



Technical Note on Quality Assessment for OceanSat-2 OCM (Quarterly report for Q1 2019)

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1. INTRODUCTION

This document is the Q1 2019 (February 2019 – April 2019) quarterly Quality Assessment (QA) report for the latest Ocean Colour Monitor (OCM) instrument, OCM-2, on-board the Indian satellite, OceanSat-2.

This QA provides a series of product checks, using a sample of OCM-2 products retrieved through ESA's *Online Dissemination* service, that relate to product format consistency as well as product content consistency and quality. This QA also provides a derivation of product quality statistics.

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] Oceansat-2 Quarterly Report No.1, IDEAS+-VEG-OQC-REP-2655, Issue 1.0, 5 December 2016.
- [RD.2] EDAP Mission Quality Assessment Guidelines, Issue 1.0, 23 April 2019
- [RD.3] Oceansat-2 Quarterly Report No.5, IDEAS+-VEG-OQC-REP-2892, Issue 1.0, December 2017.
- [RD.4] EO-SIP Specialisation for OceanSat-2 Mission, EMSS-EOPG-TN-15-002, Issue 1.0, 19 October 2015.
- [RD.5] Technical Note on Quality Assessment for OceanSat-2 OCM (Quarterly report for Q4 2018), EDAP.REP.004, Issue 0.2, March 2019.
- [RD.6] Natural Earth datasets, accessible at <http://www.naturalearthdata.com/>
- [RD.7] Chauhan *et al.* 2002. Surface chlorophyll a estimation in the Arabian Sea using IRS-P4 Ocean Colour Monitor (OCM) satellite data, *International Journal of Remote Sensing*, 23:8, 1663-1676, DOI: 10.1080/01431160110075866
- [RD.8] DIMITRI Software User Manual, v3.1.1, 20 February 2015
- [RD.9] Zibordi *et al.* 2009. AERONET-OC: A Network for the Validation of Ocean Color Primary Products. *J. Atmos. and Oceanic Technology*. 26: 1634-1651 (DOI:10.1175/2009JTECHO654.1).
- [RD.10] OCM-2 (OCEANSAT-2) LEVEL-2 HDF Data Products Format, v1.4, April 2017
- [RD.11] Preethi Latha *et al.* 2014. Validation of Chlorophyll-a concentrations in the Estuarine Waters of Bay of Bengal using OCM-2 Data: A case study in the Godavari basin, *J. Indian Soc. Remote Sens.*, 42(1): 129-138
- [RD.12] O'Reilly *et al.* 1998. Ocean color chlorophyll algorithms for SeaWiFS. *Journal of Geophysics*, 103: 24937–24963.
- [RD.13] Shanthi *et al.* 2013. Validation of OCM-2 sensor performance in retrieving chlorophyll and TSM along the southwest Bay of Bengal coast, *J. Earth Syst. Sci.*, 122(2): 479–489.

[RD.14] Baret *et al.* 2009. Report on the CEOS Land Product Validation Sub-group Meeting. *The Earth Observer*, 21(6): 26-30.

[RD.15] Bailey, S.W. and Werdell, P.J. 2006. A multi-sensor approach for the on-orbit validation of ocean color satellite data products. *Rem. Sens. Environ.*, 102: 12-23.

1.2 Glossary

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

aod	aerosol optical depth
ATBD	Algorithm Theoretical Basis Document
BOA	Bottom of Atmosphere
CEOS	Committee for Earth Observation Satellites
clo	Chlorophyll-a concentration
dac	depth attenuation coefficient
DIMITRI	Database for Imaging Multi-spectral Instruments and Tools for Radiometric Intercomparison
GAC	Global Area Coverage
HPLC	High Performance Liquid Chromatography
L1	Level 1
L2	Level 2
LAC	Local Area Coverage
LEDs	Light-Emitting Diodes
NPL	National Physical Laboratory
OCM	Ocean Colour Monitor
PUG	Product User Guide
QA	Quality Assessment
RD	Reference Document
SSO	Single Sign-On
TOA	Top of Atmosphere
tsm	total suspended matter

2. EXECUTIVE SUMMARY

The aim has been to ensure, principally, that the format and content (i.e. radiance and geophysical data) of OCM-2 products (L1B, L2B and L2C), already available to users, are of a suitable quality.

This Quarterly QA report updates the previous reporting (No .1) to include the daily data acquired during February to April 2019; performed in accordance with the QA process and tools (e.g. QA scripts) detailed in [RD.1] and since improved upon within this report.

Going forward, within EDAP, the aim is to expand the quarterly reporting to include an:

- EDAP Quality Assessment: summary in Section 2.1 with detailed analysis in Section 3
- Improve the absolute and relative geometric assessment: not started.
- Expand the sensor comparison to include Top of Atmosphere data: started and detailed in Section 4.3.1
- Expand the in-situ comparison to a greater number of Aeronet locations alongside Boussole: detailed in Section 4.3.2

2.1 EDAP Quality Assessment

A preliminary assessment has been performed using the National Physical Laboratory (NPL) EDAP guidelines [RD.2], with the summary reported in Figure 1 and detailed analysis within Section 3. It is classed as a 'preliminary assessment' as it's the first iteration, and so feedback from ESA and NPL will be sought on the analysis and updates performed in subsequent reports.

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	Ancillary Data	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

Figure 1 – OCM-2 Quality Evaluation Matrix (preliminary assessment)

2.2 OCM-2 Detailed Assessment

For this QA period, OCM-2 products were assessed from February to the beginning of May 2019 with older products also downloaded for the new analysis in the Baltic. The Product Format Consistency Check was not repeated as the focus was on improving the Product Content Check.


The results are summarised in Table 1.

Table 1. OCM-2 January 2019 QA Summary Results

OCM-2 Product Type	Product Format Consistency Check	Product Content Check	Comment
L1B	No Issues Detected – detailed analysis in [RD.2], not reassessed for this report	N/A	-
L2B	No Issues Detected – see above, for scenes being analysed	N/A	-
L2C	No Issues Detected – see above, for scenes being analysed	Minor Issues Detected – analysed 33 new files for Path 3 Row 11 and 98 new files for Path 4 Row 10 (248 as total for both sets)	As expected, see Sections 4.2 and 4.3

3. EDAP QUALITY ASSESSMENT

3.1 Product Details (preliminary assessment)

Product Information	
Product Name	Oceansat OCM2 Level 1 (L1) Local Area Coverage (LAC) products downlinked then processed on behalf of ESA, by GAF/NSG, to Level 2 (L2)
Sensor Name	OCM2
Sensor Type	Optical – Multichannel spectrometer
Product Version Number	Not provided
Product ID	OC2_OPER_OCM2
Processing level of product	L1 B and L2 B & C
Measured Quantity Name	L1: Radiance L2: CL for Chlorophyll-a concentration; DA for Vertical Diffuse attenuation coefficient (Kd) at 490-nm; SE for Total Suspended Matter concentration; AO for Aerosol Optical Depth
Measured Quantity Units	L2 nLw: $W\ cm^{-2}\ nm^{-1}\ sr^{-1}$ L2: CL ($mg\ m^{-3}$); DA 0.01-0.50 m^{-1} ; SE 0.0-200 $mg\ L^{-1}$; AO 0.0-1.0 unitless
Stated Measurement Quality	Not provided
Spatial Resolution	L1 A & B: 360 by 236 m L2 C: 360 by 360 m
Spatial Coverage	GAF receiving station: 
Temporal Resolution	Daily
Temporal Coverage	October 2015 onwards
Mission coverage	Global
Point of Contact	ESA Helpdesk
Product locator (DOI/URL)	ESA: https://tpm-ds.eo.esa.int/oads/access/collection/OceanSat2 Space Applications Centre, India: https://mosdac.gov.in/data/Missions/oceansat/oscac_home.jsp Global Area Coverage (GAC) available free of charge, with LAC charged for.

Conditions for access and use	ESA Single Sign-On (SSO) account
Limitations on public access	Registration with ESA
Product Abstract	N/A

Product Availability & Accessibility	
Compliant with FAIR principles	ESA archive is available for download after registration
Data Management Plan	Not available to users
Availability Status	Near-Real-Time availability within the ESA archive

Product Format	
Product File Format	HDF
Metadata Conventions	Metadata file provided (filename.meta within product directory) – list of parameters detail in the product specification documents
Analysis Ready Data?	Yes – L2C

Product User Documentation		
Document	Reference	QA4ECV Compliant
Product User Guide (PUG)	<ul style="list-style-type: none"> OceanSat-2-Level-1-Product-Specifications, Ver. 1.1, Jun 2010 OceanSat-2-Level-2-Product-Specifications, Ver. 1.4, Apr. 2017 PDF on IOCCG website: www.ioccg.org/sensors/OCM-2.pdf 	N/A
Algorithm Theoretical Basis Document (ATBD)	Not publicly available, but peer-reviewed papers are published, see Section 3.2	N/A

Product Traceability	
Document Reference	Error budget mentioned from Sriperambudur et al. (2015) http://dx.doi.org/10.4236/ojms.2015.54035
Traceability Chain / Uncertainty Tree Diagram Available	Level 1: not provided Level 2: <ul style="list-style-type: none"> Normalized water leaving radiance (nLw) < 5% - not provided as a product CL < 30%; DA < 15%; SE < 20%; AO < 20%

3.2 Product Generation (preliminary assessment)

Sensor Calibration & Characterisation – Pre-Flight	
Summary	Sensor characterisation: spatial and radiometric
References	<ul style="list-style-type: none"> Pre-launch calibration & Post-launch performance, May 2013 https://iocs.ioccg.org/wp-content/uploads/1450-samir-pal-ocm-2.pdf

Sensor Calibration & Characterisation – Post-Launch	
Summary	Sensor characterisation includes: <ul style="list-style-type: none"> On-board calibration using Light-Emitting Diodes (LEDs) Vicarious calibration using an oceanographic buoy Lunar calibration Spatial and radiometric Image based characterization system
References	<ul style="list-style-type: none"> Pre-launch calibration & Post-launch performance, May 2013 https://iocs.ioccg.org/wp-content/uploads/1450-samir-pal-ocm-2.pdf Post-launch calibration of Ocean Colour Monitor 2 using Kavaratti CAL-VAL site observations, Jan 2013 https://www.currentscience.ac.in/Volumes/104/01/0023.pdf Update of post launch vicarious, lunar calibrations & current status, June 2015 https://iocs.ioccg.org/2015/files/THU-935-BO9-Chauhan-Calibration.pdf Cross-calibration of the Oceansat-2 Ocean Colour Monitor (OCM) with Terra and Aqua MODIS, May 2016, https://doi.org/10.1117/12.2224046

Retrieval Algorithm Method (Include for Level 2 Products Only)	
Summary	ATBD is not made publicly available, processor Sriperambudur et al. (2015) lists SeaDAS (https://seadas.gsfc.nasa.gov/) as the process for HDF files
References	<ul style="list-style-type: none"> Sriperambudur et al. (2015) http://dx.doi.org/10.4236/ojms.2015.54035 -

Retrieval Algorithm Tuning (Include for Level 2 Products Only)	
Summary	N/A
References	N/A

Additional Processing	
<i>Additional Processing 1</i>	
Description	N/A
Reference	N/A
<i>Additional Processing 2</i>	
Description	N/A
Reference	N/A

3.3 Ancillary Information (preliminary assessment)

Product Flags	
Product Flag Documentation	OceanSat-2-Level-2-Product-Specifications, Ver. 1.4, Apr. 2017
Comprehensiveness of Flags	Section 5.1.8, L2 Flag Data Group – brief description of the L2 product flags

Ancillary Data	
Ancillary Data Documentation	None provided
Comprehensiveness of Data	N/A
Uncertainty Quantified	N/A

3.4 Uncertainty Characterisation (not assessed in this version)

Uncertainty Characterisation Method	
Summary	N/A
Reference	N/A

Uncertainty Sources Included	
Summary	N/A
Reference	N/A

Uncertainty Values Provided	
Summary	N/A
Reference	N/A
Analysis Ready Data?	N/A

Geolocation Uncertainty	
Summary	N/A
Reference	N/A

3.5 Validation (preliminary assessment)

Validation Activity #1	
Independently Assessed?	Yes – within this report for the derived L2 Chlorophyll-a product
<i>Reference Data Representativeness</i>	
Summary	For this report, we have used data from two AERONET-OC stations and BOUSSOLE with further expansion expected in future iterations. Other, referenced, papers have used cruise measurements.
Reference	Section 4.3.2
<i>Reference Data Quality & Suitability</i>	
Summary	The AERONET-OC stations and BOUSSOLE have known origins while the data quality of the reference data used within the cited peer-reviewed papers is less quantifiable; one paper uses fluorometrically derived Chlorophyll while the other is based on High Performance Liquid Chromatography (HPLC).
Reference	Section 4.3.2
<i>Validation Method</i>	
Summary	Follows the marine approach that is defined in [RD.15]
Reference	Section 4.3.2
<i>Validation Results</i>	
Summary	Simple plots at this stage.
Reference	Section 4.3.2

4. DETAILED OCM-2 ASSESSMENT

This QA is performed using a sample of OCM-2 L1B (local area coverage radiance products), L2B (local area coverage products as four geophysical parameters: Chlorophyll-a concentration (**clo**), aerosol optical depth (**aod**), total suspended matter (**tsm**) and depth attenuation coefficient (**dac**)) and L2C (local area coverage geo-referenced products as four geophysical parameters) products that have been downloaded for all scenes (i.e. all tracks and frames) applicable to a selection of dates between the 01 January 2018 and 01 May 2019 (dates chosen within this reporting period, based on presence of reduced cloud cover).

4.1 Product Format Consistency Checks

At this stage of the QA process, product format consistency checks are performed on the retrieved OCM-2 products in order to ensure that, as far as possible, the correct input files were used in the relevant processing stage(s) and that the product format conforms to the format defined in the *EO-SIP Specialisation for OceanSat-2 Mission* document [RD.4].

4.1.1 Product Format Consistency Check Results

For the format consistency check*, a total of 549 OCM-2 products were checked previously (Table 2), and all were shown to have used the correct input files and be of the correct product format; see Table 2. For the previous period [RD.5], a couple of additional files (30th and 31st August 2018) were checked for the period since December 2017 to ensure nothing had changed.

Table 2. OCM-2 EO-SIP Consistency Check [RD.2]

OCM-2 Product Type	Product SIP Information File	Product Metadata File	Product HDF File**
L1B	183/183	183/183	N/A
L2B	183/183	183/183	N/A
L2C	183/183	183/183	183/183

*The consistency check does not include checking for the existence of a QL/browse image (.png file).

**The consistency check for each L2C product includes an additional check of the HDF files found, and their validity, within the (further zipped) product folder.

4.2 Product Content Checks

At this stage of the QA process, product content checks are performed. These checks are performed, using both the QLs and GeoTIFFs (to produce daily composites) provided

by the OCM-2 L2C products retrieved, in order to visually assess product content (i.e. radiance and geophysical data) in terms of consistency and quality.

4.2.1 Product Content Check Results

A selection of QLs, associated with the OCM-2 L2C products retrieved for this reporting period, are shown in Figure 2; it is important to note that the Chlorophyll-a concentration values provided in these QLs are restricted by a pre-specified range (i.e. $0 \leq clo \leq 5$ mg.m⁻³) and not the true range. Therefore, consistency and quality assessments on Chlorophyll-a concentration values cannot be accurately performed using the QLs alone.

The aforementioned consistency and quality assessments on Chlorophyll-a concentration values are best performed using the Chlorophyll-a concentration composites (which do not enforce a pre-specified range and, usefully, include the use of a Natural Earth [RD.6] vector coastline layer at 50m resolution) generated for this assessment (shown in Figure 4 and Figure 5). As expected, poor Chlorophyll-a concentration estimations are seen to dominate high latitude regions where radiance retrievals are impacted largely by the high solar zenith angles. Improved Chlorophyll-a concentration estimations are seen to dominate the lower latitude regions (i.e. lower solar zenith angles), and overall the OCM-2 composites are comparable to the estimations derived from the ocean colour products produced by NASA's MODIS-Aqua and VIIRS sensors (see Figure 6 and Figure 7). Note: inaccurately estimated OCM-2 Chlorophyll-a concentrations also dominate those regions which are occupied by dense cloud cover, coastlines and turbid coastal waters; as expected when using an 'open ocean' band ratio algorithm, e.g. [RD.7].

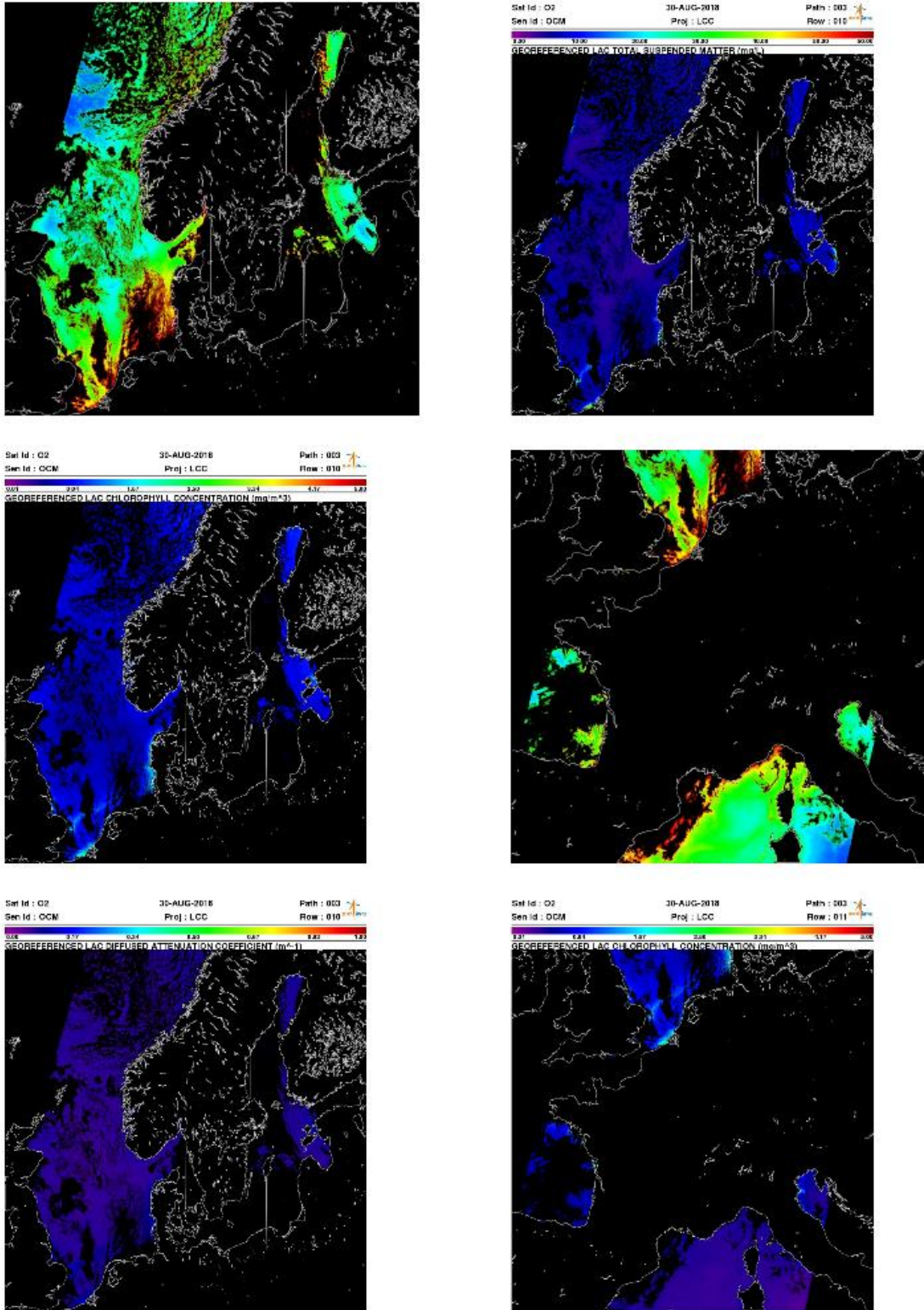


Figure 2. A sample of Chlorophyll-a concentration OCM-2 QLs for the 30th August 2018 Path 3 Row 10.

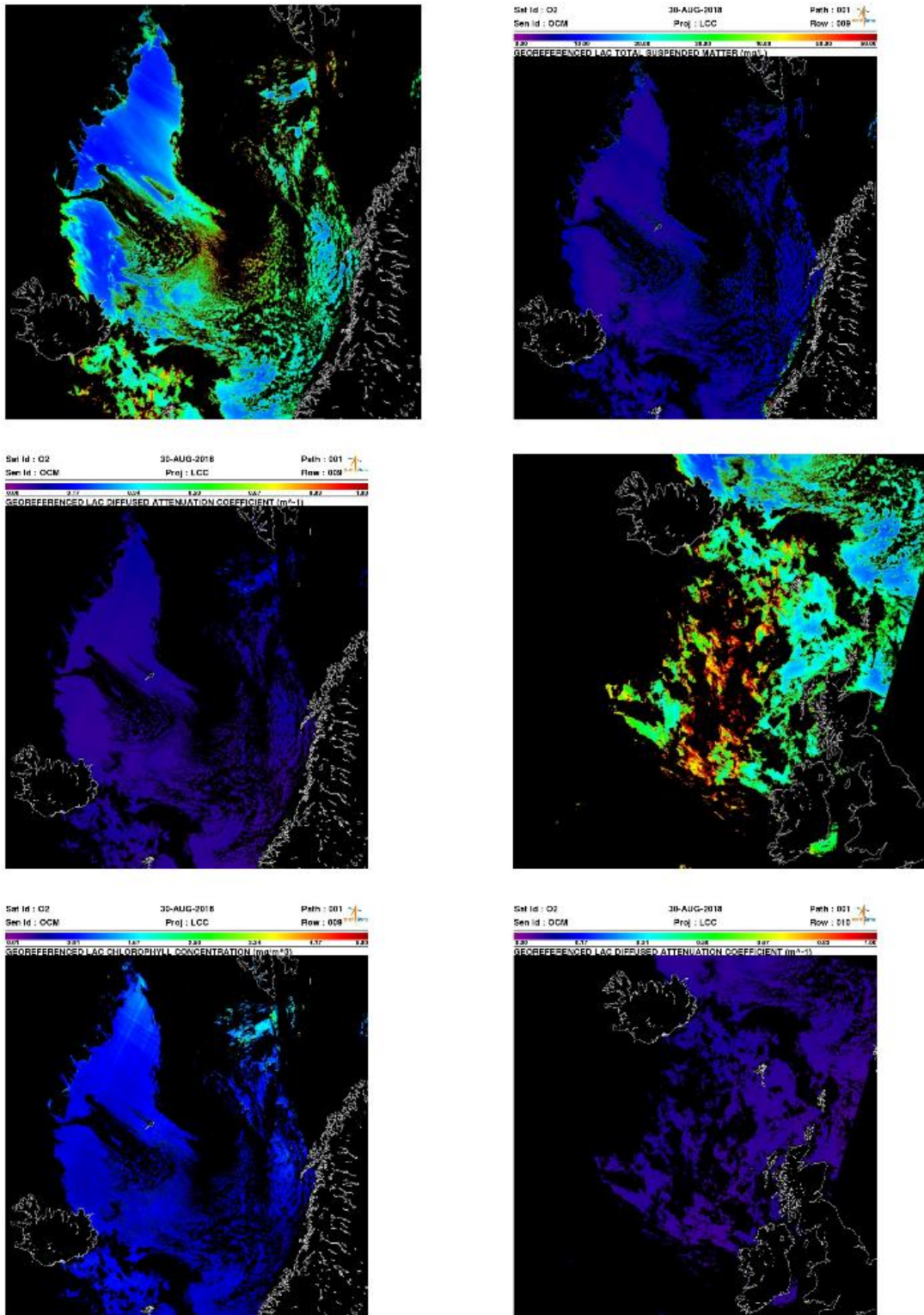


Figure 3. A sample of Chlorophyll-a concentration OCM-2 QLs for the 30th August 2018 Path 1 Row 9.

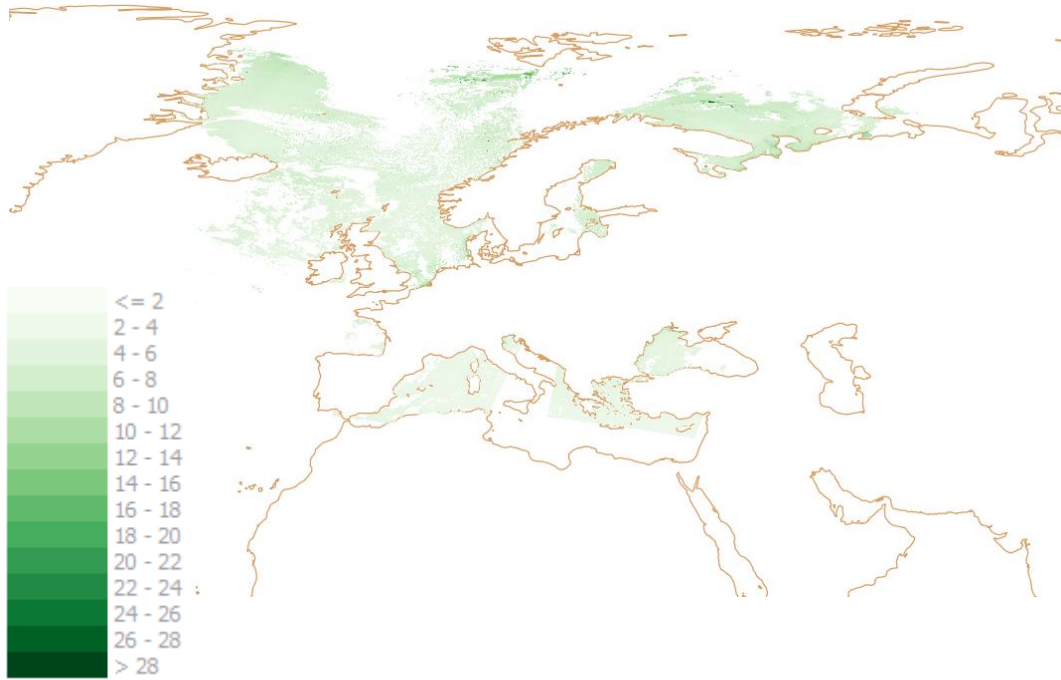


Figure 4. A snapshot from QGIS showing the daily Chlorophyll-a composite using data from 30th August 2018.

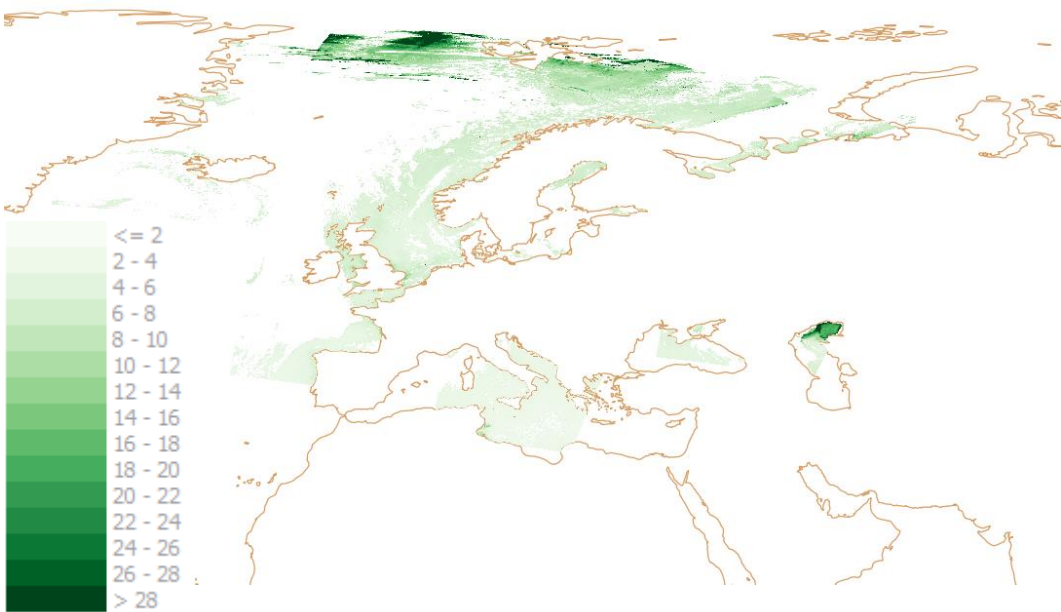


Figure 5. A snapshot from QGIS showing the daily Chlorophyll-a composite using data from 31st August 2018.

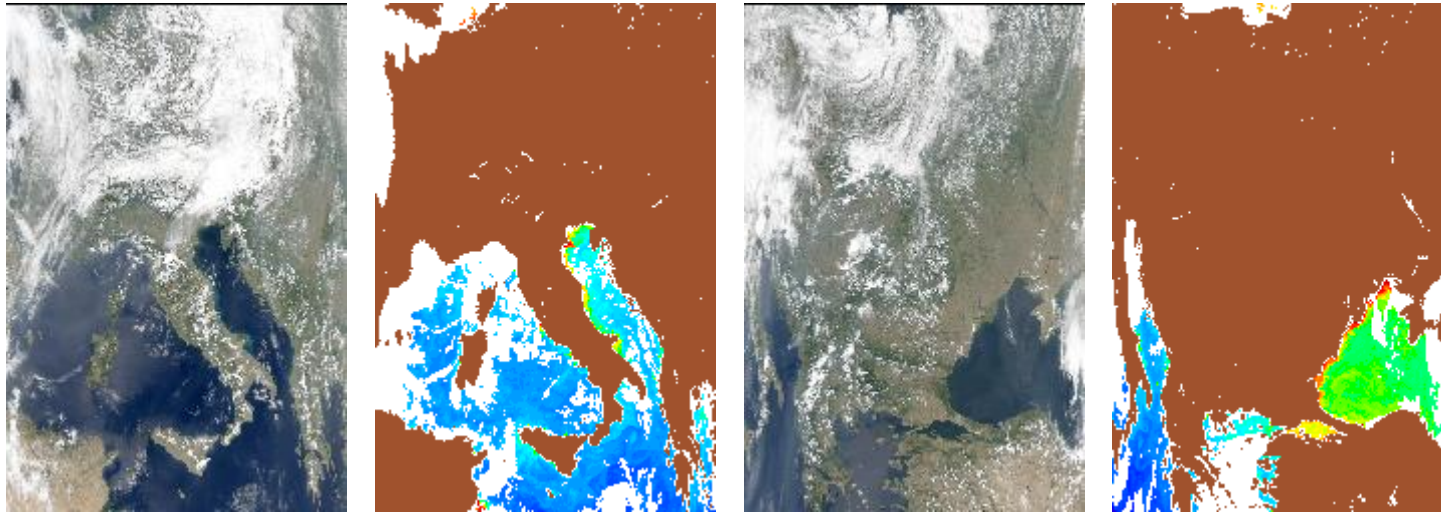


Figure 6. MODIS-Aqua Chlorophyll-a products from the 30th and 31st August 2018 (left to right, respectively) as the true colour composite and then chlorophyll product.

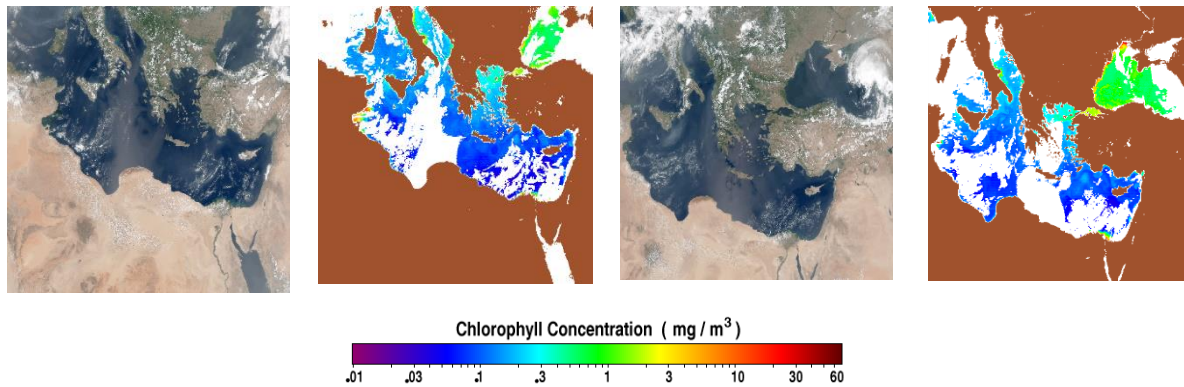


Figure 7. Suomi-NPP VIIRS Chlorophyll-a products from the 30th and 31st August 2018 (left to right, respectively) as the true colour composite and then chlorophyll product.

4.3 Product Quality Assessment

4.3.1 Top of Atmosphere DIMITRI Assessment

Initial activities have started related to expanding the sensor comparison to include Top of Atmosphere (TOA), through the Database for Imaging Multi-spectral Instruments and Tools for Radiometric Intercomparison (DIMITRI) software [RD.8]. The software has been received from ARGANS and is being updated to a newer version of IDL with OceanSat-2 data to be included.

4.3.2 Level 2 Product Validation

A Python script was developed to produce product quality statistics for inclusion in these quarterly OCM-2 QA reports; in this report the time-series has been expanded to include February 2019 onwards with historical data also processed for the newly included Gustav Dalen AERONET location in the Baltic. As described by [RD.9], the AERONET-OC network consists of globally distributed autonomous radiometer systems maintained at fixed offshore sites.

The script extracts a point of interest from a set of supplied L2C OCM-2 products, with the plot showing time-series values that correspond to the mean and standard deviation of the point of interest specified (a kernel that is three by three pixels in size and is centred on the supplied latitude/longitude).

For Figure 8, 150 products were analysed for the period from 3rd January 2017 to 1st May 2019 (33 new products from February to the start of May 2019); the values shown in correspond to the location of the AERONET-OC Acqua Alta Oceanographic Tower. The OCM-2 Chlorophyll-a (clo) concentration and Aerosol Optical Depth (aod) for each chosen date (appeared cloud free) have been plotted. In addition, the plot shows AERONET-OC (*in-situ* sensor) estimated Chlorophyll-a values; provided as part of the AERONET-OC dataset.

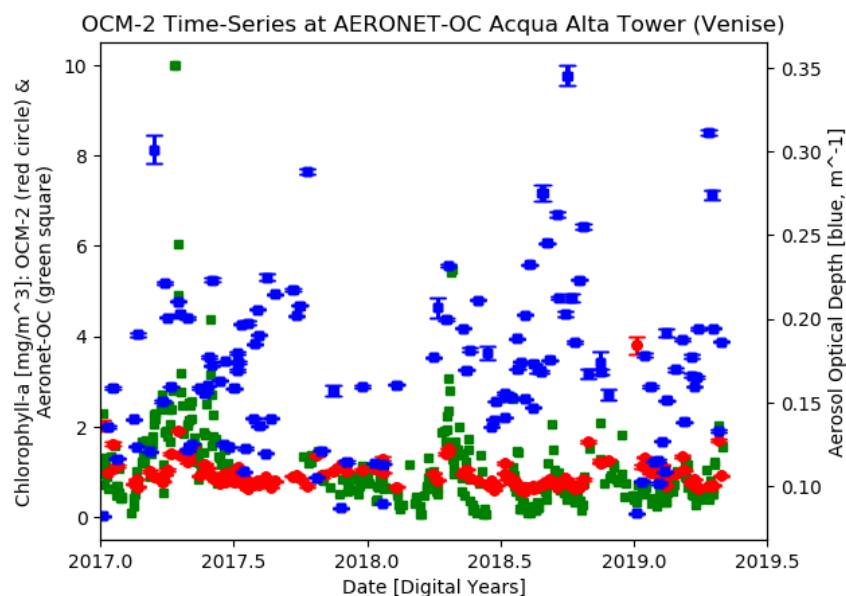


Figure 8. Time-series plot of the OCM-2 Chlorophyll-a (clo) and Aerosol Optical Depth

(aod) products extracted from the Level 2C files, and AERONET-OC estimated Chlorophyll-a for the location of the AERONET-OC Acqua Alta Oceanographic Tower; data courtesy of AERONET website¹/Giuseppe Zibordi.

Additional plots have now also been produced for Gustav Dalen (**Figure 9**) and BOUSOLLE (**Figure 10**). BOUSOLLE uses the same path and row as the Acqua Alta Oceanographic Tower, while Gustav Dalen uses Path 4 Row 10. Ninety-six scenes were downloaded for 2017 and 2018, to overlap with available AERONET-OC data, as Gustav Dalen operates during the summer months (May to September).

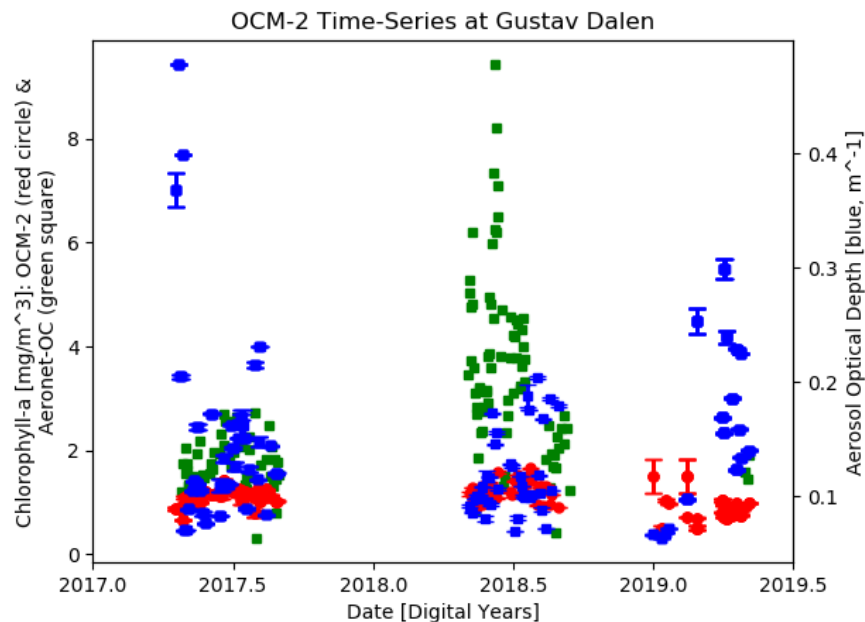


Figure 9. Time-series plot of the OCM-2 Chlorophyll-a (and Aerosol Optical Depth from the Level 2C files, and AERONET-OC estimated Chlorophyll-a for the Gustav Dalen Tower; data courtesy of AERONET website/Giuseppe Zibordi.

BOUSOLLE is a data buoy rather than AERONET-OC station and so the in-situ data needs to be acquired via another route, and this is currently on-going.

¹https://aeronet.gsfc.nasa.gov/cgi-bin/type_one_station_seaprism_new?site=Venise&nachal=0&year=25&aero_water=0&level=1&if_day=0&if_err=0&year_or_month=1

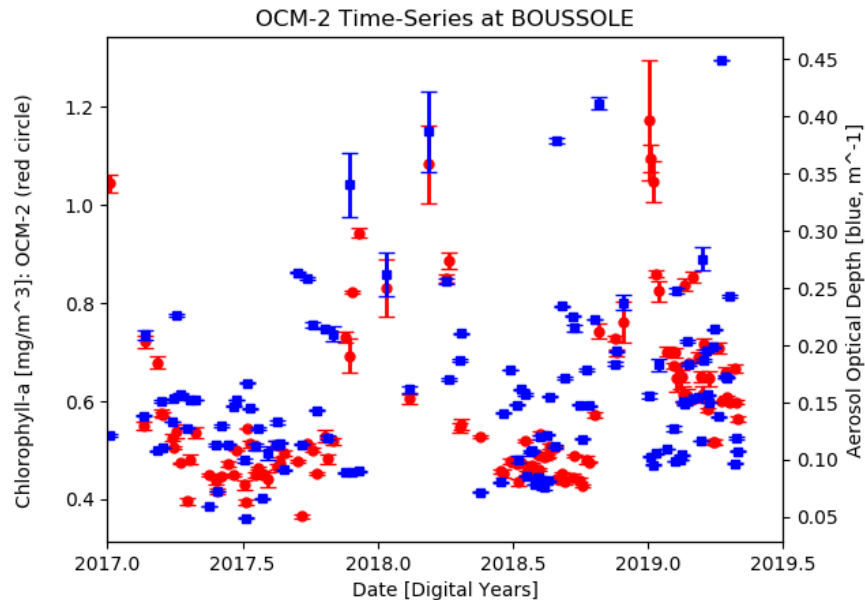


Figure 10. Time-series plot of the OCM-2 Chlorophyll-a and Aerosol Optical Depth from the Level 2C files, for the location of BOUSSOLE.

There are several sources of uncertainty, e.g. the AERONET-OC bands are not the same as the OCM-2 bands. However, overall, the plots for both the Acqua Alta Oceanographic Tower and Gustav Dalen show that the AERONET-OC estimated Chlorophyll-a concentrations are significantly higher than the OCM-2 estimates, which could mean that the OCM-2 output is underrepresenting the natural phytoplankton variability.

4.4 CONCLUSION

The conclusions from this Quality Assessment for OceanSat-2 OCM report (Quarterly report for Q1 2019) are:

- **No specific issues have been detected for the L1B or L2B products:** at this stage they have been checked in terms of product format consistency rather than scientific data quality; although it is acknowledged the L1 quality will have an impact on the L2 analysis and so needs to be analysed going forward.
- **L2C: No Issues have been detected with the product format consistency with minor issues detected for the product content:**
 - As expected, poor Chlorophyll-a concentration estimations are seen to dominate high latitude regions where radiance retrievals are impacted largely by high solar zenith angles not correctly accounted for within the atmospheric correction; acknowledged as an issue within version 1.4 of the L2 Product Spec [RD.10].
 - Inaccurately estimated OCM-2 Chlorophyll-a concentrations also dominate in those regions with dense cloud cover, coastlines and turbid coastal waters – a combination of cloud pixels not masked, or pixels affected by nearby clouds alongside a simplistic (band ratio) algorithm that doesn't account for changes in the water reflectance due to components other than Chlorophyll-a. Overestimating chlorophyll-a in complex Case 2 waters was noted by Preethi Latha et al. (2014) [RD.11] where OCM-2 L2 LAC data was processed using SeaDAS and chlorophyll algorithms like OC2 and OC4-V4 O'Rielly et al. (1998) [RD.12].

- The Product Quality Assessment analysed 202 products across 3 sites. There are several sources of uncertainty but, overall, the OCM-2 Chlorophyll-a concentration product appears to be underrepresenting the natural phytoplankton variability. It is difficult to assess the cause as the L2 Bottom of Atmosphere (**BOA**) radiance/reflectance product is not provided as part of the L2C product, but by increasing this analysis to a greater number of locations in future reports we'll be able to provide statistical comparison details. Lower chlorophyll estimates, than expected in open ocean waters, were reported by Shanthi *et al.* (2013) [RD.13] where cloud free L2 processed OCM data covering the southwest Bay of Bengal demonstrated underestimates for high (in-situ) chlorophyll concentrations and overestimates the low (in-situ) chlorophyll concentrations.

These findings potentially limit the applicability of the Oceansat-2 data in terms of it being classed as a 'Climate Quality' dataset. However, the derived biogeochemical products are comparable to a number of other ocean colour missions and so are of value to more operational applications.

Going forward, within EDAP, the aim is to continue to expand the quarterly reporting to include a more in-depth analysis of the product quality:

- Improve the assessment of the absolute and relative geometric accuracy: on hold until the DIMITRI code is running.
- Expand the sensor comparison to include TOA data: DIMITRI is now available and is being updated to handle OceanSat-2.
- Expand the in-situ comparison to a greater number of AERONET locations Boussole and Gustav Dalen have been included as new sites within this report.

An increased number of in-situ validation points will allow us to reach the Committee for Earth Observation Satellites (**CEOS**) Land Product Validation Sub-group Stage 1 Validation, where product accuracy is assessed from a small (typically < 30) set of locations and time periods by comparison with in-situ or other suitable reference data [RD.14]. The validation approach will continue to follow the marine approach that defined in [RD.15].