

# IOCCG-26 Committee Meeting

## *Frascati, Italy & Online, 27-29 June 2022*

### MINUTES

#### 1.0 Welcome and Opening Session

##### 1.1 Opening of the Meeting

The IOCCG Chair, Cara Wilson, opened the 26<sup>th</sup> IOCCG Committee meeting and welcomed all participants to Frascati, including the online attendees. She thanked ESA for hosting the meeting, and thanked Marie-Hélène Rio for making all the arrangements. Participants then introduced themselves in a brief *tour de table*. Marie-Hélène Rio followed with logistics and other announcements. A list of participants that attended the hybrid IOCCG-26 meeting is provided as an Annex to the minutes

##### 1.2 ESA Welcoming Address

Giuseppe Ottavianelli, Head of ESA Applications Section, welcomed everyone on behalf of Simonetta Cheli (Director of Earth Observation Programmes). He noted that ocean colour radiometry is a very active and changing domain with many activities taking place worldwide, so the IOCCG Committee is essential for coordination, allowing dialogue between space agencies and the ocean colour community, as well as CEOS. ESA has been supporting this group for many years, both financially as well as through active collaboration of many experts. ESA also has many key activities in ocean colour radiometry, both in terms of exploitation of current missions (Sentinels) and in preparation of future missions (FLEX, CHIME), so this is a very important forum. Furthermore, ESA has been very active in ocean carbon from space, contributing to the CEOS work plan for ocean carbon. He wished the committee and working groups great success and fruitful discussions in the days ahead

##### 1.3 Adoption of Agenda, Review of IOCCG-25 Minutes, Status of Actions

The agenda was adopted after adding new agenda items on Aeronet OC, accessibility of OC products, OC nomenclature and seasonal biases in OC. The minutes of the IOCCG-25 Committee meeting were approved by consensus. The actions from the IOCCG 25<sup>th</sup> Committee meeting were reviewed - many were still open or on-going, as follows:

- *Action 25/1*: Open - formation of the OC-SVC Task Force will be discussed under agenda item 3.5.
- *Action 25/2*: Open - the proposed White Paper for the new OC-SVC Task Force will be discussed under agenda item 3.5.

- *Action 25/3*: Open – the proposed Hyperspectral Task Force/WG will be discussed under agenda item 3.8.
- *Action 25/4*: On going - the training sub-committee has been formed and will be discussed under agenda item 6.2
- *Action 25/5*: Closed - announcements and call for paper submissions to the special issue on Aquatic carbon stocks and fluxes have been released. Agenda item 5.3
- *Action 25/6*: Closed - the official list of IOCCG Representatives for the CEOS OCR-VC has been confirmed.
- *Action 25/7*: Closed – the 25th anniversary of the IOCCG was celebrated via social media and other announcements to coincide with World Oceans Day last year.
- *Action 25/8*: Open – the planning for IOCS-2023 is on-going and will be discussed under agenda item 7.0
- *Action 25/9*: Closed – IOCCG-26 Committee meeting is being held in hybrid format, June 2022
- *Action 25/10*: Closed - electronic chat will be incorporated into the IOCCG-26 Committee meeting via WebEx.

Cara pointed out that Action item 24/8: from the previous meeting should be reopened (*Cara Wilson to follow up with the authors of IOCCG Report 3 regarding updating the volume. Cara contacted Shubha. She is interested in doing this if there is no urgent timeline*).

#### **1.4 Project Office Arrangements**

Raisha Lovindeer expressed disappointment for missing the in-person aspect of the meeting due to visa issues. Raisha indicated that at the start of 2022 she and Venetia Stuart had agreed to continue working together part time for the remainder of the year. The project office remains at the Bedford Institute of Oceanography in Halifax Canada, but both Raisha and Venetia have been working mostly remotely since the start of the COVID-19 Pandemic.

## **2.0 Agency Updates: New and Emerging Initiatives**

### **2.1 Ocean Colour Science and Application Activities in ESA**

Marie-Hélène Rio reported on Sentinel-3 activities including the Optical Mission Performance Cluster running since October 2021 and combining S2 MSI and S3 OLCI & SLSTR calibration/validation service. S3 A and B are both in good health. A new S3 processor will be released in July that will provide accurate Level 1 radiometric uncertainties. This is a big milestone in OLCI products and the first Copernicus L1 product to do so. The S3 Validation Team meeting will be organised for 18-20 October 2022 at ESA-ESRIN. Sentinel-3C and D are undergoing final activities before storage and launch (2024-25 for C, and 2026-28 for D).

For Sentinel-2, ESA is working on providing a complete L2A product suitable for the aquatic user community by adding a dedicated aquatic reflectance layer to existing L2A. This will cover all waters worldwide sensed by Sentinel-2 including inland, coastal and open waters (spatial resolution: 60m, based on open-source algorithms).

Regarding the ESA Climate Change Initiative (CCI), version 6.0 (Rrs and Chl) has been delivered and a full product suite will soon be available through the ESA CCI portal. The dataset now spans 23 years (Sept 1997-April 2022). Global merged products includes Envisat's MERIS (4<sup>th</sup> reprocessing) data and recently reprocessed data from NASA's Aqua-MODIS (end 2019), SeaWiFS and VIIRS (end 2019), plus Sentinel-3A and 3B OLCI

Several ongoing and planned OC related science and applications projects were described covering ocean health (MEDEOS), ocean carbon (BICEP Project), the ocean's role in Earth and Climate System, land-sea interactions and ocean extremes. Planned projects include the Ocean Science Cluster projects (2023-2025), The Blue Carbon project (2023-2025) and the SDG series Eutrophication project (2023-2025). Lastly, the Sentinel User Preparation (SUP) activity will be proposed at the upcoming ESA Council Meeting at Ministerial Level, as part of the FutureEO-1 Segment-2 [2023-2025] to prepare for Copernicus expansion and ensure readiness for update by users. This activity will be done in 3 phases: consultation, implementation and knowledge transfer.

## **2.2 CMEMS plans for 2022-2024 (Sentinel 3, Sentinel 2, and coastal products)**

Vittorio Brando provided a product overview of the Ocean Colour Thematic Center (OCTAC). OCTAC operates the European ocean colour component within the Copernicus Marine Service, bridging the gap between space agencies and end-users with high-quality ocean colour products. OCTAC provides both global and regional products such as CHL, IOPs and PFTs/PSCs (Phytoplankton Functional Groups and community structure). There has been an evolution in products as missions changed from science to operational missions and they now provide multi-sensor products with a significant increase of the spatial coverage of daily observations. In May 2021, OLCI datasets at 300m resolution combining Sentinel-3A and B, as well as the Sentinel-2/MSI datasets at 100m, were added to the catalogue. Blended CHL datasets are now produced for all basins applying the appropriate algorithms across the open ocean and coastal waters depending on the occurring water types, as well as the bio-optical characteristics of each regional basin. Several examples were given. Regarding Phytoplankton Functional Types (PFTs) the global models underestimate most of the functional classes, so regional algorithms are considered. There is now a focus on OLCI global and regional reprocessing (2016-2022), with updates in regional CHL and PFT/PSCs algorithms with a focus for complex waters.

## **2.3 EUMETSAT Agency Update**

Ewa Kwiatkowska provided the EUMETSAT agency update, referring to the four major groups of activities:

- Working on the OC operational ocean processor;
- Copernicus OC System Vicarious Calibration (SVC) infrastructure development;
- FRM *in situ* radiometry for validation; and

- Looking into the feasibility of geostationary OC.

The status of the S-3 OLCI Level-2 OC Collection-3 products was reviewed, noting that there was high consistency between OLCI-A and OLCI-B, as well as improved product retrievals over turbid waters. Collection-3 has been validated with *in situ* data and users can use data from both missions in tandem because of the good agreement. The EUMETSAT Data Store (<https://data.eumetsat.int>) is a single online access point for all operational and reprocessed data.

Collection-3 is a good achievement but there is still room for improvement e.g., water reflectance products only partially meet the S3 Mission Requirements, large uncertainties are still present in complex waters, particularly in CDOM-dominated waters, residual L2 flag limitations. EUMETSAT is working towards Collection-4 with a tentative time frame in the next two years. Ongoing OC product evolution and development include redevelopment of the standard atmospheric correction, implementation of new OLCI L2 products, re-evaluation of BDRF, IOP and fluorescence, and additional OC algorithm evolutions, e.g., flags, chlorophyll product, optical water types. OLCI fluorescence test products are available in a toolbox and a fluorescence time series will be processed next for user validation. The next S3 Validation Team (S3VT) meeting will take place 18-20 October 2022 at ESA.

EUMETSAT manages the OC-SVC infrastructure development activities for the Copernicus Programme on behalf of the European Commission. Currently there are five candidate locations for the Copernicus OC-SVC infrastructure including BOUSSOLE. The goal is to achieve the state-of-the-art, autonomous and dependable Copernicus OC-SVC capability for the coming 20+ years of the Copernicus Programme, including the Next Generation and Expansion missions. The review process is supported by an international Expert Review Board – their report will be published in July 2022.

The goal of the Fiducial Reference Measurements for Satellite Ocean Colour (FRM4SOC-2) project is to ensure the adoption of FRM principles across the ocean colour community including developing radiometer calibration/characterisation guidelines for laboratories, providing highly prescriptive and detailed FRM measurement procedures, and development of a community processor for *in situ* radiometric measurements (in cooperation with NASA on HyperInSPACE). The FRM4SOC-2 workshop will take place in Darmstadt from 5-7 December 2022.

EUMETSAT has a broad interest in ocean colour geostationary products but there are no plans in Europe to develop an instrument with OC capabilities. EUMETSAT is looking at development of extended geostationary capabilities from EUMETSAT's existing missions, starting Q4 2022 e.g., MSG-SEVIRI demonstration products (water turbidity time series) and scientific and technical development of the Prototype Processor into the Day-2 Multi-Mission processor.

In conclusion, many of EUMETSAT's activities match the IOCCG recommendations e.g., IOCCG/CEOS INSITU-OCR White Paper, CEOS OCR-VC deliverables.

## 2.4 ESA Ocean Colour Future missions

Craig Donlon provided an update on the status of ESA ocean colour future missions. Currently, there are 82 missions in development including FLEX, CHIME and Sentinel-2/3-NG. The FLEX mission is a visible and NIR spectrometer measuring photosynthesis and vegetation stress, but there will be measurements in the coastal zone. The FLEX satellite will orbit in tandem with one of the Copernicus Sentinel-3 satellites with a planned launch date of 2025. The FLORIS payload is a high-resolution imaging spectrometer acquiring data in the 500-880 nm spectral range (300m spatial resolution, 150 km swath) and will be able to assess fluorescence-derived photosynthesis.

The next generation of Sentinels will be launched in the 2029/2030 timeframe. For Sentinel-3, the mission will be split into two: one for ocean colour (Sentinel-3-NGO) and one for altimetry (Sentinel-3-NGT). There are several other high priority candidate missions: of relevance to us is CHIME, which will provide visible to NIR hyperspectral measurements (expected launch in 2028). It is optimized over land but there will be acquisitions in the coastal zones. It will have a ground resolution of 30 m, spectral range 400 – 2500 nm and a revisit of 12.5 days (2 satellites)

Sentinel-2 will provide high resolution optical imagery for 20+ years (they are operational missions). The next generation of Sentinel-2 (S2-NG) will ensure enhanced continuity of service for the current Sentinel-2 products. There are a huge number of applications in coastal zones, growing all the time. Key mission requirements for NG: geometric revisit time of less than 2-3 days, improved latency in the coastal zone to <1.5h, heritage bands as well as new bands. The mission is currently in Phase 0: Phase A will start in mid-2023, and there will be a call for the mission advisory group in January 2023. Only European members can apply but there is a strong collaboration with NASA.

For Sentinel-3 they are also looking at enhanced continuity of observations so the payload will be a follow-on of Sentinel-3 OLCI and SLSTR. The revisit frequency should be moderately improved and the ground sampling distance will also be improved to benefit coastal areas, inland waters, land applications. S-3 NGO will carry two instruments, the Advanced Ocean and Land Colour Imager (AOLCI) and the Advanced Sea and Land Surface Temperature Radiometer (ASLSTR). A constellation of two satellites will be needed to satisfy user requirements. For AOLCI they are looking at a spatial resolution of 150m at least for coastal areas, inland waters and land, with a goal of 100 m, as well as an increased number of spectral bands (as a goal, the full on-board recorded spectrum).

Heidi Dierssen pointed out that S-2 is very good for coastal work but there are issues such as sun glint. The NASA SPG mission has decided to go ahead with a 5° tilt to minimize sun glint for the aquatic community. It would be good for agencies to consider mechanisms that could mitigate glint over inland, coastal and oceanic waters in mission formulation, particularly high spatial resolution missions such as S2-NG. Such mechanisms can significantly improve aquatic reflectance retrievals (e.g., water quality, HABs, blue carbon) with minimal impacts to terrestrial remote sensing. Secondly, the coastal mask used for S2 is not optimized well for some areas e.g., shallow reefs. Perhaps some of these areas could be part of the standard processing. Craig replied that OLCI is tilted, but it cannot tilt too much otherwise it would result in poor performance towards the edges. Secondly, on the mask and processing, they could do a lot more, but this must come from CMEMS (Vittorio Brando) as this is an operational mission, and a lot of data must be delivered routinely. He pointed out that for the next generation there will be a lot more processing (bigger computers, cloud processing etc.) but for the current mask there is a 15 km

mask for coastal zones, including islands. There is no mandate to go further. Heidi noted that she was talking about S-2 and CHIME which would provide more data with a small tilt. Vittorio Brando agreed to discuss the issue of the coastal buffer but noted that all coral reefs, islands and shallow waters in the world are currently imaged by S-2.

Emmanuel Boss thanked the Europeans for moving towards applications and noted that Marie-Hélène Rio spoke about a 60 m global product, but CMEMS produces a 100 m product. Vittorio replied that there are two developments: a contract for 100 m data for coastal products which started in 2020, while the S-2 60 m product is still in a study phase, and should go operational in a year or two. The issue of the coastal buffer is an issue of data volume and money. The user base must make a request to the Copernicus office for any new requirement. Only then can they argue for widening their product base. It is important to get feedback from the user community, and also the data must be downloaded by the community to demonstrate user uptake. Robert Frouin also queried whether ESA would consider synchronizing MetOp-SG and Sentinel-3C orbits to optimize the synergistic use of OLCI and 3MI.

## **2.5 ESA CCI LAKES / PRISMA**

Claudia Giardino provided updates on the PRISMA mission with focus on aquatic application. There are currently over 100 images available for download from PRISMA as well as a tool to help to identify matchups with in situ campaigns. PRISMA's second generation mission (the follow-on from PRISMA) is in the operational phase with the mission scheduled for launch in 2025.

Validation of L2 products in terms of Rrs was based on *in situ* data mostly from AERONET-OC as other sites with autonomous hyperspectral radiometers. There were challenges with AERONET-OC divergence in spectral shape and magnitude. Better closure was achieved for green wavelengths for optical water type classes between 12-16. Level 1 products were also added (TOA corrected for atmospheric with Acolite) for sites with autonomous hyperspectral data (Lake Trasimeno, AAOT Venice) and the performance improved spatially over those derived by standard atmospheric correction schemes. Claudia showed that for PRISMA, the requirement to be below the threshold for noise is reached without any additional processings, so noise of L2 PRISMA products show promise for water quality retrieval.

Claudia indicated that further testing with state of the art atmospheric correction tools are needed along with the expansion of hyperspectral validation sites, and she invites *in situ* data providers to expand validation sites. PRISMA also supports algorithm development and testing for aquatic ecosystem mapping from current and future satellite imagery (CHIME, SBG)

Claudia also presented on ESA's CCI (Climate Change Indicator) Lakes project. CCI was jointly launched by UNEP and GCOS and covers the essential climate variables (ECV). The 1st phase of CCI Lakes has ended, and the result was a map of 250 lakes with a range of variables in a common netcdf format. The data covers ranges from 1992 to 2020 featuring lake level, extent, temperature, ice-cover and reflectances, including turbidity and chlorophyll-a.

The second phase of the project will increase the number of lakes to 2,000 for the same set of variables. CCI is also developing case studies for lakes using specific variables e.g. thermodynamics in Greenland lands, and temperature and biogeochemistry in large lakes globally. There are also cross-disciplinary studies with, for example, work on land fires and the effect of burn area and atmospheric deposition on

oceans and lakes. Phase 2 of CCI Lakes is expected to kick-off next July and will open new research opportunities. Claudia requested the community to participate by giving feedback and comments on the [ECV Lakes CCI Questionnaire](#).

## 2.6 NASA

Bryan Franz provided an update on the NASA Ocean Biology Processing Group. Largest change since last year is that L2 and 3 OLCI products are finally being reprocessed using NASA standard algorithms. OLCI S3A and S3B validation of their chl-a product against AERONET-OC look good, as well as comparison with MODIS and VIIRS. Reprocessing has started with MERIS and OLCI while MODIS Aqua is on deck and should hopefully start soon. Reprocessing involves instrument calibration updates and vicarious calibration updates but also algorithm updates and particularly changes in how the aerosol model is selected in multi-scattering space, as well as updating derived product algorithms including adding raman corrections to the IOPs.

MODIS Terra and Aqua are 15+ years beyond their 5-year design life and both are out of fuel. The satellites are now being allowed to drift, and it is possible to get additional (good) data for a few more years, up to possibly the end of 2025, though ocean colour will get severely degraded eventually. However, there is also discussion at NASA of early termination in Aug 2023 for budgetary reasons, which would remove this opportunity and create a gap as there would be no potential for overlap with PACE.

Heidi Dierssen asked about the Coddington [et al. 2016] solar reference spectrum. Bryan indicated that it was going to be used for PACE. He indicated that it was too late to use it for the current reprocessing but it can be incorporated later for reprocessing, especially to keep heritage missions consistent with advances made using PACE.

Laura Lorenzoni updated the group on the PACE launch date, which was pushed to Jan 2024 due to the COVID-19 pandemic. PACE validation will be announced in ROSES 2022 and proposals will be due in mid 2023, so that in situ validation teams for PACE data can be assembled and begin sampling 6 months later. NASA is very interested in collaborations / synergies / advanced planning with international partners. This is going to be a big field collection effort with a smaller airborne component off the west coast of the US in Fall 2024. In terms of SVC, science teams and validation plans, 2 projects were selected in 2019 for system vicarious calibration: HyperNAV (SeaBird Scientific/Oregon State Univ. PI: Andrew Barnard. A portable Radiometric float) and MarONet (U. Miami/NIST. PI: Ken Voss. A Radiometric buoy, not carryon size). Both projects are moving forward into their third year with some modifications pending to complement the validation work. The Science and Applications Team (SAT#2) was Selected in 2020, and runs through mid-2023. Next team (SAT#3) is likely to be completed/assembled in 2023/2024, with a scope to be refined. PACE Applications are planning for the 2022 PACE Applications Workshop (September 14-15th). There is also a newsletter for people to keep apace with PACE.

GLIMR (Geostationary Littoral Imaging and Monitoring Radiometer) will be a geostationary satellite which will be focused in the Gulf of Mexico and see critical areas like the Caribbean and part of the Pacific, and enable the study of rapid changes of water properties which have significant applications. GLIMR is in Phase B, and is doing its Preliminary Design Review – a check to demonstrate that preliminary design meets all system requirements with acceptable risk and within cost & schedule

restraints. GLIMR is set to launch no earlier than 2027. Questions about GLIMR can be directed to Chuanmin Hu.

NASA is heavily investing in the Earth System Observatory, which are 4 missions to look at the earth system holistically. The 1st is scheduled to launch no earlier than 2027. Most important to IOCCG is the SBG (Surface Biology and Geology) mission done in collaboration with the Italian Space Agency. It consists of two sensors (TIR and VSWIR) that will provide integrated data. TIR will likely launch before VSWIR, which is set to launch no earlier than 2028. SBG completed successfully its Mission Concept Review last week which evaluates the proposed objectives and the concept for meeting those objectives. SBG will also have other synergies with similar sensors being launched by our long-term space agency partners. NASA is discussing data sharing, harmonization and cross-collaboration. The partnership will enable reduced revisit time, increased capability of observing events and increased research and applications opportunities overall. Missions they are working with include CHIME (VSWIR), LSTM and TRISHNA (TIR).

Laura also told the group about Air-LUSI, which is an airborne campaign to get lunar calibrations that are highly relevant to ocean colour. A campaign flew in Feb 2022 and the more flights, the better the data becomes. Laura encouraged other agencies to get involved/use the data and opportunity that this campaign offers.

With respect to field campaigns, EXPORTS phase 1 was completed in June 2021. EXPORTS seeks to better understand export and fate of carbon in the ocean, and predict carbon cycle impacts of ocean primary production from satellite observations. All data from the North Pacific is publicly available in SeaBASS, and most of the North Atlantic is there already.

In 2023, NASA OBB (NASA Ocean Biology & Biogeochemistry) anticipates collaborating with the BioSCape campaign which is being supported by the biodiversity program at NASA headquarters and is organized around three major themes aimed at understanding the distribution and abundance of biodiversity, its role in ecosystem function and the impacts of its change on ecosystem services. OBB is also hoping to collaborate with the Arctic Radiation-Cloud-Aerosol-Surface Interaction Experiment, or ARCSIX, that has the goal of understanding how atmospheric processes impact sea ice and vice versa, specifically focusing on the Arctic summer surface radiation budget and sea ice melt during the early melt season (May through mid-July). ARCSIX is anticipated to be flying in the Arctic in 2024.

The Office of Naval Research (ONR) is sponsoring The Arabian Sea Transition Layer (ASTraL) that will combine atmosphere-ocean observations acquired via autonomous and ship-based platforms to understand the mechanisms controlling air-sea interactions in the Arabian Sea, in partnership with India. ONR's focus is very physical, and NASA/OBB's partnership seeks to expand that to include biogeochemical and biological measurements in this region. It also has synergies with NISAR, which is a mission being developed in partnership with ISRO. Field work is anticipated to take place around 2024.

Lastly, OBB hopes to get Arctic COLORS off the ground, hopefully around 2024. Arctic COLORS aims to improve understanding and predictive capabilities of land-ocean interactions in the Arctic coastal zone, and assess vulnerability, response, feedbacks, and resilience of coastal ecosystems, communities and natural resources.

NASA also continues to support continuous field measurements like SOCCOM and GO-BGC (a new investment by the NSF for 500 floats over the next 5 years), as well as biogeochemical and optical ocean time series.

## 2.7 NOAA

Menghua Wang provided an update on the status of JPSS-2 (including VIIRS), which is 3rd in the series of satellites. The initial launch timeline of September 2022 was delayed to 1 November 2022. NOAA plans to adjust the orbits of S-NPP, NOAA-20, and NOAA-21 so that there is always good coverage with the required half orbit separation, which impacts data coverage (see [Mikelsons and Wang, 2019](#))

The GeoXO mission, developed by NOAA and NASA as the next generation of the Geo series with launch date of 2032, has moved into the contract award phase for the ocean colour instrument. Program approval is scheduled for the end of this year. Phase A/B is planned for several years to 2025. Full mission details are available at [nesdis.noaa.gov/GeoXO](https://nesdis.noaa.gov/GeoXO). Ocean colour instruments will be mounted on Geo-west and Geo-east instruments.

Menghua plugged NOAA CoastWatch, which engages users for ocean colour data application. It exists to help people access new satellite data for their aquatic applications and engages in data dissemination and training for data users. CoastWatch nodes exist all over the USA, and there is now a PolarWatch node.

The Ocean Colour Team, which has conducted dedicated VIIRS cal/val cruises annually since 2014, recently completed their 2022 cruise in March. The next cruise is scheduled for the west coast of California in Spring 2023. Technical reports for the cruises are found on NOAA's website, though these technical reports do not include data from the cruises. Heidi Dierssen requested whether such data could be made available online in the future. Menghua said the data is uploaded to SeaBASS, but NOAA CoastWatch is building a database to handle their data - this is not yet available.

Menghua showed the efforts of the NOAA team to disseminate level 4 products with high spatial and temporal coverage. He demonstrated examples of daily global gap-free Chl-a, Kd and SPM developed using VIIRS, S-NPP, VIIRS-NOAA-20 and OLCI-S3A. Vittorio Brando praised the effort of NOAA in producing these products and asked if there had been comparison to L3 and L4 Copernicus products. Menghua indicated that there had not been comparisons for L3, but some comparison for L4.

Heidi Dierssen asked whether there was any way to add fluorescence bands to VIIRS, but Menghua indicated that the contract for VIIRS is already completed, so there will be no way to add. Maybe this can be included in the missions after VIIRS.

Emmanuel Boss asked whether NOAA will begin to create 100m products with Landsat and Sentinel 2. Menghua indicated that this will not be done with the VIIRS mission, but possibly will be part of the next generation polar (LEO) satellites (after VIIRS).

The Operational Satellite Oceanography Symposium (OSOS) for users and applications of all satellite ocean products (not just ocean colour) started in 2019. The first was held in Maryland USA, then in Darmstadt but moved online for 2021, and the next symposium is scheduled for the spring of 2023, tentatively in South Korea. OSOS is sponsored and hosted by NOAA and EUMETSAT.

## 2.8 Status of SABIA-Mar

Carolina Tauro updated on the SABIA-Mar ocean colour mission developed by CONAE, the Argentinian Space Agency. The mission has several cameras with the main ones being a VIS- NIR and NIR-SWIR with 15 spectral bands from 412-1610 nm. L1, 2 and 3 products in netcdf format will be available on the website. Simulated datasets for L1B (real SABIA-Mar angular configuration) and L2 products will be produced. Cameras have viewing angle differences for each spectral band with an angular split of 20° between the first and last. Also being developed is an *in situ* monitoring system in the Argentinian coastal zone with the AERONET-OC Bahia Blanca, in collaboration with Robert Frouin.

A thermal infrared camera originally planned for the mission will no longer be included due to programmatic issues, and therefore SST will not be available as part of SABIA-Mar products.

Next steps are to increase computational capacity to reach 1 day passes, and improve atmospheric correction. Critical design review that was planned for mid 2022 is delayed and is planned for the end of the year. The spectralon delivery is expected for Sep 2022, while the cameras are expected to be delivered by early 2023. The team is looking for facilities that can implement the pre-launch characterisation, which is anticipated to start in July 2023. Carolina also shared the new logo for the SABIA-Mar mission.

## 2.9 CSA

Laurent Giugni shared highlights on Canadian water colour activities, indicating that CSA supports the ocean colour science being conducted at other institutions within Canada. The Canadian government recently funded the WildfireSat mission (launch target 2028), which does not have a direct link to ocean colour, but there is an indirect link as deposition from fires affect water quality and there are gaps that can be closed by this mission. WildfireSat is a collaboration with government entities, Natural Resources Canada and Environment Canada.

The WaterSat mission exists to close the signal-to-noise, radiometric, and resolution gaps currently existing in water quality research. Phase 0 started in 2015 and CSA supported the technological development of the WaterSat Imaging Spectrometer Experiment (WISE). The WISE prototype was flown in 2018/19 and is expected to fly again in future years. The Dual Imaging Spectrometer Coastal Ocean Color Imager Experiment (DICE) prototype (higher spectral bands and resolution) is under development and the delivery was postponed to October 2022. WISE and DICE are expected to fly in tandem for upcoming research and development campaigns. Spin-off campaigns, such as Algae-WISE (2021-2024) have also been successful. Laurent indicated in the chat that the contact person for Watersat is [Dominique Poulin](#), the Mission Manager at CSA.

NetCOLOR (IOCCG for Canada) tightens the ties for the aquatic color community within Canada. The community grew to ~150 members and remains active in promoting capacity building, collaboration, and communication via webinars and annual science meetings. They will release their second report soon on cal/val of bio retrievals in Canada.

Environment Canada developed a satellite monitoring platform, EOLakeWatch, to provide water quality monitoring for several lakes. The platform continues to grow with many end users from science and the public. Additional lakes and additional data streams with MODIS have been added to fill the observational gaps between MERIS and OLCI. The system also migrated to high performance computing for stability processes, and the lead scientist, Caren Binding is experimenting with the new cloud platform and functionality with bloom products. Claudia Giardino asked if EOLakeWatch is open to international collaborators. Laurent indicated that he would follow-up with Caren Binding and get back to Claudia.

CSA supports the fishing, ocean and transport industry through the smartWhales initiative, a CAD 5.3M investment from CSA and Fisheries & Oceans Canada to help protect and identify the North Atlantic Right Whale habitat. The 2nd workshop for this initiative will be held in November 2022. Cara Wilson asked if there were any NOAA collaborators in the smartWhale initiative, and Laurent confirmed that NOAA is part of the consortium, and provides data for the US region.

CSA will soon sign an MOU with several departments to develop ASEC - Atlantis Science Enterprise Center (located in Moncton New Brunswick Canada) to increase knowledge in coastal productivity and fisheries, and to develop interdepartmental activities (like smartWhale).

## **2.10 Australian ocean colour activities**

Tim Malthus illustrated some OC activities in Australia. He introduced the AquaWatch Australia mission concept: a 3-component system with hyperspectral satellites to monitor water quality, coupled with an *in situ* sensor network and a data integration facility. Phase 0 (2021) has just been completed and now they are in Phase A (2021-2023) - the development of the end-to-end simulator for precursor missions such as Cyanosat, to test the hyperspectral capabilities. They also have a number of pilots as demonstrators for technologies required.

Australia recently announced \$1.2 billion in funding for the National Space Mission for Earth Observation (NSMEO) programme which includes AusCalVal, a satellite cross calibration mission, as well as other missions to be competed for. International collaboration will be a key component. AusCalVal brings a lot of activities together under one umbrella (Lucinda Jetty will form a key component).

There has been a lot of activity in inland water, stimulated by AquaWatch. An inland water bio-optical database has been released (316 observations in 34 waterbodies), and a permanent inland observatory is planned for late 2022 (Googong Dam), which will focus initially on above surface measurements, then other in-water bio-optical properties .

David Antoine is making key bio-optical measurements off Rottnest Island with a profiling instrument package. He will also deploy a MarONet sensor off Perth (heritage of MOBY) for vicarious calibration of PACE. Other field activities contribute to satellite OCR validation (Antarctic circumpolar expedition, the carbon extent project SOLACE etc.)

The information platform eReefs will assess water quality for the Great Barrier Reef. The remote sensing products form a key part of the data assimilation to compute water quality scores, using a

biogeochemical model that assimilates MODIS, VIIRS and Sentinel-2B reflectances. Other work in highly turbid, high DOC waters has demonstrated an increase in DOC related to land use (tropical peatland conversion). Lastly, many publications have come out of the Southern Ocean BioArgo research facility.

### **2.11 Update on GOCI/GOCI-II**

Wonkook Kim presented an update on GOCI and GOCI-II on behalf of Jong-Kuk Choi and Junghyun Kim (NOSC), and Joo-Hyung Ryu (KIOST). The GOCI mission was launched in 2010 and terminated in March 2021 (political reasons). GOCI-II was launched in Feb 2020 and Level-1 data became publicly available in October 2020, with the full 26 product suite becoming available in January 2021. GOCI-II has 12 slots for local imaging and 235 slots for full disk (FD) imaging, potentially at 250 m spatial resolution, but storage issues result in FD data being stored at 1-km resolution. GOCI-II acquires images 10 times per day, every hour from 8:30 am to 5:30 pm, using 13 multi-spectral bands.

Regarding cal/val activities there are several stations around the coast of Korea, some with AERONET-OC and TriOS sensors, and soon DALEC sensors. They also have an optical buoy on the east coast of Korea. There is a plan for international activities through the Korea-Indonesia Joint Research Center. Long-term plans include using field data from Australia for calibration of GOCI-II.

This year they have started a 5-year project to enhance accuracy of GOCI-II products including cal/val of GOCI-II products, algorithm improvement, and development of atmospheric correction techniques based on the integration of GeoKompsat-2A/2B. They are running behind schedule (political and agency issues) so the initial algorithm has not yet been validated. Currently there are 26 products, but they cannot be used in the current form. The calibration project has just started, collecting field data for cal/val.

The new National Ocean Satellite Center (NOSC) was established within the Korea Hydrographic and Oceanographic Agency (KHOA) in May, 2019. NOSC is in charge of the GOCI-II data service while KIOST is helping to develop algorithms and products. NOSC has a data distribution website but it is still only in Korean (English website planned by the end of the year). Preliminary validation results were shown from ship-collected field data. The atmospheric correction algorithm of GOCI-II showed good performance in Case-I waters when compared with matchups, and GOCI-II CHL products were highly accurate with low uncertainties in Case-I waters, but showed overestimation in Case-II waters when compared with GOCI and MODIS. They would like to establish an international CAL/VAL network. The adjusted FD schedule has led to acquisition of sufficient valid images in the open seas of the Pacific region.

### **2.12 JAXA Agency Update**

Hiroshi Murakami reviewed JAXA's Earth Observation Satellite missions. The GCOM-C/SGLI science mission has been in orbit for almost 5 years (launched Dec. 2017) and its continuation will be evaluated in December 2022. The new research period (EORA3) started in April 2022. In this phase, research will be focused on applications (IOPs, PFTs, red-tide, FAI, POC/PIC, APAR and NPP) but product development/evaluation and supporting the applications will be continued.

GCOM-C Ver.3 standard products (L1, 2 and 3) are open to the public via JAXA's data G-portal (<https://gportal.jaxa.jp/gpr/>). Some products are also available via JAXA'S multi-sensor data site, JASMES (binary or NetCDF format). Example images of a large-scale red-tide in the southeast coast of Hokkaido (Sep. to Nov. 2021) were shown, as well as monitoring pumice rafts from the submarine Fukutoku-Oka-no-ba volcano. SGLI vicarious calibration using MOBY and BOUSSOLE was published this year (Murakami et al., 2022, DOI: 10.1007/s10872-022-00632-x).

### **2.13 China's New Generation Ocean Colour Satellite Mission and Research Activities**

Xianqiang He introduced China's new generation of satellite OC missions. China has established three series of ocean satellites: the OC constellation (HY-1), the ocean dynamic series (HY-2) and the ocean monitoring constellation (HY-3 – high spatial and temporal resolution). Four OC satellites have already been launched (HY-1A to HY-1D), two of which are still in orbit (HY-1C/1D) and operating well, forming a morning and afternoon constellation. These carry three payloads: COCTS (10 bands, 1.1 km res.), CZI (4 bands, 50 m res.) and UVI (2 UV bands, 550 m res.). Overall, the performance of HY-1C is very similar to other OC sensors in coastal waters, and COCTS data agree well with MODIS and VIIRS. Merging HY-1C and D data provides better coverage in coastal waters. Atmospheric correction can be improved using the UVI sensor. HY-1C and 1D data are freely available from the China Ocean Satellite Data Service Center (<https://osdds.nsoas.org.cn/>).

China's new generation of OC satellites (HY-1E/F) will have a much higher spatial and spectral resolution. HY-1E will be launched in 2023, with a design life of 8 years, while the HY-1F mission is still in the planning stages. HY-1E will carry three payloads: the new COCTS (18 bands, 500 m spatial resolution), CZI (9 bands, 5 m or 20 m res.), and the new programmable moderate resolution imaging spectrometer (PMRIS) which has two modes: a multiple channel mode with 100 m resolution and a hyperspectral mode with 200 m resolution. It will be able to monitor OC in large rivers as well as coastal areas.

Besides the new generation OC satellites, China also has plans for a geostationary OC satellite (HY-3C), which is expected to launch in 2025 and will carry 3 payloads. The highest spatial resolution could be up to 25m, which could provide high spatial and temporal resolution observations along the coastal areas. Current AC algorithms can't process satellite data under high solar zenith angles (>70°), hindering the application of this Geo-OC mission, which observes from dawn to dusk. An AC algorithm for high solar zenith angles was thus developed using a vector RT model (PCOART-SA) and a machine learning method. They also developed an algorithm for retrieval of benthic reflectance by combining Lidar and passive high-resolution imagery in Case-1 waters.

### **2.14 CNES OC activities**

Anne Lifermann reported on CNES ocean colour science activities. CNES has been supportive of the IOCCG since the very beginning, with the first meeting in 1996 organized in Toulouse. She provided an overview of the CNES ocean programme, dealing primarily with altimetry, with extended operations of the current constellation including the SARAL and CFOSAT missions. The Venus mission, a Sentinel-2

precursor, is now entering a new phase with 2 day revisit, 5 m resolution over 26 new coastal sites that may be of interest to the OC community. In preparation there are two missions: SWOT, the wide swath altimetry mission in cooperation with NASA, and TRISHNA (in conjunction with ISRO, 2025). There are many bio-SWOT campaigns that will help to make the link between altimetry and OC.

Regarding preparation for the future, CNES will provide support to Copernicus future candidate missions (CIMR and CRISTAL) as well as the large swath altimetry Sentinel NG mission. Ocean colour geostationary observations are still a priority, but currently there is no way to implement such a payload. CNES also provides support for lidar and hyperspectral missions dedicated to the ocean, as well as supporting ESA for Sentinel-2 geometric and radiometric cal/val and for S3 implementation of 5 radiometric vicarious methods.

The TRISHNA mission is a precursor to the Copernicus LSTM mission for launch in 2025. The prime mission objective is monitoring the evapo-transpiration of land surfaces but there is a secondary objective of monitoring coastal zones. The current TRISHNA acquisition plan provides global coverage over land with a coastal fringe of (20-)100km, with bathymetry < 250m, and 3 acquisitions over 8 days. She enquired of the group whether there was interest in acquisitions at full resolution over the open ocean, or northern latitudes over 60° (especially the Arctic ocean) or multiple acquisitions at high latitude (to be discussed at the GHRSSST annual workshop). Inputs are welcome through the TRISHNA questionnaire online at

<https://forms.ifremer.fr/trishna/trishna-space-mission-for-water-ice-and-snow/>

Several studies have shown that seawater optical properties can be estimated from space-borne lidar such as CALIOP, so there is renewed interest in Lidar for ocean colour. The current work plan is to provide continuous validation of current products from CALIOP, ATLAS and AEOLUS which will be distributed. The Boussole programme has now reached 22 years of operating the EU site for OC-SVC of MERIS and OLCI. It is a candidate to host the future EU Copernicus OC-SVC infrastructure. The LOV lab In Villefranche is also promoting ocean colour radiometry on Argo floats (BGC-Argo) and the OC community is making increasing use of data from these Argo autonomous profilers. Examples were given on the use of machine learning to derive global 3D biogeochemical products using BCG-Argo data. French scientists are very active in the field of ocean colour space research and several other examples of cutting-edge research were given.

### **3.0 Status of IOCCG Working Groups, Task Forces, Protocol Series**

#### **3.1 Atmospheric correction in coastal waters WG**

Cedric Jamet reported on the progress of the IOCCG working group on atmospheric correction over turbid waters, focussing on non-zero water leaving radiances. The report is not sensor-specific but uses MODIS-A as an application, and has a dedicated chapter for adjacency effects and absorbing aerosols. Since last year the group has added the C2RCC algorithm (Doerffer and Schiller, 2007) bringing the total to 10 algorithms. Results for the classic match-up analysis using AERONET-OC for the 10 algorithms were shown, including spider-plots and statistical parameters on the retrieved spectra, as well as sensitivity

studies. They also developed a classification of 9 optical water types (OWT) from low to very high turbid waters, using the simulated data set. Depending on the algorithm, some are not very sensitive to the optical class, while others do better. They also created a simulated dataset for very turbid waters, and performed the same analyses resulting in three groups of atmospheric corrections that are sensitive to water type.

The various chapters of the IOCCG Report were reviewed (~95% complete). Because there are 10 algorithms and 9 optical classes it is difficult to have definitive conclusions, so they will group the AC algorithms in terms of their accuracy and sensitivity to optical water types. Limitations are that AERONET-OC only covers moderate turbid waters, they don't include the spectral band response of MODIS-A, and vicarious calibration is not done for each AC algorithm.

Shubha asked about the next steps of the TF, saying it would be nice to see the intercomparison exercise lead to suggestions for what can be done to improve the various AC procedures that participated in the study, as well as suggestions for the space agencies for what can be done in the design of instruments so that AC could be improved. She asked whether, after the report is published, there would be periodic revisits of the comparisons when algorithms evolve. Cedric responded saying that the report was 95% completed and they anticipated submitting a final version of the report to IOCCG by October 2022. In the IOCCG report, they would try to provide some guidance on the performance of individual algorithms and approaches for different types of waters and atmospheric conditions. The WG started 8 years ago but he was happy to pass the lead on to someone else to complete (he is shifting from AC to lidar and doesn't have time to work on the report). Perhaps it should be a living document (Technical Report) that could be updated with the new sensors, but he won't be the person doing it. Stewart suggested that he try to complete the report in some useful format, otherwise it will remain endlessly open.

**Action 26/1:** *Cedric Jamet to finalize the report on atmospheric corrections over turbid waters as soon as possible and consider including some information on the performance of individual algorithms and approaches.*

### **3.2 Task Force on remote sensing of marine litter and debris**

Shungu Garaba gave an overview of the IOCCG Task Force on remote sensing of marine litter and debris. Since 2016 there have been growing efforts related to RS of marine litter and debris funded by different agencies. The Task Force had their kickoff meeting in February 2021, and workshops in July 2021 and March 2022. The TF has been contributing towards many related conferences and symposia including the UN Oceans Conference and the ESA Living Planet Symposium. The TF is composed of international experts from several different disciplines and has four overarching core topics: technologies, algorithms & applications, datasets, and interdisciplinary aspects.

The technologies of interest include drones, ships, aircraft and satellite remote sensing (multi- to hyperspectral, optical, laser-based, microwave based). These technologies have prospects to detect, identify, quantify and track floating aggregated plastic litter. ESA has funded 25 related projects, many of which will be completed by summer 2022. ESA activities include development of 'ocean scan', a

database dedicated to RS of marine litter. There are also several projects funded by NASA as well as the Portuguese Space Agency (PSA). The Task Force has several pages on the IOCCG website including a bibliography, a list of online repositories and databases that the community should use to make data open access, and a list of upcoming events and related projects.

Craig Donlon cautioned that it may not actually be possible to detect plastics from space because the concentrations are so low. There are slicks that may be bi-generic in origin but you have to prove that they are related to plastics. We can, however, use the fleet of spacecraft in synergy to say something about the source, the degradation, the fate, and the track, but he cautioned against overselling, otherwise that would be a disservice to the community. It was agreed that these caveats should be included and addressed in the report. Heidi and Chuanmin have done sensitivity studies to see how concentrated the plastics should be to image from space, so this work should also be included in the report. Shungu mentioned that the Task Force members are aware of the capabilities and challenges of remote sensing due to the relatively low plastic concentrations and indeed the feasibility of this is what the members/community are researching. The Task Force has the mandate to provide guidelines to the community in order to prevent overselling and to optimize funding allocation for this topic, which is now of increasing interest at the research level.

### **3.3 Update: Task Force on Satellite Sensor Calibration**

Ewa Kwiatkowska reported on the IOCCG Task Force on Satellite Sensor Calibration, co-chaired Gerard Meister and herself, which is the product of one of the recommendations from the INSITU-OCR Whitepaper - to develop a permanent WG specifically dedicated to characterisation and calibration of satellite ocean colour instruments. The group held a virtual meeting in February 2022 covering a lot of different missions. A few highlights included moon observations: long term trends of lunar calibration for VIIRS on SNPP are more reliable than solar diffuser trends, and lunar observations have also taken place for OLCI's five cameras to evaluate stray light. Studies have shown that lunar calibration could, in some instances, be more reliable at quantifying trends than using onboard solar diffusers on some sensors. Artefact removal was also addressed (striping in SGLI removed, and a new striping correction for VIIRS). The discussions also touched on the significance of building engineering test units (ETU) to understand instrument performance pre-launch, as has been done for OCI in PACE. Notably, the Task Force discussed moving towards the new solar irradiance spectrum from Coddington (2021), replacing Thulier (2003). This spectrum is now recommended by CEOS and GSICS and is a good point for IOCCG to discuss. This new spectrum has a big impact on SVC when converting reflectance to radiance (Hiroshi Murakami showed that it was >2% for SGLI in the UV/blue, estimates for OLCI are ~3%). As a group, we should come to a consensus to use the new solar irradiance spectrum, acknowledging that it will have significant impact on our retrievals, and coordinating across the agencies to ensure continuity of products. Heidi noted that PACE will be using this spectrum but wasn't not sure if they will reprocess the old archive using this new spectrum.

Stewart Bernard recommended that all Task Forces provide some kind of annual output or statement as this type of information is useful for so many. Shubha suggested putting this information on the Task Force webpage so others can benefit. In order to convey this type of information to the broader

community Paula suggested creating a new section on “findings” on the IOCCG homepage. Stewart agreed that this kind of approach is the right way to go, and Venetia Stuart requested that all WG and TF Chairs report back to the Project Office with highlights for the IOCCG homepage.

**Action 26/2:** *IOCCG Project Office to create a new section for “highlights” on the IOCCG homepage. Chairs of all IOCCG WGs and TFs to report back to the IOCCG Project Office with any new findings that can be highlighted on the IOCCG homepage.*

Ewa noted that all these issues are extremely valuable, but many are specific to calibration experts. Also, it is advisable that the choice of solar irradiance spectrum is first discussed across agencies, and not just included on the IOCCG website, as it should be coordinated across the agencies since it will require significant reprocessing of data. The discussions from the virtual TF meeting were extremely productive and the next meeting of the TF will take place at IOCS-2023. The measurable benefits of the IOCCG TF are that it is the best way to get an overview of the calibration status and approaches for ocean colour missions across all agencies. A lot of information is learned from other missions, including the development of the instruments themselves.

Heidi enquired whether we should have a list of “recommendations” after each IOCCG meeting that the agencies could consider e.g., adopting the Coddington spectrum. Craig noted that these recommendations could be useful if they are written in the right way and are clear and directed, with options. They would welcome this as an output from the IOCCG, as a starting point for affecting change.

### **3.4 NASA/IOCCG Protocol Series update**

Emmanuel Boss reported on the NASA/IOCCG Protocol Series, which are vetted by the international community. The protocol series includes updated versions of the NASA Ocean Optics Protocols for Satellite Ocean Color Sensor Validation, as well as new material. Five protocols have already been published starting in 2018, with two more in final draft form (CDOM, Aquatic Primary Productivity). The protocols on backscattering (Slade and Sullivan) are in limbo, and there will be new protocols on phytoplankton carbon, suspended particulate matter, and radiometry protocols for non-ideal conditions.

Heidi commented that at the Living Planet Symposium, Arnold Dekker mentioned that some protocols were not suitable for sampling in inland waters. She suggested indicating on the website which protocols are applicable to coastal and inland waters, which may need revision, and possibly including links to published methods for diverse aquatic water types. Emmanuel replied that there is plenty of useful information in the protocols, which are not designed for specific waters. Heidi suggested that the inland water community should be invited to contribute strongly to the new radiometry protocols to avoid getting two different protocols from two different groups. Emmanuel pointed out that these are living documents so they can be revamped, and that they are dependent upon people volunteering to do this. He agreed to provide feedback to Antonio Mannino that the protocols should be inclusive of all communities (including inland waters). Claudia Giardino noted that she could share the best practices documents they developed for doing radiometry in lakes and rivers. Emmanuel suggested including a link on the IOCCG website to this document.

**Action 26/3:** IOCCG Project Office to include a link on the IOCCG website to Claudia Giardino's best practices for radiometry in lakes and rivers.

### 3.5 Discussion: Proposed Task Force on Ocean Colour System Vicarious Calibration

Ewa Kwiatkowska provided an update on the proposed Task Force on ocean colour system vicarious calibration (OC-SVC), co-chaired by Carol Johnston (NIST) and herself. OC-SVC is a fundamental requirement for all ocean colour missions in order to meet the stringent accuracy requirements for radiometric products and all downstream bio-optical products. This group used to be an IOCCG WG on "Long-term vicarious adjustment of OC sensors", but it has been converted into a TF because IOCCG considered it to be an extremely important activity (also a recommendation from the INSITU-OCR White Paper), so the TF can take care of these activities in the longer term.

OC-SVC infrastructures are important for space agencies who aim to maintain or establish new infrastructures, e.g., NOAA MOBY, NASA PACE, ESA Boussole, FRM4SOC etc. OC-SVC are highly specialized and very expensive so it is useful to have coordination across the agencies for lessons learned and methodologies. In 2020 IOCCG recommended the establishment of the OC-SVC Task Force. Initial membership was based on agency members as well as other members who were previously engaged in the working group.

There were no recent TF activities due to the pandemic, however there are many on-going activities and lessons learned at the agency level, which can be taken up by the TF. One of the first tasks is to write a White Paper describing strategy planning for global OC-SVC infrastructures (also a CEOS deliverable) – this could be addressed at the first TF meeting (perhaps Fall, 2022). Different agencies approach this activity in different ways – an example was given for EUMETSAT OC-SVC infrastructure development.

Emmanuel Boss commented on the evaluation of the modeled versus measured properties used in the comparison of reflectance, particularly related to differences in how the measurement is normalized to downwelling irradiance. When reflectance is compared, the  $E_d$  used for the *in situ* sensor should be the same model as the one used for the satellite (as it changes in time and therefore when measurements are not instantaneous with satellite pass, they need to be corrected for). The *in situ*  $E_d$  should not be used for this purpose (it could/should be used to validate the model).

Shubha noted that the OC-CCI project was also doing a lot of SVC work and should be included in the list. Also, in general, Indian participation is low to nil. With their ambitious OC programme, perhaps IOCCG could do more to engage them more actively? Ewa replied that Constant Mazeran (from OC-CCI) is a member of the TF and that there was an ISRO member on the expert review board for Copernicus OC-SVC. Emmanuel suggested adding Andrew Barnard (Oregon State Univ.) to the TF – he works on HyperNav (one of the 2 projects funded by PACE for SVC). Chuanmin Hu suggested adding Brian Barnes (USF) to this team. Emmanuel Boss noted that one of the differences between the way NASA and EUMETSAT do SVC is that EUMETSAT does it on Rrs while NASA uses water leaving radiance. One of the problems is that the downwelling irradiance that you normalize with is based on a model – is it worth

revisiting this issue? Chuanmin thought there was not much difference between the way EUMETSAT and NASA do SVC because a model is used to estimate  $E_d$  in both approaches. This was confirmed by Menghua Wang, who also wanted to be included as a member of the TF.

**Action 26/4:** *Ewa to approach Andrew Bernard, Brian Barnes, Paolo Cipollini, Marco Celesti and Menghua Wang regarding membership on the OC-SVC Task Force.*

Robert Frouin stated that it was important to specify the covariance matrix of the noise of the data, and enquired whether this could be included in the Task Force's objectives. Craig noted that ESA has some robust methods in the fiducial framework, but although these approaches are coming together, it is very difficult to do. Hubert recommended including a site at a high-altitude lake, which could provide useful information for atmospheric corrections. Ewa replied saying that the aim was to have as low uncertainty as possible for the *in situ* instruments, as well as the entire SVC process, in order to get the most reliable vicarious gains for global ocean coverage. Craig pointed out that SVC is a practical solution of how to minimize uncertainties in the water-leaving radiance, but it has many assumptions and there may be other ways of doing this. Ewa concurred, pointing out that the goal of SVC is not to calibrate atmospheric corrections, but to minimize uncertainties in water-leaving reflectances to meet mission requirements of 5 % uncertainty.

### **3.6 Benthic reflectance WG**

Heidi Dierssen gave an update on the benthic reflectance expert working group (BREW). She defined benthic reflectance as a property describing the colour of the bottom boundary in aquatic ecosystems, and clarified that the working group was not handling the topic of remote sensing of optically shallow water. She expressed challenges that the working group will address, including the variation in benthic types, three-dimensionality of benthic types, data validating, and the scarcity of instruments capable of measuring the colour of the bottom boundary.

The working group will produce a report that covers an overview of the topic of benthic reflectance. The group was formed through an open call to the community, which Heidi highly recommended for soliciting researchers as it resulted in a diverse group of scientists from many countries. She stressed that the qualifications for joining the group should be clear—in their case, the call was limited to those who had taken measurements of benthic reflectance.

The group held a kick-off meeting from 19 - 31 March 2022, hosted by Ved Chirayath at the University of Miami. Heidi indicated that it was the first time a group of this nature came together to discuss this issue, and thanked the IOCCG for facilitating the collaboration through the working group. She presented an ambitious report outline, broken into 6 parts, 17 chapters, and many subchapters. The group plans to meet at Ocean Optics in October 2022, and aims to produce a final draft by April 2023, and a complete report by October 2023.

Many individual publications are expected in conjunction with the report. A paper on benthic reflectance is expected to be compiled in tandem. Heidi requested funds from the IOCCG to pay someone for 4 months to collate the data. She also requested funds for publication fees for a proposed special issue on benthic reflectance, where many papers emerging from the activities of the working group would be published.

Venetia Stuart asked about the length of the report, given the number of proposed chapters and subchapters, and indicated that reports usually run between 100-150 pages because of the expense of printing and mailing. Heidi indicated that the report would be heavily edited to be within this range, and much of the detailed information can be moved to individual papers.

**Action 26/5:** IOCCG Executive to discuss the request for funds to pay for publication fees and to hire someone to collate data on benthic reflectance.

### **3.7 Report on IOCCG modelling report**

Stephanie Dutkiewicz presented (via a recording) an update on the working group on the synergy between ocean colour and biogeochemical and ecosystem models. The group formed in 2015 and produced a final report (Report #19) at the end of 2019, which was distributed in 2020. The word 'model' in the context of the report was defined as process-based, 3D ecosystem, large-scale models (not statistical models). The report has 9 chapters with two chapters being entry level on remote sensing and another on ecosystem and biogeochemical modelling. Stephanie indicated that these entry level chapters have been used heavily as teaching resources. She highlighted another highly used chapter, that of the mismatch between ocean colour products and model variables, as well the chapter on model skill assessment and data assimilation.

The report has 656 unique downloads from the IOCCG as of mid June, and 262 hard copies were sent. It has been viewed 1500 times on the Ocean Best Practices website and downloaded 983 times from that site. There have been 14 citations on ResearchGate, a predicted underestimate due to improper referencing of the report, and the referencing of individual chapters, which cannot be tracked.

Stephanie indicated that many modelers did not think about ocean colour products before joining the working group, and the working group spurred additional research and collaborations around the topic.

### **3.8 Proposed IOCCG Hyperspectral Task Force**

Paula Bontempi and Stewart Bernard led a discussion on the Hyperspectral Task Force. Stewart presented some background of previous discussions from the Committee meeting in Vietnam and subsequent email exchange. A key part of the thought process was to distinguish between the value of hyperspectral versus multispectral imaging, with IOCCG having the role of addressing and documenting this issue, as well as the applications that are enabled by hyperspectral from a Earth System perspective. Paula added that the question of what is needed to sell a new mission is important for the space agencies, noting that if applications are already achieved with an existing sensor, then we need to define and explore applications over and above what is already available.

Paula also outlined the need to start at the beginning with the definition of hyperspectral, because there was discussion over the definition within the room. Heidi Dierssen indicated that there was no standard definition, but a consensus of bandwidths of 5 nm. Stewart indicated that the definitions would be contextual and addressed in the report from the Task Force.

Jim Yoder asked (in the chat) whether there were good *in situ* databases coupled with actual measurements of pigments, etc. that can be used to demonstrate the science and applications of

hyperspectral. Chuanmin suggested that SeaDAS had some data of both hyperspectral reflectance and HPLC pigments. Stewart highlighted in his presentation that massive synthetic datasets are available via Jeremy KRAVITS work (NASA AIMS) and presented examples of freshwater application.

Concerns raised that should be addressed were: the examination of hyperspectral and spatial dimensions together; signal-to-noise ratios of the various applications; use of hyperspectral data above phytoplankton groups, including to improve the derivation of basic IOPs and to quantify percentage biomass (e.g. of applications to coastal and in-land waters were shared); and limitations of hyperspectral to avoid over-selling.

There was wide support for Stewart Bernard's idea of providing hyperspectral dataset(s) to the ocean colour community and facilitating a round robin where researchers could use the data for their various applications and report their findings. Heidi also suggested that this approach would get researchers keen on the topic, and Paula indicated that, as research labs can use their existing funds, the idea was very feasible. Claudia Giardino indicated that there is data available that could be used for the round robin exercise: 130 matchups of PRISMA data with AERONET-OC sites, as well as several campaigns within CHIME and SPG in which there is optical products, water quality parameters, benthic characterizations, and biogeochemistry.

Regarding someone to lead the exercise, Heidi Dierssen suggested some criteria to solicit people:

1) Published on PCC/hyperspectral 2) mid-career 3) good people-person 4) reliable at getting the job done. Names suggested by Committee members were Clarissa Anderson, Maria Kavanaugh, Julia Uitz, Astrid Bracher, B.B. Cael, Suzanna Craig, Ryan Vandermeulen, M. Hieronymi, Aleksandra Wolanin, Emmanuel Organelli and [Guifen Wang](#).

**Action 26/6:** *Paula Bontempi and Stewart Bernard to identify 2-4 goals of the hyperspectral round robin exercise, as well as the aims and some description of the process before soliciting a lead.*

### **3.9 Background of Carbon-from-Space Efforts**

Jamie Shutler presented a table from the 6<sup>th</sup> IPCC assessment showing estimates of global warming as a result of different scenarios. All scenarios show that warming of 1.5°C is likely to happen within 18 years, and could happen within 8 years – warming might actually be as high as 1.9°C. The Paris Agreement target of limiting warming to 1.5°C will not be enough to save most coral reefs, so there is a need for global societal change within 8 years! The implications are that we need our best carbon data and methods within ~5 years if we are to have maximum impact on guiding policy and societal behavior.

The ocean is a powerful constraint on the global carbon budget and so improvements in quantifying ocean carbon will help improve land and global carbon assessments. All approaches use satellite data in some form, and ocean data (satellite and *in situ*) are a fundamental input or key constraint on global carbon budgets. However, EO data are created in a non-optimal and inconsistent way as the global carbon budget (GCB) efforts lack any EO specific expertise and guidance. Many projects are unsure how to handle the increasing amount of satellite observations and the increasing reliance on them for carbon assessments. Authors misinterpret what chlorophyll-a data actually give and they misunderstand the

satellite optical basis of ocean colour, resulting in incorrect assumptions and conclusions about satellite data.

There is clearly a need to provide expert guidance on how to correctly exploit satellite observations in relation to ocean carbon. But, carbon assessments require synergistic approaches, using temperature, ocean colour, sea state and atmospheric measurements. A connected cross-disciplinary group is likely to enable faster and more coherent advice and guidance. IOCCG is in a position to lead such an expert, cross-disciplinary group by revitalising the IOCCG Ocean Carbon Task Force. This Task Force could provide a resource of expert advice across all areas of satellite observations relevant to carbon. Formation of such an expert group, could be led by the IOCCG but in partnership with other relevant expert groups (GHRSSST for temperature) and climate teams where expert groups do not exist (e.g., sea state) or individual experts where specific climate teams do not exist (e.g., David Crisp, NASA, for satellite observations of atmospheric gases over the ocean). This Task Force could actively:

- Encourage the uptake of climate quality satellite data records for all methods of quantifying ocean carbon e.g., observation-based methods, model data assimilation with Earth system models, atmospheric inversion modelling and atmospheric potential oxygen approaches.
- Provide support to annual assessments and related workshops (e.g., GCB and IPCC efforts).
- Collectively this will help support the aims of the CEOS Carbon Strategy.

### **3.10 Revisiting the IOCCG Ocean Carbon Task Force**

Shubha Sathyendranath noted that Jamie Shutler had given compelling reasons for reviving the IOCCG Ocean Carbon Task Force, and why IOCCG should take the lead. The group should take a broader view than just ocean colour. One of the outcomes should be aiming towards IPCC assessments at the community level. A good example is the global carbon report prepared by a community of modellers - we could do the same for the ocean carbon budget as there is a gap to fill. The global carbon budget focuses on what is happening to atmospheric carbon. The role of oceans is reduced to a service that modulates carbon. In talking about ocean carbon, the role is broader than just how much waste is taken up by the ocean.

Stewart Bernard suggested that we engage with the IPCC on better utilization of ocean colour imagery in global climate assessments. It is very important to convey that ocean colour data has enormous value that is not being fully exploited. We could have more impact as a combined value approach with the blue carbon and near coastal ecosystem communities by presenting a coherent ocean message. Paula noted that we cannot implement CO<sub>2</sub> removal as a strategy for mitigation of atmospheric CO<sub>2</sub> without understanding what is going on in the ocean and on land. That should be the message in going forward at the level of the UN Decade.

Heidi commented that it is very challenging to get people to work on IOCCG reports outside of ocean colour as they don't value white papers, which is how they perceive IOCCG Reports. Perhaps we need another type of report with a broader impact, not only for the OC community. Shubha responded by saying that if one of our goals is to have impact at the IPCC level, we would have a better chance with peer-reviewed publications, rather than IOCCG reports. She suggested that Jamie Shutler and Cecile

Rousseaux prepare Terms of Reference and how to handle membership in the Task Force (e.g., would it be open or have a steering committee?).

Jamie noted that peer-reviewed publications will not necessarily guarantee an impact. It's important to propose this concept of a Task Force within a scientific publication, highlighting the need for expert guidance. However, the only way to gain the attention of these communities is to work with them and embed yourself in these groups. Ideally, a small expert panel could provide advice to these groups, illustrating where the advantages are in using climate quality data sets, as opposed to using operational data. Cecile Rousseaux noted that Stephanie Dutkiewicz did a great job in linking the modelling community with the OC community but we need to go one step further and engage directly. Heidi suggested that we start identifying those meetings where we could provide input or reach out to specific groups. Cara recommended incorporating all these ideas into the ToR for the Task Force.

Ewa Kwiatkowska enquired about what we could do to make satellite data clearer and allow better understanding to avoid misinterpretation of the data. Jamie replied that there was nothing IOCCG or CEOS was doing incorrectly – these groups are experts in carbon and they don't have time to investigate the intricacies of this data. Shubha suggested holding a special side event at the IOCS meeting next year on this topic and inviting external experts and modellers to this session. This was supported by Marie-Hélène Rio who agreed that there was a need to understand why models are diverging from observations. CEOS has a 'Carbon from Space' Task Force and are encouraging us to provide an aquatic carbon roadmap. Should this be included in the Task Force's objectives? It is important to make ourselves heard at the CEOS level, perhaps through this Task Force.

**Action 26/7:** *Jamie Shutler and Cecile Rousseaux to prepare Terms of Reference for the IOCCG Task Force on Ocean Carbon, including contributions to the future CEOS aquatic carbon White Paper, concrete steps to make connections with different communities, and how to handle membership in the Task Force.*

### **3.11 Nomenclature activity**

Heidi Dierssen informed the Committee of a nomenclature focus group led by Alexandre Castagna (Ghent University) that met at the Living Planet Symposium. The group is supported by GeoAquaWatch and they discussed the need to revise hydrology optics nomenclature. In the past Robert Frouin raised revising ocean optics nomenclature, and Heidi indicated that the PACE group has also discussed the topic but had made no advances. She raised for discussion whether the IOCCG should be part of the current work being started on revising nomenclature, including for ocean optics. She gave a few examples of misunderstood terms within ocean optics (non-algal particles, which are a measurement of depigmented particles that do include algae; optically shallow, which is wavelength dependent with no clear definition; water reflectance not being a real reflectance). She said the aim would be to revise terms to be concise and consistent. The document could be hosted by IOCCG or AquaWatch and would be a living document, regularly revised. Infrastructure would be provided by GeoAquaWatch, as this is already in place. Their existing group is volunteer-based and fully open, though currently volunteers are mostly from Europe.

David Antoine objected to regular revisions of a nomenclature document as this may cause confusion about which version to use, thus not likely to be a living document.

Robert Frouin said he believed the topic of nomenclature to be a complicated one, because when there is usage of a word it becomes part of the vocabulary. Robert asked for a reminder of why the original proposal for a working group on nomenclature was turned down when it was first brought up to the IOCCG. Cara Wilson said there was concern at the time that a document of recommended uses released by IOCCG would be in conflict with the agencies within the IOCCG that have their own guidelines for how those terms are used.

Craig Donlon expressed that creating a nomenclature document must be a community effort. It is extremely complicated to do, but there could be a short IOCCG publication that addresses it.

Stewart Bernard suggested we get acquainted with dictionary making, where a corpus, or examples of use are shown, and then terms defined based on use in a descriptive way, so one is *recording* the use of the language rather than *prescribing* usage.

Heidi agreed that descriptions are useful but believed that a revision was necessary as some terms are confusing outside of the ocean optics community. She gave the example of modellers thinking non-algal particles are sediment. She thinks we should have a revision and either work with AquaWatch or do something separate. She indicated that even within IOCCG, the use of the term *ocean colour* excludes inland waters. Cara indicated that the Committee previously discussed a possible name change for IOCCG but decided to keep the name and change the byline of the IOCCG (posted on the website) to explicitly include in-land waters.

Vittorio indicated that CMEMS is obliged to use CF compliant terms, and that adding new terms requires the CF compliant database to be extended to include these terms. This would make a prescriptive approach impossible. He agreed that a descriptive approach would work, and would be very helpful.

Shubha suggested that IOCCG should be a part of this working group so that there is no inconsistency between the groups. She agreed with a descriptive dictionary approach. She acknowledged that there are many types of definitions, from scientific, to operational with links to the methodology of the measurement, but that the main purpose of a nomenclature activity would be to avoid ambiguity.

Hubert Loisel indicated that nomenclature is not right or wrong, it depends on the variable and how it was measured. Emmanuel Boss raised a similar point. Emmanuel and Hubert gave examples of the measurement of NAP, and differences between dissolved and particulate. Hubert indicated that even descriptions for biogeochemical particles are not standardized, and it may be useful to include people who use these terms in the working group.

Several members from IOCCG volunteered to join the effort including Heidi Dierssen, Robert Frouin, Vittorio Brando, Claudia Giardino, and Frederic Melin as representatives of IOCCG, and the consensus was that a descriptive over prescriptive approach is preferred. Claudia Giardino indicated that a similar activity is currently being done within the Horizon 2020 Water-ForCE.

Robert Frouin asked for suggestions on how to move forward with the activity, whether hosting on IOCCG website or otherwise. There was agreement that hosting on the IOCCG website would be beneficial, possibly shared with some hosting by AquaWatch. Javier Concha suggested the definitions of

the term reflectance done by Curtis Mobley in the Ocean Optics Web Book could be used as an example. Emmanuel Boss suggested a period for community input before the terminology report is finalized.

## 4.0 Other Ocean Colour Initiatives

### 4.1 WATERHYPERNET autonomous hyperspectral radiometer systems project

Kevin Ruddick presented updates on the WATERHYPERNET project that he introduced to the IOCCG four years ago. The project consists of a suite of hyperspectral automated data acquisition sensors at a number of sites around the world. The advantages of the project are that hyperspectral data acquisition matches any satellite instrument bands available from the international space agencies represented by the IOCCG. The data collection sites are networked so the data can be downloaded in the same format with a reasonable expectation of homogenous data quality.

The project uses two measurement systems: the PANTHYR system (based on TRIOS/RAMSES, 400 - 900 nm, 10 nm FWHM - Full Width-Half Max) deployed in the Adriatic Sea, North Sea and a reservoir in Belgium, and a new hyperspectral radiometer, Hyperstar (380-1020 nm, 3nm FWHM), currently deployed at 6 sites (Blankaart in Belgium, Etang de Berre in France, Acqua Alta in Italy, Rio de La Plata in Argentina, Gironde in France, and Lake Garda in Italy) with 6 more coming up soon. The data collected from these systems have already been used to validate existing sensors in addition to new space instruments. Kevin showed data collected at a single site over the course of a month used for validation of 6 different sensors. In answer to a question raised by Emmanuel Devred, Kevin indicated that the timing of data acquisition was every 20 minutes, which removes worry about matchup time with satellite imagery.

Vittorio Brando raised that in addition to hyperspectral measurements being collected at the Acqua Alta site in Italy, a flow cytometer will be installed by the end of July. This additional data will prepare the site to be used as one of the sites for data validation of the use of hyperspectral data.

### 4.2A Discussion: AERONET-OC

Laura Lorenzoni gave an update on how the management of AERONET-OC is going to change. She reported that NASA currently manages the AERONET network infrastructure but the processing of algorithms and quality control of data products for AERONET-OC resides with Giuseppe Zibordi (JRC), who is retiring. NASA is working with AERONET to integrate AERONET-OC, which would make AERONET-OC more robust to future changes. Laura informed the group that over the next few months, through NASA, the capability to develop algorithms and have quality control will be adopted, and NASA is going to hire Giuseppe, part-time, to assist with this knowledge transfer. The JRC should ensure the functioning of their sites for the foreseeable future, at least until 2025, and will continue to do inter-calibrations with NASA. The move gives us the opportunity to rethink improvements to AERONET-OC. Laura pitched that connecting *in situ* efforts (WATERHYPERNET specifically) is part of the discussion. Divisions between sites might have been historic but we have an opportunity to determine how we use these sites for future hyperspectral missions. How can we improve and what is the future of this large insitu network?

Kevin stated that some of the WATERHYPERNET sites are co-located with AERONET-OC sites, facilitating comparison of data sources and consistency. Laura reiterated interest in connecting those data streams. Paula mentioned the possibility of redesign of the instruments used within AERONET-OC. Craig mentioned that going to hyperspectral is really important, as there may be dynamic combinations of sensors in the future and we need hyperspectral data to validate these dynamic systems.

Cedric asked whether the community can sustain two networks doing similar things (WATERHYPERNET and AERONET-OC) and asked whether we should change AERONET-OC to hyperspectral. There was consensus that one was not to replace the other. Kevin indicated that both were needed as AERONET-OC is the main source of data for satellite validation, and WATERHYPERNET is not at the same stage of maturity. The two systems need to work together to ensure consistency. Claudia agreed and added that WATERHYPERNET cannot provide aerosol properties like Aeronet-OC, which is another key point to keep both.

#### **4.2B Discussion: Accessibility of OC products**

Laura Lorenzoni reported on a recent workshop supported by the hydrology program at NASA (led by Steve Grebb) from which a discussion emerged about the IOCCG protocols. Whereas the protocols are great, they are not always accessible to all levels of scientists or data users. Laura asked if the IOCCG could include an appendix to the protocols written for non-experts that gives basic steps of how to take measurements and explain why these steps are required—allowing the protocols to be accessible for those geared towards applications.

Ewa Kwiatkowska (Juan Gossn from the EUMETSAT's team was present at the workshop) stated that EUMETSAT engages in follow-up activities, and one major goal is to develop a set of radiometry protocols and make them as prescriptive and simple as possible to be followed by everyone. Currently this is being geared at two families of radiometers (TRIOS and Sea-Bird) for taking above-water radiometric measurements. Kevin added that while we do need to make the protocols simpler, people need to also be well trained to use and understand the measurement they are taking, and this can sometimes take months.

Laura said that posting instructional videos on YouTube was recommended, adding that the IOCCG lectures that are recorded and posted on YouTube are currently a tremendous resource. Chuanmin Hu agreed with video training, but cautioned about lowering the standard of a protocol, and the collection of bad data that could result. Laura agreed that bad data is to be avoided, but argued for various levels of precision required for various applications. Chuanmin agreed, and suggested establishing a second set of protocols for application-oriented data collection. Ewa argued that adding more prescriptive, detailed explanations (or recipes) for how to perform tasks does not degrade the quality of protocols, but makes them more accessible and increases the ability of the community to collect the highest quality measurements.

Heidi Dierssen showed that she was working on a paper to determine criteria for the quality of data collected based on the applications of data. She argued that stringency in data quality to satellite-calibration standard does not always benefit the whole community. Heidi Dierssen and

Emmanuel Boss suggested training classes before/in conjunction with every IOCS meeting on selected topics.

Craig agreed that the protocols could be simplified to increase usability and accessibility. He also agreed that a practical approach to making measurements will be useful, and argued that it has to be a community effort with buy-in from instrument manufacturers.

Kevin argued that a measurement value must have reliable uncertainty attached. Craig added that the concept of fiducial reference measurements (FRM) allows us to separate a subset of measurements to derive uncertainty, and helps with this problem.

There was general agreement in creating prescriptive documents for applications, and David Antoine shared [this community of practice document](#) to illustrate the point. Paula Bontempi reiterated the creation of videos to demonstrate the use of an instrument for beginners and senior scientists alike, and added that round robin intercomparison with the instruments is another great method for training while also checking for measurement consistency. Aurea Ciotti added that in addition to instructions/protocols for collecting data, we could also have instructions for processing data, for example, simple Jupyter notebooks with lots of documentation.

Shubha shared that the Trevor Platt Science Foundation has a three-tiered system for training: 1- online training for a broad audience, 2-selection of a subset for in-person training, and then 3-selection of a further subset for a longer-term internship.

Ewa Kwiatkowska invited everyone to the FRM4SOC-2 workshop from 5-7 December 2022 where 'cooking recipe' protocols as well as the *in situ* community processor and instrument calibration guidelines will be discussed.

#### **4.2C Ocean Color Remote Sensing from the first Earth-Sun Lagrange point**

Robert Frouin advocated for an ocean colour remote sensing mission from the Lagrange-1 (L1) orbit, which is ~1.5 million km from Earth in the direction of the sun. He noted several advantages including simultaneous viewing of the sunlit ocean at high temporal and spatial coverage from a single platform, which can resolve diurnal variability of biology, as well as mitigation of sunglint, facilitation of atmospheric correction and radiometric calibration, and a more steady thermal environment.

Robert presented examples from EPIC/DSCOVR in L1 orbit. The chl-a product was less noisy with no gaps at low and mid-latitude compared to MODIS-derived chl-a. Also shown were comparisons of daily mean planar and scalar fluxes just below the surface, daily mean water reflectance just above the surface, and surface chlorophyll concentrations. The spatial resolution of EPIC is 10-km at nadir and is coarse for ocean-colour application and especially coastal regions—a spatial resolution of 1-km or less is desirable. A large telescope would be required to acquire this resolution. Other instrument concepts recommended included a full disk imager and a geographic scanning instrument.

Preliminary calculations indicate that it is feasible to build a hyperspectral, polarimetric sensor measuring from UV to NIR with 1-km resolution from L1. Robert requested that space agencies consider an ocean colour mission from the L1 orbit and commission a pre-phase 0/A study.

David Antoine indicated that this is one of the most original missions for some time, and there was general interest from many others. Kevin Ruddick asked whether a paper showing these DSCOVER/EPIC results were available. Cédric Jamet shared the following: <https://doi.org/10.3390/s19051243>.

### **4.3 Discussion: request for full resolution OCR data over coastal waters**

Hubert Loisel emphasized the need and requirements to get good data at 1-km spatial resolution over coastal waters. He showed examples of MERIS data at 1-km spatial resolution to extract mud bank dynamics in coastal waters, submesoscale processes, and processes within large estuaries. Though MODIS gives good data at every band at this resolution, the data still requires specific processes and expertise that is not always available to end users. CCI now delivers data at 1-km spatial resolution using POLYMER for open ocean but it is not the best solution for coastal waters. Hubert requested agencies if it is possible in the context of long-term studies to reprocess MODIS, and other data, using appropriate cloud masking and atmospheric correction algorithms that are decided by the group and by removing flags in coastal regions. This will stimulate the use of ocean colour data in coastal research.

Craig Donlon agreed there is work to be done to continuously reprocess and improve the data. In the past IOCCG advocated for new sensors but today the big challenge is getting end users engaged, and justifying the missions and the data. He thus agrees with a reprocessing exercise to have more data for use in coastal areas.

Frederic Melin agreed and asked whether there was an atmospheric correction algorithm that could be applied operationally by the space agencies in coastal waters. Hubert indicated that many algorithms give about the same level of performance, and that we should not wait for the perfect algorithm but reprocess as algorithms improve, and state any known error or uncertainty.

Chuanmin Hu clarified that the process being requested is not a standard reprocessing but more a coastal driven processing. NASA's processing with conservative flags is driven by accuracy for climate data records. Relaxation of those flags will lead to higher quantitative data in coastal areas, but will degrade global ocean data and sacrifice the climate data record. He agrees that more data is needed in the coastal region, and said we will have to compromise to get data quantity in coastal waters, but as a coastal-driven process.

Vittorio Brando raised that NASA's masked data is not available to the end user to be able to relax the mask. This issue of flagging and how to apply the mask would have to be left up to the user if the data is to be made available. Emmanuel Devred indicated that for MODIS, NASA would need to process the data at 250 m, to match MERIS/OLCI resolution and increase data in coastal areas, deltas, and estuaries.

Kevin Ruddick indicated that for SPM the turbid water atmospheric correction only needs to be good enough for the red and NIR bands. He also indicated that AVHRR, which goes back to the 1980s, can be used to do long-term studies of SPM in coastal areas.

Shubha Sathyendranath wondered whether the atmospheric correction in turbid waters working group had some recommendations on how to approach the coastal problem? She also asked Hubert to give feedback to CCI, as they rely on user feedback to improve.

Ewa wondered if adding the measure of uncertainty to the products might help users decide on their own to use the data for their applications. She also agreed with Shubha, that good guidance from the atmospheric correction working group would be useful to guide development activities.

Stewart Bernard agreed with Hubert's request, indicating that there is no global high resolution coastal product that goes across all water types, and the issue is a major concern when trying to reach end-users. He argued that the IOCCG needs to treat this as a major issue as most ecosystem benefits claimed from ocean colour cannot be observed if people do not have access to the data.

Craig echoed what Ewa said about declaring uncertainties and posed a question to Vittorio relating to the lack of engagement with the 100 m product at CMEMS. He asked what could be done to get more user engagement.

#### **4.4 Generation of water quality products from high resolution satellites**

Emmanuel Boss made the case for the generation of water-quality operational products from high resolution remote sensing data. He stated that the 5 day coverage at 30 x 30 m resolution between Sentinel-2A/B and Landsat 8/9 have huge potential and utility for society beyond climate - raising applications such as aquaculture, pollution, HAB detection, and land-use.

Emmanuel showed the plans for the TRaversing European Coastlines (TREC) project, which will visit all the European coasts with a moving lab that will measure soil, sediment, water, aerosols, and are looking for collaborators. The lab will stop at 47 institutions with a timeline for coastline sampling from April 2023 - July 2024. Vittorio Brando added that they analyze existing OLCI and Sentinel-2 imagery to give the best design to the project. He stated that most funding is dedicated to routine measurements, and the support being requested now is to apply optics at a fine scale. They wished to make the community aware of the project so people can get involved.

David mentioned a similar effort of high resolution spatial sampling for lakes in Canada, and encouraged Emmanuel to contact Yannick Huot, who may be able to share lessons learned beforehand. Emmanuel agreed. Marie-Hélène agreed with the strong opportunities to make a link with data users.

Carolina asked whether sampling could be organized with matchups for PRISMA or other hyperspectral missions, and suggested that a proposal to the space agency would get support. Vittorio agreed and stated that he intended to communicate with both agencies once he finalizes the tracks, with an aim to incorporate EnMAP and PRISMA.

Hubert Loisel shared a similar sampling effort in France and expressed a desire to have the two projects coordinate and collaborate. He will send contact information for the existing project to Emmanuel Boss. Emmanuel was keen and stated that one unique thing about TARA's measurements is the same protocol is used for all measurements which allows for direct comparison with anywhere that TARA has sampled, enhancing cross-coordination.

Anne Lifermann asked how coincident satellite imagery will be coordinated with the sampling effort. Vittoria stated that they would be using the revisit times to help to plan, and would adjust to be coincident with as many satellite overpasses as possible. Vittorio also suggested to Emmanuel that they have a workshop between October to December 2022 to involve as much of the community as possible.

#### 4.5 Establishing an efficient international database of match-up data points

Hubert Loisel requested a community effort to get more *in situ* databases with match-up data points made publicly available to the community. He said there were many tools to get matchup data, and more papers with *in situ* data emerging, but no access to the matchup files open to the community with at least TOA reflectance, and maybe Rrs depending on community. Javier Concha said there was an effort by EUMETSAT to create the matchup databases in common netcdf files. Maybe that is the way to go to standardize the data and a way to share the data.

Cedric Jamet asked whether there was a pool of *in situ* datasets for matchups with Sentinel-3, and stated that it would be good to gather the datasets used for validation and have the data be freely available, especially because tax-payers money was often used to generate the data.

Ewa Kwiatkowska agreed with a push for increased availability of data. She mentioned that it would be good to discuss at the next S3VT meeting in October and asked Cedric if he would be willing to have a slot in the meeting. She stated that NASA and EUMETSAT are already working on a funded project to make interoperable *in situ* databases, starting from the SeaBASS template, and for *in situ* and satellite data in a single file for everyone to use. She heard it would be useful to include L1 data in the matchup as well, so they have been doing this and they would be happy to share. She stated that it would be a good incentive and helpful if they received more clear direction on whether this service is needed and requested by the community.

Craig Donlon agreed that IOCCG could help by promoting open and shared datasets. An automated matchup system would be good, similar to Felix for SST, and could work for the ocean colour community.

Vittorio Brando pointed out that there is often a mandate to share data after projects in the EU have closed, but there is low compliance, and there is no centralized place for people to deposit or access data, which would be helpful. He suggested that the community needed to make a concerted effort towards this and agreed that the IOCCG could help to push this forward.

There was clarification that both single-mission and multi-mission match-ups are desirable. Emmanuel Boss gave an example of the BGC Argo datasets, which are great for matchups.

Shubha Sathyendranath suggested that the request could be more tractable if split into two: 1- make sure that *in situ* data becomes publicly available through various initiatives; 2- depending on the user activity, have data available for matchup with a set of observational data. Maybe an extraction procedure based on coordinates would be helpful for global accessibility to the database.

Hubert's original request for a database was geared towards the space agencies, and there was a discussion and agreement that the space agencies are well poised to maintain such databases as when people leave institutions, their data is not maintained. Craig Donlon warned that there should be independence between the space agencies that produce the instruments and the independent validation of those instruments, including the collection of the data used to validate. He also cautioned that the sharing of data by scientists comes with their desire to be properly cited, compensated, and acknowledged for the work in collection and quality control.

Shungu Garaba stated that he could assist by providing lessons learned or recommendations on making *in situ* data available based on datasets collated for remote sensing of plastics.

#### **4.5A Discussion: Seasonal Biases in Ocean Colour**

Emmanuel Boss reported on a recent paper by Bisson et al. (2021, <https://doi.org/10.1364/AO.426137>) that revealed a significant seasonal bias in ocean colour reflectances at the MOBY validation site. Products derived from Rrs are affected by the bias to varying degrees, in particular backscattering and CHL. NASA has funded a group in the US to understand the sources of this bias, but it deserves global attention. Robert Frouin noted that it's a complex problem and will take time to figure out. The bias could arise from many different sources including vicarious calibration, modelling of TOA reflectance, a residual error of atmospheric correction etc. Amir Ibrahim has shown that the look up tables of aerosol properties might cause the apparent seasonal bias at MOBY. At this time, the strongest contender seems to be an issue with the aerosol scattering contributions in the backscattering region for large particles. Chuanmin Hu pointed out that even if we know the reasons, there is still not a solution because some assumptions change the data e.g., an assumption of the vicarious calibration changes everything, including seasonal responses. Kevin Ruddick pointed out that in high latitude areas you can get two overpasses per day with two different sun zenith angles for the same day. We could look at GOCI data where there are many sun zenith angles per day – he referred to the paper by Javier Concha et al. (2019) (<https://doi.org/10.3390/rs11030295>).

Menghua Wang has looked at NOAA processing and was not convinced that there are seasonal changes. There is high variation in the summer for the MOBY site but there is also a lot less data in the summer, so data matchups are low. He does not believe there is an issue with vicarious calibration as there is a consistent and solid approach. A more careful study is required to look at the matchups and the statistics. Many participants also wondered why this has not been reported previously.

Craig suggested that several groups should look at this independently to confirm the results and then discuss a plan of what to do if it stands. It could be an issue with sampling. Laura Lorenzoni agreed that a Tiger Team should be established to address this issue, which will need time and money. The timeline is probably around one year as it has to be done seriously. Suggestions/volunteers for Tiger Team participants included Amir Ibrahim, Brian Barnes, Kelsey Bisson, Lorraine Remer, Frédéric Mélin, Jaehyun Ahn and Myung-sook Park.

**Action 26/8:** *Agencies to report back on the outcomes of their investigations on the causes of seasonal bias observed in vicarious calibration measurements from MOBY and the implications.*

#### **4.6 Showcase of HyperNAV**

Emmanuel Boss and Robert Frouin introduced HyperNAV, one of the two funded cal/val activities for PACE funded by NASA. It is a flexible system that can be deployed rapidly in a variety of places around the world and facilitates multiple sites for cal/val, and a higher number of match-ups on clear days. The system is based on floats with two optical heads close to the surface to provide higher confidence in

results, and low perturbation from nearby platforms. Measurement uncertainty criteria is below NASA's required threshold. The HyperSVC engine will handle data collection and link the *in situ* data to satellite overpasses. Floats can be steered by changing the depth in conjunction with physical circulation. From 2021-2022 floats were deployed in Hawaii, USA and in Crete, Greece (on-going).

Emmanuel showcased the website for HyperNAV Engine (<http://misclab.umeoce.maine.edu/HyperNAV>) which surfaces data collected by floats as well as float locations. Chuanmin Hu asked about bio-fouling and Emmanuel noted that it is handled by sinking the float to a depth where water is colder. Furthermore, there is pre-and post deployment calibration, so bio-fouling can be tracked.

Frédéric Mélin raised the topic of SVC requiring controlled conditions with respect to a single target and higher uncertainties arising from the variability of locations. Emmanuel indicated that this effort will be in addition to MOBY, and can help to uncover assumptions about single site calibration that are not yet realized. Robert agreed, and indicated the criteria useful for SVC can be selected for, and that it would be useful to compare SVC in different places to gauge consistency.

#### **4.7 Discussion: OC User Needs survey & data use**

Cara Wilson gave context for a discussion on user needs that emerged from the last Committee meeting, using a quote from Robert that stated that IOCCG should take on the task of documenting and explaining ocean colour data utilisation. Cara shared data from a 2011 paper on the international use of various country's sensors showing that data from some sensors were used more internationally than others. Cara highlighted the need to know the barriers to usage of ocean colour data, and indicated that a survey was suggested, with the caveat of getting the right people to participate. She shared examples from NOAA CoastWatch as a value-added provider that works with the users to know their needs and make data more accessible to users.

Stewart Bernard indicated that we're missing the last link of the value chain, and said that how products are presented to people to increase understanding is critical. He urged a return to the idea of using IOCCG to establish forward-looking user needs. Ewa agreed that this is an excellent role for IOCCG. Heidi Dierssen suggested that a Task Force on user needs that creates a website presence would be useful for moving this forward.

Laura Lorenzoni expressed that the question of the barriers to satellite data usage has been addressed by many groups, and a lot has been done on this topic. She stressed that we need to capitalize on what has already been done as there is a wealth of information from different nations that we could leverage before attempting any type of survey.

Vittorio Brando indicated that in Europe there are two types of initiatives, one involving a large user community utilising multi-sensor, multi-optical type products, and another that uses products that go beyond the standard L2 data. He also indicated that he does not always have direct access to users as there is the additional layer of product distributors, so getting the needs of users is not straightforward.

Heidi Dierssen suggested expanding the IOCCG committee to include someone who does outreach, e.g. Hayley Evers-King (who conducts teach-the-teacher training) or Karen Joyce. Shubha added that we should match the uptake of data use with training and capacity building so that users know the limitations and possibilities of the available data.

Shungu Garaba expressed that data utilization could be a good update to *IOCCG Report 7: Why Ocean Colour? The Societal Benefits of Ocean-Colour Technology*. He opined that a Task Force could be formed to deal with Interdisciplinary Aspects of data utilization—how remote sensing quantitative and qualitative end-products can support a wide range of applications. Heidi agreed with this. Marie-Hélène expressed that if we are putting together a report of data utilisation we should be clear about the scope.

David Antoine expressed that doing surveys does not necessarily produce very good results, and expressed strong support for working directly with users to understand what they need, which was supported by Marie-Hélène, Menghua Wang, and others. He suggested that having data delivered with uncertainties is useful, and definitely more demand-driven data. Ewa agreed, noting that Agencies need to develop products based on needs, and also expand into other end-user applications such as fisheries, aqua culture, HABS, water quality forecasting, etc. Heidi Dierssen also agreed and indicated that two-way communication with users—getting their feedback for when things work or not—is also very important. Cara also agreed that doing a survey was not necessarily the way forward.

There was a discussion in the Webex chat about whether users want forecasting or to handle the actual ocean colour data, and defining users (scientists versus policy). Stewart indicated that we should separate future-looking user needs, and the user survey, but that regarding the survey, there are very many different types of users, and the archetype of that user would need to be defined. He raised the structure of the [European Association of Remote Sensing Companies \(EARSC\)](#) as an example of defining users and forming a structure. Laura indicated that the NASA applied sciences program could probably provide input from a breadth of users.

It was decided that Cara, Stewart and Vittorio would meet virtually and have further discussion on the user types and value chain.

**Action 26/9:** *Vittorio Brando, Stewart Bernard & Cara Wilson to meet virtually and discuss user types and value chain and report back on any suggestions for the IOCCG.*

## 5.0 CEOS OCR-VC Deliverables

### 5.1 Update on CEOS OCR-VC

Ewa Kwiatkowska updated the group on the OCR-VC deliverables for the CEOS work plan. Regular reports are given to CEOS on the progress of the deliverables. A total of 8 deliverables are currently active, including the IOCCG/CEOS INSITU-OCR White Paper. Many agencies are contributing to the recommendations written in the White Paper and it is coming along slowly but successfully. IOCCG capacity building (including the SLS and online tools) are also included in the CEOS deliverables. The aquatic carbon workshop and special issue work to fill a gap in the CEOS understanding of carbon contributions from the oceans, and CEOS is very supportive of these activities. There are also synergistic activities with CEOS Coverage activities.

Maycira Costa (via a recording) summarized the working group in the OCR-VC on CEOS analysis-ready data (ARD) for the ocean. CEOS ARD defines geophysical measurements and specifies the criteria for these measurements. Examples of analysis-ready products already available are Landsat-8 L2 surface

reflectance, Sentinel-2/L2A surface reflectance, JAXA's ALOS-2 PALSAR-2 polarimetric decomposition and normalized radar backscatter. In order to have CEOS ARD definitions, we must first define product family specifications. The current stage of focus is to add ocean ARD product specifications. These specifications will then be put forward for peer review, and then approval from CEOS as an ARD product. The Ocean CEOS ARD is arising from the new product family of the Aquatic CEOS ARD.

Maycira showed the information required on a per pixel basis in a range of categories that needs to be defined, and requested input from the IOCCG on whether any of the current specifications listed need to be changed or updated. This feedback on the specifications is desired by mid-August (submitted to [maycira@uvic.ca](mailto:maycira@uvic.ca)) She also attached the [CEOS ARD aquatic specification](#) for review.

**Action 26/10** IOCCG Committee Members to give feedback to Maycira Costa ([maycira@uvic.ca](mailto:maycira@uvic.ca)) by mid-August 2022 on specification for the CEOS ARD Ocean product family.

Laura Lorenzoni presented on the Oceans Coordination Team (OCT), which is spinning up within CEOS to examine CEOS ocean related activities across virtual constellations and external stakeholders. The OCT aims to identify commonalities, possible synergies, and gaps. The team emerged from a request from the Ocean Decade to CEOS, which required a coordinated effort to respond to the needs of the Decade. The OCT had its first meeting in March 2022, but it has been slow progress. A questionnaire was developed to capture the main activities of the CEOS groups as part of the coordination effort, but only 3 responses had been received so far.

**Action 26/11:** OCR-VC members to complete the questionnaire from the CEOS Oceans Coordination Team

## 5.2 Ocean Carbon from Space workshop in 2022

Marie-Hélène Rio gave the context of the Ocean Carbon from Space workshop which took place in February 2022 and was organized by PML and ESA. The workshop was a contribution to the CEOS work plan. The CEOS aquatic carbon roadmap is the aquatic leg of the CEOS roadmap to support the global carbon stocktake. The workshop was the first step in developing this roadmap.

One of the main questions of the workshop was what are the gaps /missing elements to move towards a consistent and coherent ocean carbon budget from space data? The workshop would aim to bring together remote sensing scientists and modellers and try to articulate a collective view on the current status, and identify gaps in knowledge and formulate a scientific road map. There were two main outcomes: i) write a community white paper to be published in Earth Science Review special issue; ii) on ESAs side, prepare for a large ocean carbon project in synergy with other existing initiatives to build on the previous activities.

All the information for the workshop is available on the website, including presentations and posters along with a synthesis of each session provided by the chair (<http://oceancarbonfromspace2022.esa.int>). Over 100 abstracts were received, and invited submissions contributed to a range of topics. Out of these topics, 6 main sessions were selected. A Padlet was also open the week before the workshop to gather ideas and thoughts about the challenges, gaps, and opportunities from the participants. The workshop was a big success, with more than 440 participants from all over the world. The workshop recommendations were built from the synthesis of the sessions.

Shubha Sathyendranath presented the following two workshop outcomes:

1. A special issue in *Frontiers in Marine Science* (Research Topic) Volume 2 in the series on 'Colour and Light in the Ocean' with a focus on ocean carbon from space. This will build on the contributions at the workshop.
2. Scientific roadmap on ocean carbon from space, including chairs from the sessions and others. This roadmap on the carbon pools and fluxes would go into the journal *Earth Science Reviews* special issue on *Aquatic carbon stocks and fluxes: the big picture from remote sensing*. The document is currently in preparation and an advanced draft has been circulated to co-authors for comment. The deadline for submission is 22 July 2022 and the paper is on track for submission.

### 5.3 Journal special issue on Carbon

Laura Lorenzoni gave an update on the journal special issue on '*Aquatic carbon stocks and fluxes: the big picture from remote sensing*'. She recapped that the idea for the special issue was born from an initial presentation at IOCS in 2019, looking at how remote sensing can help address carbon sources, stocks, fluxes, and everything in between. A group of guest editors were recruited and the scope was defined within the first half of 2020. A decision on the journal and a draft of the call was prepared. It was decided that authors would be invited to submit to the journal, and the reason was that leaders in the field would be able to adequately review the status of aquatic carbon from space. Conversations with lead authors occurred by the end of 2021, and one-pagers to verify scope were submitted. The original timeline has slipped from publication in the summer of 2022 to publication expected by December 2022. Manuscripts are due by mid July. The journal *Earth Science Reviews* was selected to try to reach a more diverse audience with the state of carbon in the ocean. Manuscripts on future directions were also included. There are 14 topics covered, though there are a few for which no lead authors were secured. However, many of the topics overlap and no gaps in topics are anticipated.

Stewart Bernard admired the level of energy putting these together, but asked whether we could take it further with regards to impact. Specifically, how do we show the value of ocean colour regarding climate and carbon, especially in the IPCC space, and regional policy spaces?

Shubha Sathyendranath highlighted that in the current IPCC Report 6, highlights were selected from the special issue in oceans and cryosphere. She quoted the report stating "high uncertainty in ocean primary production" with a reason cited as "short length of time series, the number of studies, the lack of independent verification of satellite-based estimates". She urged that for the next IPCC Report it would be good to have a collective community effort on primary production compared with *in situ* observations and make a case for IPCC to take these estimates seriously. She also raised the general assumption that ocean biological processes are important for the long-time scale carbon cycle (geological time scale) but has little role in the current rapid change in the Earth's carbon budget, and urged us as a community to discuss this topic and address it more closely. Emmanuel Boss said the current inability of biology to balance CO<sub>2</sub> has been shown in Galen McKinley's work, where surface ocean CO<sub>2</sub> can completely be explained by the solubility pump. He said that when we stop pumping carbon to the atmosphere, biology will be very important, but currently the role of ocean biology is not shown quantitatively because we are still pumping too much CO<sub>2</sub> into the atmosphere.

Paula Bontempi raised that if all the aspects of the role of biology in ocean carbon is not fully included, there is no way to verify the Paris agreement drawdown. Heidi Dierssen agreed, and indicated that we need to write the kind of papers that will prove that carbon is sequestered, as that is the only time the IPCC becomes interested. Paula suggested a series of keynote speakers that hit this topic at the next Ocean Sciences meeting. The discussion segued into the presentation by Jamie Shutler on the background of carbon-from-space efforts.

## 6.0 IOCCG Training and Outreach

### 6.1 Plans for 2022 Summer Lecture Series

David Antoine presented an update on the planning for the 5<sup>th</sup> edition of the IOCCG Summer Lecture Series, which will take place on 18-29 July 2022. Applications were open for a period of 6 weeks starting in January 2022 and a total of 145 applications were received (48 different nationalities, 75 with a PhD). A “Selections Committee” (5 people) ranked all participants independently using 5 criteria (background knowledge, quality of application, impact of attending on candidate and community, need for training). The 22 selected students comprised 15 different nationalities, although many were living in other countries (9 females, 13 males, average age 31). There are fewer lecturers (12) than in previous years, in an attempt to minimize the budget. The organisation of the lectures and practical sessions was similar to previous years: the first week will cover the fundamentals of optics (scattering, radiometry, IOPs, AOPs, radiative transfer) as well as the AC-lab and Hydrolight practical sessions. The second week deals with satellite OCR, atmospheric corrections, hyperspectral remote sensing and applications. This year, the second week includes 2.5 days of “Copernicus practicals”, intended to train students on accessing and using Sentinel products, because of significant funding from the Copernicus Programme.

It was challenging to obtain sufficient funds to cover all expenses - all students and lecturers are fully funded unless they are covered by their own institutions. Contributions were received from IOCCG (i.e., all agencies), CNES, LOV, EUMETSAT, Copernicus Programme, IMEV and OCB (US). Around 20% of the cost of the course is covered by IOCCG, and 80% by other sponsors. The course will take place in LOV (Villefranche) and students will be able to stay in the new student accommodation building. All lectures will be recorded as in previous years. David queried whether the SLS should continue to be held at IMEV in the future. Villefranche is attractive to students and has subsidised student accommodation, but it is increasingly difficult for David to justify the time he spends on this. Should other models be considered e.g., a fee-paying summer school, assuming students are supported by their institutions? This would allow the SLS to be moved to different locations? We could consider splitting the course into two – one concentrating on the optics, and the second focusing on satellite applications, field sampling etc. (but this would require another coordinator and may be too ambitious). Also, perhaps we should repeat the Q&A online sessions that we did in 2020 when the SLS was cancelled due to COVID (students listened to the recorded lectures beforehand).

Emmanuel Boss expressed that the value of the summer school is to create a community for the students, so the webinar option is not a great idea. David clarified that the idea was to have the online sessions *in addition* to the SLS (not replacing). Heidi thought a fee-paying model is not necessarily a bad

thing (with a grant system for those that need it), and liked the idea of dividing it into two. Hubert proposed holding the course at LOG Wimereux, in the north of France, but a coordinator would be required. There are two universities that may be able to provide some funding. David would follow up with Hubert.

Kevin Ruddick congratulated David on his extraordinary accomplishments over the past 10 years: building a community of young scientists with friendships that will last over their entire careers. He suggested canvassing all previous students regarding the value of the SLS and what models would work in the future. David noted that feedback is requested from the students every year, and that all the students from previous years were canvassed in 2016 regarding how they have benefitted from attending the SLS training.

## **6.2 Training and Education Sub-Committee activities**

Raisha Lovindeer gave an update on the Training and Education sub-committee that was formed as an action item from the last Committee Meeting. Volunteers for the sub-committee met in July 2021 and had two main recommendations: i) organize the existing content on the website so that users can identify introductory ocean colour material, and ii) design and run an online course for introduction to ocean optics.

Raisha indicated that the organization of the website was her task and was still outstanding. With regards to the online course, as IOCCG is not an accrediting body, the sub-committee believed it would need to be done in collaboration with a University or training facility. Raisha asked whether the IOCCG wanted to move towards developing an introductory massive open online course (MOOC).

Raisha also raised for discussion whether introductory in-person training courses should be resumed as they had not occurred in many years, and whether the Trevor Platt Memorial Fellowship would be resumed for 2022.

Venetia Stuart added that the IOCCG used to have courses once a year for 10-14 years in different countries around the world. She added that the Trevor Platt Science Foundation was thinking of having a symposium with a training portion attached, and it would be a good idea for IOCCG to be involved in training specifically related to ocean colour. Shubha Sathyendranath indicated that the symposium is in the very early stages of planning, that plans are evolving, but that ocean colour would be an important component of the symposium, which is proposed for 12 August 2022.

Cédric Jamet said the SLS and summer school have all the materials online and accessible, and asked what addition the MOOC would bring. Raisha responded that the SLS material is geared for more advanced users, while the MOOC would be introductory. Hubert Loisel indicated that a MOOC allows for credit to be earned for the course. Heidi Dierssen indicated that a MOOC also allows for a cohort with discussion groups, and can build community when done well. She suggested someone with experience in pedagogy should be selected to teach, and suggested her postdoc Jessie Turner as a good example. Emmanuel Boss indicated he would be happy to help Jessie. Heidi also suggested that a certification of

completion might be more applicable than accreditation, and that if students pay a fee to get certified, they would be incentivized to complete the course.

Paula Bontempi suggested an introductory class for students might be possible at the University of Rhode Island (URI), though it will likely come with a fee. She indicated that she would investigate the possibilities, though she would not be able to lead the course.

Cara Wilson noted that there was consensus to do an introductory MOOC, where students can pay to complete the course. Cedric indicated that there should be fee waivers for students from developing countries, and this was agreed. Heidi Dierssen suggested that a proposal be drafted with funding considerations and possibly payment for teachers. Cara indicated that the sub-committee should move the action forward. David Antoine also indicated that an introductory MOOC would be a good prerequisite for selection of students for the SLS, and a way to channel students to complete it.

**Action 26/12:** *The education subcommittee to move forward with a proposal for an introductory ocean optics MOOC and follow up with suggestions, including with Paula Bontempi on possibly hosting at URI.*

### **6.3 IOCCG news bulletins and communication channels**

Raisha Lovindeer reported on IOCCG's Communication channels: quarterly news bulletins distributed via a mailing list, as well as community announcements and a Twitter feed. She inquired about what should be included in the news bulletins, which are tailored to the ocean colour community. Stewart Bernard noted that this is an opportunity to talk to new communities. Paula Bontempi suggested engaging in the "blue agenda" being developed through the UN and providing input to it. Existing task forces can come up with policy relevant science achievements they would like to highlight. Stewart Bernard suggested having frequent expressions of new achievements or capabilities in the OC community. Cara advised that all IOCCG working groups and task forces should have a plain language summary describing what they do for the non-OC community. Paula noted that the climate policy time scales are only decades now, and that is something we can effectively engage in. IOCCG is a consensus group so we should take our role as leaders and coordinators very seriously, and represent the OC community.

Emmanuel Boss suggested that in the next news bulletin we ask people what they would like to see in future bulletins. Also, the relationship between IOCCG and the Ocean Optics meetings could be closer – Vittorio Brando recommended having a town hall at Ocean Optics or IOCS meetings, led by IOCCG.

Stewart Bernard suggested trying a 1-page mock-up of a policy briefing and requested participants to send anything of value to him (e.g., carbon from space, recent publications, agency-specific achievements). Paula pointed out that it was important to have a coordinated voice – everyone should agree with what is in the document. The primary target audience would be 20 to 30 high-value stakeholders as well as the IOCCG mailing list. Shubha Sathyendranath also proposed that an opinion piece for Nature could be valuable.

**Action 26/13:** *Project Office to ask the community what items they would like to see in the next IOCCG news bulletin.*

**Action 26/14:** *IOCCG Committee members to submit topics to Stewart Bernard for a 1-page policy briefing for the news. Stewart to circulate to the Committee for comment before releasing.*

## 7.0 Plans for Next IOCS Meeting (USA 2023)

### 7.1 IOCS-2023 logistics update

Raisha Lovindeer provided a brief overview on the planning and logistics for the next IOCS meeting in 2023. The meeting will be hosted by the University of South Florida, in St. Petersburg, USA, home to Chuanmin Hu's Optical Oceanography Lab. There is a 50% discount if the department serves as our host sponsor. The dates proposed are 13-17 November 2023, a combination of the venue's availability, US public holidays and the fact that we are trying to alternate with the Ocean Optics meetings which occur in October in even years.

The main ballroom is available for the meeting (holds over 400 people, AV included, can also host the poster sessions,) plus there are classrooms for breakout sessions. The entire second floor has been booked, and includes a number of smaller rooms which could serve as speaker ready rooms etc. The classrooms can only be booked in Fall 2023 (but they are being held). We will have to arrange poster boards, signage, catering (USF has packages), hotels etc. The total cost should be around \$200K, similar to previous meetings (includes a reception, poster boards, coffee breaks, meeting manager cost etc.). Income from registration fees was estimated at around \$55K.

### 7.2 Sponsorship for IOCS-2023

Menghua Wang reported that NOAA can likely contribute about \$30K towards IOCS-2023, and that there is already a mechanism in place to transfer funds from NOAA to USF, but he won't know until the FY 2023 budget has been released (~March 2023). Raisha has also been in contact with Laura Lorenzoni regarding submitting a proposal to NASA for funding. Venetia Stuart pointed out that registration fees were very low at the last meeting (starting at \$200) whereas registration fees for Ocean Optics are around \$600 (including lunches). Chuanmin Hu suggested raising registration fees for non-students, to cover more of the costs, and also including lunches in the fee. Shubha suggested that the student fees could probably go up to ~\$100 (with grants available if required). Raisha pointed out that there are also some funds from the last IOCS meeting that could be used towards this meeting.

**Action 26/15:** *Menghua Wang to investigate NOAA support for IOCS-2023 (transfer funds to USF).*

**Action 26/16:** *IOCCG Project Office to submit a proposal to NASA for funding for the IOCS-2023 meeting.*

### 7.3 Format, proposed breakout sessions and keynote speakers

Cara presented the background idea for the IOCS: an opportunity for the larger community to have feedback about what the space agencies are doing; to build the voice of the ocean colour community; and to give recommendations and advice for the IOCCG. The format is different from other meetings,

with breakout groups for lots of discussion and very few presentations. The breakout topics were displayed, with a proposed nine (9) topics for discussion at the IOCS based on meetings in 2017 and 2019.

A discussion on the outcome of recommendations that had emerged from previous IOCS breakout sessions and meetings was raised. Ewa Kwiatkowska and Shubha Sathyendranath reiterated that recommendations are indeed used by space agencies. Cara indicated that there were 3 categories of recommendations: i) advice for the space agency, ii) advice for IOCCG and, iii) suggestions for the community facilitated through the IOCCG. It was suggested that the outcome of previous recommendations be synthesized and addressed in the opening plenary of the IOCS meeting, as well as on the IOCS website for those not in attendance at subsequent meetings.

**Action 26/17:** *Cara Wilson to go through and synthesize previous recommendations from IOCS and report on their outcomes.*

A long discussion took place to get suggestions for the format and theme of the meeting, as well as the breakout sessions and keynote speakers. It was said that just bringing the community together to talk and discuss is very valuable. The topic of keynote speakers was tabled for another time as the discussion focused on the meeting format and suggested points for discussion in breakout sessions.

### **Meeting format suggestions**

- Have one main meeting theme or question and have the sessions linked into that main theme/question and convey these messages at the beginning and end [Robert]
  - finding value in a changing world [Stewart]
  - OC: Growing up [Heidi]
  - OC: To Infinity and Beyond [Heidi]
  - Revealing the ocean in all its colors [E. Boss]
  - Aquatic Color: From observation to decision [E. Devred]
- Use the meeting as a way to engage/target end-users [Craig], and especially those outside of research and academia [David, Wonkook]. (Note: there was mixed positive and negative feedback for this suggestion)
- Increase developing country participation (with concerns about who bears the costs of flying people across continents)
- Have plenaries address previous IOCS recommendations
- Dream big for the plenaries - international engagement in IPCC assessments / Ocean Decade / Policy relevance [Paula]

### **Session format suggestions**

- Have session names framed as questions [Cara]
- Orient towards technical topics and session [Cedric, Hubert]
- Include user-focussed sessions/applications [Craig, Carolina]
- Include sub-groups within the group to get feedback [Heidi]

- Include electronic Jamboard, Padlet or Slido for interactivity by all people in the session [Stewart, Javier, Laurent]
- Include practical sessions, not just training activities associated with the IOCS, but embedded within [Heidi] - Note: there was disagreement with practicals as part of the meeting [Vittorio, Cedric]

### Breakout topic suggestions

- Remote sensing of floating matter at the sea surface (plastic, oil, *Sargassum*) [Heidi, Chuanmin, Shungu]
- Ocean carbon [Marie-Hélène], Carbon from ocean colour [Tim]
- Other scientific applications of ocean colour and get recommendations [Marie-Hélène]
- Engagement in IPCC assessments / Ocean Decade / Policy relevance - have more discussion based on the plenaries to get feedback that agencies can use [Paula]
  - Do we have global observations to determine the remaining uncertainties in oceanic uptake of CO<sub>2</sub>? [Paula]
  - Do we have observations to promote climate stabilization? [Paula]
  - Do we have observations to address the scientific challenges of the 21st century? [Paula]
  - Industry and science partnerships [Heidi]
  - Climate and policy [Heidi]
  - Blue Economy [Laurent]
  - Value of ocean colour radiometry to the user community [Chuanmin et al]
  - How ocean colour can support decision-making and policies [E. Devred]
- How will IOCCG interact with Newspace operators, like Planet? [Kevin]
- Use of sensors designed for terrestrial use and for ocean colour: linkages between land and ocean remote sensing [Shubha] suggested name: *hijacking other community sensors for ocean colour science*
- Connection of inland and ocean across transitional waters [Claudia, E. Devred]
- Societal applications of ocean colour - pollution, fisheries, aquaculture etc. [E. Boss]
  - Water management, water quality/pollution/eutrophication, climate change and SLR, fisheries/seafood security, Earth data exploding and how to handle it, tourism and recreation, renewable energy, etc.
  - How to make OC more globally impactful in climate models, applied users, ecosystem services, etc...[Heidi]
  - Citizen science and low cost instruments [Cedric]
- Climate change and its signature in ocean colour [E. Boss]
- How to validate ocean colour imagery [Heidi]
- Validation, uncertainties, Lidar -- what can it give us, Lagrange vs. Geostationary [Heidi]
- Phytoplankton community composition -- what is it and what can we get [Heidi]
- Practical session: Data fusion, Machine Learning, Understanding HPLC and Chemtax. Google Earth Engine [Heidi]
  - Teaching and Outreach [Heidi]
- Fusion of ocean colour with active and passive sensors combined [Hubert]
- Big data for dummies [E. Boss]

**Action 26/18:** IOCCG Project Office to extract and collate all the suggestions and notes from the meeting before the next online meeting for the IOCS.

**Action 26/19:** IOCCG Project Office to form an IOCS scientific committee by the end of July 2022, and hold an online meeting as soon as possible to discuss the suggestions made and decide on the theme, format and speakers for the IOCS.

## 8.0 Next IOCCG Committee Meeting

### 8.1 Dates & host for IOCCG-27 meeting in 2023

One of the proposals for the next IOCCG Committee meeting was to hold it in conjunction with the IOCS-2023 meeting (November 2023) with a virtual meeting in between. Paula Bontempi offered to host the Committee meeting at the University of Rhode Island and Emmanuel Boss offered to hold it in Maine. There was consensus for an online meeting in Spring 2023, followed by an in-person meeting in Florida either before, or after IOCS-2023.

Shubha also suggested that the IOCCG should consider holding the 2024 Committee meeting in a developing country, in order to engage the community (in combination with a capacity building event beforehand). It was agreed that IOCCG should make more of an effort at outreach, as has been done at some previous meetings (giving talks to local students or the community). Raisha pointed out that the Caribbean is starting to make more use of satellite data to track *Sargassum* blooms (through the University of the West Indies) so the presence of the IOCCG Committee on the island would help raise awareness of satellite applications. Raisha could also help arrange a meeting there. Robert Frouin suggested Fiji (University of the South Pacific) as another option, but Craig drew attention to the rising reluctance to travel because of the climate crisis. Marie-Hélène Rio agreed saying that as a community we should think about how we can reduce our carbon footprint. She suggested keeping the hybrid approach. There was some agreement that an entirely remote approach has missing elements but a hybrid approach was feasible. Ana Dogliotti suggested Buenos Aires as another option, the Argentine Space Agency (CONAE) is developing the SABIA-Mar ocean-color mission and IOCCG activities could promote local engagement. Carolina Tauro (CONAE) agreed and supported the idea.

#### 8.1A General Discussion

During the general discussion in the closing session, Heidi Dierssen tabled a list of topics for consideration based on her notes and suggestions from meeting participants. It was agreed that the list was very useful.

Chairs and the Project Office agreed to study the list with a view to incorporating the suggestions into the minutes or action items. Cara suggested that the group could have more frequent meetings to be able to discuss items that arise from the meeting, rather than waiting until the next meeting to discuss some of these topics.

Robert Frouin and others agreed that there needs to be a lot of discussion, especially on any consensus recommendations from the group. Shubha agreed that we could meet online and/or collaborate through Google Docs to follow-up, and Robert indicated that it might be good to consider other topic suggestions that were not yet listed.

**Action 26/20:** *IOCCG Project Office and Chairs to meet virtually to discuss actions arising from the general discussion.*

## **8.2 Rotation of IOCCG Committee members**

Bryan Franz and Chuanmin Hu had completed their term of service on the Committee. It was agreed that Jeremy Werdell would replace Bryan and that Chuanmin would be invited to serve a second term. It was also agreed that it was important to have a modeller on the Committee, particularly someone with assimilation expertise, and with links to IPCC. Stephanie Dutkiewicz and others had proposed several names of modellers – they would be contacted in order of preference.

**Action 26/21:** *Project Office to contact the list modellers in order of preference, regarding membership on the IOCCG Committee.*

## **8.3 Hand over of Chair**

Cara Wilson passed the chairmanship of the IOCCG over to Shubha Sathyendranath, who thanked Cara and all past chairs for leading the IOCCG Committee - a vibrant, effective, friendly, and happy community. She offered special thanks to Robert Frouin, who helped start the IOCCG, Venetia Stuart for her outstanding service, as well as Raisha Lovindeer and all the committee members for their continued support, and requested their assistance and collaboration in moving forward together.

Stewart Bernard also thanked Cara for leading the IOCCG through a difficult time with the pandemic, and for her diplomacy in the way she chaired the Committee over the past 5 years.

## **8.4 Closing**

Thanks to Marie-Helene Rio and the ESA for hosting the meeting in person and online, including Lea Chivetta and Javier Concha for their help and support.

Shubha Sathyendranath closed the meeting.

## Appendix I: LIST OF PARTICIPANTS IOCCG-26

*Frascati, Italy & Online 27-29 June 2022*

**\*\*indicates virtual participant**

### **IOCCG Members**

Bernard, Stewart (past-Chair)	-	SANSA, South Africa
Bontempi, Paula	-	University of Rhode Island, USA
Brando, Vittorio	-	CNR-ISMAR, Italy
Ciotti, Aurea**	-	Universidade de São Paulo, Brazil
Devred, Emmanuel**	-	Bedford Institute of Oceanography, Canada
Dogliotti, Ana	-	IAFE/CONICET, Argentina
Franz, Bryan**	-	NASA GSFC, USA
Giardino, Claudia	-	CNR-IREA, Italy
Giugni, Laurent**	-	CSA, Canada
He, Xianqiang**	-	Second Institute of Oceanography, China
Hu, Chuanmin	-	University of South Florida, USA
Kim, Wonkook**	-	Pusan National University, South Korea
Kwiatkowska, Ewa	-	EUMETSAT, EU, Germany
Lifermann, Anne	-	CNES, France
Loisel, Hubert	-	Université du Littoral, France
Lorenzoni, Laura	-	NASA HQ, USA
Malthus, Tim**	-	CSIRO, Australia
Mélin, Frédéric	-	EU Joint Research Center, Italy
Murakami, Hiroshi**	-	JAXA EORC, Japan
Rio, Marie-Hélène	-	ESA/ESRIN, Italy
Sathyendranath, Shubha (in-coming Chair)	-	University of Plymouth, UK
Tauro, Carolina**	-	CONAE, Argentina
Wang, Menghua**	-	NOAA/NESDIS/STAR, USA
Wilson, Cara (Chair)	-	NOAA/NMFS, USA

### **IOCCG Project Office**

Lovindeer, Raisha**	-	IOCCG Scientific Officer, Canada
Stuart, Venetia	-	IOCCG Scientific Coordinator, Canada

### **Invited Participants**

		<b>Affiliation</b>
Antoine, David (past-Chair)**	-	Curtin University, Australia
Concha, Javier A.	-	ESA/ESRIN, Italy
Choi, Jong-Kuk**	-	NOSC, KHOA, South Korea
Costa, Maycira <sup>1</sup>	-	University of Victoria, Canada
Dierssen, Heidi	-	University of Connecticut, USA

Donlon, Craig	-	ESA/ESTEC, The Netherlands
Dutkiewicz, Stephanie <sup>1</sup>	-	MIT, USA
Frouin, Robert	-	SIO/UCSD, USA
Garaba, Shungu	-	University of Oldenburg, Germany
Jamet, Cédric	-	Université du Littoral Côte d'Opale, France
Rousseaux, Cecile**	-	NASA GSFC, USA
Ruddick, Kevin	-	Royal Belgian Institute of Natural Sciences
Shutler, Jamie**	-	University of Exeter, UK
Yoder, James (past-Chair)**	-	Woods Hole Oceanographic Institution, USA

#### **Apologies**

Ryu, Joo-Hyung

#### **Affiliation**

- KIOST, South Korea

<sup>1</sup>invited participants that were not in attendance but submitted narrated talks

#### **Supporting Documentation:**

<https://ioccg.org/ioccg-26-supporting-documentation/>

## Appendix II: List of Actions: IOCCG-26 Committee Meeting

**Frascati, Italy 27 - 29 June 2022**

Action	Brief Description	Status
26/1	Cedric Jamet to finalize the report on atmospheric corrections over turbid waters as soon as possible and consider including some information on the performance of individual algorithms and approaches.	Open
26/2	IOCCG Project Office to create a new section for “highlights” on the IOCCG homepage. Chairs of all IOCCG WGs and TFs to report back to the IOCCG Project Office with any new findings that can be highlighted on the IOCCG homepage.	Open
26/3	IOCCG Project Office to include a link on the IOCCG website to Claudia Giardino’s best practices for radiometry in lakes and rivers.	Closed
26/4	Ewa to approach Andrew Bernard, Brian Barnes, Paolo Cippolini, Marco Celesti and Menghua Wang regarding membership on the OC-SVC Task Force.	Open
26/5	IOCCG Executive to discuss the request for funds to pay for publication fees and to hire someone to collate data on benthic reflectance.	Closed
26/6	Paula Bontempi and Stewart Bernard to identify 2-4 goals of the hyperspectral round robin exercise, as well as the aims and some description of the process before soliciting a lead	Open
26/7	Jamie Shutler and Cecile Rousseaux to prepare Terms of Reference for the IOCCG Task Force on Ocean Carbon, including contributions to the future CEOS aquatic carbon White Paper, concrete steps to make connections with different communities, and how to handle membership in the Task Force.	Open
26/8	Agencies to report back on the outcomes of their investigations on the causes of seasonal bias observed in vicarious calibration measurements from MOBY and the implications.	Open
26/9	Vittorio Brando, Stewart Bernard & Cara Wilson to meet virtually and discuss user types and value chain and report back on any suggestions for the IOCCG	Open
26/10	IOCCG Committee Members to give feedback to Maycira Costa ( <a href="mailto:maycira@uvic.ca">maycira@uvic.ca</a> ) by mid-August 2022 on specification for the CEOS ARD Ocean product family.	Open
26/11	OCR-VC members to complete the questionnaire from the CEOS Oceans Coordination Team.	Closed

26/12	The education subcommittee to move forward with a proposal for an introductory ocean optics MOOC and follow up with suggestions, including with Paula Bontempi on possibly hosting at URI.	Open
26/13	Project Office to ask the community what items they would like to see in the next IOCCG news bulletin.	Closed
26/14	IOCCG Committee members to submit topics to Stewart Bernard for a 1-page policy briefing. Stewart to circulate to the Committee for comment before releasing.	Open
26/15	Menghua Wang to investigate NOAA support for IOCS-2023 (transfer funds to USF).	Open
26/16	IOCCG Project Office to submit a proposal to NASA for funding for the IOCS-2023 meeting.	Open
26/17	Cara Wilson to go through and synthesize previous recommendations from IOCS and report on their outcomes.	On-going
26/18	IOCCG Project Office to extract and collate all the suggestions and notes from the meeting before the next online meeting for the IOCS.	Closed
26/19	IOCCG Project Office to form an IOCS scientific committee by the end of July 2022 and hold an online meeting as soon as possible to discuss the suggestions made and decide on the theme, format and speakers for the IOCS	Closed
26/20	IOCCG Project Office and Chairs to meet virtually to discuss actions arising from the general discussion.	Closed
26/21	Project Office to contact the list modellers in order of preference, regarding membership on the IOCCG Committee.	Closed