) products, to the EDAP Task 4 assessment for atmospheric applications [RD.1]. The approaches included are:

- EDAP Maturity Matrix assessment
- Assessment of product suitability for time-series analysis over a terrestrial site by performing an image quality, radiometric calibration, and geometric assessment of the Land products.
- Data quality analysis over a marine site for the Ocean products in terms of the image quality and radiometric calibration.

2.1 EDAP Maturity Matrix

An assessment has been performed using the National Physical Laboratory (NPL) EDAP guidelines [RD.2], with the summary reported in

Figure 2-1 and detailed analysis within Section 3. The assessment started with the Maturity Matrix generated by Task 4 [RD.1], and it has been updated herein for the Land and Ocean products.

Product Details	Product Generation	Ancillary Information	Uncertainty Characterisation	Validation
Product Information	Sensor Calibration & Characterisation Pre-Flight	Product Flags	Uncertainty Characterisation Method	Reference Data Representativeness
Availability & Accessibility	Sensor Calibration & Characterisation Post-Launch	Additional Information	Uncertainty Sources Included	Reference Data Quality
Product Format	Retrieval Algorithm Method	If target mission data product is Level 2	Uncertainty Values Provided	Validation Method
User Documentation	Retrieval Algorithm Tuning		Geolocation Uncertainty	Validation Results
Metrological Traceability Documentation	Additional Processing			

Key
Not Assessed
Not Assessable
Basic
Intermediate
Good
Excellent

Information Not Public

Figure 2-1: GCOM-C/SGLI Quality Evaluation Matrix focused on the Land and Ocean Products

2.2 Summary of Quality Assessment

Considering the EDAP Task 4 assessment [RD.1], the Land and Ocean Product validation results from the EDAP assessment, alongside the more extensive GCOM-C validation exercises led by JAXA team, show the high quality of the products. In terms of the radiometric accuracy, especially for the Land Products, there has been a significant update for Version 2 compared to 1. However, the Version 2 products have not achieved their final accuracy as the atmospheric correction includes a temporal assessment to correct for the effect of the aerosols and so those products are evolving as more products are processed.

With GCOM-C being a space agency mission, there is an abundance of open-access documentation that allows us to provide a high rating within the EDAP Maturity Matrix. Most of the documentation is available in English, as well as or instead of Japanese, and JAXA's G-Portal provides one location for it to be accessed from.

3. DETAILED EDAP QUALITY ASSESSMENT

3.1 Product Details

Product Information	
Product Name	GCOM-C SGLI Level 2 Land and Ocean Products
Sensor Name	SGLI (Second-generation Global Imager)
Sensor Type	19-channel radiometer, 17 narrow-bandwidth in VIS/NIR/SWIR and two broadband in the Thermal IR
Product Version Number	v1 & v2 from 29 June 2020 (there has been a reprocessing, but only for 2020 at this stage, so the date determines the product version)
Product ID	Land: RSRF; Oceans: NWLR
Processing level of product	Level 2
Measured Quantity Name	Land: Atmospheric corrected reflectance Oceans: Normalised water leaving radiance
Measured Quantity Units	none
Stated Measurement Quality	
Spatial Resolution	Land 250 m; Ocean 250 m & 1km
Spatial Coverage	Tiles (Tiles are defined as 10 degrees square at the equator on the Sinusoidal grid) & Granules
Temporal Resolution	1 day
Temporal Coverage	Global coverage in 3 days (in daylight)
Mission coverage	2018 to ≥2022
Point of Contact	Z-GCOM_QA@ml.jaxa.jp
Product locator (DOI/URL)	https://gportal.jaxa.jp/gpr/
Conditions for access and use	Free
Limitations on public access	None
Product Abstract	• Global Attributes • Processing Attributes • Geometry & Timing Data • Image Data

Product Availability & Accessibility	
Compliant with FAIR principles	Yes
Data Management Plan	https://iocs.ioccg.org/wp-content/uploads/1415-hiroshi-murakami-iocs-data-sgli-murakami-201305-v1.pdf
Availability Status	Available via user subscription (graphical interface and FTP)

Product Format	
Product File Format	HDF5

Metadata Conventions	N/A
Analysis Ready Data?	Yes

Product User Documentation		
Document	*Reference*	*QA4ECV Compliant*
Product User Guide (**PUG**)	https://gportal.jaxa.jp/gpr/assets/mng_upload/GCOM-C/GCOM-C_SHIKISAI_Data_Users_Handbook_en.pdf [SGC-180025] – December 2018	
Algorithm Theoretical Basis Document (**ATBD**)	Available for each product at https://suzaku.eorc.jaxa.jp/GCOM_C/data/product_std.html	

Metrological Traceability Documentation	
Document Reference	https://gportal.jaxa.jp/gpr/assets/mng_upload/GCOM-C/SGLI_Higher_Level_Product_Format_Description_en.pdf
Traceability Chain / Uncertainty Tree Diagram Available	Yes https://suzaku.eorc.jaxa.jp/GCOM_C/data/files/GCOM-C_L1_L3_productlist.pdf

3.2 Product Generation

Sensor Calibration & Characterisation – Pre-Flight	
Summary	Pre-launch Calibration and Characterisation of flight model includes analysis and measurements of: 1. Gain Calibration 2. Signal to Noise ratio 3. Spectral Response 4. Polarisation Sensitivity 5. Stray-light 6. Geometrical Model
References	• https://suzaku.eorc.jaxa.jp/GCOM_C/data/prelaunch/index.html • http://extranet.wmo.int/pages/prog/sat/meetings/documents/GSICS-EP-10_Doc_03-06_JAXA.pdf • https://suzaku.eorc.jaxa.jp/GCOM_C/resources/files/SGLI_Calibration_IGARSS2018.pdf

Sensor Calibration & Characterisation – Post-Launch	
Summary	SGLI evaluates the health check and the trend by evaluating the data obtained through on-orbit calibration and three calibration manoeuvres (lunar, solar angle, 90-yaw) conducted periodically. VNR has the radiometric calibration function using solar light, internal lamps, and lunar light, and has an electrical calibration function. For the calibration employing the solar light and internal lamps (white LED and infrared LED), the light reflected from the expanded diffuser is used. For the short wavelength infrared channel (**SWIR**), the radiometric calibration is conducted using the solar light, internal lamp (LED with a wavelength of 1.6 μm, halogen lamp), deep space and lunar light.

	Also, for the thermal red channel, every two-point calibration is conducted for each scanning using the data obtained by observing the black body (high-temperature calibration source) and deep space (low-temperature calibration source).
References	• Operation Concept of Second-generation Global Imager (SGLI), K. Tanaka, Y. Okamura, T. Amano, and M. Hiramatsu, K. Shiratama, SPIE-AP, Incheon, 13 October 2010 • https://suzaku.eorc.jaxa.jp/GCOM_C/resources/files/SPIE_Hawaii_SGLI_a.pdf https://suzaku.eorc.jaxa.jp/GCOM_C/data/prelaunch/index_cal.html

Retrieval Algorithm Method *(For Level 2 Products Only)*	
Summary	Various in-situ data, which were obtained for evaluating algorithm and geophysical parameters, are available.
References	https://suzaku.eorc.jaxa.jp/GCOM/insitu/GCOM_In-situ_data_en.pdf

Retrieval Algorithm Tuning *(For Level 2 Products Only)*	
Summary	Granule scene, global, and tile (*1) data of geophysical variables derived from Level 1B or Level 2 products including global and tiled mosaic products with the spatial resolutions of 250m and 1km for scene and tile products, and 4km (1/24deg.) for global products. *1: Tiles are defined as 10 degrees square at the equator on the Sinusoidal grid.
References	https://gportal.jaxa.jp/gpr/assets/mng_upload/GCOM-C/GCOM-C_SHIKISAI_Data_Users_Handbook_en.pdf

Additional Processing	
Description	Spatial (1/12deg. and 1/24deg.) and temporal (1-day, 8-day and 1-month) statistics of Level-2 products with the global spatial coverage.
Reference	https://gportal.jaxa.jp/gpr/assets/mng_upload/GCOM-C/GCOM-C_SHIKISAI_Data_Users_Handbook_en.pdf

3.3 Ancillary Information

Product Flags	
Product Flag Documentation	• Event information on satellite operation (orbit control information, calibration manoeuvre information etc.): https://suzaku.eorc.jaxa.jp/GCOM_C/users_portal/docs/event_information.pdf • Data loss information on observation data: https://shikisai.jaxa.jp/docs/SGLI_data_missing.pdf
Comprehensiveness of Flags	Yes

Additional Information	
Ancillary Data Documentation	• https://gportal.jaxa.jp/gpr/assets/mng_upload/GCOM-C/SGLI_Higher_Level_Product_Format_Description_en.pdf
Comprehensiveness of Data	Ancillary data are described at a high level in the ATBD, even if they are reported inside the Level-2 products and in the product format document.
Uncertainty Quantified	No

3.4 Uncertainty Characterisation

Uncertainty Characterisation Method	
Summary	To support the assessment of uncertainties, the following concrete goals are set under the GCOM: • Development of an algorithm to highly accurately calculate physical quantities; • Preparation of weather values for input to models; • Separation of trends from natural changes using long-term data sets and verification of models; • Understanding of regional characteristics; • Clarification of the process and improved accuracy of models.
Reference	• GCOM_SP_ENG_v.1.1.pdf

Uncertainty Sources Included	
Summary	Any improvement of the accuracy of climate change prediction requires improved observation accuracy for uncertain factors listed in the IPCC report. Those uncertain factors which can be observed under the GCOM are listed: • Uncertainty of radiative forcing • Uncertainty of flux (energy, carbon, and water cycles) • Uncertainty of process and feedback • Signs of global warming
Reference	• GCOM_SP_ENG_v.1.1.pdf

Uncertainty Values Provided	
Summary	The "release threshold" is minimum levels for the first data release at one year from launch. The "standard" and "research" accuracies correspond to full- and extra success criteria of the mission, respectively. Accuracies are shown using RMSE.
Reference	Details provided in table https://suzaku.eorc.jaxa.jp/GCOM_C/data/product_goal_std.html and https://suzaku.eorc.jaxa.jp/GCOM_C/data/product_goal_re.html
Analysis Ready Data?	Yes

Geolocation Uncertainty	
Summary	For the Land products, the target accuracy is release < 1 pixel; standard < 0.5 pixel and target < 0.25 pixel with the standard accuracy classed as being achieved using GCPs extracted from AVNIR data.
Reference	• https://suzaku.eorc.jaxa.jp/GCOM_C/data/files/V2_Land_en.pdf

3.5 Validation for the Land Products

Reference Data Representativeness

Independently Assessed?	Yes, see Section 4
Summary	The approach is to global data, collated from multiple sources.
Reference	https://suzaku.eorc.jaxa.jp/GCOM_C/data/files/V2_Land_en.pdf

Reference Data Quality & Suitability	
Summary	Based on internationally accepted sources.
Reference	https://suzaku.eorc.jaxa.jp/GCOM_C/data/files/V2_Land_en.pdf

Validation Method	
Summary	International standards are being followed.
Reference	https://suzaku.eorc.jaxa.jp/GCOM_C/data/files/V2_Land_en.pdf

Validation Results	
Summary	Extensive results are reported in the PDF, with live results in the monitor.
Reference	• https://suzaku.eorc.jaxa.jp/GCOM_C/data/files/V2_Land_en.pdf • Online Calibration and Validation Monitor: https://suzaku.eorc.jaxa.jp/cgi-bin/gcomc/validation/gcomc_validation_nwlr_i.cgi

3.6 Validation for the Ocean Products

Reference Data Representativeness	
Independently Assessed?	Yes, see Section 5 for the EDAP assessment. There are also ongoing assessments by other teams around the world including international PIs
Summary	The approach is to global data, collated from multiple sources.
Reference	https://suzaku.eorc.jaxa.jp/GCOM_C/data/files/V2_Ocean_en.pdf

Reference Data Quality & Suitability	
Summary	Based on internationally accepted sources.
Reference	https://suzaku.eorc.jaxa.jp/GCOM_C/data/files/V2_Ocean_en.pdf

Validation Method	
Summary	International standards are being followed.
Reference	https://suzaku.eorc.jaxa.jp/GCOM_C/data/files/V2_Ocean_en.pdf

Validation Results	
Summary	Extensive results are reported in the PDF, with live results in the monitor.
Reference	• Online Calibration and Validation Monitor: https://suzaku.eorc.jaxa.jp/cgi-bin/gcomc/validation/gcomc_validation_nwlr_i.cgi • https://suzaku.eorc.jaxa.jp/GCOM_C/data/files/V2_Ocean_en.pdf

4. DETAILED ASSESSMENT OF THE LAND PRODUCTS

The Second generation GLobal Imager (SGLI) on GCOM-C1 is an optical sensor capable of multi-channel observations at wavelengths from near-Ultra Violet (**UV**) to Thermal InfraRed (**TIR**) wavelengths [RD.3]. SGLI obtains global observation data once every 2 or 3 days, with a spatial resolution that varies from 250 m to 1 km.

This section of the report includes Landsat reflectance products assessments regarding the image quality, radiometric calibration and geometric calibration that are important for multi-temporal analysis.

4.1 Image Quality Assessment

Displayed in Figure 4-1 is the atmospherically corrected reflectance (**RSRF**) for the 06 July 2019 as initially loaded into SNAP and then contrast stretched for bands 7 (672 nm), 5 (528.64 nm) and 4 (489.85 nm). Table 4-1 shows the full set of GCOM-C wavebands.

Table 4-1: GCOM-C wavebands [RD.4], [RD.5]

SGLI channels						
CH	λ	λΔ	L_{std}	L_{max}	SNRatLstd	IFOV
	VN, P, SW:nm T:μm		VN, P, SW: W/m2/sr/μm T: Kelvin		VN, P, SW: SNR T: NEΔT	m
VN1	380	10	60	210	250	250/1000
VN2	412	10	75	250	400	250/1000
VN3	443	10	64	400	300	250/1000
VN4	490	10	53	120	400	250/1000
VN5	530	20	41	350	250	250/1000
VN6	565	20	33	90	400	250/1000
VN7	673.5	20	23	62	400	250/1000
VN8	673.5	20	25	210	250	250/1000
VN9	763	12	40	350	1200	250/1000
VN10	868.5	20	8	30	400	250/1000
VN11	868.5	20	30	300	200	250/1000
P1	673.5	20	25	250	250	1000
P2	868.5	20	30	300	250	1000
SW1	1050	20	57	248	500	1000
SW2	1380	20	8	103	150	1000
SW3	1630	200	3	50	57	250/1000
SW4	2210	50	1.9	20	211	1000
T1	10.8	0.7	300	340	0.2	250/500/1000
T2	12.0	0.7	300	340	0.2	250/500/1000

λ: Wavelength L_std: Standard radiance SNR: Signal to Noise ratio
λΔ: Wavelength width L_max: max radiance IFOV: Instantaneous Field Of View
NEΔT: Noise Equivalent Temperature Difference

The data is for tile T0418 that is in sinusoidal equal-area projection. This tile covers southern France, and so is useful for the radiometric assessment using the La Crau test site. There is a white triangle in the bottom right, which is missing data, while the other white areas are clouds.

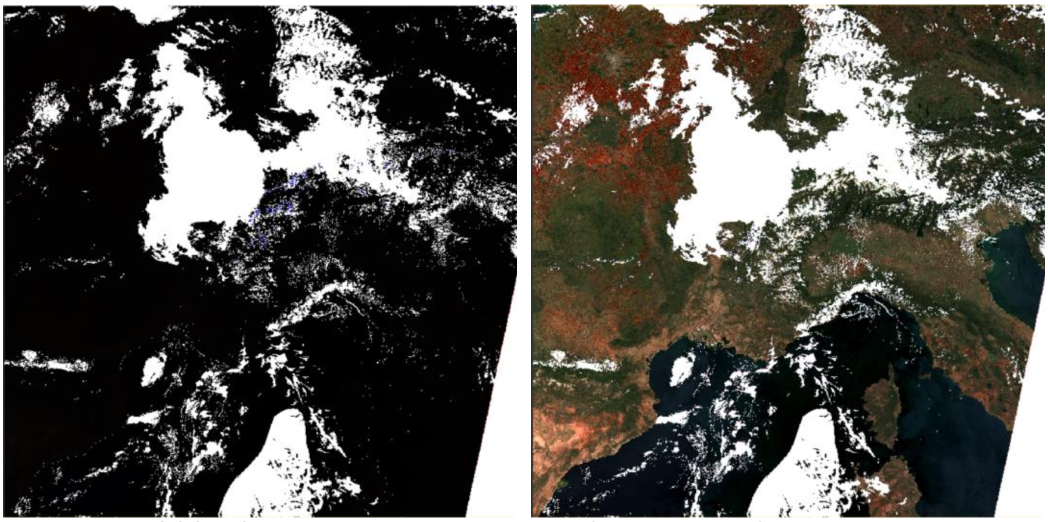


Figure 4-1: GCOM-C atmospherically corrected reflectance data for the 06 July 2019 as initially loaded into SNAP and then contrast stretched for bands 7, 5 and 4.

Figure 4-2 shows the layers held within this file alongside the QA flag band shown using a colour palette. As can be seen, the size of the tile is 4800 by 4800 pixels. Each reflectance band is stored in an individual layer, and there are layers for the:

- Sensor/solar observation geometry
- Land/water and QA flags
- Angstrom, tau (aerosol optical depth) and Photosynthetically Active Radiation (**PAR**) Atmospheric Correction (**AC**) outputs
- Thermal bands stores as brightness temperatures (**Tb**).

The definition of the QA flags, extracted from [RD.5], is shown in Figure 4-3.

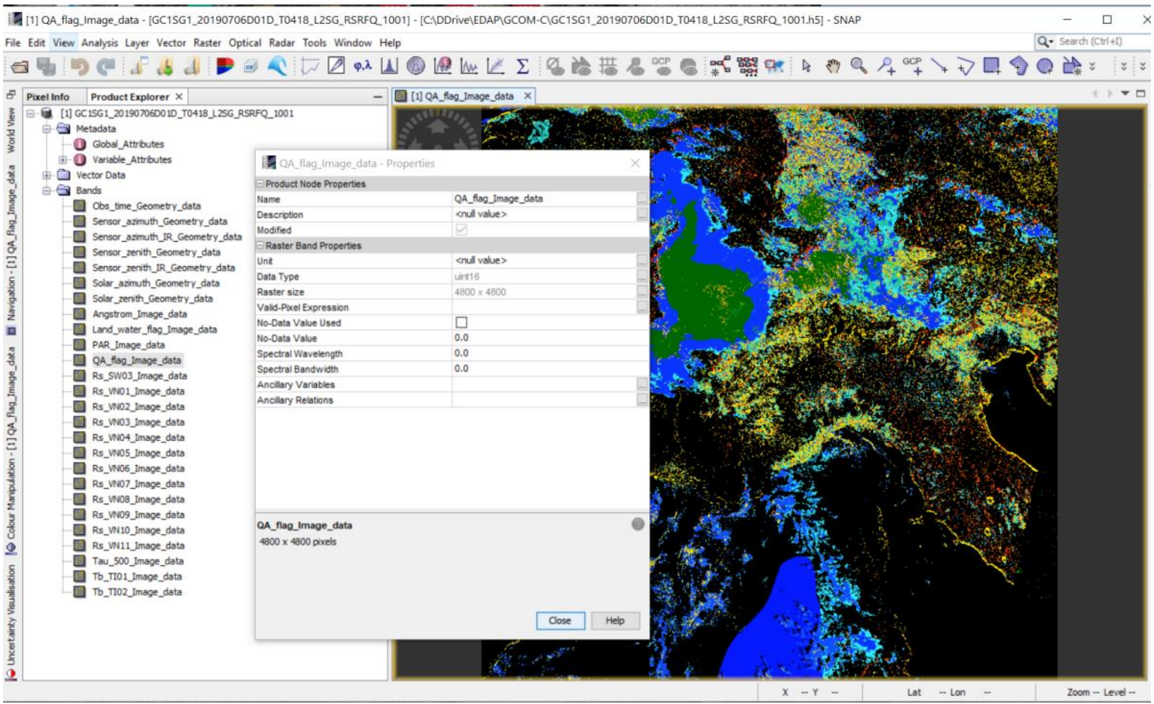


Figure 4-2: Atmospherically corrected reflectance for the 06 July 2019 as initially loaded into SNAP and then contrast stretched for bands 7, 5 and 4.

2.8 Mask/Flag

The first 0-1bits are common for the Level-2 products, input data lack and land/water flags. Others are defined as the right table.

Cloud masks are set by the target date, and the probably cloud is set by the multiple day tests. Bit-13 is set by additional cloud cover tests by polarization channels. Bit-14 (non-polarization) and 15 (polarization) are set when the grid is recovered by the pre-day's BRDF table.

The Level-3 statistics processing will use data with the QA_flag of bit-4, 7, 8, and 12=0 and the product value is within the valid range.

Table 5 Bit specification of QA_flag

bit	Description	Level-3 mask
0	no data (mask)	0
1	land (0: ocean, 1: land) (flag)	0
2	coast (flag)	0
3	sun-glint >0.005(flag)	0
4	sun-glint >0.12 (mask)	1
5	snow or ice (flag)	0
6	cloud (mask)	0
7	probably cloud (by multi-day) (flag)	1
8	high tau-a>0.8 (flag)	1
9	saturation recovery (flag)	0
10	BRF samples<=3(flag)	0
11	stray light (flag)	0
12	shadow (mask)	1
13	pol cloud or hi-tau (mask)	0
14	recovery by pre-days (flag)	0
15	recovery (pol) (flag)	0

Figure 4-3: Definition of the QA flags from [RD.5].

4.2 Validation of the Radiometric Calibration

RadCalNet is an initiative of the Working Group on Calibration and Validation of the Committee on Earth Observation Satellites (**CEOS**). The RadCalNet service provides satellite operators with SI-traceable Top-Of-Atmosphere (**TOA**) spectrally-resolved reflectances to aid in the post-launch radiometric calibration and validation of optical imaging sensor data [RD.6].

The free and open access service provides a continuously updated archive of TOA reflectances derived over a network of sites, with associated uncertainties, at a 10 nm spectral sampling interval, in the spectral range from 380 nm to 2500 nm and at 30-minute intervals.

For this analysis, we have used the RadCalNet measured Bottom-Of-Atmosphere (**BOA**) reflectance data compared to the GCOM-C RSRF product, which will assess both the instrument calibration and AC. The RadCalNet 2020 data collection [RD.7] consists of a reprocessed full archive of RadCalNet archive data; the La Crau BOA reflectance data are Version 2.

The GCOM team have assessed the post-launch calibration using TOA radiances [RD.8] from RadCalNet, East Greenland Ice Core Project (**EGRIP**) [RD.9], and Railroad Valley, see Figure 4-4.

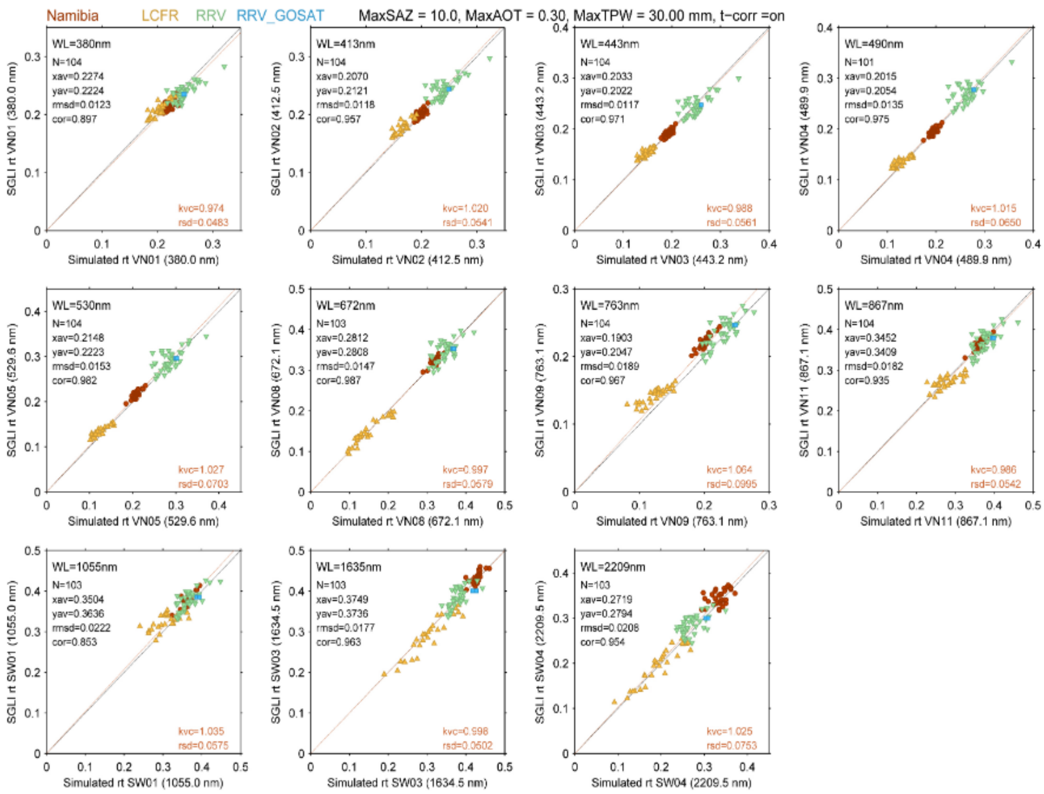


Figure 4-4: Assessment of the TOA radiances using RadCalNet, EGRIP, and Railroad Valley [RD.8].

4.2.1 Methods and Data

The method used for this exercise consists of different processing stages, as shown in Figure 4-5.

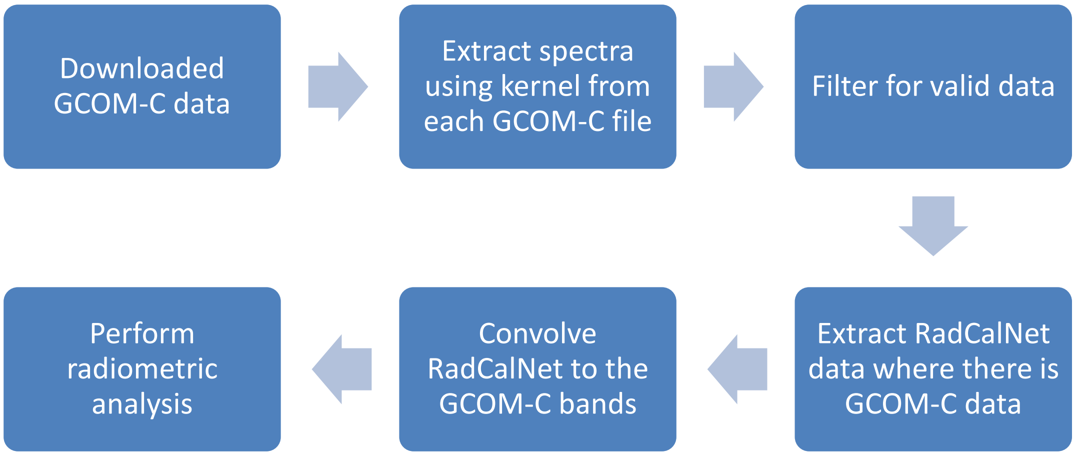


Figure 4-5: The workflow of the radiometric calibration assessment using RadCalNet data.

These different processing stages can be summarised as follows:

- Download GCOM-C data from the JAXA G-Portal portal [RD.7].
- Extract multispectral BOA measurements from the GCOM-C L2 products for tile T0418 recorded over the La Crau RadCalNet station.
- The measurement is spatially integrated over a 3 by 3 kernel, which is a window of size of 750 by 750 m, where there is valid data, i.e. value < 65535 (null value).
- Extract the RadCalNet 2020 data collection [RD.7] BOA measurements where there is valid GCOM-C data. It is not possible to get exact observation time of the GCOM-C product, so temporal interpolation is performed to overcome this.
- Convolve the RadCalNet 10 nm BOA spectrum with the GCOM-C spectral bandpass to get the reference measurements for each sensor spectral band.
- Plot the convolved RadCalNet data against the GCOM-C data.
- Compute the calibration ratio between GCOM-C mean BOA reflectance and RadCalNet BOA reflectance, then compute the percent difference as follows:

$$\%Difference = \frac{100 * (BOA\_Measure - BOA\_Reference)}{BOA\_Reference}$$

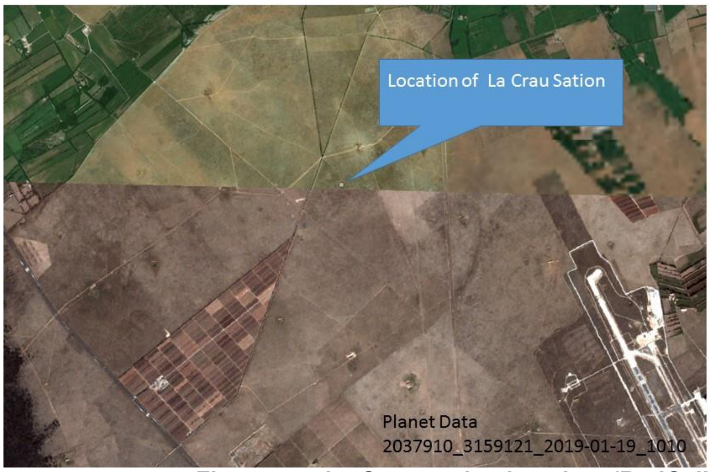
Where $BOA\_Measure$ is the measurement processed from the GCOM-C product and $BOA\_Reference$ is the measurement processed from RadCalNet data.

Figure 4-6: GCOM-C tile T0418 (top left) from 01 July 2019, and RadCalNet location in the zoomed-in part of the image (red arrow).

As detailed in [RD.11], the TOA reflectance spectra over the La Crau RadCalNet site are representative of a disk of 30 m radius centred on 43.55885 degrees Latitude and 4.864472 degrees Longitude. This report is using the BOA nadir-observed surface reflectance data and the GCOM-C pixels are 250 m in resolution, so we are assuming there is homogeneity between the original point BOA measurement and 3 by 3 GCOM-C kernel being investigated. The input RadCalNet data are required to be valid for an area of at least 45 m by 45 m [RD.6].

The site is shown in Figure 4-7 (EDAP Dove-R report [RD.12] Figure 5-18). From Figure 4-7, it can be seen that also there is spatial variability, a radius of the 750m around the site would include fields with the same land cover. In [RD.6] it is described as being in an area that has a dry, and sunny Mediterranean climate with the soil mainly composed of pebbles and sparsely covered by low vegetation. This variability is further assessed by calculating both the mean and standard deviation for the extracted GCOM-C kernels.

Use of RadCalNet , https://www.radcalnet.org/#!/sites/LCFR , for radiometric calibration of planet data.



La Crau station	
Latitude	43.558889
Longitude	4.864167
Altitude	20m
Characteristics	The RadCalNet top-of-atmosphere reflectance spectra are representative of a disk of 30 m radius

Figure 4-7: La Crau station location, (RadCalNet) [RD.12]

The GCOM-C data used for the comparison is the RSRF that is corrected for directional anisotropic effects and is unitless. Below are listed the downloaded files, including GCOM-C filenames and UTC extracted from inside the HDF file (in bold are those where we had RadCalNet matchups):

- **GC1SG1_20190701D01D_T0418_L2SG_RSRFQ_1001 1110**
- **GC1SG1_20190706D01D_T0418_L2SG_RSRFQ_1001 1038**
- **GC1SG1_20190710D01D_T0418_L2SG_RSRFQ_1001 1032**
- **GC1SG1_20190713D01D_T0418_L2SG_RSRFQ_1001 1053**
- **GC1SG1_20190714D01D_T0418_L2SG_RSRFQ_1001 1026**
- **GC1SG1_20190722D01D_T0418_L2SG_RSRFQ_1001 1015**
- **GC1SG1_20190724D01D_T0418_L2SG_RSRFQ_1001 1102**
- **GC1SG1_20190725D01D_T0418_L2SG_RSRFQ_1001 1035**
- **GC1SG1_20190726D01D_T0418_L2SG_RSRFQ_1001 1009**
- **GC1SG1_20190728D01D_T0418_L2SG_RSRFQ_1001 1056**
- **GC1SG1_20190729D01D_T0418_L2SG_RSRFQ_1001 1029**
- **GC1SG1_20190802D01D_T0418_L2SG_RSRFQ_1001 1024**
- **GC1SG1_20190804D01D_T0418_L2SG_RSRFQ_1001 1111**
- **GC1SG1_20190805D01D_T0418_L2SG_RSRFQ_1001 1044**
- GC1SG1_20190806D01D_T0418_L2SG_RSRFQ_1001 1018
- **GC1SG1_20190816D01D_T0418_L2SG_RSRFQ_1001 1053**
- GC1SG1_20190817D01D_T0418_L2SG_RSRFQ_1001 1027
- GC1SG1_20190821D01D_T0418_L2SG_RSRFQ_1001 1021
- **GC1SG1_20190823D01D_T0418_L2SG_RSRFQ_1001 1108**
- **GC1SG1_20190824D01D_T0418_L2SG_RSRFQ_1001 1042**
- **GC1SG1_20190825D01D_T0418_L2SG_RSRFQ_1001 1015**
- **GC1SG1_20190829D01D_T0418_L2SG_RSRFQ_1001 1009**
- GC1SG1_20200706D01D_T0418_L2SG_RSRFQ_2000 1049
- GC1SG1_20200718D01D_T0418_L2SG_RSRFQ_2000 1031
- GC1SG1_20200721D01D_T0418_L2SG_RSRFQ_2000 1051
- GC1SG1_20200726D01D_T0418_L2SG_RSRFQ_2000 1019

The comparison is for version 1.001 (v1) of the GCOM-C land product as there are not currently RadCalNet matchups for version 2.000 (v2). The Q in the filename after RSRF indicates these are the 250 m resolution products.

We have concentrated the comparison on the summer of 2019 (July and August) to give us a greater chance of cloud-free conditions and for the site itself to be relatively uniform. The v2 dates are analysed to see the differences – the L2 RSRF accuracy will be degraded for a maximum of three months because of the insufficient input data at the version transition. As a result, all land and atmosphere products will be affected by the RSRF accuracy because they use RSRF as an input. [RD.13]; the aerosol estimation is based on multi-temporal variation – low variation in surface reflectance compared to atmospheric contamination [RD.5]. As the comparisons in this report have been semi-automated, then rerunning the RadCalNet comparisons for 2020 would be straightforward. At the moment, the GCOM-C v2 reprocessing has concentrated on 2020 but, over time, it will include previous data; reprocessing status available at [RD.14].

4.2.2 Results

The calibration results based on in situ RadCalNet data are described by showing the steps involved, which have been implemented within a series of Jupyter notebooks. Figure 4-8 shows a plot of the BOA RadCalNet reflectance spectra and the spectra convolved to the GCOM-C bands for the 29 August 2019 (day of year 241).

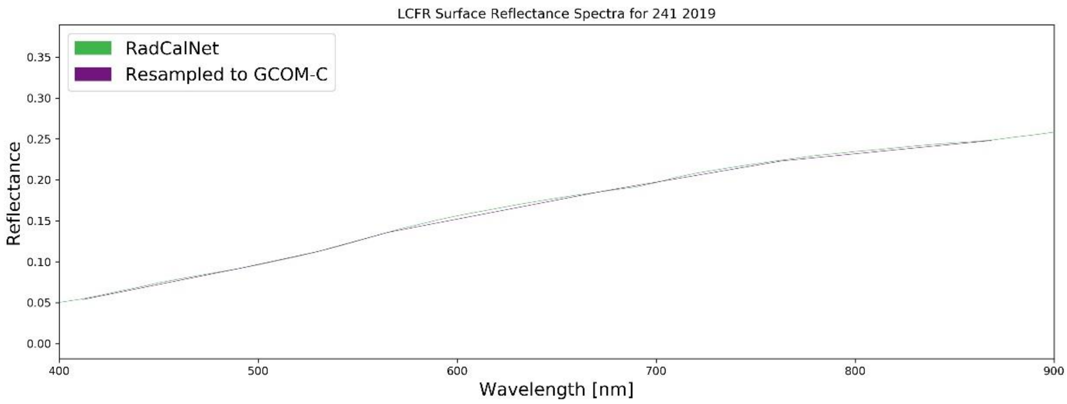


Figure 4-8: Convolution of the RadCalNet reflectance spectra into the GCOM-C bands

For each GCOM-C generated data, an input GCOM-C file is looked for and the data extracted with the two spectra being compared (Figure 4-9). There are two values for xxx nm as GCOM-C has two bands (VN7 & VN8), see Table 4-1, with different Signal-To-Noise Ratio (**SNR**). The actual GCOM-C data is plotted as the mean of the kernel with the vertical error bars showing the standard deviation.

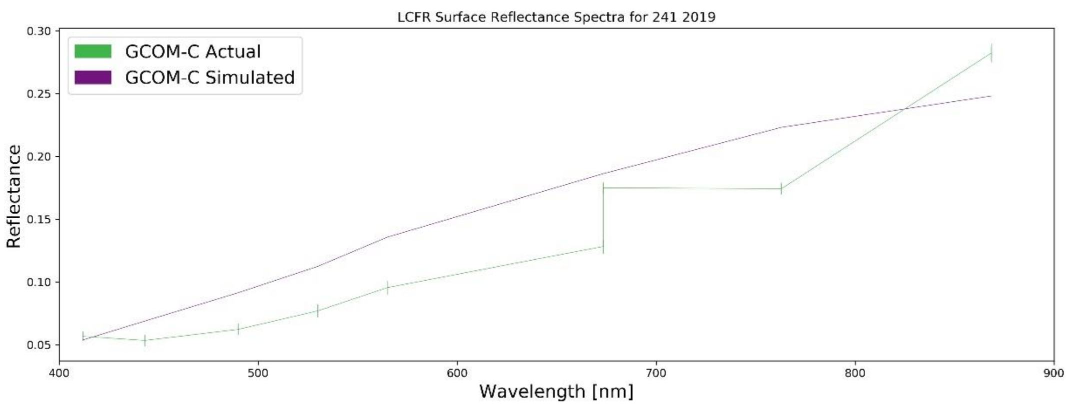


Figure 4-9: Comparison of GCOM-C data with RadCalNet convolved to GCOM-C for a single date

The, Figure 4-10, shows a plot for all valid dates and GCOM-C bands.

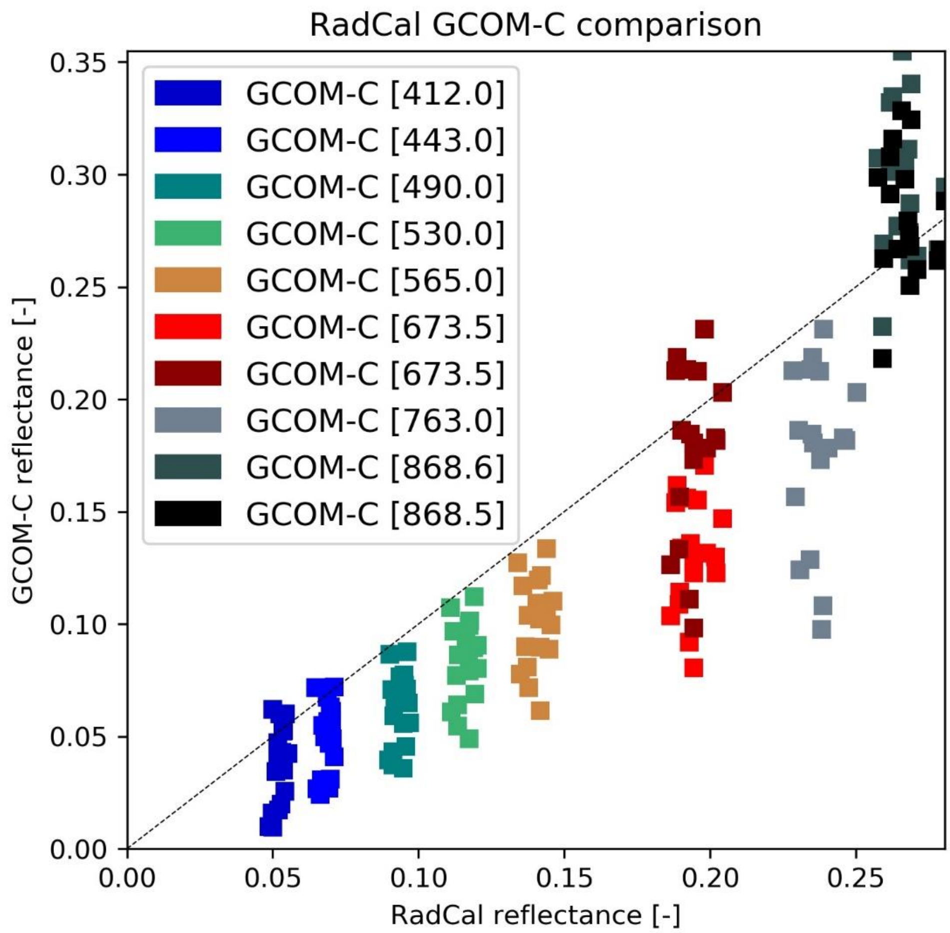


Figure 4-10: Comparison of GCOM-C data with RadCalNet convolved to GCOM-C for all dates

Figure 4-11 shows the calculated percentage difference between the GCOM-C and convolved RadCalNet data. As is also evident in Figure 4-10, most bands have lower values than the RadCalNet data but with the Near-InfraRed (**NIR**) band, wavelength greater than 800 nm, having higher values.

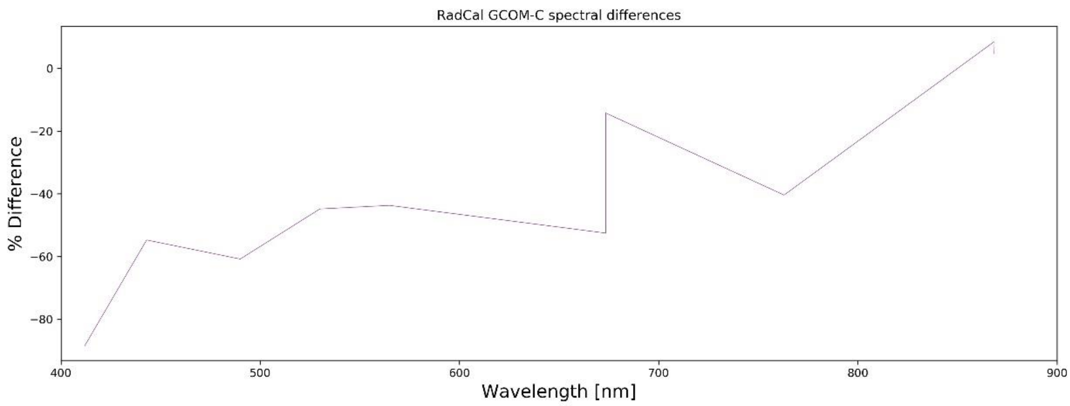


Figure 4-11: Spectral plot of the percentage differences between GCOM-C and convolved RadCalNet data

The GCOM-C team Land Products validation results [RD.15], which include La Crau (LCFR), show that v1 (Figure 4-12) has a broader spread compared to v2 (Figure 4-13). In the document, it is detailed that a bug was fixed for the BDRF correction, plus an improvement in the L1B calibration and QA (cloud screening). The accuracy improves as the products change from meeting the release to standard to target accuracies.

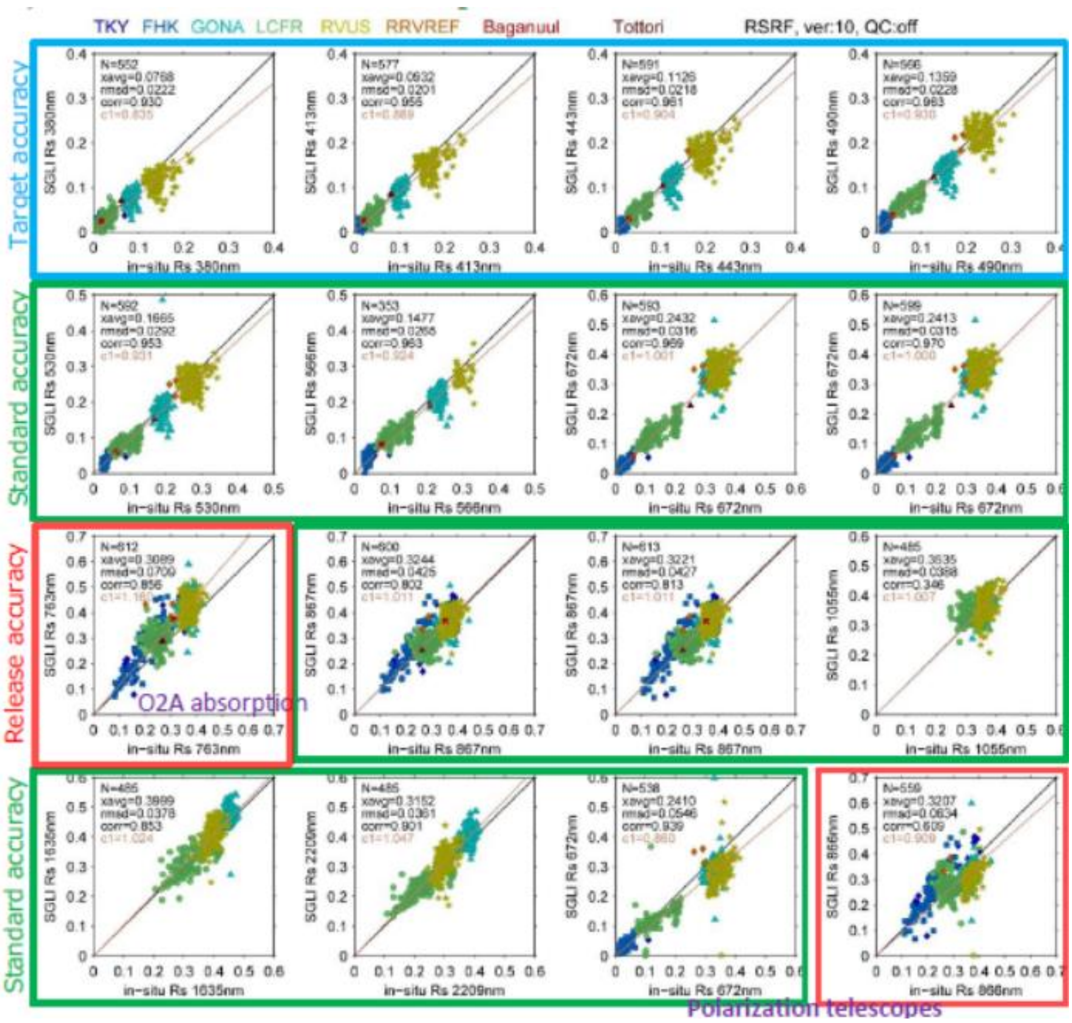


Figure 4-12: GCOM-C RSRF validation for v1 [RD.15]

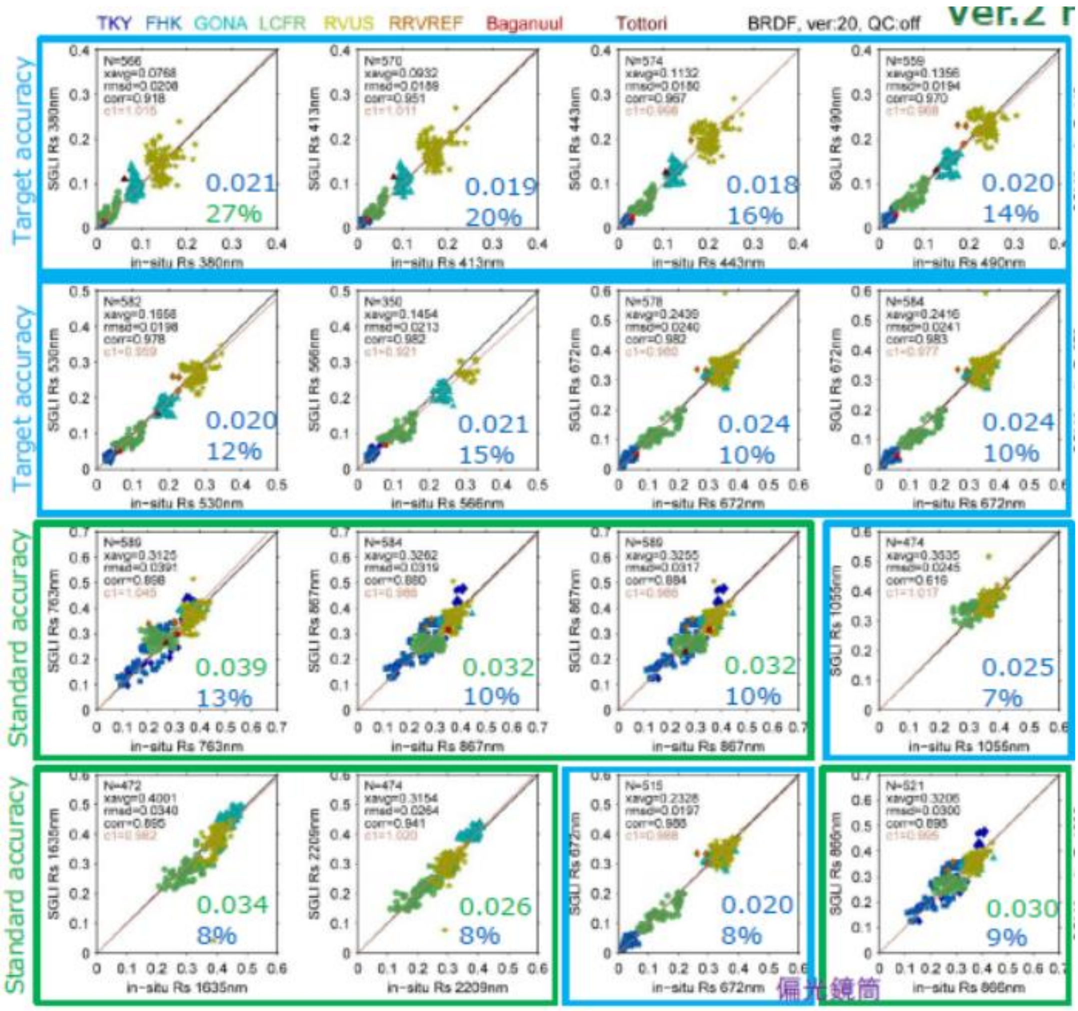


Figure 4-13: GCOM-C RSRF validation for v2 [RD.15]

4.3 Validation of the Geometric Calibration

This section is dedicated to the analysis of geometry, which is less of a focus for medium resolution instruments as GCOM-C's highest spatial resolution is 250 m.

4.3.1 Method and Data

The absolute geometric accuracy is considered for the input L2 products (ortho tile) and consists of creating a multi-temporal assessment. The input is two GCOM-C L2 RSRF 250 m resolution products, which should have been corrected for systematic and non-systematic effects:

- GC1SG1_20190706D01D_T0418_L2SG_RSRFQ_1001
- GC1SG1_20200715D01D_T0418_L2SG_RSRFQ_2000

The files are also different versions, although there was no significant change reported to the geometric processing and so the outputs are expected to be consistent.

4.3.2 Results

To check for offsets, Figure 4-14 shows an RGB composite created with the R and B bands from 2019 and G band from 2020. The main difference in the overall tile (see top right) is due to differences in cloud coverage and the overpasses that result in missing data. Within this tile overview, a smaller area is indicated that includes the coastline. The zoomed-in view of this area mainly shows difference due to cloud cover with a pixel difference along the coastline that shows that the geometric referencing is to an accuracy of the order of a pixel.

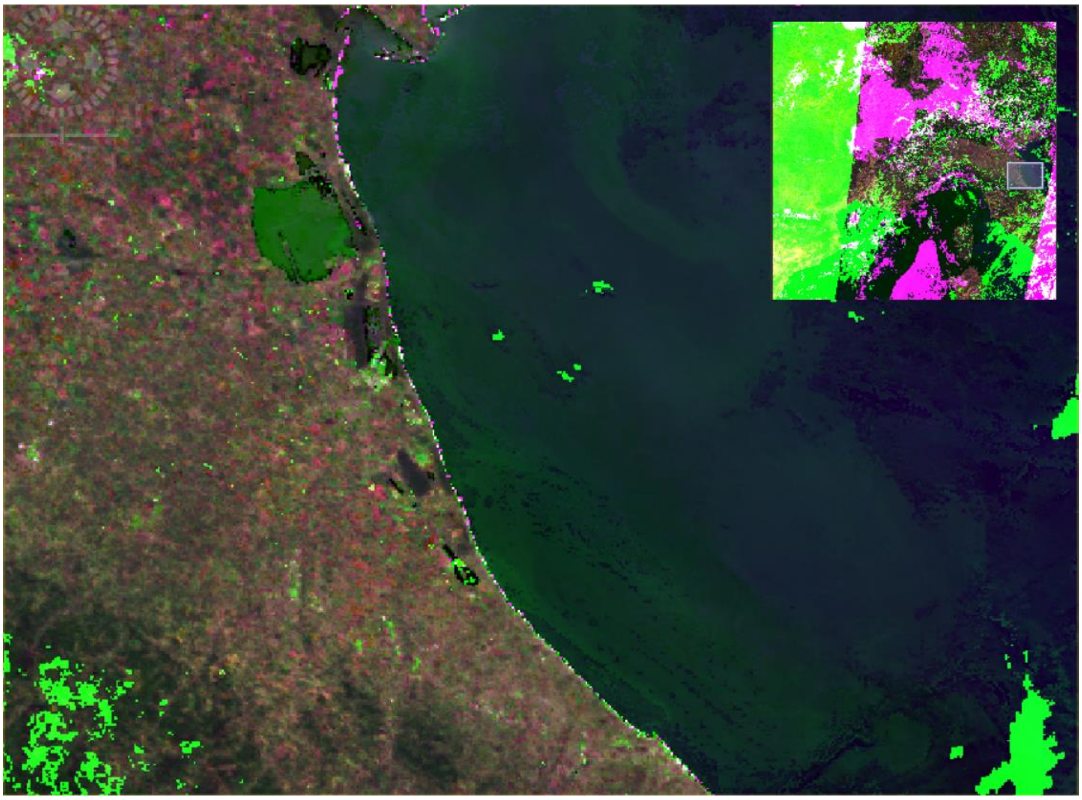


Figure 4-14: Geometric Comparison: T0418 tile with R & B band from 2019 and G band from 2020.

5. DETAILED ASSESSMENT OF THE OCEAN PRODUCTS

5.1 Image Quality Assessment

Displayed in Figure 4-1 is the atmospherically corrected Normalised Water-Leaving Radiance (**NWLR**) for the 07 July 2020 as initially loaded into SNAP and then contrast stretched for bands 7 (672 nm), 6 (566.15 nm) and 4 (489.85 nm). The data is for a granule file called GC1SG1_202007151010D**22510**_L2SG_NWLRK_2000 that covers Italy – Path 225 Scene 01. The white areas are missing data due to clouds, the land and sun glint. The data is in the L1B reference grid.

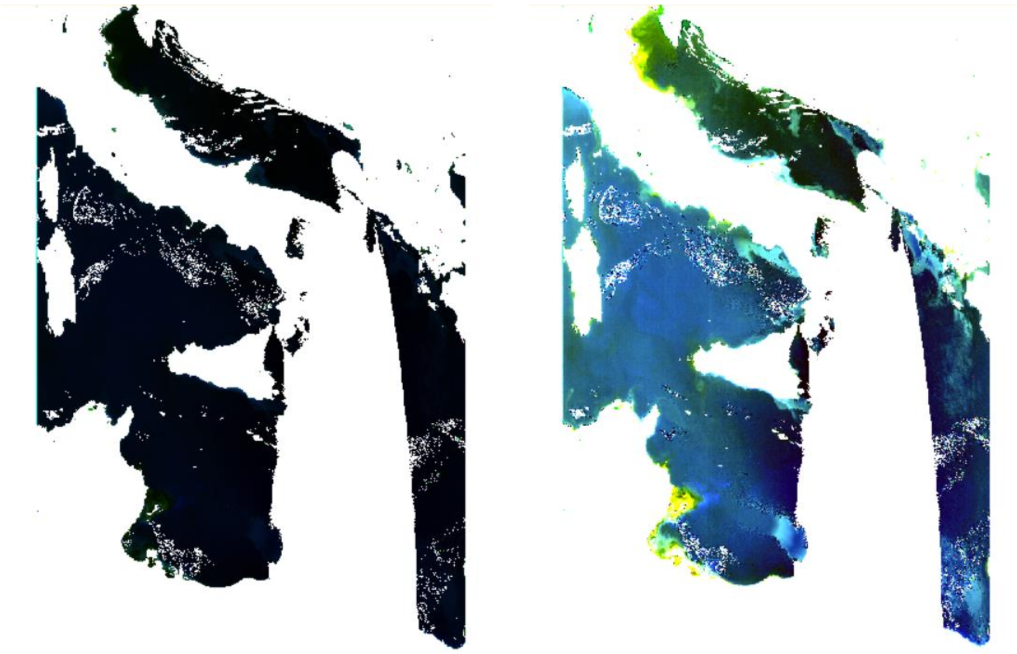


Figure 5-1: GCOM-C atmospherically corrected water leaving radiance data for the 07 July 2020 as initially loaded into SNAP and then contrast stretched for bands 7, 6 and 4.

Figure 4-2 show the layers held within this file alongside the QA flag band shown using a colour palette. As can be seen, the size of the file extent is 5000 by 7820 pixels that means this is a 250 m resolution product. These products are available in coastal waters with 1 km resolution products in the open ocean.

Each radiance band is stored in its each layer, and there are layers for the:

- QA flags.
- tau (aerosol optical depth) at 670 nm and 865 nm plus PAR AC outputs.

The definition of the QA flags, extracted from [RD.15], is shown in Figure 4-3.

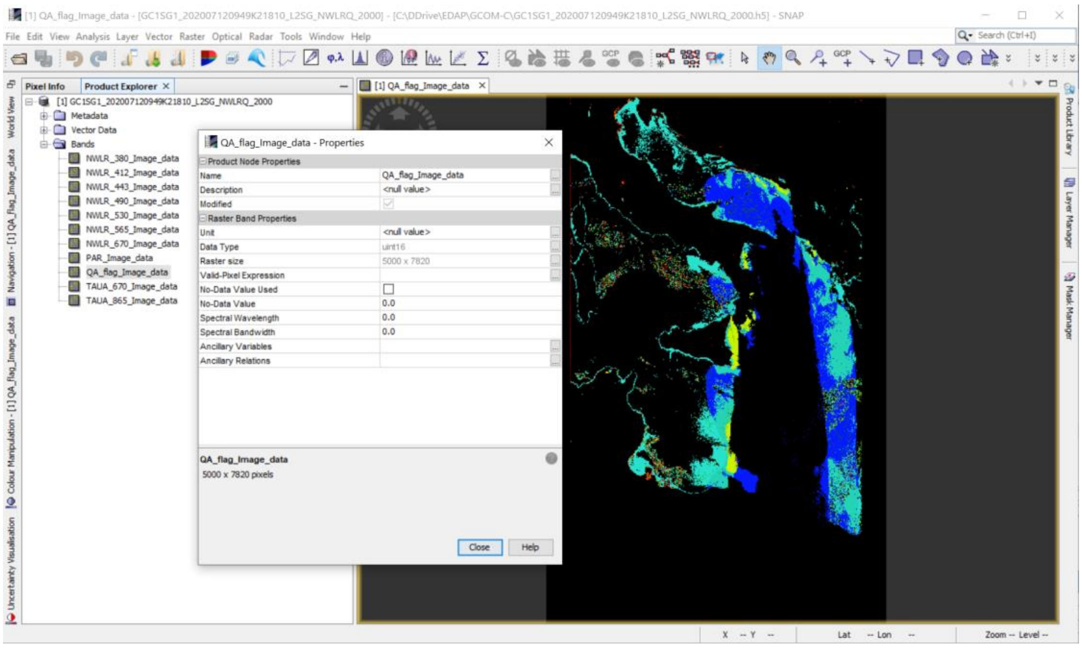


Figure 5-2: Atmospherically corrected normalised water leaving radiance for the 07 July 2020 as initially loaded into SNAP and then contrast stretched for bands 7, 6 and 4.

5.2 Validation of the Radiometric Calibration

For the Ocean Product validation, a time-series of NWLR has been extracted over the BOUSSOLE vicarious calibration site [RD.17] from both 250 m and 1 km resolution products. This site should be stable and so it's expected to see only small variations in the spectra.

5.2.1 Methods and Data

Files were downloaded manually from JAXA's G-Portal [RD.7]. The datafiles (GCOM-C filenames and times extracted from inside the HDF files) included in the comparison are from July 2020, so are v2 products:

- GC1SG1_202007061044R23909_L2SG_NWLRK_2000 1049
- GC1SG1_202007061044R23909_L2SG_NWLRQ_2000 1049
- GC1SG1_202007061048V23910_L2SG_NWLRK_2000 1053
- GC1SG1_202007061048V23910_L2SG_NWLRQ_2000 1053
- GC1SG1_202007151010D22510_L2SG_NWLRK_2000 1014
- GC1SG1_202007151010D22510_L2SG_NWLRQ_2000 1014
- GC1SG1_202007211051N23910_L2SG_NWLRQ_2000 1056
- GC1SG1_202007261018T22810_L2SG_NWLRK_2000 1023

K and Q in the filename after NWLR indicate the 1 km and 250 m resolution products, respectively.

Extracting the spectra required generating a Jupyter notebook that read in the HDF files, calculate the position of the BOUSSOLE site using the Latitude and Longitude arrays and then extracted the values using a kernel (3 by 3 pixels) from the individual band arrays. If the central kernel pixel had no valid data, then that file was ignored.

Table 5-1: Definition of the QA flags from [RD.15]

Bit	Name	Description	Criterion	Mask
0	DATAMISS	No observation data in one or more band[s]		L2
1	LAND	Land pixel		L2
2	ATMFAIL	Atmospheric correction failure		L2
3	CLDICE	Apparent cloud/ice (high reflectance)	$\rho_A > 0.04$	L2
4	CLDAFFCTD	Cloud-affected (near-cloud or thin/sub-pixel cloud)	$\rho_A > 0.03$	L3
5	STRAYLIGHT	Stray light anticipated (ref. L1B stray light flags & image)		
6	HIGLITN	High sun glint predicted (atmospheric corr. abandoned)	$[\rho_G]_N > 0.02$	L2
7	MODGLINT	High sun glint predicted (atmospheric corr. abandoned)	$[\rho_G]_N > 0.005$	L3
8	HIOSOLZ	Solar zenith larger than threshold	$\theta_0 > 70°$	L3
9	HITAUA	Aerosol optical thickness larger than threshold	$\tau_A > 0.5$	
10	GAMMA-OUT	Atmospheric correction warning: Gamma out-of-bounds		
11	OVERITER	Maximum iterations reached for NIR correction		
12	NEGNLW	Negative nLw in one or more bands		
13	HIGHWS	Surface wind speed higher than threshold	W/S > 12m/s	
14	ATM-METHOD	NIR atmospheric correction: 0, SWIR atmospheric correction: 1		
15	SPARE	Spare		

5.2.2 Results

Figure 5-3 shows the extracted July 2020 NWLR spectra for the BOUSSOLE vicarious calibration site. The spectra have the expected shape for this site and are showing similar values for the dates where we have extracted spectra from both the 250 m and 1 km resolution products.

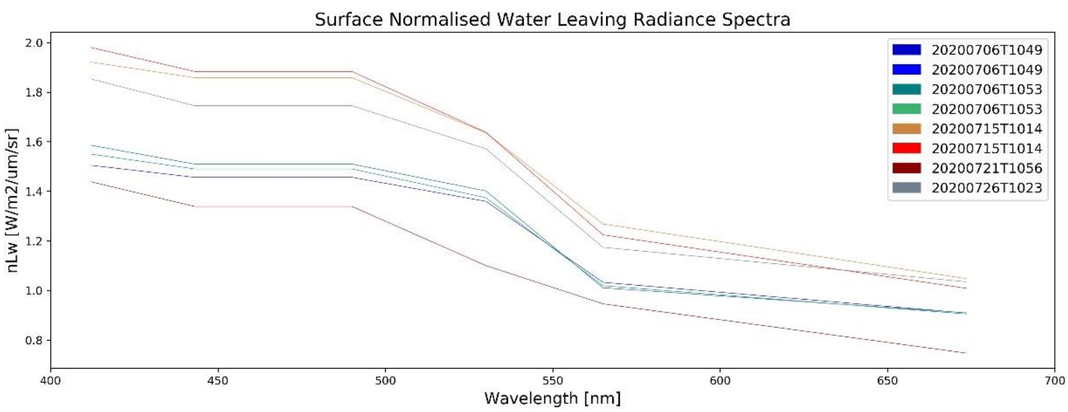


Figure 5-3: Normalised water leaving radiance spectra for BOUSSOLE for July 2020

The GCOM-C team NWLR results [RD.17] for v2 are shown in Figure 5-4, which includes many more points than Figure 5-3. It shows that the standard accuracy is not achieved for 670 nm but is achieved or exceeded (target accuracy) for the other bands.

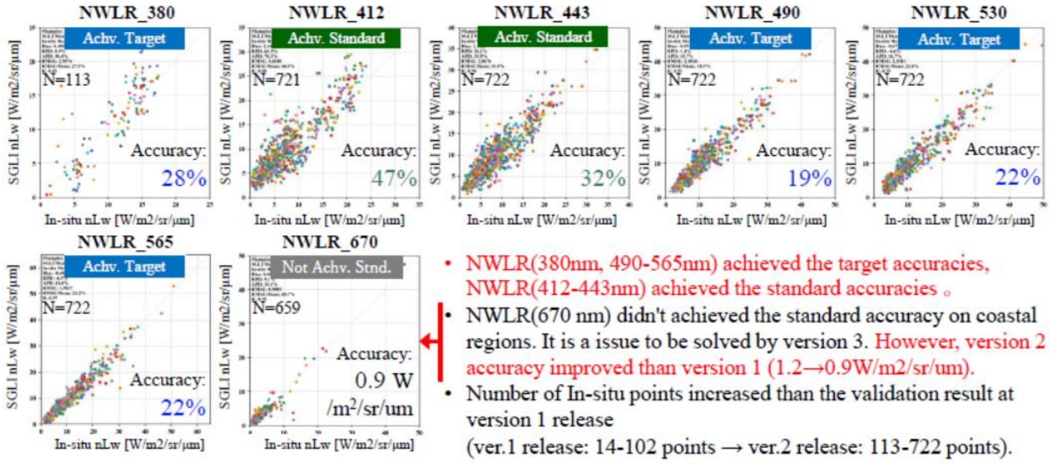


Figure 5-4: GCOM-C RSRF validation for v2 [RD.17]

6. CONCLUSIONS

The conclusions of the EDAP analysis of the Land and Ocean products are:

- Land:
    - The image quality analysis demonstrated that the Land products are stored as tiles in a cartesian (sinusoidal) grid projection. The choice of this tile approach, as used for other missions such as Sentinel-2, makes it straightforward to identify files of interest as a specific geographic location will always be in the same tile. However, that tile may not have full overpass coverage.
    - Inside the HDF file, the different products are held as individual arrays with arrays for the geometric and time information plus QA flags. At this stage, SNAP does not recognise the GCOM-C specific HDF format. It is possible to load and view the data, but the QA band is not recognised, and the individual wavebands are not understood such that spectral plots can be generated.
    - The EDAP validation of the radiometric calibration focused on the BOA reflectance data as the JAXA lead team have already undertaken extensive work on the TOA radiometric calibration. Using the BOA data allowed us to assess both the calibration and performance of the atmospheric correction. The results from independently comparing the RadCalNet data at La Crau with the GCOM-C RSRF provided results that agreed with the JAXA results for the TOA GCOM-C v1 data. There is some variability with v1, compared to RadCalNet, that is likely to be the result of artefacts that have now been corrected for in v2. However, the BOA v2 product is still maturing and so will need assessment once it has reached stability. The TOA v2 product shows improved results for the JAXA led GCOM results, and so the focus will be the improvement carried through the atmospheric correction.
    - Validation of the geometric calibration also confirmed the reported JAXA led results. The EDAP results showed consistency to the pixel level when comparing a v1 to v2 product.
- Ocean:
    - The image quality analysis demonstrated that the Ocean products are stored in a geographic projection – L1B satellite projection – with filenames that include a path and scene reference. Inside the HDF file, the different products are held as individual arrays with arrays for the geometric and time information plus QA flags. As with the Land Products, SNAP does not recognise the GCOM-C format, and so although it is possible to view the data, the QA band is not recognised. Also, the individual wavebands are not understood such that spectral plots can be generated.
    - The validation of the radiometric calibration focused on extracting and plotting BOA normalised water-leaving radiance data as again there has already been extensive work by the JAXA lead team; in this case, the JAXA results shown are the BOA analysis. The results from independently plotting this data showed the consistency of the product in terms of the spectra being consistent between the 250 m and 1 km resolution products and over the timescale analysed (July 2020).
- Overall:
    - The GCOM-C products have extensive documentation, as demonstrated by the analysis performed as part of this report and EDAP Task 4 Maturity Matrix assessment [RD.1].
    - Following the documentation has allowed EDAP to perform independent analysis; there was sufficient information to write Jupyter notebooks (Python code) to read the products and produce the comparisons. Also, the provided JAXA team validation results allowed us to compare our smaller-scale findings to theirs and hence reach an agreement.

[End of Document]