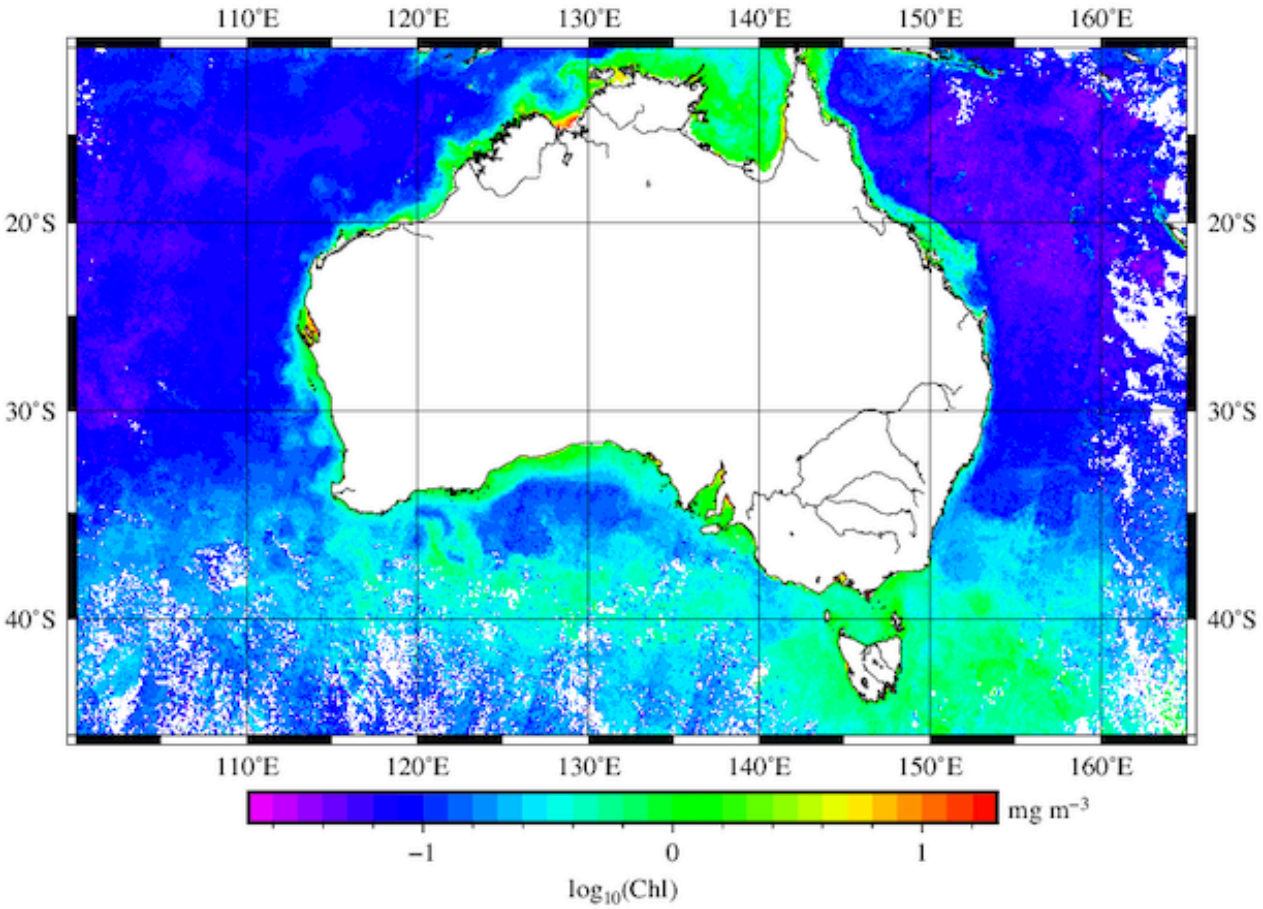

Monthly composite map of chlorophyll concentration around Australia for April 2019, derived from the Sentinel3A-OLCI sensor observations (taken from the Australasian Copernicus Data Hub); Curtin Uni RSSRG development.

Community consultation on IMOS ocean colour products

IMOS
Integrated Marine Observing System

IMOS satellite ocean colour sub-facility, February 2020

1 Rationale

The IMOS satellite remote sensing Ocean Colour sub-facility is seeking to:

- Review its production of remote sensing products,
- Evaluate their use by the research and wider communities, and
- Plan for the generation of new products where demand is identified (subject to resourcing for implementation and validation)

The context is the opportunity afforded by the availability of ocean colour data from several new instruments (VIIRS and OLCI), the looming end of the MODIS missions, and the need to ensure that the Ocean Colour sub-facility is making the best use of finite resources to deliver to IMOS user community needs.
We are requesting your feedback on the usefulness and use of the IMOS Ocean Colour products, and to identify unmet needs, a short online survey has been made available at this link:

https://www.surveymonkey.com/r/BZZ8S2K

The remainder of this note serves as background for the survey.

Potential outcomes of the process, depending on both feedback and available resources, could include:

- No change, or
- A reduction of the current product set and/or
- The addition of new products

The IMOS remote sensing facility will collect all answers and prepare a summary for presentation to IMOS at the annual planning meeting in Hobart, 3-5 March 2020.

2 Current Product Offerings

2.1 Product levels

Level2 (L2) products are geophysical products at full resolution (dictated by the sensor), time-referenced, geolocated and annotated with ancillary information and flags. They are not on a map grid but provided in the native satellite swath geometry.
Level 3 products are composite gridded products accumulating L2 data over given time windows (from daily to weekly, monthly, seasonal and climatological). L3 can come either as “L3 binned” products where the grid is an equal area grid or as “L3 mapped” products, generated from the L3 binned products after re-projection on a regular latitude / longitude grid. More detail on product levels can be found here: https://oceancolor.gsfc.nasa.gov/products/

IMOS makes available L2 products on the National Computational Infrastructure (NCI), and delivers a limited set of Level 3 mapped products via the AODN Portal. Currently the L3 products are only single-day single-sensor composites.

2.2 Current product list

Table 1 (below) summarises the current situation in terms of availability of products, with the following key:

+= yes, supplied from https://portal.aodn.org.au/
-= not computable/computed
2= present in L2 but not remapped

r= ready as L3 but not yet provided
?= potentially available but further investigation or more detail required before release

Sensor	SeaWiFS	MODIS	VIIRS	OLCI[1]
Processing code				**EUMETSAT**
Product name (see appendix for a description of what they are) **SEADAS only products**				
Reflectance (Rrs)	2	2	2	2
K_490	+	+	r	2
Chl_gsm	+	+	r	-
Chl_oc3	+	+	r	-
Chl_oc4	+	?	?	-
Chl_oci	?	2	2	-
Chl_carder	?	2	?	-
Chl_clark	-	2	?	-
Ipar	+	+	r	-
L2_flags	+	+	r	2
Par	+	+	r	2
Tsm_clark	+	?	?	-
Owtd	?	+	?	?
Npp_gsm	+	+	?	-
Npp_oc3	+	+	?	-
Picop10at	-	+	?	-
Nanop10at	-	+	?	-
Picop12in	-	+	?	-
Nanop12in	-	+	?	-
Adg_443_gsm	2	2	2	-
Adg_443_qaa	2	2	2	-
Adg_443_carder	2	2	-	-
OCLI-only products				
Chl_oc4me	-	-	-	2
Chl_nn	-	-	-	2
Tsm_nn	-	-	-	2
Adg_443_nn	-	-	-	2

Table 1. Current list of IMOS ocean colour products (see Table 3 in Appendix 2 for description of these various products)

2.3 What is specific to the IMOS ocean colour products?

The IMOS product sets are a legacy of the perceived needs of the Australian aquatic/marine research community from ~2012 when ocean colour data were only routinely available from MODIS/Aqua via https://oceancolor.gsfc.nasa.gov/. At that time, a range of radiometry products (e.g., reflectances) were in demand by local ocean colour practitioners, and a smaller range of derived/modelled products (e.g., Chl concentration, Net Primary Productivity, Diffuse Attenuation Coefficient) were needed by the marine research community. In particular, full resolution (1km) L3 products were not

[1]All OLCI products come with an error field as well

available directly from NASA. To meet these needs, IMOS established a base data set of MODIS/Aqua Level-0 data and used the NASA SeaDAS software to provide the desired products at the resolution needed. This allowed computation of the full range of radiometry and other products at Level-2, and the delivery of a subset of these as Level-3 daily products at 1km resolution. The Level-2 products are not suited to delivery via the AODN portal so they are maintained on the NCI in Canberra and are available from there. The data set is maintained for the whole of mission (September 2002 to the present) covering the greater Australasian region, roughly 90<longitude<180, -60<latitude<+10.

Product validation efforts by the Ocean Colour Sub-facility are mostly focused on chlorophyll-a from MODIS and VIIRS as the requirements for in-situ matched ground observation data have been met and are available through the IMOS Bio-optical Database. In situ data for validation however are not available in every region, and some marine areas around Australia (e.g. the Great Australian Bight, Tasman Sea or the Gulf of Carpentaria) are sparsely or not at all covered by ground observations. To enable product validation in these under-sampled regions, the Ocean Colour Sub-Facility has adopted a validation approach that is based on a classification of Optical Water Types (OWT, Moore et. al 2009). This approach assumes that the match-up results obtained for a given water type can be used to estimate the accuracy of a specific Ocean Colour product in the absence of ground observations with the help of a corresponding satellite-derived water type map. Water type maps are produced by IMOS as a separate ocean colour product (Owtd in Table 1) to guide this accuracy interpretation. Radiometric validation of surface reflectance products is also performed on regular basis at the Lucinda Jetty Coastal Observatory focussing on MODIS and Sentinel-3.

3 What is foreseeable?

Potential new IMOS products could include:

1. Products listed in Table 1 that are available as L2 products only, and that could be made available via the AODN portal as L3
2. Products not listed in Table 1 but supported by NASA (SeaDAS), i.e., products based on existing published algorithms, which are not yet generated and distributed through IMOS, see Table 2 for examples. The processing code however exists (e.g. SeaDAS) so that it is merely a matter of "ticking the box" in the processing code for the product to be generated. The list of such potential products is given in Table 2.
3. Products for which published algorithms exist (but not in SeaDAS) and could be used to generate these products (e.g. regionally adapted).
4. Products not listed in Table 1, for which user-specific algorithms may exist (published or not), and which could be generated as "evaluation products". Feedback on quality and usefulness would then be sought for from any potential user (examples of such possible developments include a GBR-tailored atmospherically corrected product or Australia-wide chlorophyll maps from S3-OLCI; see the illustration on cover page).

Other outputs of the survey could include changes in spatial/temporal resolutions and formats if needed.

Product	What is it?	Sensor	Reference
PIC	Particulate inorganic matter	MODIS, VIIRS, SeaWiFS	1)
POC	Particulate organic matter	MODIS, VIIRS, SeaWiFS	2)
nFlh	Normalized fluorescence line height	MODIS only	3)
zLee	Euphotic depth	MODIS, SeaWiFS	4)
L_rayl	Rayleigh corrected radiances at TOA	MODIS, VIIRS, SeaWiFS, S3A/B	5)

…?			

1) https://oceancolor.gsfc.nasa.gov/atbd/pic/
2) https://oceancolor.gsfc.nasa.gov/atbd/poc/
3) https://oceancolor.gsfc.nasa.gov/atbd/nflh/
4) https://oceancolor.gsfc.nasa.gov/products/special/
5) https://oceancolor.gsfc.nasa.gov/atbd/rrs/

Table 2. List of SeaDAS products not currently included into the IMOS product portfolio

4 Appendix 1: where to get information on current ocean colour products

4.1 SeaWiFS / MODIS / VIIRS:

The SeaWiFS/MODIS/VIIRS products are generated by IMOS through the SeaDAS software. Details on the underlying algorithms for most products can be found at:
https://oceancolor.gsfc.nasa.gov/atbd/

4.2 OLCI:

Algorithm Theoretical Basis documents for OLCI products can be found at:
https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-olci/document-library

Some direct links from that page:
https://sentinel.esa.int/documents/247904/349589/OLCI_L2_ATBD_Atmospheric_Corrections_case-1_waters.pdf
https://sentinel.esa.int/documents/247904/349589/OLCI_L2_ATBD_Ocean_Colour_Products_Case-1_Waters.pdf
https://sentinel.esa.int/documents/247904/349589/OLCI_L2_Transparency_Products.pdf
https://sentinel.esa.int/documents/247904/349589/OLCI_L2_ATBD_Ocean_Colour_Turbid_Water.pdf
https://sentinel.esa.int/documents/247904/349589/OLCI_L2_ATBD_Atmospheric_Corrections_Bright_Waters.pdf
https://sentinel.esa.int/documents/247904/349589/OLCI_L2_ATBD_Photosynthetically_Active_Radiation.pdf

5 Appendix 2: product names and meaning

References are either found at the end of the document or through the links in the Table below or here: https://oceancolor.gsfc.nasa.gov/atbd/chlor_a/

Product name	What is it?
Reflectance (R_{rs})	Remote-sensing reflectance (sr^{-1}) in the sensor spectral bands. $R_{rs} = L_w/E_s$, where L_w is the water-leaving radiance and E_S the downward above-surface irradiance.
K_490	Diffuse attenuation coefficient for downward irradiance at 490 nm (m^{-1})
Chl_gsm	Chlorophyll concentration derived through the GSM algorithm (mg m^{-3})
Chl_oc3	Chlorophyll concentration derived through the OC3 algorithm (mg m^{-3})
Chl_oc4	Chlorophyll concentration derived through the OC4 algorithm (mg m^{-3})
Chl_oci	Chlorophyll concentration derived through the OCI algorithm (mg m^{-3})
Ipar	Instantaneous Photosynthetically Available Radiation
L2_flags	Level2 flags
Par	Daily Photosynthetically Available Radiation https://oceancolor.gsfc.nasa.gov/atbd/par/
Tsm_clark	Total suspended Matter, Clark algorithm (mg m^{-3})
Owtd	Optical Water types
Npp_gsm	Net primary productivity, using the GSM chlorophyll and the Eppley-VGPM algorithm http://www.science.oregonstate.edu/ocean.productivity/eppley.model.php
Npp_oc3	Net primary productivity, using the OC3 chlorophyll and the Eppley-VGPM algorithm http://www.science.oregonstate.edu/ocean.productivity/eppley.model.php
Picop10at	Fraction of pico-phytoplankton, from the OC3 chlorophyll and the Brewin et al 2010 algorithm
Nanop10at	Fraction of nano-phytoplankton, from the OC3 chlorophyll and the Brewin et al 2010 algorithm
Picop12in	Fraction of pico-phytoplankton, from the OC3 chlorophyll and the Brewin et al 2012 algorithm
Nanop12in	Fraction of nano-phytoplankton, from the OC3 chlorophyll and the Brewin et al 2012 algorithm
Adg_443_gsm	Coloured Dissolved Organic Matter absorption at 443nm, from the GSM algorithm
Adg_443_qaa	Coloured Dissolved Organic Matter absorption at 443nm, from the QAA algorithm
Adg_443_carder	Coloured Dissolved Organic Matter absorption at 443nm, from the Carder algorithm https://oceancolor.gsfc.nasa.gov/meetings/ocbam/
Morel Chl_oc4me	Chlorophyll concentration derived through the OC4Me algorithm (mg m^{-3}) https://sentinel.esa.int/documents/247904/349589/OLCI_L2_ATBD_Ocean_Colour_Products_Case-1_Waters.pdf
For the 3 following products: https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-olci/document-library under "Sentinel-3 OLCI Ocean Colour Turbid Water ATBD"	
Chl_nn	Chlorophyll concentration derived through a neural network algorithm (mg m^{-3})
Tsm_nn	Total suspended Matter, neural network algorithm (mg m^{-3})
Adg_443_nn	Coloured Dissolved Organic Matter absorption at 443nm, from the neural network algorithm

Table 3. Product name definitions

6 References

Brewin et aL; references:

Brewin, RJW, T. Hirata, N. J Hardman-Mountford, S. J Lavender, S. Sathyendranath, and R. Barlow, 2012. The influence of the Indian Ocean Dipole on interannual variations in phytoplankton size structure as revealed by Earth Observation Deep Sea Research Part II: Topical Studies in Oceanography, 77, 117-127

Brewin, RJW, S. Sathyendranath, T. Hirata, S. J Lavender, R. M Barciela, N. J Hardman-Mountford, 2010. A three-component model of phytoplankton size class for the Atlantic Ocean ,Ecological Modelling, 221, 1472-1483

Brewin, RJW, S. J Lavender, N. J Hardman-Mountford, and T. Hirata, 2010. A spectral response approach for detecting dominant phytoplankton size class from satellite remote sensing, Acta Oceanologica Sinica, 29, 14-32.

QAA reference:

Lee, Z., K. L. Carder, and R. A. Arnone, 2002. Deriving inherent optical properties from water color: a multiband quasi-analytical algorithm for optically deep waters, Appl. Opt. 41, 5755-5572.

GSM references:

Garver S.A. and D. A. Siegel, 1997. Inherent optical property inversion of ocean color spectra and its biogeochemical interpretation: 1. Time series from the Sargasso Sea, J. Geophys. Res. 102, 2156-2202.

Maritorena, S. D. A. Siegel, and A. R. Peterson, 2002. Optimal tuning of a semi-analytical model for global applications," Appl. Opt. 41, 2705-2714.

OC4Me reference:

Morel, A., Huot, Y., Gentili, B., Werdell, P.J., Hooker, S.B. and B.A. Franz, 2007. Examining the consistency of products derived from various ocean color sensors in open ocean (Case 1) waters in the perspective of a multi-sensor approach. Remote Sensing of Environment, 111, 69-88.