IOCCG-23 Committee Meeting

Rome, Italy, 6-8 March 2018

DRAFT MINUTES

1.0 Welcome and Opening Session

1.1 Opening Remarks, Adoption of IOCCG-23 Agenda

The IOCCG Chair, Cara Wilson, opened the meeting and welcomed everyone to Rome, Italy. She thanked, the Director of CNR, Fabio Trincardi, for hosting the meeting and paid special thanks to Rosalia Santoleri for making all the arrangements. New IOCCG members were welcomed, and a brief *tour de table* allowed participants to introduce themselves (the list of participants is provided as an Annex to the minutes). The IOCCG-23 agenda was adopted as stands. Details of all presentations are available on the IOCCG website under supporting documentation (see: http://ioccg.org/23rd-ioccg-committee-meeting/). A summary of meeting discussions and actions is presented below.

1.2 CNR Welcoming Address

Rosalia Santoleri welcomed participants to Rome and to CNR and introduced Fabio Trincardi, Director, CNR Department of Earth System Science & Environmental Technologies. He presented an overview of marine research at CNR, including the ISAC institute dealing with marine science and satellite observations.

1.3 CNR Ocean Colour Research Activities

Rosalia Santoleri outlined the major lines of OC research at CNR institutes in Rome (ISAC-GOS), Venice (ISMAR) and Milan (IREA). CNR's role in the development and implementation of the satellite component of the European Copernicus Marine Environment Monitoring Service (CMEMS) was also addressed, including efforts to develop new ocean colour algorithms and products for European regional seas and coastal and inland waters, development of new products (based on synergy with ocean colour, SST, altimeter, SSS, SAR and *in situ* data) and bio-optics and CAL/VAL activities.

1.4 EO Activities at the Italian Space Agency and PRISMA Mission

Rosa Loizzo, PRISMA mission manager, outlined the Italian Space Agency (ASI) Earth observation programmes and ground segment, and provided an overview of the

hyperspectral PRISMA mission, scheduled for launch by the end of 2018. A revisit time of less than 7 days is possible. Emmanuel Boss noted the need for interaction between science community and PRISMA. Bryan Franz queried whether the SNR was valid for oceans (655 nm band is suitable).

1.5 IOCCG-22 Minutes and Status of Actions

The minutes of the IOCCG-22 Committee meeting were approved by consensus. Cara Wilson summarised the status of actions from the meeting, most of which had either been completed, or would be addressed further during the meeting.

- *Action 22/*1: The IOCCG water quality report has been reviewed internally by all the authors and will be further discussed under agenda item 2.3.
- *Action 22/2:* Closed: Ewa Kwiatkowska led a telephone conference call on 12 December 2017 to discuss the functioning of the new Ocean Colour Radiometry-Implementation Team (OCR-IT). This will be further discussed under item 3.1.
- *Action 22/3:* EOVs and ECVs will be further discussed under agenda item 9.0.
- *Action 22/4:* ECVs will be further discussed under agenda item 9.0.
- *Action 22/5:* Lake ECVs will be further discussed under agenda item 9.0.
- *Action* 22/6: Closed: Paula Bontempi reported that NASA had a formal collaboration with a group in Washington to perform an economic evaluation of OC data. The group felt strongly about starting with carbon cycle science. A paper should be in review/in press by the next meeting, and will be very valuable to the community.
- *Action* 22/7: Paul DiGiacomo noted that it may be possible to lead a study on the economic value of ocean colour data through a visiting scholar supporting the Blue Planet Initiative.
- *Action* 22/8: Closed: successful completion of Copernicus Plenary Session at IOCS-2017.

2.0 Status of IOCCG Working Groups

2.1 GEOHAB/IOCCG Harmful Algal Bloom

Stewart Bernard reported on the IOCCG GEOHAB working group. He recently hired a post-doc student to work on the report and help bring it to completion. The report will consist of a short introduction (to be written), a background section on OC and detecting harmful algal blooms (HABs), followed by several examples of HAB detection (dinoflagellates, diatoms, cyanobacteria, fish killing blooms, high biomass blooms, ecologically disruptive blooms). Feedback was requested on a new chapter on

managing the transition from research to operational. This chapter examines several examples of emerging systems from around the world (CSIR, NOAA, EPA, PML) paying particular attention to the science and user development components. The last chapter deals with "Future Perspectives and Recommendations" including sensor characteristics (bands, spatial resolution and revisit, hyperspectral vs multi-spectral, SNR), atmospheric correction and in-water algorithms (atmospheric correction currently the major constraint), science validation (the need to routinely measure & characterise phytoplankton assemblage), user driven products, and policy & economics.

A draft version of the report should be ready for review within 3 months. SCOR requested that the report also be recognised as a GEOHAB report (now called GlobalHAB) since SCOR covered some of the funding for working group meetings. SCOR would also like to comment on the recommendations.

Paula Bontempi suggested that a short section be included on the economics of HABS in the "Policy and Economics" section, and Chris Brown recommended that the cost of transition, such as personnel and equipment costs, be included in planning to go from research to operations. Emmanuel Boss pointed out that the validation infrastructure (e.g., monitoring groups) should also be considered.

2.2 OC Applications for Biogeochemical, Ecosystem and Climate Modelling

Stephanie Dutkiewicz reported on the IOCCG Working Group on "The Role of Ocean Colour in Biogeochemical, Ecosystem and Climate Modelling". This working group is important for users of OC data since there is limited dialogue between modellers and the OC community. Several WG meetings had taken place as well as monthly conference calls. The report will consist of 9 chapters, about half of which are well under way. Chapter 2 (Biogeochemical and Ecosystem Models) provides an introduction to the use of OC data by the modelling and OC communities. It also includes examples of a range of different types of models (depending on the questions being asked). Cara volunteered to review the chapter as a non-modeller.

Action 23/1: *Cara Wilson to review Chapter 2 of the Modelling WG.*

Chapter 3, led by Colleen Mouw, provides an overview of OC remote sensing. Frédéric Mélin will write the section on uncertainties (to understand the level of uncertainty that comes from OC products). A non-US person was requested to review the chapter – Tim Malthus offered.

Action 23/2: *Tim Malthus to review Chapter 3 of the Modelling WG.*

One of the more important chapters is Chapter 4, which deals with the mis-match between model output and OC products, highlighting issues non-experts might not be aware of if they treat model products the same as OC products. The chapter also looks at different pools of carbon determined from satellites (POC, DOC, PIC, C_{phy}) and also requires expert review – Emmanuel Boss offered to review.

Action 23/3: *Emmanuel Boss to review Chapter 4 of the Modelling WG.*

Chapter 5 (Model Skill Assessment) had stalled since Charlie Stock (NOAA) has been too busy with the IPCC model set for the upcoming CMIP6. He plans to spend time on this after April. Chapter 6 on data assimilation has made good headway this year under the leadership of Mark Baird. Funds were requested for a final 2-day meeting, which will be discussed in the IOCCG Executive meeting.

David Antoine pointed out that it is better to assimilate radiances rather than chlorophyll, but the way radiances are generated by the model is not always ideal. Stephanie noted that many models, especially climate models, are not radiance-based models and both avenues should be maintained (this will be explained in the report).

2.3 Earth Observations in Support of Global Water Quality Monitoring

Chris Brown presented an update on the water quality working group report, on behalf of Paul DiGiacomo who could not attend the meeting. The report is partitioned into three sections, focused on three different audiences (end users/managers, research community and space agencies). The overarching objectives are to assess current knowledge regarding coastal and inland water quality and associated use of RS data, assess existing and identify new space-based and *in situ* observing capabilities, identify supporting research/development activities, and user engagement/outreach. Most of the chapters are complete apart from Chapter 7 led by Paul DiGiacomo (*Coastal and Inland Water Quality Observing System Assets and Supporting Infrastructure*). The consensus was that the chapter was trying to cover too much: observing system assets and supporting infrastructure might fit better in a science Chapter, and calibration of satellite observations is already covered in IOCCG Report 14.

It was recommended that a new section dealing with integrated research needs should be incorporated into this report. Are there frontiers in research that should be encouraged? This would be very valuable from a management policy perspective. There was also some concern about Chapter 6 on sensor requirements, which is heavily based on the CEOS feasibility study published by CSIRO in November 2017 (http://elib.dlr.de/115781/1/CEOS_Aquatic_Study_for_CEOS_Endorsement2.pdf). The

report has been endorsed by CEOS and will be released at the CEOS SIT meeting (24-25 April 2018, in Boulder CA). Tim Malthus agreed to check with Arnold Dekker whether sections of the CEOS report can be republished by IOCCG.

Action 23/4: *Tim Malthus to check with Arnold Dekker whether sections of the CEOS feasibility report can be republished in Chapter 6 of the IOCCG Water Quality report.*

The working group plans to have all the chapters internally reviewed by 1 July 2018, for delivery to the IOCCG in September 2018. Xianqiang He (Second Institute of Oceanography, China) offered to print this report in China, which was gratefully accepted. The status of the IOCCG Reports being printed by NOAA (Reports 15 and 16) should also be followed up.

Action 23/5: *Menghua Wang to follow up on the status of IOCCG Reports 15 and 16 being printed by NOAA.*

2.4 Uncertainties in OC Remote Sensing

Frédéric Mélin provided a status report of the Uncertainties working group. Several interesting contributions had been received since last year, and the report was nearing completion. The many factors creating uncertainties in satellite remote sensing were reviewed and the outline of the various chapters was presented. A new chapter (Chapter 2) had been added on *Terminology and Main Principles*. Chapter 3 provides an overview of uncertainty propagation: inherent/stochastic, structural/epistemic and uncertainty due to editing (Level-2-to-Level-3 averaging) which is not discussed sufficiently in the community. Added knowledge can reduce the various sources of uncertainty. Covariance fields of OC data need to be examined to treat uncertainty propagation. Chapter 4 (uncertainty estimates) is very important and includes field observations, out-of-scope conditions, a presentation of the various methods currently proposed to derived uncertainty estimates, and current knowledge on uncertainties. Chapter 5 includes representation and distribution of uncertainties (flags etc.) while Chapter 6 deals with requirements from different applications of OC data. The last chapter provides recommendations (i.e., ensure traceability, terminology, comparison of methods etc.). The current draft is over 170 pages (might be too long for an IOCCG report) and is almost ready for review. Stewart Bernard enquired whether an example would be included showing uptake of uncertainty and how to use it, since some users might not understand a highly quantitative approach? This would be covered in Chapter 6.

2.5 Atmospheric Correction in Coastal Waters

Cédric Jamet reported on the IOCCG WG on "*Atmospheric Correction in Coastal, Optically-Complex Waters*". The goal of the WG is to inter-compare and evaluate existing atmospheric correction algorithms over turbid waters using nine atmospheric correction algorithms based on availability of MODIS-Aqua data. Initially large errors were associated with the simulated dataset, which has since been fixed - the dataset will be provided to the community. Most of the work has been completed (classic match-up analysis, simulated dataset for sensitivity studies, as well as inspection of satellite images over contrasted coastal regions). Two atmospheric correction algorithms were removed because researchers did not provide results, and the Polymer algorithm was added. Cédric requested that the AC codes of He and Chen be made publically available on the IOCCG website, as in IOCCG Report 5 (Emmanuel Boss recommended putting it on GITHUB).

Stewart Bernard pointed out that atmospheric correction procedures have changed a lot in last 5 years with new sensors coming onboard, and that IOCCG may be in danger of not looking forward with this report. He encouraged the authors to consider the heavy focus on MODIS, which is near the end of its life. A chapter could be added to consider other sensors, as well as a review chapter, showing the value of the NIR signal (VIIRS and OLCI also have SWIR bands). Some algorithms for VIIRS have been tuned for MODIS but it would take too much effort to repeat the exercise on VIIRS. Paula Bontempi encouraged the authors to review the section on AC in IOCCG Report 13 - is MODIS satisfactory for coastal waters? The status of this working group would be further discussed in the IOCCG Executive meeting.

2.6 Long-Term Vicarious Adjustment of OC Sensors

Steffen Dransfeld provided an update on this WG on behalf of Craig Donlon, who was unable to attend. The group was created last year to define the best practices to reach a high standard of precision and accuracy for *in situ* OCR measurements necessary to fulfill the system vicarious calibration (SVC) requirements. In this context different projects were established including the ESA FRM4SOC (Fiducial Reference Measurements for Satellite Ocean Colour), which held a workshop in Feb 2017, and the EUMETSAT OC-VCAL project, which defined detailed requirements for an OC vicarious calibration infrastructure for the Copernicus Programme (document distributed to the IOCCG Committee for comment on 15 December 2017). An outcome from the FRM4SOC workshop was the recommendation of two SVC sites for Europe (upgraded BOUSSOLE plus one further site), since the current Copernicus setup lacks a full robust

European infrastructure for SVC, relying on MOBY and the quasi-operational BOUSSOLE platform.

The WG is still new and members have not yet been solicited for report inputs, but co-chairs have started discussing the report content. David Antoine pointed out that it should be made clear that the WG activity is not just for Copernicus but for any long-term mission.

3.0 Building the Operational Component of OCR-VC

3.1 Status of CEOS OCR-VC and OCR-IT/ OC Vicarious Calibration

Ewa Kwiatkowska reported that various agencies have been collaborating on OC system vicarious calibration as part of OCR-VC activities (ocean colour radiometry – virtual constellation). SVC is one of the recommendations in the INSITU-OCR White paper (the baseline document for OCR-VC). European Copernicus VC activities were described, including the EUMETSAT document "*Requirements for Copernicus Ocean Colour Vicarious Calibration Infrastructure*", which addresses recommendations on vicarious calibration and is offered by EMUETSAT as a joint contribution to OCR-VC/OCR-IT (it will be included on the OCR-VC webpages). The document presents a defined set of requirements for all aspects of Copernicus SVC development, and has been in review by IOCCG since 15 December 2017, as well as an international review team and two public reviews. It is a "living document", so further comments from the IOCCG Committee were welcomed. Detailed comments will be taken into account and the reviewers will be contacted.

Action 23/6: *IOCCG Committee members* to review *the EUMETSAT document "Requirements for Copernicus Ocean Colour Vicarious Calibration Infrastructure" and provide comments to Ewa Kwiatkowska by 26 March 2018.*

3.2 Outcome of NASA Vicarious Calibration Projects

Paula Bontempi reported on three NASA-funded vicarious calibration projects: i) HYPERNAV, a hyperspectral radiometric device for accurate measurements of water-leaving radiance from autonomous platforms for satellite vicarious calibrations, led by Andrew Barnard, ii) HARPOONS, Hybrid-spectral Alternative for Remote Profiling of Optical Observations for NASA Satellites, led by NASA Goddard using a wave glider platform, and iii) a packable-shippable MOBY-NET instrument, led by Ken Voss. All projects had some merit. NASA and EUMETSAT agreed that the agencies could

significantly benefit from each other's investments. Discussions will take place on how the FRM4SOC report diverges from the INSITU-OCR White Paper, since there are different approaches and different scientific objectives.

Other issues pointed out were that the NIR signal in newer sensors is very important as well as choice of site. Also, some issues that users encounter are not due to the application of the SVC gains, but due to imperfect algorithms that do not perform well in coastal waters.

3.3 OCR-VC/OCR-IT Discussion and Actions

Ewa Kwiatkowska reported on EUMETSAT's vision and support for the OCR-IT (ocean Colour Radiometry – Implementation Team). At the last IOCCG meeting there was an issue with having another coordination team and office (difficult to fund), so it was agreed that the OCR-IT will be distributed and virtual. All activities will be overseen by IOCCG, CEOS and OCR-VC, and contributing agencies will have a goal to execute the OCR-IT rolling implementation plan and provide feedback. Resources will be coordinated since there are a variety of projects and activities that can contribute to OCR-VC efforts. EUMETSAT's contribution is product development and evolution studies (based on ITT procurements), where the goals are of common interest to OCR-IT agencies. Deliverables can be presented to OCR-IT for review and endorsement, and made available on the OCR-VC webpages. Other agencies can also contribute in a similar fashion. EUMETSAT also offered to support visiting scientists to work on specific activities (e.g., primary production round-robin). EUMETSAT's priorities are the contribution to fiducial reference measurements as well as algorithm improvements and new product development (e.g., NIR correction, fluorescence from OLCI).

Three geographically distributed co-leads of OCR-VC (Ewa, Paul DiGiacomo and Craig Donlon) attend CEOS Plenaries/SIT meetings, and enable coordination to facilitate international and interagency collaboration. Since Paul is stepping down, a nomination from outside Europe is required. Chris Brown offered to act as co-chair if necessary and Xianqiang He was also proposed. This will be further discussed in the IOCCG Executive meeting.

4.0 Agency Presentations

4.1 NOAA OC Activities Including VIIRS

Chris Brown reported on the progress of the NOAA OC team, on behalf of Paul DiGiacomo. NOAA has developed the capability for end-to-end satellite OC data

processing, and also supports *in situ* data collections for VIIRS Cal/Val activities, e.g., MOBY, AERONET-OC sites and NOAA dedicated Cal/Val cruises. For the global open ocean, OC products are routinely generated with good data quality. For coastal and inland waters, satellite OC data are derived with reasonable accuracy (some outstanding issues for cases with strongly-absorbing aerosols). OC data can be accessed through NOAA CoastWatch/OceanWatch/PolarWatch. This is an unprecedented time for satellite OC remote sensing with two operational satellites (VIIRS-SNPP and VIIRS NOAA-20) plus OLCI-Sentinel-3A, SGLI-GCOM-C and OLCI-Sentinel-3B. See presentation for further details.

4.2 Update on NOAA MOBY Operations and Impact on NASA Missions

Chris Brown reported that MOBY *in situ* data are essential for vicarious calibration and performance monitoring of satellite OC sensors, but the current system is out-dated, and a "MOBY Refresh" is in the works with a new imaging spectrometer system and full spectral resolution. During late 2017, the 1997-2011 data were reprocessed using a new straylight correction (SLC), and this reprocessed 1997-2011 dataset was released in December 2017. Now the 1997 to current data and forward processing (i.e., MOBY full mission) are all consistent with both the new SLC developed in 2011, and the K_L extrapolation improvements (and associated corrections) developed in 2016. This new SLC was applied to the old data to construct a consistent data set for MOBY over the whole period (SeaWiFS through VIIRS).

Bryan Franz reported on the impact of MOBY reprocessing on NASA data. In October 2017, NASA OBPG initiated the R2018.0 reprocessing of MODIS/-Aqua including the latest MOBY SLC update, and saw a significant bias shift in R_{rs} retrieval, traced to a bias shift in MOBY time-series. Changes in the MOBY time-series have had a significant impact on the NASA ocean colour record (one of the largest bias changes ever, including a global mean R_{rs} increases in the order of 2-10%, and global mean chlorophyll reductions in the order of 10%). The overall impact is to improve the quality of the satellite time-series by reducing the bias in the blue, relative to *in situ* data, and reducing the frequency of negative water-leaving radiances. The largest impact is from the revised stray light correction, which varies with time (lesser impact to older missions, e.g., SeaWiFS, MERIS). The MOBY reprocessings have occurred in stages, resulting in an inconsistency in the distributed record after 2011 (prior to Nov 2017) so other missions that rely on MOBY should ensure that they are working with a consistent and current (Nov. 2017) MOBY time-series.

4.3 NASA: Update on Current and Future Missions

Bryan Franz reviewed the status of NASA's operating missions: the NASA 2018.0 OC reprocessing resolved many issues with MODIS-Aqua. VIIRS-SNPP instrument calibrations and updated vicarious calibrations for SeaWiFS, MODIS-Aqua and VIIRS-SNPP have been refined providing a more reliable data record. NASA also provides international mission support to GOCI, Sentinel-3A, GCOM-C SGLI and Sentinel-2 MSI.

Paula Bontempi provided an update on the NASA PACE (Plankton, Aerosol, Cloud, ocean Ecosystem) mission, which is now in phase B. It is not just an OC mission, but focusses on systematic ocean biological, ecological, and biogeochemical climate data records as well as cloud and aerosol climate data records. Scheduled launch is fall 2022 (but will slide). The mission has a cost-cap, so will be cancelled if it goes over budget. The President's FY18 budget identified termination of five missions, including PACE (but will be appealed). Pre-launch and post-launch science teams will be competed through ROSES, including the validation programme.

4.4 ESA: Update on Sentinel-2 and 3

Steffen Dransfeld provided an update on the status of the Sentinel-3 and Sentinel-2 missions on behalf of Craig Donlon, including the timeline of events since launch, and reprocessing of datasets. Sentinel-3B is scheduled for launch on 25 April 2018. Initially, it will be operated in a tandem orbit with Sentinel-3A for cross-calibration purposes, and after 5 months, Sentinel-3B will be manoeuvred to its operational orbital position (phased 140°) with a 10 am equatorial crossing time.

Both Sentinel-2A and -2B are operational and provide systematic coverage over Europe, Greenland and Africa every 5 days, and the rest of the World every 7 days using the EDRS (European Data Relay System). Since January 2018, Sentinel-2A has acquired data over Antarctica.

4.5 EUMETSAT Ocean Colour Services

Ewa Kwiatkowska outlined EUMETSAT Ocean Colour Services, the major thrust of which is associated with Sentinel-3 OLCI ocean colour processing, validation and applications. Since 26 April 2016, OLCI data have been processed using the same consistent algorithms and calibration approach, and data is available to all users. Some biases are still apparent in OLCI products at L1, but these are being mitigated by applying SVC. The temporal stability of the mission is good and water-leaving reflectance meets mission requirements. Validation of algal pigment products using the CHL_OC4ME and CHL_NN

algorithms is still preliminary. CHL_OC4ME underestimates oligotrophic chlorophyll, so implementation of the Hu et al. (2012) algorithm is being investigated. There is also reduced quality in coastal /turbid waters which is being investigated. Regarding product development, an IOP study has been initiated and a fluorescence ITT is open.

EUMETSAT is preparing for Sentinel-3B launch together with ESA (changes to ground segment/system have been implemented, cal/val planned for commissioning phase etc.). The S3VT meeting will take place from 13-15 March 2018 – the major focus will be on the status of OLCI products, and fiducial reference measurements. ESA, EC-JRC and EUMETSAT are cooperating on Copernicus OC system vicarious calibration planning. Ocean training events were also briefly discussed including the 2 week courses, MOOCs, Hackathons, TEDx, code repositories etc.

4.6 JAXA: GCOM-C/SGLI New Developments

Hiroshi Murakami provided an update on JAXA GCOM-C/SGLI, launched on 23 December 2017 and now in the initial check-out period until March 2018. The first observation images of VNR-SWIR and TIR were acquired successfully on 1 and 22 January 2018, respectively. Sensor calibration model including detector offset, gain, geometries, and their temperature dependency will be confirmed and revised by the lamp, solar, moon, and Earth observation data (vicarious calibration). GCOM-C Level-1 and geophysical data products (Level-2 and -3 data) will be evaluated by comparing *in situ* observation data and other satellite products, and will be released one year after launch. The next research announcement (for JFY 2019-2021) will be in summer 2018.

4.7 KIOST: Updates on GOCI and GOCI-II

Seongick Cho briefly introduced the status of GOCI and development of GOCI-II. Last year KIOST was relocated to the new headquarters in Busan. Plans are underway to construct a dedicated operations facility early next year, with antennae to receive GOCI and GOCI-II simultaneously. The GOCI mission has a planned 7-year lifetime (from 1 April 2011) so the committee will vote soon on extending the mission by 2 years. Technically, there are no issues to extend the lifetime to provide GOCI data continuity.

GOCI-II is similar to GOCI in terms of instrument design, but it has four times better spatial resolution, so the instrument is bigger. It has two imaging modes: local area coverage (10 times per day at 60 minute intervals) and full disc image mode (1 image per day). The tentative launch date for GOCI-II is September 2019.

4.8 CSA Update

Simon Bélanger gave an update on Canadian OC activities, on behalf of Martin Bergeron who was unable to attend. There is still no OC mission in Canada but CSA supports OC work through IOCCG and NetCOLOR, a network of Canadian experts and end-users initially led by Marcel Babin, to develop a national strategy for research, training and dissemination of water colour products. The first phase of NetColor is almost complete and Phase 2 will be led by another group (funding permitting).

Since 2013 CSA has been working with federal departments on the hyperspectral Watersat mission concept, as part of the Microsat Initiative. The Watersat mission objectives are to monitor water quality and productivity of aquatic ecosystems in Canadian coastal and inland waters to support environmental assessment, climate change monitoring, and economic and recreational activities. The feasibility study for the Microsat class mission was too expensive, so the hosted payload option (i.e., to put the sensor, renamed COCI, on PACE) was investigated but in March 2017, there was no budget to go forward. Canada has been supporting sensor development in the context of WaterSAT/COCI (Canadian Coastal Ocean Color Imager) mission concept and a compact airborne demo (WISE - Watersat Imaging Spectrometer Experiment) has been developed and tested. A high performance prototype also started with DICE (Dual Imaging spectrometer COCI Experiment). A contract has been awarded for a breadboard version with performance goals consistent with the most demanding coastal water applications (high SNR, low polarization and stray light), and an Arctic demonstration of both WISE and DICE is being planned for 2020-2022 (in conjunction with the NASA Arctic-Color initiative).

CSA has supported IOCCG for around 20 years through the Earth Observation Application and Utilization (EOAU) programme, which is now under review. In this context, it is difficult to justify unsolicited funding requests while the programme objectives, stakeholders and governance is being revised. The funding request from IOCCG, if found to be aligned with the new programme objectives, should be part of the very first proposals considered for funding, but it is too early to know if funds will be available for the 2018 fiscal year, or only in the new fiscal year (starting 1 April 2019).

4.9 Update on the Chinese Ocean Colour Missions

Xianqiang He reported that five Chinese OC satellites will be launched before 2025, four of which will be polar orbiting (HY-1C/D and E/F) and the other geostationary. HY-1 C and D are successor missions to HY-1A (2002-2004) and HY-1B (2007-2016), and are scheduled for launch in 2018 and 2019 respectively. One mission will observe in the

morning (~10:30AM), and the other in the afternoon (~1:30PM). They will each carry a Chinese Ocean Color and Temperature Scanner (COCTS), a Coastal Zone Imager (CZI), an Ultraviolet Imager (UI) and a Calibration sensor (10 UV/VIS/NIR bands, 11 samples).

The HY-1E/1F missions are under development and will be launched in 2021. HY-1E is a new generation experimental OC satellite while HY-1F is operational. The 3 main payloads are a new COCTS sensor, a programmable MWI (Moderate-resolution Wide-wavelengths Imager) and a CZI sensor. A prototype MWI was launched on-board Tiangong-2 Space Lab on 15 September 2016. Lastly, the geostationary OC mission is scheduled for launch in 2022 and a prototype sensor (GOR) has been developed.

4.10 ISRO update on OCM-2/OCM-3 (?)

Cara Wilson gave the ISRO update on behalf of Prakash Chauhan who was unable to attend. ISRO is involved in operational data products and dissemination of OCM-2 data, the AVIRIS-NG hyperspectral airborne campaign over coastal and inland waters, and Oceansat-3 OCM sensor development, which is planned for the latter half of 2018. OC data products from OCM-2 include improved AC in turbid and coastal water, improved estimates of chlorophyll, and an *in situ* database of AOPs and IOPs and in-water constituents for waters around India. There are also plans for multiple acquisitions from a geosynchronous orbit (GISAT mission) which will also include a hyperspectral sensor, to be launched in 2018/2019.

4.11 CSIRO Ocean Colour Activities

Tim Malthus, who recently took over from Nick Hardman-Mountford on the IOCCG Committee, presented a brief summary of Australian OC activities (see website for full report). At the National level, Australia has announced its intention to establish a national space agency (the government will make a recommendation at the end of March 2018). In 2017 the Australian EO community formed Earth Observation Australia (EOA) to develop a community plan for Earth observation in Australia. A proposal to support EO calibration and validation infrastructure and activities was submitted to NCRIS (National Collaborative Research Infrastructure) in August 2017 under the auspices of EOA. The proposal is still under review but it is anticipated this will include support for ocean colour calibration and validation activities. The CEOS report "*Feasibility Study for an Aquatic Ecosystem EO mission"* was published by CSIRO and will be endorsed at the SIT meeting in April 2018.

For the Bio-Argo programme, two profiling floats equipped with bio-optical sensors were deployed in March 2016 in the Pacific sector of the Southern Ocean, providing

interesting information about phytoplankton dynamics and light availability. Three further deployments are planned over next few months near the Southern Ocean Time Series (SOTS) moorings.

In Western Australia, David Antoine was involved with the Antarctic Circumpolar Expedition (ACE) which took place from December 2016 to February 2017. David has been leading the development of a profiling mooring off Perth in Western Australia. Preparations are underway for the planned research voyage of the RV Investigator in the frame of the "IIOE-2" (International Indian Ocean Expedition 2). This cruise will take place from May to June 2019 and will traverse the 110°E line. The overall goal of the optics/primary productivity team is to contribute to better determination of carbon (phytoplankton) and primary productivity from satellite OCR.

The IMOS radiometry task force was established with the aim of improving consistency among IMOS radiometric measurements, to improve their usability for research and for validation of international satellite OC products. An intercalibration activity was undertaken at the Lucinda Jetty Coastal Observatory in Queensland, with the aim of evaluating the consistency among sea-going radiometers (report recently released).

Two research projects are underway dealing with the Great Barrier Reef: i) Marine pollution in the Great Barrier Reef using the ESA Sentinels missions, and ii) Water quality and phytoplankton blooms dynamics in Australian coastal waters using ESA and NASA satellite OC sensors.

5.0 Validation of Ocean Colour Sensors

5.1 FRM4SOC Protocols for Radiometric Validation of OC Sensors

Kevin Ruddick presented the technical report delivered to ESA on Fiducial Reference Measurement (FRM) protocols for satellite radiometric validation. The document is complete and has been reviewed by ~20 scientists with input from S3VT, but further review and input is still possible before end of March 2018. Historic MERIS validation data did not contain uncertainty estimates - it is very difficult to make good measurements with reliable uncertainties. Field measurement protocols are the biggest source of uncertainty. The useful and authoritative NASA Protocols (2004) need to be updated in light of maturing above-water radiometry, the transition from supervised to unsupervised measurements (e.g., MOBY/BOUSSOLE), and the need to validate high resolution satellite data. Because of the diversity of measurements, the FRM4SOC protocols "just" require a validated estimate of a total uncertainty budget instead of providing instructions on how to make the measurements. The FRM4SOC protocols

summary reviews all families of method for L_w and E_d measurements in the context of uncertainty estimation.

Emmanuel Boss suggested that this document could be part of the IOCCG Technical Report Series, as it could be embraced by the full OC community rather than just being part of an ESA exercise. The document is currently a FRM4SOC Project deliverable, but with non-FRM4SOC co-authors and reviewers, ESA may agree to such a repackaging (but Kevin would need formal confirmation from the ESA Project Officer). Stewart Bernard liked the approach and asked whether a template or model would be provided to show how to estimate the uncertainty budget? Kevin affirmed that a list would be provided showing what was required in an uncertainty estimate.

David Antoine suggested that IOCCG members review the document and decide whether it should be adopted as one of the IOCCG protocols, since this kind of protocol document is coming from a specific project, and at this stage is not considered community consensus. Kevin pointed out that he received comments from S3VT so it was wider than just a project.

Kevin noted that a new draft would be submitted on 1 April 2018 but there was no fixed deadline for comments. If IOCCG is not interested, the document would be made available via the FRM4SOC Project web. Emmanuel Boss noted that Ken Voss, together with Giuseppe Zibordi and Antonio Mannino, were also planning a Radiometry Protocols document, so they should be contacted to enquire about the progress and plans for this document (they have been approached – feedback should be available soon). Paula Bontempi cautioned that since the PI is responsible to do due diligence with respect to the uncertainties (no protocols specified for uncertainties) it may not be a good idea for IOCCG to endorse the document.

Action 23/7: *IOCCG members to review the ESA FRM4SOC Radiometry Protocols document by 1 May 2018 and provide comments to Kevin Ruddick. Also provide a recommendation about whether this document should be adopted as an IOCCG protocol in the IOCCG Technical Report Series, after suitable IOCCG review, improvement and repackaging.*

5.2 WATERHYPERNET Network

Kevin Ruddick presented WATERHYPERNET, a hyperspectral network for validation of water reflectance for VIS/NIR spectral bands of all instruments. This is very useful since many satellites can be validated with a single instrument – cruises are not required for

radiometric validation. In 10 years of MERIS measurements there were only a few matchups. AERONET-OC is very useful but does not have all the necessary wavelengths – a hyperspectral sensor is required to measure all bands. The TRIOS/RAMSES instrument was chosen (hyperspectral 350-900 nm) for WATERHYPERNET v1. The instrument is relatively low cost for high performance and is well characterised. The first tests on an offshore platform will take place in summer 2018, and three sites should be operational by 2019 (2 coastal, 1 inland). The network is similar in functionality to the AERONET network. A new HYPERNETS instrument will be used for WATERHYPERNET v2 (prototype instruments 2019-2020, commercialization by Feb 2022). IOCCG could contribute to user needs for the instrument (spectral characteristics, etc.) as well as data processing and distribution service (parameter corrections, download format, etc.). New sites could be supported in 2019 onwards (hardware~25K€) and intercomparison of calibration labs could be strengthened.

6.0 International Ocean Colour Science Meeting 2017

6.1 Plans for IOCS-2019

Hee-Jeong Han informed the Committee of KIOST's plans for the 2019 International Ocean Colour Science (IOCS) meeting. KIOST is a Korean government-funded research institution dedicated to ocean related science and technology. KOSC (Korea Ocean Satellite Center) is the designated operational agency for GOCI. KOSC is preparing for GOCI-II launch in late 2019. KIOST's major project is "ISABU" dealing with ocean resources and protecting the ocean.

The venue for IOCS-2019 is the metropolitan city of Busan, on the SE coast of Korea (<1 h from Gimhae International Airport by bus). The weather should be warm and clear, and there are many restaurants and hotels near the proposed venue (initially Paradise Hotel, but since changed to the Grand Hotel). The proposed dates were 13-16 May 2019. The main meeting room can accommodate 400 – 600 people and the breakout rooms ~100 people each. A Scientific Planning Committee should be established soon (to include KIOST and Korean members) as well as a Local Organizing Committee (KIOST support team plus IOCCG). KIOST encourages costs to be shared between KIOST and other sponsors and agencies. A small registration fee of $150 could be considered to cover the cost of coffee breaks and icebreaker (lunches will not be provided). A group tour of Busan city will also be offered.

Emmanuel Boss pointed out that Ocean Optics is taking place in October 2018 and OceanObs in September 2019, so there may be some competition. There was consensus

that a webpage for IOCS-2019 should be set up as soon as possible, and advertising should start well before August 2018. A half-day session will focus on remote sensing in Asia showcasing missions from Korea, China, Japan and India. Paula Bontempi announced that a NASA OCRT meeting will likely take place in Busan, the day before IOCS-2019 (preferable 13 May, with the IOCS meeting taking place on 14-17 May 2019). The OCRT meeting will be open to other participants. Other side meetings could also take place on Monday 13 May 2019. After consultation with IOCCG members not present at the meeting, the dates for IOCS-2019 were finalized as **14-17 May 2019**.

Regarding breakout sessions, a top-down approach was recommended. Breakout session themes should be announced, requesting proposals around those themes. Emmanuel Boss recommended breakout sessions for each of the IOCCG protocols that are being work on e.g., radiometry validation. Other suggestions for breakout sessions included modelling and optics, atmospheric correction in coastal waters, water quality, characterising the phytoplankton assemblage, polarimetry, carbon from space (focussing on polarimetry and Lidar). Stewart Bernard suggested that forward-looking and provocative breakout sessions also be included. Suggestions for IOCS-2019 keynote speakers or breakout sessions should be submitted to Venetia Stuart.

Action 23/8: *IOCCG Committee members to submit suggestions for IOCS-2019 keynote speakers and breakout sessions to Venetia Stuart.*

Volunteers for the Scientific Planning Committee included Cara Wilson, Paula Bontempi, Emmanuel Boss, Stewart Bernard, David Antoine, Chris Brown, Vittorio Brando, Cedric Jamet, Hubert Loisel and Bryan Franz. The proposed registration fee of $150 was accepted (to be waived for students or researchers from developing countries). Keynote speaker travel could be covered from the registration fee or from other funds. The website should be set up to handle funds (e.g., PayPal). Small scholarships will be offered for students.

7.0 Training and Capacity Building

7.1 Plans for 2018 Summer Lecture Series

David Antoine reported on plans for the 2018 IOCCG Summer Lecture Series (SLS) which will be held in Villefranche-sur-Mer (France) from 25 June - 7 July 2018. Sponsorship was similar to last year with CNES providing significant funding. An attempt was made to decrease the number of lecturers to save funds, but still cover a wide range of topics. The first week would cover the basics including radiative transfer, in-water properties,

practical sessions in the lab etc. The second week will include applied topics such as RS in turbid waters, and going from optical properties to biogeochemical properties. Curt Mobley had stepped down and his lectures will be covered by John Hedley.

To date, 132 applications from 51 different countries had been received and ~22 students will be selected. Construction of the new student accommodation at LOV has been delayed so students may have to be housed in dormitories. Elements for discussion include the format of SLS (should it stay the same or should it evolve) and whether it should stay in Villefranche or move elsewhere? David had started looking at moving the course to Australia. The larger IOCCG Capacity building plan should also indicate how the SLS is integrated. Regarding funding, this is always difficult to obtain, but OOV/LOV have applied to the "Copernicus Academy" call, which could provide funds to substantially support subsequent editions of the SLS. David requested feedback on the Villefrance Summer Lecture Series and also requested volunteers to review the applications (Cara Wilson volunteered). Xianqiang He noted that his lab in China could benefit from such intensive classes. Kevin Ruddick pointed out that he understood value of having local intensive training courses, but it is also very beneficial to bring people together.

7.2 Ocean Colour Online Primer

Paula Bontempi outlined the history of this agenda item. Around 2 years ago IOCCG discussed the desirability of having an online IOCCG training course for OC remote sensing. 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 proving an online primer ($5K stipend and $5K for material). Paula had agreed to prepare a draft solicitation, which will be circulated to Committee members for comment.

7.3 IOCCG Capacity Building Strategy

Cara Wilson reported that there was some interest in conducting a joint training course in China within the context of the Copernicus marine stream. Ewa Kwiatkowska noted that the stumbling block was the budget. Decisions would have to be made on what level of training is required, where to hold the course, and whether standard ESA-EUMETSAT training is sufficient for the user needs. Ewa agreed to set up email contact between EUMETSAT (Christine Traeger, Hayley Evers-King) and Xianqiang He to discuss possibilities and details.

Action 23/9: *Ewa Kwiatkowska to set up email contact between EUMETSAT (Christine Traeger, Hayley Evers-King) and Xianqiang He to discuss possibilities and details of a joint ESA-EUMETSAT-IOCCG training course in China.*

Lia Santoleri noted that a tender was available for providing capacity building in CMEMS – this will consist of training courses at the regional level for different regions in Europe. She agreed to check if it were possible to have a joint training course for developing countries in Europe, and if it was possible to propose something outside of Europe. Stewart Bernard noted that there might also be scope to fund a 2-week training course through GMES Africa, with a strong Sentinel-3 emphasis. There was greater potential if EUMETSAT and CMEMS were also on board.

Action 23/10: *Stewart Bernard to assess GMES potential for a dedicated IOCCG training course in Africa (perhaps in conjunction with CMEMS and EUMETSAT) and possible core funding.*

Emmanuel Boss suggested that it was also important to engage with South America (INPE, CONAE) regarding capacity building. More introductory courses are required to encourage new users, although it was recognised that this type of course was difficult to organise with limited resources. Another option is to leverage ongoing activities such as tacking on an OC course to IOCS-2019, as was done in 2017.

8.0 Science Discussions

8.1 Emerging Technologies for Ocean Retrievals beyond Passive Radiometry Using Space-Borne Lidar

Emmanuel Boss drew attention to two key publications (Behrenfeld et al. 2016; Hostetler et al. 2018) that use space-borne Lidar for OC observations. He outlined the limitations of passive OC measurements (no direct information on vertical distribution, sampling compromised by clouds/polar night etc.) and the benefits of active Lidar measurements. Several airborne Lidar campaigns have studied chlorophyll fluorescence, backscattering attenuation and CDOM, and Jim Churnside used airborne Lidar profiling to quantify fish schools, plankton layers and vertical distribution of net primary productivity. In 2006, the NASA-CNES partnership launched CALIOP (still active but not designed for ocean applications). Yongxiang Hu managed to get good results in terms of ocean retrievals. CALIOP is very important in polar systems as it can measure phytoplankton biomass dynamics when other sensors cannot (e.g., polar winter). Good ocean data can be obtained from Lidar (CALIOP) even though it is not designed for oceans.

One of the problems with Lidar is that it is not possible to separate b_{bp} and k_d so there are large potential errors that accumulate with distance from the sensor. The science value will be far greater for a Lidar that provides independent, calibrated retrievals of b_{bp} and k_d without propagation of errors. This may be possible with a High Spectral Resolution Lidar (HSRL). A future constellation to enable 3-D reconstruction of global ocean ecosystems may include an optimized ocean-atmosphere Lidar, an advanced OC sensor, a scanning polarimeter and a BGC-global Argo array.

Lia commented that a group in Italy was working on ship-based Lidars and may be willing to collaborate. Other groups in the U.S. are also working on ship-based Lidars. Kevin enquired about the limitations and opportunities for using Lidar in coastal waters (pixel size of CALIOP is 90 m). There was consensus that a White Paper on Lidar would be very useful. Cédric Jamet and colleagues had submitted an abstract to OceanObs2019 for a White Paper on Lidar and synergy with ocean colour. When this White Paper was available, an international group could review and edit the document to ensure that it is relevant for all space agencies. Paula Bontempi mentioned that she will be submitting an abstract for a White Paper on Ocean Carbon to OceanObs 2019, with an economist as co-lead, and will also circulate for comment.

Exploitation of Polarized Light

Hubert Loisel provided a brief update on the exploitation of polarized light in the frame of OC observations. These discussions could help to develop a Ph.D. subject in this field. Measurements that include the polarimetric characteristics of light provide more information about particulate scattering. Ibrahim et al. (2016) demonstrated that the linear degree of polarization is related to the ratio of attenuation-to-absorption coefficients (c/a) over coastal waters, allowing the scattering coefficient (b_{bp}/b_p) to be computed, which has been confirmed from *in situ* measurements. A preliminary intercomparison using a Trios multispectral radiometer equipped with a polarized filter showed a good relationship between polarisation and b_{bp}/b_p. For OC applications, the signal may be very small (water-leaving polarized signal <9% of TOA polarised reflectance) although for non-phytoplankton dominated water, the polarisation contribution can be as much as 20% in the wavelength range from 470 to 670 nm.

In open ocean waters, the TOA polarized reflectance is not sensitive to the biomass concentration but can be used for aerosol detection and atmospheric correction. In coastal and inland waters the signal is greater so water-leaving polarized reflectance can be retrieved from space. He et al. (2014) proposed a new simple concept for ocean colour satellite remote sensing using the parallel polarization radiance (PPR) instead of

the traditional radiation intensity. PPR has a slightly higher OC signal at TOA and thus has great potential for improving the OC signal detection from satellite

POLDER sensor data is currently available, and the proposed NASA PACE and ESA 3MI missions will provide a similar suite of measurements as POLDER, but with improved spatial resolution (4 km at nadir) and coverage, over an extended spectral range (400 - 2100 nm). Benefits of polarisation include potential improved atmospheric correction, which should be further exploited, and the use of the PPR concept in bio-optical algorithms should also be further examined. IOCCG should take ownership of these types of new avenues for the OC community.

Emmanuel Boss agreed that IOCCG should either produce a report on this type of new avenue or stimulate the community to do research in this direction (e.g., atmospheric correction). A proposal for a new WG on this topic could be submitted for the next IOCCG meeting, and it may also be a good topic for an IOCS breakout session. Paula Bontempi noted that because of cost, the likelihood that OC community will get their own mission with their own Lidar and polarimeter, is very slim. However, because the aerosol community also use these tools, synergistic oceanographic requirements should be considered. It may be too late to wait until next year for an IOCCG WG to spin up, so it might be better to start working on requirements sooner.

Brian Franz pointed out that there is already a PACE-centric White Paper on polarisation which could perhaps be endorsed by IOCCG and included on the IOCCG website. Alternatively, people might agree to contribute to a refined White Paper? David Antoine cautioned about endorsing documents from different agencies and activities – IOCCG may not have the authority to endorse, and may also get overwhelmed with requests for endorsement. It may be better to include a link to "interesting" papers on the IOCCG website (endorsing implies taking responsibility). There was consensus that a more timely approach was required than a dedicated IOCCG polarisation working group. Hubert Loisel, Xianqiang He, Bryan Franz Cedric Jamet were tasked with reviewing the PACE White Paper, to see if the requirements could be modified for a generic IOCCG White Paper on polarisation requirements.

Action 23/11: *Hubert Loisel, Xianqiang He and Bryan Franz to review the PACE White Paper, to see if the requirements can be modified for a generic IOCCG White Paper on polarisation requirements.*

Related to these discussions and follow-up discussions with Hubert Loisel and Emmanuel Boss, Bryan Franz submitted an abstract for a White Paper on "*Advancement in ocean color remote sensing using the polarization of light*" to the OceanObs19

conference. Amir Ibrahim was asked to lead the effort with a diverse group of contributors.

8.2 Ocean Carbon Cycle Science

Paula Bontempi and Chuanmin Hu (via Skype) led a discussion about ocean carbon research. Satellite observations of carbon are critical for carbon-monitoring, so CEOS published the *Strategy for Carbon Observations from Space* which details the adequacy of past, present, and planned satellite measurements of carbon in the land, oceans, inland waters, and atmosphere domains, to support GEO. Many terrestrial people were involved in preparing the document but oceans were not well represented in the document. It might be prudent to think about the EOVs and how these can feed into the CEOS Carbon Strategy, if there is a next round.

Secondly, IOCCG received a proposal from Jamie Shutler (University of Exeter) and Cecile Rousseaux (NASA GSFC/USRA) for an IOCCG working group on "*Ocean Carbon from Space".* The proposal was reviewed by the Committee and several recommendations were made (letter outlining recommendations and proposal distributed on 5 February 2018). Jamie and Cecile agreed to write a short, forwarding-looking review paper for a journal, rather than an exhaustive scientific review, which they see as the first major step. The paper will include a table listing the different approaches and their relative accuracies (precision and bias). The need for, and focus of, an IOCCG task force, will be re-assessed once the paper is complete.

Another option, proposed by Chuanmin Hu, is to release a journal special issue on *Aquatic Carbon From Space*. Papers should provide substantial advancements and contributions to carbon budgets and fluxes i.e., what we have learned, and NOT what we have done. Spatial coverage could include oceans (open and coastal), land-water interface and large lakes. Themes should include stocks, sources/sinks and fluxes. Also, a global view of different reservoirs of carbon, wetlands, land/ocean and ocean/atmosphere interface, global/regional modelling (using RS) and perhaps future observational and modelling requirements. Invited review papers could provide a possible retrospective on aquatic carbon from space/observations to modelling, methodologies used/being developed/uncertainties, and economic valuation of ocean colour data records starting with carbon cycle. The journal *Remote Sensing of the Environment* could be a good option, or alternatively, *Frontiers in Marine Science*. Emmanuel Boss suggested that the focus could be on a biogeochemical journal (rather than a remote sensing journal) as others are more likely to read that e.g., OCB community. Chuanmin Hu noted that a special volume in Global Biogeochemical

Science would change the scope and focus. Any future papers will also be published there and would not have the same impact.

Guest Editors could include Corinne Le Quéré, Mike Behrenfeld, Dave Siegel, Scott Doney, Pete Raymond, Barney Balch, Ray Najjar, Maria Tzortziou, Cecile Rousseaux, Stephanie Henson and Jim Yoder, to mention a few. Paula Bontempi was happy to serve as a guest editor to provide a perspective from a space agency (e.g., preface) and to bring in high-quality papers from all OBB-funded PIs. International participation is critical and guest editors must be international. The OCB community should be asked to join in as well.

Stephanie Dutkiewicz recommended approaching Shubha Sathyendranath to do a review paper on the ESA POCO project (Pools of Carbon in the Ocean, led by Plymouth Marine Laboratory). Ewa noted that this was an extremely important initiative which she strongly supports. The objective of the Special Issue is not to get justification for a mission, but to raise the profile of oceans. It is also important to address impacts (e.g., ocean acidity) and not just the science. Papers should be forward looking as well as retrospective.

There was consensus that the IOCCG should support a special issue on aquatic carbon from space. Stephanie Dutkiewicz suggested that all space agencies write a review paper together (either historical or forward-looking), as an indication to readers that the IOCCG endorses the special issue. Initial contact should be made with the journal to enquire about the cost of a special issue. All correspondence to the broad science community should be distributed under Cara and Venetia. NASA agreed to contribute to the cost of the special issue (no acknowledgment required).

9.0 Linkages with GOOS and Ocean Colour

9.1 GOOS and G7: Including Satellite Observations in Ocean Observations

Paula Bontempi provided a recap of discussions on essential climate variables (ECVs) and essential ocean variables (EOVs) from the IOCCG-22 meeting. In 2010, ocean colour was proposed and accepted as an EVC by GCOS and described in the 2010 Update of the *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC*. Some issues were identified that impeded the development of a coordinated and sustained Ocean Colour radiance (OCR) observing system; CEOS space agencies, in consultation with IOCCG and GEO, were tasked by GCOS and GOOS with developing plans to implement an Ocean Colour Radiometry Virtual Constellation (OCR-VC). In

2012, IOC released the Framework for Ocean Observing (FOO), which promoted the idea of EOVs. Ocean colour was not part of the initial set of EOVs. Recognizing its importance, GOOS recommended the development of a related EOV in 2016. At the IOCCG-22 meeting there was much debate about whether ECVs could be adopted as EOVs. The requirements should be well defined and consistency should be maintained between ECVs and EOVs. It was agreed that the ocean colour EOV would contribute to both the Biological and Biogeochemical EOVs/panels.

Emmanuel Boss circulated the Ocean Colour EOV draft document prior to IOCCG-23 for comment (many IOCCG members provided comments on the document). IOCCP has planned a telephone conference call with the EOV OC team after the IOCCG-23 meeting to confirm whether the Committee agrees with the content of the document in general. It was noted that the process for lake EOVs would be updated next year through the terrestrial panel, so a separate section for inland water requirements is not necessary at this stage.

Regarding the G7 status, the G7 working group on "*Future of the Seas and Oceans*" has highlighted satellite remote sensing as a critical asset to achieve the goals of the WG. At their recent meeting (December 2017) it was recommended that the WG coordinate with CEOS and the different VCs regarding the type of Earth observing data that is available for furthering ocean research and sustainability by G7 nations. One of the recommendations has a specific point on integrating satellite with *in situ* observations. In 2018, the G7 presidency is with Canada, and healthy oceans are high on list of priorities. The EU recently expressed a desire to support a possible G7 initiative specifically focused on Earth observation technologies applied to coastal resilience.

9.2 Status of the Ocean Colour EOV Specification Sheet

Emmanuel Boss gave a brief outline of "*Essential Ocean Variable (EOV): Ocean Colour*" document including background and justification, derived products and supporting variables, requirements, current observing networks for these measurements etc. Paula Bontempi pointed out that this is an opportunity to go beyond just chlorophyll-a. Committee members were encouraged to review the EOV document and submit comments/edits before 9 March 2018 (many IOCCG members submitted comments). There was general consensus that the approach should be adopted.

10.0 Any Other Business

10.1 IOCCG Ocean Optics Protocols

Emmanuel Boss informed the Committee about the decision to move the NASA *Ocean Optics & Biogeochemistry Protocols for Satellite OC Sensor Validation* under IOCCG the umbrella so that they are readily available to the international community. The protocols for the absorption coefficient (coordinated by Antonio Mannino) is available on the IOCCG website and NASA personnel are working on incorporating comments received. In addition, the protocols for flow-through IOPs (coordinated by Emmanuel Boss) are also available for comment. Protocols for CDOM absorption should be posted early April 2018 and POC protocols are currently being written (should be posted on the IOCCG website for review by December 2018). A workshop is planned for Fall 2018 (with support from PACE project science and IOCCG) to discuss net primary production protocols. There is no clear deadline for two other technical protocols on scattering (led by Sullivan and Slade) and Radiometry (Zibordi and Voss). These documents will all have a *doi* designation and will be considered living documents.

The correct citation for the documents was discussed (e.g., cited by the author list vs. cited as IOCCG). Participants were in favour of citation as IOCCG, as this implies that it is a community document. However, it is also important to have all the authors listed on the front page of the document. Individual chapters can also be cited by authors, as in a book citation. The name of the person coordinating the protocol document, as well as the editor, should also be recognised. This should be consistent within the whole series. There was consensus that the cover of the report should be in colour to distinguish it from the historical NASA protocols. Paula Bontempi suggested that the statement on the front page "*International Ocean Colour Coordinating Group (IOCCG) in Collaboration with NASA*" was not necessary but she would confirm with colleagues.

Action 23/12: *Paula Bontempi to confirm the correct citation for the IOCCG Technical Report Series.*

10.2 Coordination of Field Campaigns on IOCCG Website

Ewa Kwiatkowska noted that the S3VT team requested information about planned field campaigns be made available across the community, especially if there are opportunities for collaboration and/or berths on ships. She proposed that this information could be placed on the IOCCG website if agencies were willing to share this information. An example was given of the list of planned cruises for validation of JAXA SGLI/GCOM-C in 2018FY which included cruise, region, dates, PI as well as types of

radiometric quantities to be measured. There was general agreement that the information was useful but would get outdated very quickly considering the large number of cruises planned, plus there would be a lot of overhead. One option would be to provide links to time-series sites that are visited regularly. The Villefranche lab disseminates a monthly mailing list of cruises, which people could subscribe to. The consensus was that it was better for individuals to do their own legwork. If spaces are available on cruises, this could be advertised in the IOCCG news bulletin.

10.3 BCG Argo Programme

Cara Wilson submitted an abstract on using BGC Argo as a validation platform to OceanObs 2019 (co-authors Emmanuel Boss and Huber Loisel), and enquired whether IOCCG could support/endorse BGC Argo as a validation platform? There was consensus that a link could be added to the abstract/White Paper on the IOCCG website. IOCCG has a report on Bio-Argo so clearly recognises its importance.

10.4 Fluorescence-Derived Chl

Stewart Bernard recently published results from a Southern Ocean validation effort. They found that the bias from fluorometric chlorophyll-a is very bad due to chlorophyll-c containing assemblages (e.g., diatoms). The bias could be tracked to biomass composition and chl-c concentration. The option of using fluorescence chl-a for algorithm development should be strongly discouraged. The perception that Southern Ocean algorithms do not perform well might thus just be an issue with *in situ* measurements (there is a wide body of literature on discrepancies between fluorescence Chl-a vs. HPLC).

10.5 Ocean Optics Town Halls

Cedric Jamet enquired whether agencies would agree to a joint Town Hall at the upcoming Ocean Optics meeting, as was done 2 years ago, rather than each agency having their own session (e.g., PACE mission). Paula enquired whether scientists were actually interested in listening to agency presentations, especially since they are presented at IOCS meetings.

11.0 Organisation and Membership

11.1 Hosting of IOCCG-24 meeting in Vietnam in 2019

Hubert Loisel presented a proposal to host the next IOCCG meeting at the University of Science & Technology (USTH, 5th floor) in Hanoi, Vietnam. USTH is temporarily located on the campus of Vietnam Academy of Science and Technology (VAST). Hotel accommodation would be in the Tay Ho area, ~20 min. from the airport and ~30 min. from VAST (a chartered bus will be available). Coffee breaks will be provided by USTH.

The president of VAST and rector of USTH will provide a welcoming address, and the French embassy has agreed to host a reception for IOCCG participants. Part of the dinner cost can be covered by IRD. A typical Vietnamese dinner will also be organized by VAST, hosted by the director of the space programme. Optional tours could be organised to Halong Bay.

It was initially proposed to hold the meeting towards the end of March to avoid the Tet holiday (4-9 February 2019), but this was revised to 9-10 May 2019 to hold the meeting back-to-back with the IOCS-2019 meeting in Korea, to minimise travel expenses. A request was made for an IOCCG member to give a talk about OC applications to students and researchers in Hanoi – Stewart Bernard volunteered to give a talk on HABs.

11.2 Proposals for Hosting IOCCG-25 in 2020

Hiroshi Murakami presented a proposal for JAXA to host the IOCCG-25/26 Committee meeting in Japan, to commemorate the successful launch of the GCOM-C mission. Three candidate locations were proposed a) Hakodate, a smaller city, 1.5 h by plane from Tokyo (snow might be an issue in winter); b) Tokyo, a major hub, but very crowded - the meeting would take place in a rented conference room; c) Tsukuba, a “science” city ~1 h from Tokyo airport but not many restaurants etc. JAXA is located in the Tsukuba Space Center (TKSC).

Other potentially conflicting meetings include the JAXA EO meeting (end of January 2020), and the Ocean Sciences meeting (16-21 February 2020, San Diego) so the third week in March would work (before the end of the Japanese fiscal year). Tokyo was the preferred location.

11.3 Rotation of IOCCG Committee Members

Simon Bélanger would be rotating off the Committee and suggested a replacement from Canada (to be discussed during the Executive meeting). Bryan Franz was also due to rotate, but Paula Bontempi requested that he serve a second term (confirmed). Paul DiGiacomo will step down as the NOAA representative and will be replaced by Menghua Wang. Other new members would be discussed during the Executive meeting.

Cara Wilson thanked everyone for travelling to Rome and for their engaging contributions, and thanked Lia Santoleri and the CNR staff for hosting a very successful and fruitful meeting in Rome.

Actions: IOCCG-23 Committee Meeting

Rome, Italy, 6-8 March 2018

	Brief description	Status
23/1	Cara Wilson to review Chapter 2 of the Modelling WG.	Open
23/2	Tim Malthus to review Chapter 3 of the Modelling WG.	Open
23/3	Emmanuel Boss to review Chapter 4 of the Modelling WG.	Open
23/4	Tim Malthus to check with Arnold Dekker whether sections of the CEOS feasibility report can be republished in Chapter 6 of the Water Quality report. *Action: 15/5/18 Dekker responded that CSIRO holds the copyright. CSIRO and CEOS both approve.*	Closed
23/5	Menghua Wang to follow up on the status of IOCCG Reports 15 and 16 being printed by NOAA.	Open
23/6	IOCCG Committee members to review the EUMETSAT document "*Requirements for Copernicus Ocean Colour Vicarious Calibration Infrastructure*" and provide comments to Ewa Kwiatkowska by 26 March 2018. *Action: Comments were provided to Ewa by several IOCCG members.*	Closed
23/7	IOCCG members to review the *ESA FRM4SOC Radiometry Protocols* document by 1 May 2018 and provide comments to Kevin Ruddick. Also provide a recommendation about whether this document should be adopted as an IOCCG protocol in the IOCCG Technical Report Series, after suitable IOCCG review, improvement and repackaging. *Action: After consultation with Zibordi and Voss, the IOCCG sub-committee recommended that a revised version of the radiometry chapters of the NASA Ocean Optics Protocols is needed, since the FRM4SOC document relies to some degree on this for a description of the relevant methods. Voss and Zibordi have started with this revision. The committee encouraged Kevin to be involved in the revisions and also suggested posting links to the FRM4SOC document on the IOCCG website.*	Closed
23/8	IOCCG Committee members to submit suggestions for IOCS-2019 keynote speakers and breakout sessions to Venetia Stuart. *Action: 9 breakout sessions identified, keynote speakers under discussion.*	Closed

23/9	Ewa Kwiatkowska to set up email contact between EUMETSAT (Christine Traeger, Hayley Evers-King) and Xianqiang He to discuss possibilities and details of a joint ESA-EUMETSAT-IOCCG training course in China. *Action: 28/3/18 Ewa put Xianqiang in contact with Christine and Hayley Evers-King regarding a joint ESA-EUMETSAT-IOCCG ocean colour training course in China. The course would also be open to participants from east / south-east Asia.*	Closed
23/10	Stewart Bernard to assess GMES potential for a dedicated IOCCG training course in Africa (perhaps in conjunction with CMEMS and EUMETSAT) and possible core funding.	Open
23/11	Hubert Loisel, Xianqiang He and Bryan Franz to review the PACE White Paper, to see if the requirements could be modified for a generic IOCCG White Paper on polarisation requirements. *Action: 15/3/18 Bryan Franz submitted an abstract for a whitepaper on polarimetry for advancing OC to OceanObs19 (Amir Ibrahim to lead the effort). Authorship can be further expanded once the whitepaper is selected.*	Closed
23/12	Paula Bontempi to confirm the correct citation for the IOCCG Technical Report Series.	Open

Appendix I: LIST OF PARTICIPANTS

Rome, Italy, 6-8 March 2018

IOCCG Members		**Affiliation**
Antoine, David (Past-Chair)	-	Curtin University, Australia
Bélanger, Simon	-	Université du Québec à Rimouski, Canada
Bernard, Stewart (Chair)	-	CSIR, South Africa
Bontempi, Paula	-	NASA HQ, USA
Boss, Emmanuel	-	University of Maine, USA
Dutkiewicz, Stephanie	-	Massachusetts Institute of Technology, USA
Franz, Bryan	-	NASA Goddard Space Flight Center, USA
He, Xianqiang	-	Second Institute of Oceanography, China
Kwiatkowska, Ewa	-	EUMETSAT, EU, Germany
Loisel, Hubert	-	ULCO, France
Malthus, Tim	-	CSIRO, Canberra, Australia
Mélin, Frédéric	-	JRC, Italy
Murakami, Hiroshi	-	JAXA/EORC, Japan
Santoleri, Rosalia	-	ISAC-CNR, Italy
Stuart, Venetia	-	IOCCG Project Office, BIO, Canada
Wilson, Cara	-	NOAA/NMFS, USA

Invited Participants		**Affiliation**
Brando, Vittorio	-	CNR, Italy
Brown, Christopher	-	NOAA/NESDIS/STAR, USA
Cho, Seongick	-	KIOST, Korea
Dransfeld, Steffen	-	ESA-ESRIN, Italy
Han, Hee-Jeong	-	KIOST, Korea
Jamet, Cédric	-	Université du Littoral Côte d'Opale, France
Loizzo, Rosa	-	ASI, Italy
Lorenzoni, Laura	-	NASA, USA
Ruddick, Kevin	-	RBINS, Belgium
Trincardi, Fabio	-	Director CNR, Italy

Apologies		**Affiliation**
Bergeron, Martin	-	CSA, Canada
Chauhan, Prakash	-	ISRO, India
DiGiacomo, Paul	-	NOAA/NESDIS/STAR, USA
Donlon, Craig	-	ESA/ESTEC, Netherlands
Dowell, Mark	-	Joint Research Centre, EU, Italy
Hu, Chuanmin	-	University of South Florida, USA
Larue de Tournemine, Amaury	-	CNES, France
Park, Youngje	-	KIOST, Korea
Yoder, James	-	Woods Hole Oceanographic Institution, USA