Technical Note on Quality Assessment for OceanSat-2 OCM (Quarterly report for Q4 2018)

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AMENDMENT RECORD SHEET

The Amendment Record Sheet below records the history and issue status of this document.

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0.2	14/02/19	First EDAP version (Report No. 1)
1.0	22/03/19	First issue after ESA feedback

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1. INTRODUCTION

This document is the Q4 2018 (November 2018 – January 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] Oceansat-2 Quarterly Report No.5, IDEAS+-VEG-OQC-REP-2892, Issue 1.0, December 2017.

[RD.3] EO-SIP Specialisation for OceanSat-2 Mission, EMSS-EOPG-TN-15-002, Issue 1.0 0, 19 October 2015.

[RD.4] Natural Earth datasets, accessible at http://www.naturalearthdata.com/

[RD.5] P. Chauhan, M. Mohan, R. K. Sarngi, B. Kumari, S. Nayak & S. G. P. Matondkar (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.6] Zibordi, G., Holben, B., Slutsker, I., Giles, G., D'Alimonte, D., Melin, F., Berthon, J. F., Vandemark, D., Feng, H., Schuster, G., Fabbri, B. E., Kaitala, S., and Seppala, J. 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.7] Baret F., Nightingale J. Garrigues S., Justice C., Nickeson J. 2009. Report on the CEOS Land Product Validation Sub-group Meeting. *The Earth Observer*. Vol 21, 6, 26-30.

[RD.8] 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
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
OCM	Ocean Colour Monitor
QA	Quality Assessment
RD	Reference Document
TOA	Top of Atmosphere
tsm	total suspended matter

2. EXECUTIVE SUMMARY

This Quarterly QA report updates the previous reporting (under IDEAS+) to include the daily data acquired in 2018 and January 2019; performed in accordance with the QA process and tools (e.g. QA scripts) detailed in [RD.1]. 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.

For this QA period, OCM-2 products were assessed from the full 2018 and January 2019, and 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] and a couple additional scenes for the period since December 2017 (30^{th} & 31^{st} August 2018)	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 55 new files (130 total) for Path 3 Row 11	As expected, see Sections 3.2 and 3.3

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

- Improve the absolute and relative geometric assessment.
- Expand the sensor comparison to include Top of Atmosphere data, through the DIMITRI that does not include OceanSat-2 data but does include missions (such as Sentinel-3 OLCI) that it should be compared to.
- Expand the in-situ comparison to a greater number of AERONET locations, alongside Boussole and MOBY (international vicarious calibration sites) and potentially other sites.

3. 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 31 January 2019 (dates chosen within this reporting period, based on presence of reduced cloud cover).

3.1 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.3].

3.1.1 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 this period, 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.*

3.2 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.

3.2.1 Product Content Check Results

A selection of QLs, associated with the OCM-2 L2C products retrieved for this reporting period, are shown in Figure 1; 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.4] vector coastline layer at 50m resolution) generated for this assessment (shown in Figure 3 and Figure 4). 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 5 and Figure 6). 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.5].

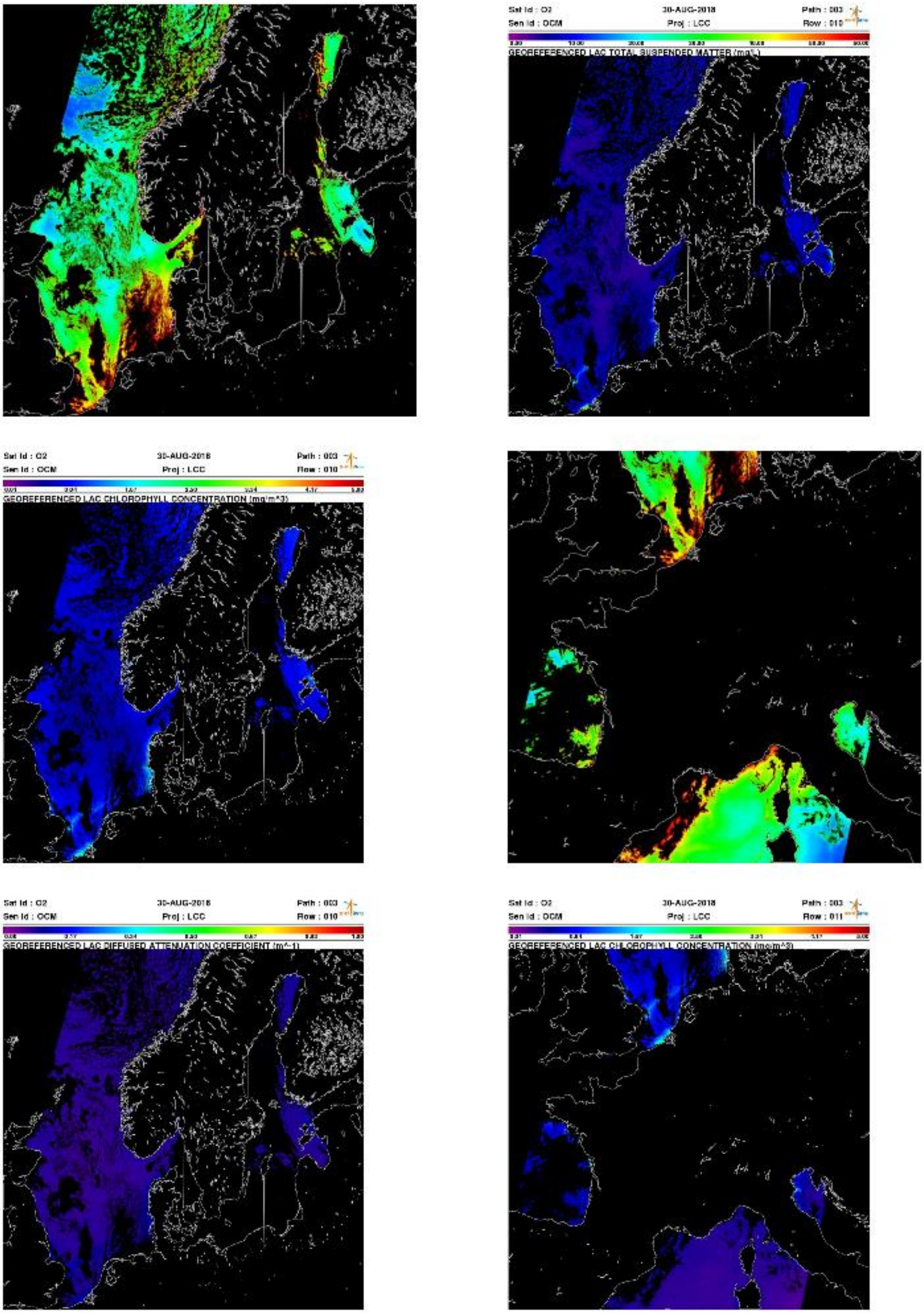

Figure 1. A sample of Chlorophyll-a concentration OCM-2 QLs for the 30th August 2018 Path 3 Row 10.

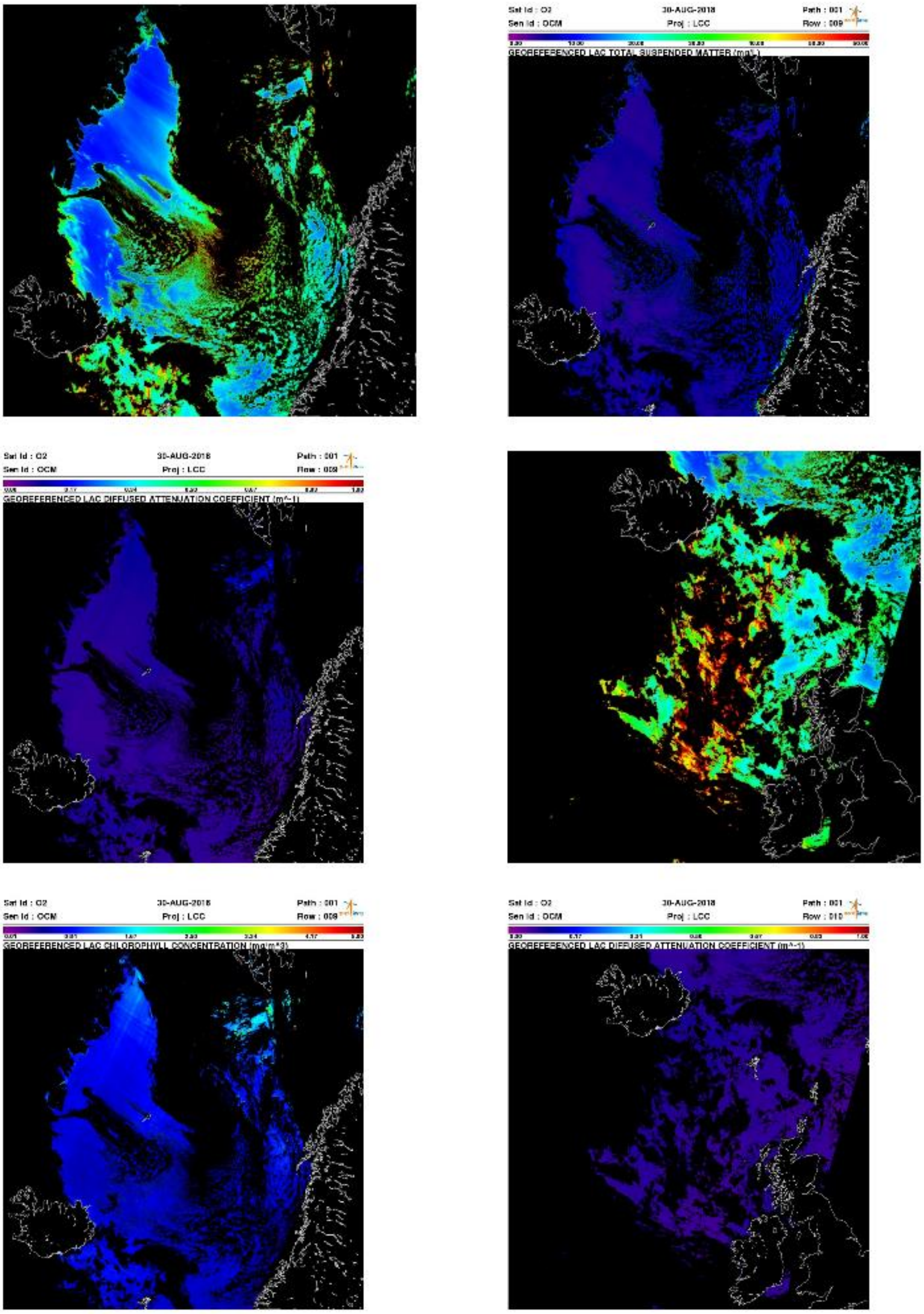

Figure 2. A sample of Chlorophyll-a concentration OCM-2 QLs for the 30th August 2018 Path 1 Row 9.

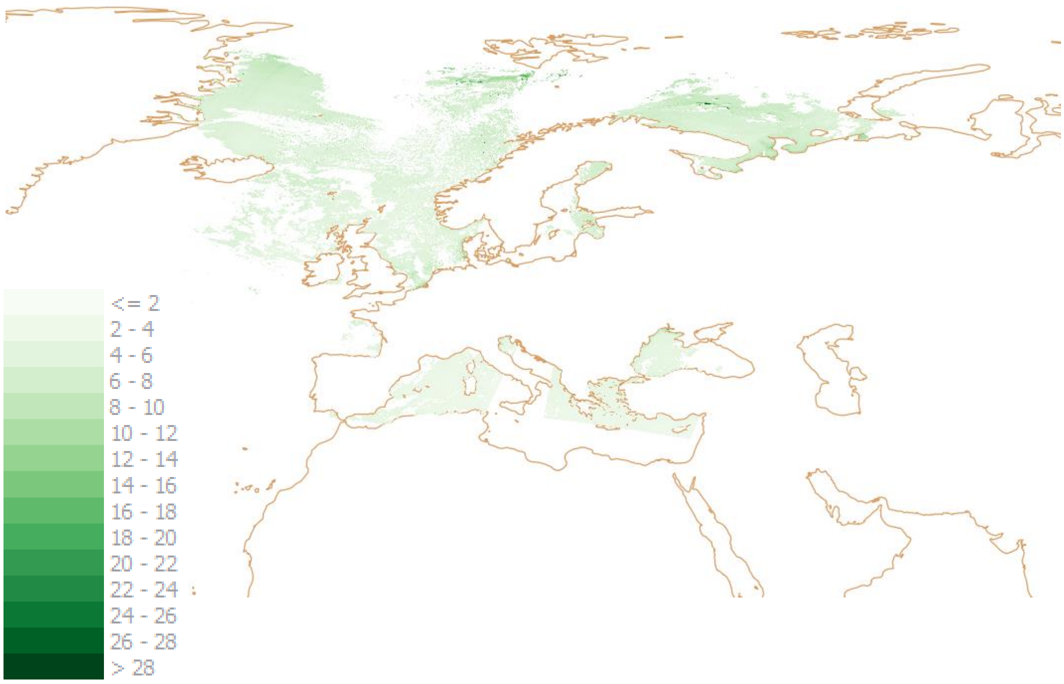

Figure 3. A snapshot from QGIS showing the daily Chlorophyll-a composite using data from 30th August 2018.

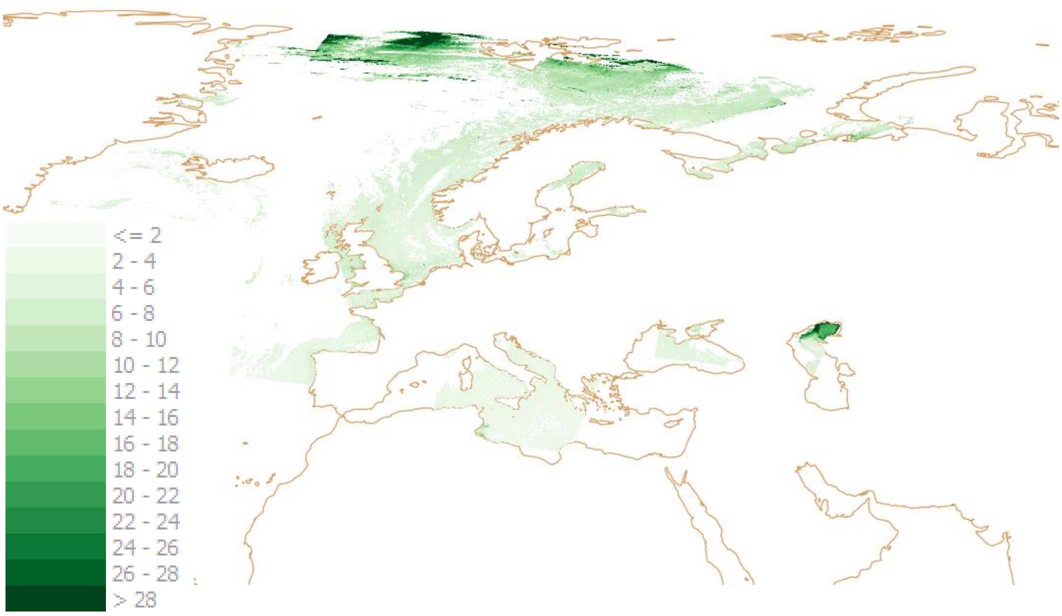

Figure 4. A snapshot from QGIS showing the daily Chlorophyll-a composite using data from 31st August 2018.

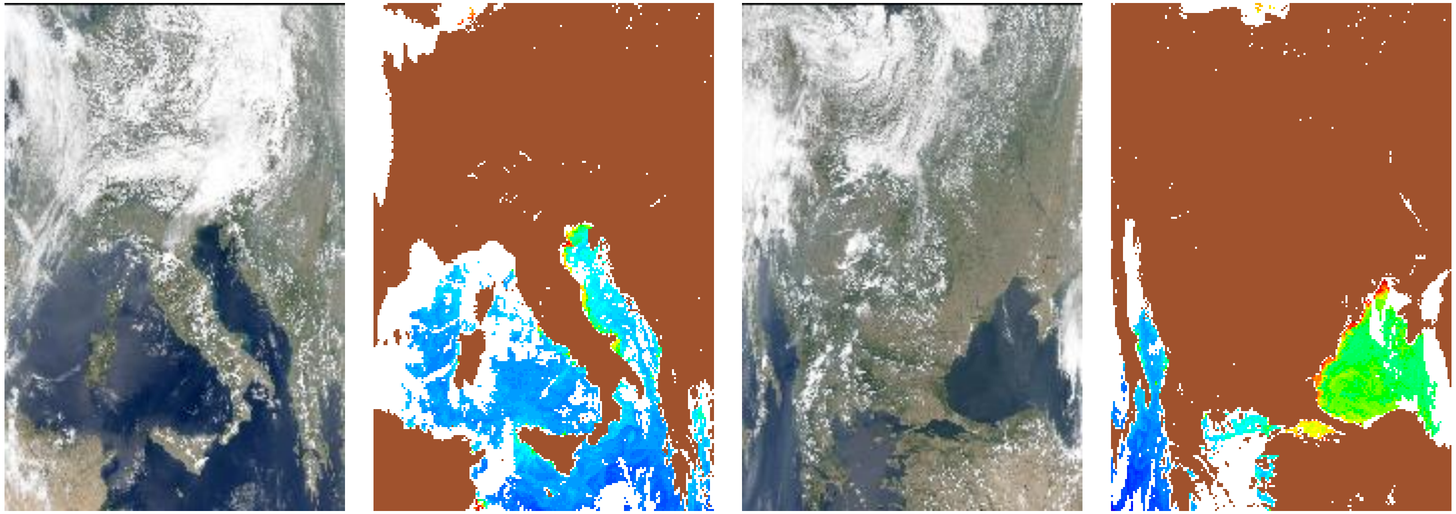

Figure 5. MODIS-Aqua Chlorophyll-a products from the 30th and 31st August 2018 (left to right, respectively) as the true colour composite and then chlorophyll product.

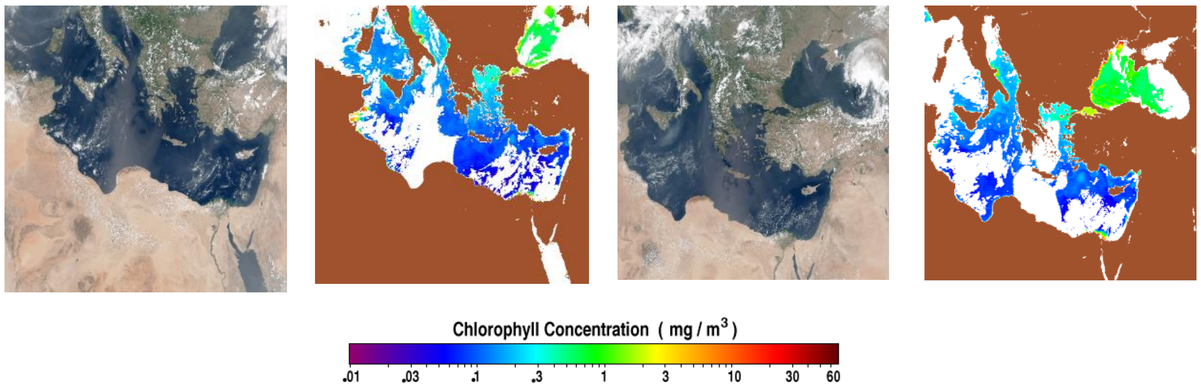

Figure 6. Suomi-NPP VIIRS Chlorophyll-a products from the 30th and 31st August 2018 (left to right, respectively) as the true colour composite and then chlorophyll product.

3.3 Product Quality Assessment

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 2018 plus January 2019. The script extracts a point of interest from a set of supplied L2C OCM-2 products, in this case 130 products were analysed for the period from 3rd January 2017 to 15th January 2019 (55 new products for the year 2018 and January 2019); the values shown in Figure 7 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, which is the location of the AERONET-OC Acqua Alta Oceanographic Tower). As described by [RD.6], the AERONET-OC network consists of globally distributed autonomous radiometer systems maintained at fixed offshore sites.

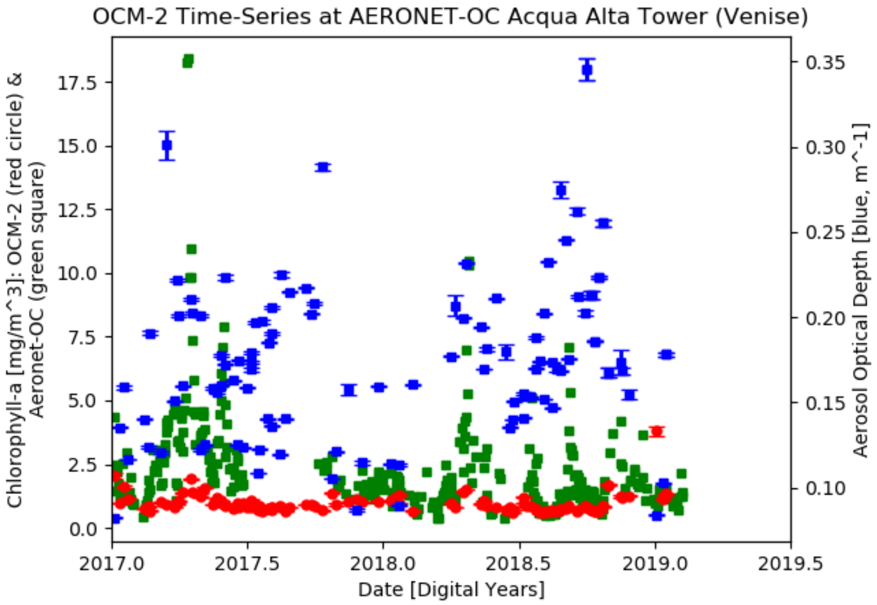

Figure 7. Time-series plot of the OCM-2 Chlorophyll-a (clo) and Aerosol Optical Depth (aod) products extracted from the Level 2C files, and AERONET-OC estimated Chlorophyll-a for the location of the AERONET-OC Acqua Alta Oceanographic Tower; data courtesy of AERONET website[1]/Giuseppe Zibordi.

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.

There are several sources of uncertainty, e.g. the AERONET-OC bands are not the same are the OCM-2 bands. However, overall, the plot shows 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.

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[1] https://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

4. CONCLUSION

The conclusions from this first report within the EDAP contract are:

- **No specific issue has 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 issue has 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.
  - 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.
  - The Product Quality Assessment analysed 130 products, from the 3rd January 2017 to 15th January 2019, for the AERONET-OC Acqua Alta Oceanographic Tower. 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 provided statistical comparison details.

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 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.
- Expand the sensor comparison to include Top of Atmosphere (**TOA**) data, through the Database for Imaging Multi-spectral Instruments and Tools for Radiometric Intercomparison (**DIMITRI**) that does not include OceanSat-2 data but does include missions (such as Sentinel-3 OLCI) that it will be compared to.
- Expand the in-situ comparison to a greater number of AERONET locations, alongside Boussole and MOBY (international vicarious calibration sites) and potentially other sites.

The first priority will be expanding the in-situ comparison to include a greater number of AERONET locations and starting work on setting up the TOA comparison.

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.7]. The validation approach will continue to follow the marine approach that defined in [RD.8].