IOCCG-24 Committee Meeting

Hanoi, Vietnam, 4-5 April 2019

MINUTES

1.0 Welcome and Opening Session

1.1 Opening remarks

The IOCCG Chair, Cara Wilson, opened the meeting and thanked, VAST, the local scientists and Hubert Loisel for hosting the meeting in Hanoi, Vietnam. She welcomed the new IOCCG Committee members: Emmanuel Devred (DFO, Canada), Ana Dogliotti (IAFE, Argentina) and Marie-Hélène Rio (ESA, ESRIN, Italy). In addition, Chuanmin Hu (USF, USA), Joo-Hyung Ryu (KIOST, South Korea) and Menghua Wang (NOAA, USA) were welcomed back onto the Committee. The Chair invited a brief tour de table for participants to introduce themselves - the list of participants is provided as an Annex to the minutes.

1.2 Welcoming address from French Embassy

The Premier Conseiller de l'Ambassade de France au Vietnam, Olivier Siguad, welcomed IOCCG Committee members to Hanoi. He outlined the strategic partnership between France and Vietnam aimed at strengthening the relationship in all areas including political, education and culture. France and Vietnam have developed many academic and scientific cooperation projects such as the intergovernmental agreement with the University of Science and Technology of Hanoi (USTH). There is also an agreement between CNES and VAST on climate change studies, promoting important scientific and academic cooperation in many different areas, which were outlined.

1.3 Overview of ocean colour research at USTH

Marine Herrmann (USTH, Vietnam) gave a brief overview of ocean colour and climate research at USTH, aimed at improving our knowledge of regional marine systems. Using modeling as well as satellite and *in situ* observations, she is gaining a better understanding of the functioning of ocean circulation, its response to various forcings (anthropogenic, atmospheric, oceanic) and its influence on marine ecosystems. A primary focus is the Nha Trang upwelling, one of the key ocean circulation processes in the East Sea. This upwelling impacts biological activity and therefore the fishery resources of the region. She is also investigating the evolution of carbon pools in Vietnam waters and the impact of climate change in SE Asia using IPCC projections to understand regional climate change.

1.4 Review of IOCCG-23 Minutes, Status of Actions

The minutes of the IOCCG-23 Committee meeting were approved by consensus. The Chair summarised the status of actions from the IOCCG 23rd Committee meeting, all of which have been closed.

- *Action 23/1*: Cara Wilson reviewed Chapter 2 of the Modelling WG report.
- *Action 23/2*: Tim Malthus reviewed Chapter 3 of the Modelling WG report.
- *Action 23/*3: Emmanuel Boss reviewed Chapter 4 of the Modelling WG report.
- *Action 23/4*: Arnold Dekker confirmed that sections of the CEOS feasibility report could be republished in Chapter 6 of the IOCCG Water Quality report.
- *Action 23/5*: IOCCG Reports 15 and 16 have been printed by NOAA.
- *Action 23/6*: Ewa Kwiatkowska received comments from IOCCG members on the EUMETSAT document "Requirements for Copernicus Ocean Colour Vicarious Calibration Infrastructure".
- *Action 23/7*: After consultation with Giuseppe Zibordi and Ken Voss, the IOCCG sub-committee recommended that a revised version of the radiometry chapters of the NASA Ocean Optics Protocols was required, since the FRM4SOC document relied to some degree on this for a description of the relevant methods. Voss and Zibordi have prepared a revised document which is currently available on the IOCCG website for public comment.
- *Action 23/8*: Keynote speakers and breakout sessions for IOCS-2019 have been finalised.
- *Action 23/9*: The joint EUMETSAT-IOCCG training course in China will be addressed under agenda item 7.3.
- *Action 23/10*: Stewart Bernard reported that the GMES-Africa Marine and Coastal Service Development for Southern Africa (MarCoSouth) project, in collaboration with EUMETSAT, will host a 10 day marine Earth observation training course in Zanzibar in November 2019 for 20 applicants. The training course will focus primarily on ocean colour and SST applications for African coastal applications, and will be aimed at African young professionals and postgraduates.
- *Action 23/11*: Bryan Franz submitted an abstract for a whitepaper to OceanObs19, on polarimetry for advancing ocean colour, with Amir Ibrahim leading the effort.
- *Action 23/12*: The correct citation for the IOCCG Protocol Series has been finalised.

2.0 Status of IOCCG Working Groups and Protocol Series

2.1 Ocean colour applications for biogeochemical, ecosystem and climate modelling

Stephanie Dutkiewicz presented the progress of the modelling working group, noting that the report has a new title: "*Synergy between Ocean Colour and Biogeochemical/Ecosystem Models*". In this report, the word "model" refers to process-based three-dimensional biogeochemical/ecosystem computer models at large regional or global scales. Working group members have completed a full draft of the report with contributions from other researchers as well. The report has been reviewed by eight external reviewers including IOCCG Committee members Emmanuel Boss, Tim Malthus and Cara Wilson.

The report contains a total of nine chapters including an introduction (Chapter 1) and an overview of ocean colour remote sensing (Chapter 2), which includes a section on uncertainties. Chapter 3 deals with biogeochemical and ecosystem models: what are they and how can they be used? Chapter 4 addresses the mis-match between biogeochemical/ecosystem model variables and ocean colour products. This chapter is currently in revision after the second round of reviews. Modellers need better information about using satellite data, for example, chlorophyll in a model is not the same as the chlorophyll ocean colour product. It is recommended that agencies should examine how additional information can be presented alongside satellite products to help modellers make informed choices and interpretations.

Chapter 5 examines the use of ocean colour to assess models, and highlights the many challenges that need to be addressed. Skill assessment metrics should closely fit the space and time scales of interest. Chapter 6 deals with assimilation of ocean colour data, which is still a relatively new field. The use of Argo float data to provide depth information will be an important development. Chapter 7 addresses the synergistic use of ocean colour data and models to understand marine biogeochemical processes, and includes several case studies. Chapter 8 deals with the use of models to inform ocean colour science. Numerical models can be used as laboratories to elucidate some of the limitations and uncertainties of ocean colour products. A stronger collaboration between modellers and ocean colour scientists is required. The last chapter, Chapter 9, has not yet been reviewed, so Committee members are requested to take a look and provide feedback. All revisions are expected to be completed by early May 2019.

Action 24/1: *IOCCG Committee members to review Chapter 9 of the modelling report, and send comments to Stephanie Dutkiewicz.*

It was suggested that the recommendations section should highlight what satellites could do well e.g., phenology, location of fronts etc. The report should also identify what products are most relevant to modellers in terms of spatial and temporal resolution scales (likely model dependant). Stephanie pointed out that this was addressed in the skill assessment chapter. Modellers have to deal with a great range of input, but they try to use all available products. Chapter 5 will be reviewed in terms of expanding the discussion on spatial scales. Other suggestions related to future satellite observations to help prediction, including the value of Lidar. This could be included in Chapter 8 (what is missing for trend analysis, forward looking observations etc.).

2.2 GEOHAB/IOCCG harmful algal bloom working group

Stewart Bernard reported on the GEOHAB/IOCCG harmful algal bloom working group, which has been ongoing for some time. Funding has been secured to re-hire a post-doc student (Lisl Robertson Lain) for 3 months to help bring the report to conclusion. Most of the chapters are almost complete apart from Chapter 3, which is still in draft form. Recommendations will form an important part of the report and will include agency focussed sensor aspects (NIR bands, hyperspectral), as well as the importance of atmospheric correction. For intense blooms, Rayleigh-corrected reflectance can be used to determine Chl-a thus circumventing atmospheric correction problems associated with turbid waters and the correction of aerosol absorption. Ocean colour is effective in detecting high biomass blooms, but does not work well for low biomass blooms, so some examples of indirect approaches will also be shown. Science validation aspects and user driven aspects will also be addressed in the report, and a section on policy and economics will be added. Stewart requested Committee members to submit examples of new publications dealing with harmful algal blooms. It is anticipated that the report should be completed within 6 months.

Action 24/2: *IOCCG Committee members to submit examples of new publications dealing with harmful algal blooms to Stewart Bernard.*

2.3 Uncertainties in ocean colour remote sensing

Frédéric Mélin reported on the status of the IOCCG working group on “Uncertainties in Ocean Colour Remote Sensing”. The report has a broad authorship with a total of seven chapters, and is already in the IOCCG format. Following the introductory chapters, Chapter 3 deals with sources of uncertainties and chapter 4 deals with uncertainty

estimates i.e., methods used to define and quantify uncertainties (this is the most complex section of the report). Chapter 5 addresses representation and distribution of uncertainties and Chapter 6 examines requirements from different applications of ocean colour data. The last chapter presents the recommendations in three broad categories:

1) Promoting dialogue and transparency between communities. This includes adopting an appropriate terminology, providing full documentation and source codes for the whole processing chain, and distribution of non-calibrated TOA data.
2) Distributing complete and clear uncertainty fields, including uncertainty estimates associated with each datum, ensuring a clear description of the uncertainty fields distributed with satellite data, and encouraging dialogue between data providers to promote consistency between distributed uncertainty fields.
3) Strategy and methodological developments to obtain improved uncertainty estimates, including further development of techniques to estimate uncertainties of ocean colour products and comparison between these approaches.

Frédéric is currently integrating last-minute contributions and feedback, after which the report will be further reviewed and then published. Stewart Bernard pointed out that the recommendation for distribution of non-calibrated TOA data might not be possible, as IOCCG had previously probed dissemination of Level 1A Sentinel data, which was not well received. Frédéric noted that it is nevertheless important to make this recommendation. The Chair thanked Frédéric for doing such an excellent and thorough job with this report, and everyone looked forward to its publication.

2.4 Atmospheric correction in coastal waters

Cédric Jamet reported on the progress of the IOCCG working group on atmospheric correction over turbid waters. The goal of the working group is to inter-compare and evaluate existing atmospheric correction algorithms over turbid waters, to understand the advantages and limitations of each algorithm and their performance under certain atmospheric and oceanic conditions. The focus of the report is on atmospheric correction algorithms that deal with non-zero NIR water-leaving radiances, and is not sensor specific (MODIS-A is just an application). A total of nine atmospheric correction algorithms were taken into consideration and a simulated dataset was used for sensitivity studies.

Despite the fact that the scope of this report is more technical than a traditional IOCCG report, the authors would nevertheless prefer that it is published as an IOCCG document (perhaps a technical report), rather than as a journal article, as was suggested at the IOCCG-23 Committee meeting. It was recommended that another chapter be included to cover Constant Mazeran's work. In addition, it was suggested that the appendix be

converted into another chapter (i.e., results from other projects such as the ESA Project on Extreme Case-2 Waters (Case2X) using MERIS and Sentinel-S3 data).

Emmanuel Boss pointed out that the report fits well as an IOCCG Technical Report, as it deals with methodology. Advantages include availability on the IOCCG website, less effort and expense to format than an IOCCG Report, and easily citable (it will have a DOI). Cedric indicated that this would be a suitable avenue for publishing the report.

2.5 Long-term vicarious adjustment of ocean colour sensors

Marie-Hélène Rio reported on the status of the IOCCG Working Group on "Long-term vicarious adjustment of ocean colour sensors", co-chaired by Christophe Lerebourg (ACRI-ST, France). Vicarious calibration i.e., the indirect sensor calibration based on ground targets of known radiometry (e.g., instrumented buoys/stations), is fundamental to reach the accuracy requirements for ocean colour Level-2 products, for the creation of Climate Data Records. In this context, different projects have been set up including the ESA FRM4SOC Project (June 2016 – Oct 2018) which will publish their results in a special issue of the journal *Remote Sensing*. Another project is the EUMETSAT OC-VCAL which is defining detailed requirements for ocean colour system vicarious calibration infrastructure for the Copernicus Programme. Building on these results, the IOCCG WG on long-term vicarious adjustment was established in 2017, to define the best practices to reach a high standard of precision and accuracy for *in situ* OCR measurements necessary to fulfill the SVC requirements. The Co-chairs started discussing the content of an IOCCG report, although activities have been on hold due to a heavy work load of the chairs. The working group hopes to resume in mid-2019.

2.6 Proposal for a new IOCCG WG on nomenclature and definitions

Robert Frouin presented a proposal for a new IOCCG working group on "Nomenclature and Definitions in Ocean Colour Remote Sensing". He pointed out that ocean colour cuts across traditional physics, biology, and chemistry disciplines, making it difficult to normalize terminology and symbols. Precise terms, definitions and standardization are necessary to master the discipline and to remove ambiguities. The working group will attempt to produce a list of concepts, terms and quantities used in ocean colour remote sensing, with accurate definitions and agreed upon symbols and units. The motivation is to standardize disparate nomenclature, symbols, and units, and suggest the best descriptive phrases to ensure full understanding and correct usage of terminology

Chuanmin Hu liked this approach as many people within the OC community use different symbols of terminology. Menghua Wang pointed out that physics quantities are already

well defined, and using different terminology in an attempt to homogenise could add to the confusion. Others noted that there was a good argument for this kind of document. This proposal would be further discussed during the IOCCG Executive meeting.

2.7 NASA-IOCCG protocol series

Emmanuel Boss briefed the Committee on the IOCCG Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation. Instead of the protocols being associated with a single agency, such as NASA, as in the past, they are now associated with IOCCG to encourage broad international acceptance. Some protocols are updates of the original SeaWiFS protocols (ca. 2002 - 2003), while others are new. The protocols are intended to be "living documents" and will be updated semi-regularly as knowledge and technology matures. They are published online in the "IOCCG Protocol Series" and are peer-reviewed by the scientific community. Each protocol has a DOI for easy reference, and they are archived at the IODE Ocean Best Practices repository, as well as being available on the IOCCG website. Thus far the updating of the protocols has been largely supported by NASA and shepherded by NASA GSFC staff, with recent support from IOCCG, OCB, EUMETSAT and JAXA.

The process to develop updated protocols includes: assembling a team of experts, identifying lead/contributing authors, soliciting funding for a workshop, writing the protocol document and presenting the progress at conferences, posting the draft protocols on the IOCCG website for comments (60+ days), revising the protocols based on public comments, final peer review by Editorial Review Board, final technical revisions and copy editing/proof reading, obtaining a DOI, adding cover pages and posting on IOCCG website. To date, the *Absorption Coefficient* (Nov 2018) and the *Beam-C* (April 2019) protocols have been published. The *Apparent Optical Properties* protocol and the *Inline Flow-Through IOP* protocols are currently under review by the editorial review boards. Five other protocols are either in early writing stages (CDOM Absorption, POC, Phytoplankton Taxonomy, Scattering Properties and Aquatic Primary Productivity).

Robert Frouin queried whether there were any protocols to address water leaving radiance apart from the AOP document which was too general, as well as atmospheric properties related to ocean colour. He was encouraged to assemble a group and write the protocols as a contribution to the global community.

3.0 IOCCG Task Forces

3.1 IOCCG Task Force on Satellite Sensor Calibration

Cara Wilson reported on the IOCCG Task Force on *Satellite Sensor Calibration*, on behalf of Ewa Kwiatkowska who was unable to attend the meeting. The motivation for the task force came from a recommendation from the INSITU-OCR White Paper, to form a joint satellite calibration working group with members from all relevant ocean colour sensor teams. The Task Force has met at the biennial IOCS meetings as well as other side-meetings (e.g., S3VT). There are also inter-agency collaborations (visiting scientists etc.). To date there are several measureable benefits of task force collaborations e.g., Sentinel-3 OLCI in-flight diffuser characterization and improved prelaunch calibration approaches via shared experience from similar sensors. The Task Force will meet again at the IOCS-2019 meeting as one of the breakout workshops.

3.1 Discussion on IOCCG Working Groups and Task Forces

Cara Wilson summarised the difference between an IOCCG Working Group (short term, IOCCG provides some funding for meetings, end product usually an IOCCG Report) and Task Force (semi-permanent group to address issues that require ongoing expertise, usually no funding for meetings). The IOCCG working groups have a clear mandate and Terms of Reference, but the guidelines for proposing a new IOCCG Task Force have not yet been established. Cara and Venetia have prepared draft guidelines which will be circulated for comment.

Action 24/3 *Venetia Stuart to circulate draft guidelines for proposing a new IOCCG Task Force. Committee members to submit their comments.*

Stewart Bernard was indirectly involved with the IOCS breakout group led by Astrid Bracher, which proposed establishing an IOCCG Task Force to develop a hyperspectral *in situ* dataset for PFT algorithm development. Furthermore, in 2016 Cecile Rousseaux submitted a proposal for an IOCCG working group on "Hyperspectral Measurements of Water Constituents", but the time was not right since the PACE Science Team was addressing similar issues, and many new papers would be coming out. The question is whether IOCCG should create a mechanism to engage with hyperspectral issues and how best to proceed e.g., by establishing an IOCCG hyperspectral Task Force. Stewart suggested that in order to do this right, the IOCCG should provide documentation on what the Task Force should address. Also, the composition of the Task Force should be determined by the IOCCG Committee. Jim Yoder pointed out that the National Academy of Science recommended a high spatial resolution, hyperspectral mission which was

supported by three groups (ocean ecology, terrestrial ecology and solid earth). An IOCCG Task Force could help provide clarity on ocean requirements and specifications. Paula Bontempi pointed out that there was a big shift away from hyperspectral to multi spectral e.g., OLCI. An IOCCG Task Force could play a role in determining where hyperspectral remote sensing offers serious quantitative advantages and where it does not. Otherwise there will be repeated calls for these types of missions. Some of the ground work has already been done for the PACE mission. The next PACE science team will have the task of developing hyperspectral requirements for ocean colour. Hubert Loisel pointed out that a lot of hyperspectral data is already available (e.g., HICO, *in situ* data) which needs to be further studied in order to move forward.

The Committee agreed that an IOCCG Hyperspectral Task Force should be established, and that the ToR should include a short review paper on ocean colour hyperspectral requirements, highlighting what multispectral sensors cannot do. Who will lead this group? Hubert Loisel informed that a workshop is being organized by Heidi Dierssen and co-leads in Belgium (4-6 June, 2019) entitled "*Data needs for hyperspectral detection of algal bloom diversity across the globe*". Ideally the proposed IOCCG Task Force should be clarified ahead of that meeting, including constraints on how to move forward. IOCCG Committee members were requested to submit a list of bullets to constrain the proposed Task Force, suggestions for Terms of Reference, membership etc.

Action 24/4: *IOCCG Committee members to submit suggestions for constraining the proposed IOCCG Hyperspectral Task Force, including proposed Terms of Reference, membership etc.*

4.0 Building the Operational Component of OCR-VC

4.1 Status of CEOS OCR-VC and OCR-IT/ OC

Paula Bontempi presented the current status of the OCR-VC, which had been presented by Paul DiGiacomo at the recent CEOS SIT-34 meeting in Miami (2-4 April 2019). Requirements from the original INSITU-OCR White Paper are being addressed in a modular fashion by the OCR-IT, coordinated across the various agencies. CEOS action VC-09 from 2014 (Implementation of INSITU-OCR) is still open but advancing - all the recommendations in the White Paper still hold. Various agencies are contributing towards ocean colour system vicarious calibration (NOAA, NASA, ESA, EUMETSAT) and there is a continuous consolidation and update of ocean optics and biogeochemistry measurement protocols. IOCCG working groups and task forces are currently addressing issues identified in the White Paper (uncertainties, calibration etc.). Regarding the COVERAGE

initiative, a recommendation was provided to include variables beyond chlorophyll and to increase spatial resolution <0.25°. Furthermore, a recommendation was proposed for COVERAGE to progress with chlorophyll Level-4 development, and to liaise with IOCCG with initial results for verification, validation and general review. There was also a recommendation to CEOS for stronger emphasis on aquatic biology, biogeochemistry, ecology and harmonization with the "CEOS Strategy for Carbon Observations from Space". Lastly, possible merging of the four current Ocean Virtual Constellations into one Oceans Virtual Constellation, to create an integrated and coordinated multi-variable picture of the oceans, was received with mixed feelings.

4.2 OCR-VC discussion: actions, EOVs for GOOS, OCR-VC gap analysis, leadership

Paula Bontempi recapped the events leading to the development of an ocean colour Essential Ocean Variable (EOV). In 2010, ocean colour was proposed and accepted as an Essential Climate Variable (EVC) by GCOS, and in 2012 IOC released the Framework for Ocean Observing (FOO), which promoted the idea of Essential Ocean Variables (EOV's). Recognizing its importance, GOOS recommended the development of an ocean colour EOV in 2016. After much deliberation and consultation, Emmanuel Boss submitted the final recommendation for the ocean colour EOV after the IOCCG-23 meeting. The ocean colour EOV will be considered as a transversal EOV and will contribute to both the biological and biogeochemical EOVs/panels. IOCCP will publish updated versions of all EOV Spec Sheets (where needed) in September 2019. Artur Palacz will add the new IOCCG protocols under best practices section of the document. It was reported that IOCCG proposed a special journal issue on "Aquatic Carbon from Space" to showcase the capacity of the ocean community to address ground breaking (aquatic) carbon research using space borne assets such as satellites, the ISS, etc.

CEOS could be the right forum to gain support for requirements for measurements beyond polar passive multi-band radiometry, including inter-agency mission development and coordination (e.g., hyperspectral spectroscopy, Lidar and polarimetry). In the annual international report on the status of missions from all agencies, ocean colour was listed as "marginal" to "adequate". This was based, however, on chlorophyll alone! Going forward, it should be made clear that ocean colour is a method, and not just one product, and each product has different requirements. It may be better if ocean colour were listed as "inadequate" to encourage planning for more missions, although that might discourage agencies from investing in ocean colour missions.

5.0 Challenges and Issues of Ocean Colour Missions from Various Agencies

5.1 NOAA ocean colour activities

Menghua Wang reported on NOAA ocean colour activities and the production of routine global ocean colour products, including 10 operational standard products e.g., normalized water-leaving radiance, Chl-a concentration as well as 29 experimental products which are now routinely produced e.g., IOPs, Chl-a anomaly and Chl-a anomaly ratio. Since 2014 NOAA has conducted an annual dedicated VIIRS Cal/Val cruise - the fifth cruise will take place in May 2019. NOAA also supports MOBY since high quality *in situ* optical data are required for sensor on-orbit vicarious calibration and for on-orbit sensor performance monitoring. NOAA and EUMETSAT are sponsoring and conducting the first International Operational Satellite Oceanography Symposium (18-20 June 2019) in Washington DC.

5.2 NASA update on current and future missions

Paula Bontempi briefed the Committee on NASA's current and future missions. NASA OBPG is processing JPSS-J1 (NOAA-20) VIIRS with standard algorithms and producing/ distributing continuity ocean colour products, but with no vicarious calibration applied. Results are in reasonable agreement with SNPP VIIRS products, but no rigorous validation has been done yet. NASA's PACE mission is scheduled for launch ~December 2022. It has 5 nm bands from 340-890 nm plus several SWIR bands, and will provide 1-2 d global coverage, with a ground pixel size of 1 km^2 at nadir. It is tilted ± 20^o fore/aft to avoid Sun glint and will undergo twice monthly lunar calibration and daily on-board and solar calibration. It will have a performance that meets or exceeds heritage missions. The primary instrument is the Ocean Color Instrument (OCI), a wide swath, UV-VIS imaging spectrometer with SWIR channels designed for ocean colour applications, and useful for aerosols and clouds. It will undergo a critical design review in December 2019. Other instruments onboard PACE include the wide-swath multi-angle polarimeter HARP2 (Hyper Angular Rainbow Polarimeter 2), and the Spectro-Polarimeter for Planetary Exploration (SPEXone), a narrow-swath hyperspectral, multi-angle polarimetric spectrometer.

Regarding NASA's budget status, the FY20 President's Budget maintains the Administration's previous termination of PACE and CLARREO Pathfinder missions, but PACE activities are planned till September 2020. The *2017-2027 Decadal Survey for Earth Science and Applications from Space* will drive the next 10 year plan. There will be two competitions for PACE: ROSES 2019 and ROSES 2022 for pre- and post-launch algorithm and applications development. The post-launch science team will likely be competed through ROSES 2025. There is also an open competition for vicarious calibration – the teams will be selected this summer. Lastly, Paula mentioned that the Deputy Director of

NASA's Earth Science Division has retired. Paula is currently the Acting Deputy Director, and she has been asked to apply for the Deputy Director position. She nevertheless hopes to stay engaged with IOCCG; Laura Lorenzoni will cover if necessary.

5.3 ESA: Update on Sentinel-2 and 3

Marie-Hélène Rio provided an update on the ESA Sentinel-2 and 3 missions. Sentinel-2A was launched on 23 June 2015 and Sentinel-2B on 7 March 2017. The main instrument of the Sentinel-2 mission is the MultiSpectral Instrument (MSI) which has four bands at 10 m spatial resolution, six bands at 20 m and three bands at 60 m. Sentinel-2A and 2B are operating 180 degrees apart, with global coverage every 5 days (since February 2018), monitoring inland and coastal waters. Next steps include L2A on-demand data for Copernicus services (later for all users). Also geometry-refined production using Global Reference Image (GRI) and continuous improvement of L1C and L2A products.

Regarding the Sentinel-3 mission, the start of Sentinel-3B routine operations in March 2019 allows an almost complete daily coverage with the OLCI and SLSTR instruments. The space and ground subsystems and instruments of both Sentinel-3A and B (OLCI, SLSTR, SRAL, MWR) are performing nominally. All core data products for both Sentinel-3A and B have been released, and are available open and free. Reprocessed OLCI data (L1 and L2) have been available to users since September 2018. The tandem phase between S-3A and S-3B was completed in mid-October 2018 and comparison of OLCI-A and B data confirmed that the instruments are radiometrically aligned within a few percent. With two satellites, global coverage is less than 2 d. The next Sentinel Validation Team meeting will take place 7-9 May 2019 at ESA/ESRIN, and the next Sentinel-3 OLCI Quality Working Groups will take place at the end of 2019.

5.5 JAXA: Update on GCOM-C/SGLI

Hiroshi Murakami reported on the GCOM-C/SGLI mission, launched on 23 December 2017. All standard SGLI products have been released to the public via G-Portal since 20 December 2018, and one year of data is now being reprocessed. SGLI has onboard calibration functions (weekly onboard diffuser, solar and lamp calibration, monthly moon calibration). Vicarious calibration is carried out using MOBY and BOUSSOLE. Product validation is implemented using *in situ* matchup data, but more *in situ* data are required, especially for CDOM and TSM. Match-ups are generally good but there are a few problems which JAXA is trying to solve. The GCOM-C mission has been operating continuously since 1 January 2018 and is generally stable except for ~ 2% degradation in the blue channels. The new science team for JFY2019-2021 has been selected.

5.6 KIOST: Updates on GOCI and GOCI-II

Joo-Hyung Ryu (KIOST) provided an update on the GOCI and GOCI-II missions. Recently, a new KIOST president had been elected with a change of focus on research. KIOST also has a new satellite operation facility in Busan. The GOCI/COMS operational lifetime will be extended until March 2021 (TBD) so that GOCI and GOCI-II can acquire data simultaneously for about one year. GOCI data service consists of near real-time data distribution for government users and a web-based open access data service for researchers/public. NASA OBPG has a mirror site with Level-2B data the same as KOSC and Level 2 data processed by SeaDAS.

GOCI-II launch has been delayed and is now scheduled for March 2020. GOCI-II will have a smaller ground sampling distance than GOCI (from 55 m to 250 m), full disk imaging in global observation mode, moon imaging capacity, improved stray light performance and more spectral bands (from 8 to 12 bands). GOCI-II will also have two imaging modes: local (10 images per day) and full disk observation (once per day). There are several dedicated cal/val stations in the Korean Sea, and a joint GOCI-II network has been proposed – to be called Gi-JOON (GOCI-II JOint Ocean reference Network) with collaboration between Asia and other countries. GOCI-II algorithms are being developed based on the GOCI algorithms adjusted for GOCI-II spectral characteristics.

5.7 Australian ocean colour activities

Tim Malthus reviewed recent Australian OC activities (see report on Australian Ocean Colour Activities). At the national level, the Australian Space Agency was established in July 2018, headquartered in Adelaide. Earth Observation services is one of the 7 priorities of the agency. Earth Observation Australia (EOA) was formed in 2017 as a forum to share and discuss EO activities. CSIRO released its Space Roadmap in 2018 to highlight its strategic directions and those of the new space agency. In 2018, the Australian Government invested in Digital Earth Australia (DEA), a data cube for medium resolution satellite imagery for the Australian continent. DEA will provide a wide suite of information products to the Australian government and industry. In addition, an operational capability to monitor inland water quality using EO data will be developed under DEA, as well as the establishment of a national spectral library for aquatic ecosystems (Arnold Dekker).

The Australia Integrated Marine Observing System (IMOS) has created a new Biogeochemical-Argo facility to advance the deployment and data quality control of BGC-Argo floats. The three floats deployed at the Southern Ocean Time Series are still operational. Ocean colour cal/val activities are carried out at Curtin University (David Antoine), while CSIRO continues to manage the Lucinda Jetty Coastal Observatory.

Preparations are underway for a cruise along the 110°E line (May-June 2019). The overall goal of the optics/primary productivity team is to contribute to better determination of carbon (phytoplankton) and primary productivity from satellite OCR.

5.8 Update on the Chinese ocean colour missions

Xianqiang He reported on the Chinese ocean colour missions. The HY-1C mission, launched on 7 September 2018 is a successor to HY-1A and 1B. Comparisons of HY-1C daily and 8-d Chl-a, Lwn and SST with MODIS and SNPP/VIIRS were consistent. It is anticipated that three main ocean colour payloads will be launched before 2021: the HY-1D operational satellite, the next generation HY-1E experimental ocean colour satellite and the HY-1F next generation operational mission.

5.9 ISRO update on OCM-2/OCM-3

Cara Wilson gave the ISRO update on behalf of Prakash Chauhan who was unable to attend. OCEANSAT-2 continues to provide quality data even after ten years of operation. The OCEANSAT-3 mission should be launched in early 2020. The Indian Institute of Remote Sensing (IIRS) recently published a compilation of images from the OCEANSAT-1 and 2 missions in the form of an atlas entitled “Ocean’s Colour from Space”, highlighting different oceanic phenomena. A workshop/training course on Coastal and Ocean Management recently took place at IIRS, Dehradun (Jan/Feb 20-19), while a course on “Marine phytoplankton optics, pigment and taxonomy” took place the INCOIS International Training Centre for Operational Oceanography in Hyderabad (March 2019).

5.10 CSA update

Emmanuel Devred gave a brief report on Canadian ocean colour activities. Laurent Giugni will replace Martin Bergeron as the CSA representative on the IOCCG Committee, and will present CSA activities at IOCS-2019 through a recorded presentation. CSA’s proposed WaterSat mission (hyperspectral, 100 m spatial resolution, 5 nm spectral resolution) is designed to monitor Canada’s coastal and inland waters. Initially, CSA teamed up with NRL to develop the Coastal Ocean Color Imager (COCI), to be integrated onto the PACE platform, but this was not funded in the last budget. CSA is now exploring national and international partnership opportunities to initiate Phase A of a second version of the WaterSat mission.

5.11 CONAE update

Sandra Torrusio provided a recorded presentation on Argentina's SABIA-Mar mission, which is primarily an ocean colour mission with 2 d revisit. Regional/coastal acquisitions have 200 m spatial resolution for the measurement bands and 400 m for atmospheric correction bands, while the global scenario has 800 m spatial resolution. Sea surface temperature is a secondary observable (450 m resolution). The main products will include LnW, Chl-a, Kd(490), PAR, turbidity and SST. Data will be available within 24 h (near real time products for Chl-a and SST only). Level-3 products (daily, 8 d and monthly) will also be distributed. Vicarious calibration sites are located in north and south of the equator to get a range of data for calibration. The mission is scheduled for launch in 2023. Robert Frouin reported on a few issues that are still being addressed: the resolution of SST and OC products do not match exactly (450 m and 400 m respectively), and there are different viewing angles for different measurements (10 degree difference).

5.12 Report on the final outcome of the NASA Earth Science Decadal Survey

Jim Yoder reported on the US National Academies of Sciences *Decadal Strategy for Earth Observation from Space*, the goal of which was to make recommendations for a 10 year plan for NASA Earth-system science programs. The study involved a Steering Committee plus five panels including one for Ecosystems/Biogeochemistry – Jim Yoder was a Co-Chair of the latter panel. The panels responded to community proposals and published a comprehensive report in 2018, as well as an Executive Summary. Based on all information received plus science questions, the Ecosystem Panel recommended the following ocean missions/measurements (to be endorsed by the Steering Committee):

1. A space-borne ocean Lidar (532 and 355 nm), as the highest priority mission.
2. A hyperspectral and 30-m pixel resolution polar orbiting imager, rated the highest land/ocean priority.
3. Radiometry from a geostationary orbit (e.g., GOCI).
4. The ACE mission focusing on aerosols, clouds, and ocean ecosystems (PACE is one model).

Important science themes identified by the Steering Committee include ecosystem changes in time and space, and fluxes (of carbon, water, nutrients, and energy) within ecosystems as well as between ecosystems and the atmosphere, ocean and solid Earth. Lidar and hyperspectral/high spatial resolution imagery was a high priority (but no ocean biology priority for Lidar). The Ecosystem Panel provided proof-of-concept for ocean Lidar: e.g., CALIOP on CALIPSO and high spectral resolution Lidar (HSRL) on aircraft that provide vertically-resolved aerosol size, concentration and composition, plus ocean particle profiles. The two key wavelengths are 355 and 532 nm (to separate particles from molecules). The big advantage of Lidar, especially for polar regions, is that it can

penetrate three optical depths and can also collect data at night and under cloudy skies. Since the Steering Committee did not propose ocean Lidar as a high priority measurement so the ocean colour community will have to lobby hard for a Lidar "aerosol" mission.

It was noted that the aerosol cloud community is somewhat resistant to working with the ocean colour community, but Emmanuel Boss pointed out that we are making headway with the atmospheric community who are willing to have a representative from ocean sciences on their team. He suggested that IOCCG prepare a report on the value of Lidar for OC science, although Stewart Bernard was of the opinion that a feature article in EOS might be a better way forward (a position paper, not a science paper). There was some concern that a report might take too long, and it was pointed out that Cedric was leading a White Paper on Lidar for OceanObs-19. Hubert Loisel emphasised that it was important to target the atmospheric community. Emmanuel Boss suggested that the IOCCG contact Mike Behrenfeld regarding the promotion of ocean Lidar and how to engage the atmospheric community.

Action 24/5: *Emmanuel Boss to contact Mike Behrenfeld regarding the promotion of ocean Lidar and how to engage the atmospheric community (action closed).*

6.0 International Ocean Colour Science Meeting 2019

6.1 Arrangements for IOCS-2019 meeting

Wonkook Kim briefed the committee on preparations for the upcoming IOCS-2019 meeting, to take place in Busan, South Korea (9-12 April, 2019). To date over 230 people had registered, the majority from USA, China and South Korea. The meeting would take place on the second floor of the Haeundae Grand hotel with the Ice Breaker event on the 6th floor and a breakout room on the 22nd floor. Four poster sessions are scheduled (two of them will be poster lightening sessions).

Stewart Bernard remarked that participants at IOCS-2017 in Lisbon wanted to know how the agencies had responded to recommendations from previous IOCS breakout workshops. For IOCS-2019, it is important to provide concrete examples of how the agencies have implemented recommendations. This could be addressed during the opening IOCCG address, as well as during the final Q&A session. Breakout chairs should be asked for three bullet points, prioritising actions the agencies can address. It was also pointed out that some of the recommendations could be addressed by the ocean colour

community, and/or the IOCCG (e.g., establishing working groups, writing reports etc.), and are not only the responsibility of the space agencies.

6.2 Discussion on the next IOCS meeting

Emmanuel Boss queried whether the IOCS meetings were happening too frequently, as two years is not really enough time to move forward with the recommendations from the breakout workshops. Perhaps the IOCS meetings should be held every four years, although continuity is also important and the potential impact of holding the meeting in four years' time is that the community will have less insight into what the IOCCG is doing. Holding Town Halls at other meetings e.g., Ocean Optics, Ocean Sciences, could be a way of keeping the community informed (note: a proposal has been submitted for a Town Hall at AGU, Ocean Sciences deadline is 23 May). Feedback should also be requested from the ocean colour community about the desirable frequency of IOCS meetings.

Action 24/6: *IOCCG Committee members who attend future ocean-colour related meetings should consider submitting a proposal for an IOCCG Town Hall, especially for the upcoming Ocean Sciences meeting.*

Regarding future IOCS meetings, it is important to coordinate with Ocean Optics (Jenny Ramarui) to avoid too much overlap. The Fall 2022 Ocean Optics Conference would be identified later this year, but in keeping with the customary rotation, the conference will be located outside of the United States (the next Ocean Optics meeting will take place 24-30 October 2020 in Norfolk, Virginia, USA). The timing and location of the next IOCS meeting will be further discussed during the IOCCG Executive meeting (likely North America). Venetia and Cara will coordinate with Jenny Ramarui.

Action 24/7: *Cara Wilson and Venetia Stuart to coordinate with Jenny Ramarui regarding the next IOCS meeting to avoid potential conflict/overlap with future Ocean Optics meetings.*

7.0 Training and Capacity Building

7.1 Report on 2018 Summer Lecture Series and plans for 2020 SLS

David. Antoine reported remotely on the fourth IOCCG Summer Lecture Series, which took place from 25 June to 7 July 2018 in Villefranche sur mer, France. Sponsorship was similar to previous courses (LOV, CNES, the local French consortium, EUMETSAT, NOAA,OCB and SCOR). There were 13 lecturers in total (a few less than in previous years

in an attempt to reduce costs) and 21 students with range of backgrounds and countries, and a good gender balance. The organisation of the lectures was similar to previous years with the basics being covered in week one, and atmospheric correction, applications and practical session in week two. All lectures were video recorded as in the past, and are available through the IOCCG website. The new building was not ready in time for the course so students were accommodated in the old building. If the course is held in Villefranche in 2020 the new building can be used (accommodation on 5 floors). The budget for the 2018 course was less than 2016 because there were fewer lecturers and more students who supported their own participation.

Regarding future courses, David queried whether the format and/or location should be stay the same (it works well) or whether it should evolve. There are two options for the 2020 training course: Villefranche again (IMEV/LOV have applied to the "Copernicus Academy" call, which could provide funds to support SLS 2020), or hold the course at Curtin University, which is easier to justify David's time, but would be more expensive. It is difficult to find support in Perth; David will make a decision in about 3 months' time. It is also important to integrate the Summer Lecture Series with IOCCG's capacity building plan.

Stewart Bernard fully understood the issues at Curtin University but pointed out that the branding in Villefranche has been built up over the years, and offers a strong attraction for students. In response to a query about other possibilities being considered, David pointed out that there were no other offers to host the training course, but it was totally open if someone would like to take over. Menghua Wang recommended SLS 2020 be held in Villefranche, if it worked for David. If the Copernicus funding was awarded, this could potentially further decrease IOCCG's contribution to the training course.

7.2 Ocean colour online primer

Paula Bontempi provided a brief history of the online ocean colour primer. A few years ago IOCCG discussed the desirability of having an introductory online IOCCG ocean colour training course. A proposal solicited from Sam Lavender was outside IOCCG's budget, so it was proposed that IOCCG prepare a solicitation for students to compete on providing an online primer using left over NASA funds from the IOCS-2017 meeting ($5K stipend, $5K for material). Paula prepared a draft solicitation which was circulated to Committee members for comment. There was some concern about the quality of the proposals that would be received from students who may not be proficient in the subject matter themselves. To do it properly would require substantial resources. Another action was for Venetia Stuart to summarize all available online ocean colour resources on the IOCCG

web page, which has been done. The question is whether IOCCG should pursue the online ocean colour primer, or whether the funds are better spent elsewhere? The Committee noted that there are substantial online resources available for different audiences, with a wide range of focus, including the SLS videos and PowerPoint presentations. Stewart Bernard suggested that the IOCCG rather look into updating IOCCG Report 3 on optically-complex waters, instead of developing an online primer, as this is the best introduction to ocean colour radiometry, and the most widely requested IOCCG report. There have been many new advances since the report was published in 2000, so an update is timely. This idea was positively received by the committee and Cara Wilson agreed to follow up.

Action 24/8: *Cara Wilson to follow up with the authors of IOCCG Report 3 regarding updating the volume.*

7.3 EUMETSAT/IOCCG training course in China

Yan Bai reported on arrangements for the proposed IOCCG/EUMETSAT/SIO training course in Hangzhou, China, scheduled to take place from 24-31 October 2019. Hayley Evers-King and Ben Loveday (PML/EUMETSAT) will provide hands-on training to introduce the EUMETSAT Copernicus Marine Data Stream and OLCI instrument in particular. SIO lecturers will introduce the Chinese OC satellite data and applications (HY-1C), and will provide hands-on practical sessions on the marine satellite data online analysis platform (SatCO2). A field investigation will take place in Lake Qiandao for participants to gain experience with optical instruments, and to carry out a small project. Trainees will be requested to bring their own laptops but 15 desktop computers will also be available.

SIO will cover all the local costs including meeting rooms, expenses for invited speakers and some expenses for the trainees from China. EUMETSAT will cover the cost of their two trainers, while IOCCG is requested to cover 4-5 international flights ($4-5K) for Asian trainees outside of China. The first announcement will be released in May 2019 and selected students will be notified by 15 July 2019.

There are four ground stations in China (Hangzhou is one) receiving data from 28 different satellites. SIO has a lot of experience in operational processing as well as carrying out satellite-based marine carbon research, including a field monitoring system with underway measurements, buoys etc. Over the last few years they have developed a satellite-based operational monitoring and assessment system for ocean carbon fluxes (SatCO2), which is now available online. Users can conduct interactive analyses and use their own algorithms to compare Chl derived from MODIS or Chinese satellites. They also have models to do carbon-flux calculations. There was overwhelming consensus that the IOCCG should support regional training courses such as the proposed Hangzhou training.

7.4 Discussion - IOCCG capacity building strategy

Stewart Bernard informed participants that GMES Africa will be conducting an 8-day training course in mid-November in Zanzibar, analogous to the Chinese training course, with lectures plus student projects, also in conjunction with EUMETSAT. There will soon be an open call for ~ 20 students from Africa. The course will focus on how to develop an operational EO-based service, primarily using OC and SST, and covering applications such as aquaculture and fisheries, using EUMETSAT data cubes (Sentinel data).

It was noted that the Summer Lecture Series is always over subscribed (~140 applications for 20 slots) even though it is directed at career researchers. Many of the applications are, however, misplaced and might fare better in an introductory course. Ideally there should be courses of 3 different levels around the world with reasonable mechanisms and decent volumes. Ana Dogliotti pointed out that the Antares network still exists, but has no funding, so cannot offer training. Local starter courses might be less expensive to conduct and can benefit these countries. Another option is for universities to include an EO module, which will allow more people to attend to gain basic knowledge.

Jim Yoder pointed out that there is so much information and so many courses available on the internet that many students are overwhelmed. Rather than trying to develop an introductory online course, it might be better to provide students with a roadmap directing them to the appropriate resources for each topic/level. For example, new users should first read certain chapters of IOCCG Report 3 then view certain SLS lectures. Cara Wilson, Stewart Bernard and Jim Yoder were tasked with providing a roadmap for training, to be posted on the IOCCG website, targeting different audiences, and combining upcoming meetings with available resources.

Action 24/9: *Cara Wilson, Stewart Bernard and Jim Yoder to develop a training roadmap for the IOCCG website, targeting different audiences.*

8.0 Any other business

8.1 Economic valuation of ocean colour data records

Paula Bontempi reported on determining the economic value of an ocean colour observing system, something which has been examined by the climate community. An economist was enlisted to help define economic boundaries on the data collected, focussing on aquatic carbon. The oceans play an important role in the global economy:

the carbon cycle, together with coupled carbon-climate feedbacks are central to the ocean economy. The value of ocean goods and services rely on healthy conditions. Currently, the net value of the economic impact of foregoing the sustained observations of the Earth's carbon cycle range from US$1 to 10 trillion dollars (large uncertainties). It is important to quantify the economic value of aquatic carbon science and compare this to an agency's investment in a global ocean colour observing system (rigorous analysis must take into account uncertainties in aquatic carbon science, economic impacts, policy etc.). The economic value of reducing uncertainty must also be computed (new and better measurements reduce uncertainty, but cost money). In all cases examined, the value of information for an advanced carbon cycle observing system, using the satellite ocean colour remote sensing example, appears to be large, relative to their cost. Current advanced, global, ocean colour satellite observations costs in the US are roughly 1 billion USD/year. If we account for comparable and complementary synergistic international efforts of roughly similar magnitude for planned missions and future observations globally, the estimate might head towards a total of 3 to 4 billion USD/year for all of ocean colour remote sensing observational capability.

8.2 Journal special issue on aquatic carbon from space

Chuanmin Hu revisited last year's proposal to have a journal special issue on "Aquatic Carbon from Space" (see also Agenda Item 4.2). Aquatic carbon is a critical component of the Earth system (e.g., carbon cycling, carbon sequestration) and substantial advancements have been made in the past decade. The motivation for the journal is to demonstrate how ocean colour remote sensing can help assess carbon sources, stocks, and fluxes in wetlands, ocean/land interface, ocean/atmosphere interface, and open ocean/large lakes. Proposed journals include *Remote Sensing of Environment* (Menghua Wang, Chief Editor, more expensive, 75% rejection rate), *Frontiers* (Laura Lorenzoni, Associate Editor) or *Biogeosciences*. A virtual special issue could also be considered (individuals papers are published as soon as accepted).

Invited review papers could include a possible retrospective on aquatic carbon from space/observations, to modeling or maturity of ocean carbon estimates from space, especially in perspective to land carbon research. Guest editors should be invited (self-nomination welcome). The journal can be determined by the guest editors. Chuanmin Hu agreed to work with Laura Lorenzoni to draft an outline for guest editors (draft to be circulated before reaching out to potential guest editors). NASA PIs with aquatic carbon proposals will be encouraged to submit papers. The special issue will be announced at IOCS-2019.

Action 24/10: *Chuanmin Hu and Laura Lorenzoni to draft an outline for a special journal issue of Aquatic Carbon from Space, and circulate to the IOCCG Committee for comment.*

8.4 Discussion: name change for "ocean colour"

Stewart Bernard noted that discussions on a name change for "ocean colour radiometry" come up periodically because some scientists feel that it is not inclusive of the freshwater community. "Ocean colour" has a strong history, and is commonly used by the space agencies, so changing the name would be problematic. Ideas tossed around included renaming IOCCG to International Inland and Ocean Colour Coordinating Group (I^2OCCG), and perhaps promoting the use of terminology such as "water colour radiometry", "aquatic optical radiometry", "aquatic colour" etc. It was pointed out the "Inland Colour" does not make sense, and the Committee agreed that it is <u>not</u> desirable to change the name. In some languages (e.g., French and Chinese) the translation of "ocean colour" is actually "water colour". There was consensus, however, that IOCCG should make more of an effort to be inclusive and to better represent the freshwater community (e.g., changing the byline on the IOCCG website to include inland water, appoint another freshwater representative on the IOCCG Committee, better consultation on planning etc.). Emmanuel Boss also suggested that some problematics specific to the inland community, such as atmospheric correction, could be specifically addressed in an IOCCG report or through an IOCS breakout session dedicated to inland waters.

Action 24/11*: Venetia Stuart to change the byline on the IOICCG homepage to be more inclusive of the inland water community.*

9.0 Organisation and Membership

9.1 Hosting of IOCCG-25 meeting in Tokyo in 2020

Hiroshi Murakami announced that JAXA was willing to host the IOCCG Committee meeting in 2020 or 2021 (2020 was better with regard to funding). Tokyo is the most convenient location (~1 h from the airport by fast train) but Hakodate could also be a candidate (1.5 h from Tokyo by plane, small interesting city, Hokkaido Fishery Institute). Possible dates were January/February (generally fine but cold, 1-2 snow days/month, JAXA workshop end of Jan) or March (warmer, cherry blossoms, 18-19 March not available for EORC). The most convenient dates would be the week of 23-27 March 2020. Candidate areas in Tokyo include the Tokyo station area (convenient, easy access), the Ueno area (many museums, temples) or the Asakusa area (shrines, historic sites, water-bus river cruise). The GCOM-C ocean group will support the meeting - PIs, Mitsuhiro

Toratani, Joji Ishizaka, Toru Hirawake and Takafumi Hirata would be invited to attend, and other scientists could also be invited (e.g., climate modellers, fishery applications scientists, or JAXA CEOS members etc.).

Cara Wilson noted that traditionally, IOCCG Committee meetings alternate between North America/Europe and another destination in Asia/Africa/Australia etc. If the meeting were held in Tokyo in 2020, it would be the second Asian meeting back-to-back. Hiroshi informed the Committee that, financially, it was important to host the meeting relatively close to the launch of the GCOM mission – it may not be possible at a later date. There was consensus that the meeting should take place the week of 23-27 March 2020 in Tokyo, noting that the Ocean Sciences meeting was scheduled to take place from 16-21 February 2020 in San Diego, USA.

9.2 Rotation of IOCCG Committee members

Emmanuel Boss, Hubert Loisel, Xianqiang He, and Rosalia Santoleri were scheduled to rotate. Names of several prospective members were added to the (long) list, with a focus on gender balance, regional representation, and junior scientists. Desired areas of expertise were also discussed including freshwater remote sensing and detection of marine plastic litter from space (perhaps invite Paulo Corradi from ESA to attend the meeting in Tokyo). Membership would be further discussed in the IOCCG Executive meeting.

9.4 Closing comments

Cara Wilson expressed gratitude to past members for their service on the IOCCG Committee, and thanked all participants for travelling to Hanoi. She especially thanked Hubert Loisel and VAST for hosting the meeting, and Dat Dinh Ngoc and the other students for all their help in ensuring a very successful meeting in Hanoi.

List of Actions: IOCCG-24 Committee Meeting

Hanoi, Vietnam, 4-5 April 2019

	Brief description	Status
24/1	IOCCG Committee members to review Chapter 9 of the modelling report, and send comments to Stephanie Dutkiewicz.	Closed
24/2	IOCCG Committee members to submit examples of new publications dealing with harmful algal blooms, to Stewart Bernard (due ASAP)	Closed
24/3	Venetia Stuart to circulate draft guidelines for proposing a new IOCCG Task Force. Committee members to submit their comments. *Action: V.S. circulated document on 27 May 2019*	Closed
24/4	IOCCG Committee members to submit suggestions for constraining the proposed IOCCG Hyperspectral Task Force, including proposed Terms of Reference, membership etc. *Action: Feedback received from Stewart Bernard, Paula Bontempi and Ewa Kwiatkowska - to be discussed at IOCCG-25 meeting*	On going
24/5	Emmanuel Boss to contact Mike Behrenfeld regarding promotion of ocean Lidar and how to engage the atmospheric community. *Action (10 May 2019): Mike Behrenfeld is promoting an ocean Lidar through a town hall lecture at NASA Goddard. He and others have also been involved in discussion of an upcoming atmospheric satellite to convince them to include an ocean Lidar.*	Closed
24/6	IOCCG Committee members who attend future ocean-colour related meetings should consider submitting a proposal for an IOCCG Town Hall, especially for the upcoming Ocean Sciences meeting (due by 23 May). *Action (10 May 2019): Cara Wilson held IOCCG Town Halls at the Fall AGU meeting (Dec 2019) and Feb 2020 Ocean Sciences meeting.*	Closed
24/7	Cara Wilson and Venetia Stuart to coordinate with Jenny Ramarui regarding the next IOCS meeting to avoid potential conflict/overlap with future Ocean Optics meetings. *Action (25/4/19): Cara and Venetia held a telcon with Jenny Ramarui. Ocean Optics 2022, Fall, outside of USA (Cape Town, Australia, Spain, Colombia, St. Thomas Virgin Islands and Quebec City – a decision will be made by end 2019, not public). Ocean Optics 2024: in USA but NOT on the east coast.*	Closed

24/8	Cara Wilson to follow up with the authors of IOCCG Report 3 regarding updating the volume. *Action: Cara contacted Shubha. She is interested in doing this if there is no urgent timeline.*	Closed
24/9	Cara Wilson, Stewart Bernard and Jim Yoder to develop a training roadmap for the IOCCG website, targeting different audiences.	Open
24/10	Chuanmin Hu and Laura Lorenzoni to draft an outline for a special journal issue of Aquatic Carbon from Space, and circulate to the IOCCG Committee for comment. *Action (Sept 2019): Journal = Remote Sensing of Environment. Chuanmin and Laura reaching out to find guest editors.*	On-going
24/11	Venetia Stuart to change the byline on the IOCCG homepage to be more inclusive of the inland water community. *Action (23/5/19): Byline on IOCCG website has been changed.*	Closed

Appendix I: LIST OF PARTICIPANTS

Hanoi, Vietnam, 4-5 April 2019

IOCCG Members		**Affiliation**
Bernard, Stewart	-	CSIR, South Africa
Bontempi, Paula	-	NASA HQ, USA
Boss, Emmanuel	-	University of Maine, USA
Devred, Emmanuel	-	Bedford Institute of Oceanography, Canada
Dogliotti, Ana	-	IAFE, CONICET/UBA, Argentina
Dutkiewicz, Stephanie	-	Massachusetts Institute of Technology, USA
He, Xianqiang	-	Second Institute of Oceanography, China
Hu, Chuanmin	-	University of South Florida, USA
Kim, Wonkook	-	Pusan National University, Korea
Loisel, Hubert	-	ULCO, France
Malthus, Tim	-	CSIRO, Canberra, Australia
Mélin, Frédéric	-	EC-JRC, Italy
Murakami, Hiroshi	-	JAXA/EORC, Japan
Rio, Marie-Hélène	-	ESA/ESRIN, Italy
Ryu, Joo-Hyung	-	KIOST, Korea
Stuart, Venetia	-	IOCCG Project Office, BIO, Canada
Wang, Menghua	-	NOAA/NESDIS/STAR, USA
Wilson, Cara (Chair)	-	NOAA/NMFS, USA

Invited Participants		**Affiliation**
Bai, Yan	-	Second Institute of Oceanography, China
Frouin, Robert	-	SIO/UCSD, USA
Jamet, Cédric	-	Université du Littoral Côte d'Opale, France
Kwiatkowska, Ewa	-	EUMETSAT, EU, Germany
Delu, Pan	-	Second Institute of Oceanography, China
Yoder, James	-	Woods Hole Oceanographic Institution, USA

Apologies		**Affiliation**
Antoine, David (Past-Chair)	-	Curtin University, Australia
Chauhan, Prakash	-	ISRO, India
Franz, Bryan	-	NASA Goddard Space Flight Center, USA
Kampel, Milton	-	INPE, Brazil
Kwiatkowska, Ewa	-	EUMETSAT, Germany
Lifermann, Ann	-	CNES, France
Lorenzoni, Laura	-	NASA HQ, USA
Santoleri, Rosalia	-	ISAC-CNR, Italy
Torrusio, Sandra	-	CONAE, Argentina