IOCCG-22 Committee Meeting

Perth, Australia, 7-9 February 2017

MINUTES

1.0 Welcome and Opening Session

1.1 Welcome and Introductory Remarks

The Chairman, Stewart Bernard, opened the meeting and welcomed everyone to Perth, Australia. He thanked the local host, CSIRO, particularly Nick Hardman-Mountford and Tracee Nguyen, for their help with the meeting, which was very much appreciated and welcomed new IOCCG Committee members Frédéric Mélin (representative for JRC, replacing Giuseppe Zibordi) and Wonkook Kim (representative for KIOST, replacing Joo-Hyung Ryu). Representations from China, Korea, Argentina, the U.S. Consul General, the Chief Scientist of Western Australia, and local scientists were also warmly welcomed.

1.2 CSIRO Welcoming Address

Nick Hardman-Mountford welcomed participants to Perth and to the new home of CSIRO at the Indian Ocean Marine Research Centre (IOMRC) in the University of Western Australia. He welcomed all the guest speakers and introduced Prof. Klinken, the official government Chief Scientist of the State of Western Australia. Prof. Klinken acknowledged the Noongar people in their own Australian aboriginal language and wished participants a very successful scientific meeting. Next Dr. Charlie Thorn, Director of Research at Curtin University, welcomed participants and commented on the cutting edge work being done by his group at Curtin University, and thanked past IOCCG Chair, David Antoine for his efforts. They had a small group doing extraordinary work and he welcomed the collective wisdom of the IOCCG Committee. Lastly, U.S. Consul General, Rachel Cooke, welcomed the delegates and noted that prior to joining the Foreign Service she had worked for the U.S. Environmental Protection Agency and for NASA, so she was very honoured to attend the opening of the IOCCG-22 meeting. 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.

1.3 Adoption of IOCCG-22 Agenda, Minutes, Status of Actions

The IOCCG-22 agenda was adopted and the minutes of the previous Committee meeting (IOCCG-21) were approved by consensus. The Chairman summarised the status of

actions from the 21st Committee meeting, most of which had either been completed, or would be addressed further during the meeting.

- *Action 21/*1: The IOCCG water quality report would be further discussed under agenda item 2.2.
- *Action 21/2:* Paula Bontempi, Stewart Bernard and Paul DiGiacomo would address the economic evaluation of Earth science data under agenda item 7.3.
- *Action 21/3:* The workshop on long-term vicarious adjustment would take place in 2 weeks' time.
- *Action 21/4:* The priorities of the proposed international OCR-VC project office would be further discussed under agenda item 6.1.
- *Action 21/5:* The call-for-proposals for IOCS parallel workshops had been issued.
- *Action* 21/6: A proposal for an online training course would be addressed under agenda item 9.1.
- *Action* 21/7: Comments on band placement of the SABIA-Mar mission instrument had been forwarded to David Caruso.

2.0 Status of IOCCG Working Groups

2.1 Role of OC in Biogeochemical, Ecosystem and Climate Modelling

Stephanie Dutkiewicz reported on the IOCCG working group examining the role of ocean colour in biogeochemical, ecosystem and climate modelling. The group was formed to create a closer connection between the biogeochemical OC community and the modelling community and to facilitate the integration of OC observations with modelling. Most of the working group members are numerical modellers working on different models, apart from two members who are ocean colour specialists with connections to modelling. The report will address global as well as sub-mesoscale models.

The WG will hold a full-day session at the upcoming ASLO meeting entitled "Toward greater synthesis: ocean colour imagery and biogeochemical/ecosystem numerical modeling", as well as a session at the EGU General Assembly in April 2017, dealing with data assimilation. The outline of the nine chapters of the WG Report was presented. It included chapters on basic biogeochemical and ecosystem models (modelling for dummies), ocean colour products, the (mis)match between model output and ocean colour products (in conjunction with the ESA funded project "Pools of Carbon in the Ocean" comparing different ways of looking at POC and DOC), model skill assessment, OC data assimilation (teaming up with GODAE OceanView and the Joint-DA-MEAP-TT

team), integrated use of OC and models, and how models can help inform OC. A draft of all chapters is expected by January 2018, with the final report ready by April 2018.

2.2 Earth Observations in Support of Global Water Quality Monitoring

Paul DiGiacomo reported on the IOCCG Water Quality WG, which was established in 2014, co-chaired by himself, Steve Greb and Arnold Dekker. The report is converging upon a complete draft. It is currently being revised to address missing content, being checked for consistency in terms of symbols as well as flow from chapter to chapter, and should be finalized by the end of August 2017, at which time it will be submitted to the Committee for review. It is anticipated that it will be ready for printing at end of this calendar year.

The AquaWatch Water Quality Community of Practise, under the auspices of GEO, has been building off of the IOCCG WG activity. The group is starting to develop operational WQ monitoring capabilities, and the reports from Work Packages 3 and 4 should be completed within the next few months, and will highlight the value of OC data for WQ services. Craig Donlon noted that OC is just one element as a WQ indicator and it is important to demonstrate *bone fide* products that are useful, perhaps working with bigger integrated systems such as CMEMS. Lia Santoleri pointed out that CMEMS does not work in coastal areas. It is nevertheless important to integrate coastal areas with the open ocean.

Regarding the review of the IOCCG report produced by the WG, there was consensus that it should be subjected to a limited external review by appropriate experts in the field. Paul DiGiacomo agreed to suggest names of suitable reviewers for each chapter.

Action 22/1: *Paul DiGiacomo to submit a list of names of potential reviewers for the IOCCG Water Quality report, including specific chapters they could review.*

2.3 Uncertainties in Ocean colour Remote Sensing

Fréd Mélin presented a status report on the IOCCG WG on uncertainties in OC remote sensing. The group was established in 2011 and had met several times since then. An updated draft report had been circulated in 2016 (~80 pages) but several chapters still need to be completed. The group had decided to omit the following action from the terms of reference: "*develop and compile a data set to test uncertainty and out-of-scope algorithms".*

This report will deal with uncertainties associated with various factors e.g., uncertainty in TOA radiance at 547 nm induced by imperfect ozone correction. Various approaches of uncertainty propagation will be discussed in the report as well as representation and distribution of uncertainty fields. The report will also include a comparison of satellite products as well as a description of other approaches e.g., uncertainty propagation using the Monte Carlo approach, covariance matrix or Bayesian approach. Chapter 5 will discuss the requirements from different applications of OC data e.g., users requirement (CCI survey), biogeochemical/ecosystem modeling, climate or fisheries applications. The final chapter will include recommendations. The group has gathered a lot of material and will work on the report in the Spring to fill the gaps. They expect to have a final draft version to be submitted this year. Paula Bontempi expressed concern about the workload of the user survey in Chapter 5, but many people had already responded so it could be used as an illustrative example.

2.4 GEOHAB/IOCCG Harmful Algal Bloom Working Group

Stewart Bernard reported on the GEOHAB/IOCCG harmful algal bloom WG, established in 2010, when he became IOCCG Chair, so it had been slightly delayed. Raphael Kudela had come to Cape Town in November to help to bring the report to conclusion.

Various case studies are presented in the report, split according to their impact. Chapters are devoted to *Pseudo-nitschia* (toxic diatom), cyanobacteria (mostly inland), fish killers, red tides (high biomass mixed blooms) and ecologically disruptive algal blooms e.g., *Aureococcus.* There is also a short chapter on emerging approaches e.g., hyperspectral remote sensing. A slightly surprising output from the report is that the main constraint of remote sensing of HABs is atmospheric correction. Ocean colour is good at detection of high biomass blooms, but for many harmful blooms, OC remote sensing cannot be used. Blooms may have major ecological impacts, but if they occur deep in the water column, or at low cell numbers, they cannot be detected using OC, especially in Case 2 waters.

2.5 Atmospheric Correction in Coastal Waters

Cédric Jamet reported on the IOCCG WG on atmospheric correction in coastal, optically-complex waters. Last year, one member of the group had resigned and they were also having issues with the simulated datasets. The group is currently focussing on match-up analyses using AERONET-OC and the LOG *in situ* dataset. The group is evaluating 6 different atmospheric correction algorithms using classic match-up analysis, a simulated dataset for sensitivity studies, and inspection of MODIS-A satellite images over contrasted coastal regions, but they are having issues with the simulated dataset

(radiance and reflectance definitions, viewing angles, etc.). They recently held a telephone conference call to decide whether or not they should disband the working group. Other issues include the aging MODIS-Aqua sensor which is no longer stable, and the fact that Sentinel-3 instrument does not have same wavelengths as MODIS-Aqua.

The Committee discussed whether it was possible and realistic to complete the remaining tasks and prepare a WG report, or whether the group should just publish their results in a scientific paper. Cédric indicated that he would prefer to keep going and attempt to prepare an IOCCG report. If he could fix the synthetic dataset, then he should be able to make rapid progress. The Committee agreed to give him one more year, with a mid-year review to see how the simulated dataset was coming along. Ewa Kwiatkowska noted that it would be useful to have a report explaining why certain algorithms work better in certain water types, as well as recommendations for development of future algorithms.

3.0 Proposals for New IOCCG Working Groups/Initiatives

3.1 Long-Term Vicarious Adjustment of Ocean Colour Sensors

Craig Donlon reported on the FRM4SOC project dealing with the long-term adjustment of ocean colour sensors. ESA would like to ensure that product validation of the Sentinel-2 and -3 mission data is traceable to international SI standards in order to obtain the best quality ocean colour data. The FRM4SOC project was initiated in 2016 to address quality and traceability issues related to *in situ* OCR validation activities in the EU. The output of this project could be written in the form of an IOCCG report, and a proposal for an IOCCG working group to address these issues was discussed at the IOCCG Executive meeting in San Francisco (2015). The primary objective of the proposed IOCCG WG is to define the best practises to reach a high standard of precision and accuracy for *in situ* OCR measurements necessary to fulfil the system vicarious calibration requirements.

A workshop on vicarious infrastructure will take place at ESA-ESRIN (21-23 February 2017) and will help to raise the issue of vicarious adjustment to a high level. The output from the workshop will include conference proceedings as well as a monograph, which will serve as a baseline for the proposed IOCCG report on the topic. For the next generation of OLCI, the system requirements documents must include requirements on vicarious calibration.

The Chair noted that this working group was different from traditional IOCCG WGs as it is agency driven, but it could be the first in a new form of documents. David Antoine was concerned about an IOCCG WG just on Copernicus data, but Craig pointed out that it would be an open workshop, open to all agencies, and that the report would be produced anyway, since funding was available. Paula Bontempi pointed out that the offer was a good one, and that the group should ensure that the right people attend the workshop so they can do an external review. Furthermore, they should ensure that the right language is used in the report and that the report should encompass all agencies' needs (and not just ESA). Craig noted that the workshop was a springboard to start discussions on what vicarious infrastructure was required for Europe. The Chair concluded that if the workshop provides a good start on a report and if there is enough inclusivity, then the group should go ahead and prepare an IOCCG report, as discussed.

4.0 Building the Operational Component of OCR-VC/ INSITU-OCR

4.1 Status of CEOS OCR-VC

Paul DiGiacomo informed participants that the CEOS "Virtual Constellations" (VCs) were formed to coordinate activities amongst agencies. The OCR-VC was currently chaired by himself, Paula Bontempi and Craig Donlon, and he was ready to handover to Ewa Kwiatkowska. Paul attended the CEOS-SIT meeting in October 2016, and presented the INSITU-OCR strategic plan (synthesis of the mapping exercise), which went over well. He is also helping to facilitate the COVERAGE project, as a potential CEOS project in coordination with the Ocean VCs, to layer together different satellite data sets. There was some discussion about the value of contributing to CEOS in terms of cost-benefits (time invested versus return), but it was agreed that attending the SIT meetings was a valuable opportunity to present critical messages in front of agency heads to reinforce certain points, and to gain visibility.

4.2 Decadal Survey for Earth Science and Applications from Space

James Yoder reported on the second NASA decadal survey (U.S. National Research Council's Decadal Survey for Earth Science and Applications from Space, 2017-2027), which aimed to engage members of scientific community to recommend an integrated approach for the U.S. government's space-based Earth-system science programs. Ocean colour falls under the Marine and Terrestrial Ecosystems and Natural Resource Management Panel. The group was encouraged to think about measurements, not missions. Measurements from space proposed in response to a community Request for Information (RFI) included ocean Lidar, (aircraft and CALIOP Lidar on CALIPSO),

hyperspectral (HyspIRI is one model), radiometry from a geostationary orbit (e.g., GEO-CAPE) and Aerosol-Cloud-Ecosystem (e.g., PACE mission).

High Spectral Resolution Lidar (HSRL) can provide vertically-resolved aerosol size, concentration and composition, plus ocean profiles, using two key wavelengths (355 and 532 nm). There is potential for a space borne ocean Lidar, which would enable assessments and improvement of the aerosol corrections. Lidar is an active sensor, so can operate at night as well as during light cloud cover, and can obtain coverage over Polar regions (e.g., Behrenfeld 2016 paper) as well as subsurface measurements of particulate carbon.

The Decadal Survey report should be ready in Fall 2017, and will include recommendations for measurements. A commercial company will estimate how much these missions will cost. Many on the Committee are worried about the PACE mission in light of budget cuts by the new administration.

4.3 System Vicarious Calibration of the NASA PACE Mission

Paula Bontempi reported on the progress of vicarious calibration of the NASA PACE mission, which has a primary focus on global climate research. The current target for calibration uncertainty of satellite ocean colour sensors is below 0.5% (with a target value of 0.3%) ensuring absolute radiometric uncertainty lower than 5% in R_{rs} satellite-derived products in the blue-green spectral regions for oligotrophic-mesotrophic waters. Following the 2014 NASA ROSES grant solicitation for ocean colour remote sensing vicarious calibration instruments, three selections were funded:

I. HYPERNAV – a hyperspectral radiometric device for accurate measurements of water leaving radiance from autonomous platforms for satellite vicarious calibrations. This will utilize autonomous floats as a platform to collect hyperspectral radiometric data to minimize uncertainty.
II. HARPOONS – a hybrid-spectral alternative for remote profiling of optical observations for NASA satellites. The above- and in-water spectral range is 320-1,640 nm.
III. Developing a MOBY-NET instrument, suitable for a federation network for vicarious calibration of ocean colour satellites. The goal is to develop a MOBY-type structure that can fit in a 40’ container and be able to accept a modular optical system.

All the instruments are custom built and there are no publications yet. For PACE planning there will be other competitions (2018 and 2021) for vicarious calibration and *in situ* data validation.

4.4 Vicarious adjustment infrastructure for Europe

Ewa Kwiatkowska outlined plans develop jointly between ESA and EUMETSAT for decades of upcoming Copernicus ocean colour operations. It is a multi-step process – they are currently developing a requirements document for all aspects of the OC-system vicarious calibration (OC-SVC) programme (planning, design, technical definitions, development, testing and long-term operations). The error budget must be the justification for the scientific, technical and operational requirements. Clear justification of why we need to meet these requirements can convince the Commission that the expense is necessary and warranted.

Craig Donlon then provided an overview of the ESA FRM4SOC project (Fiducial Reference Measurements for Satellite Ocean Colour), aiming to provide support for evaluating and improving the state of the art in satellite OC validation. FRM4SOC also strives to help fulfil the IOCCG INSITU-OCR white paper objectives and contributes to the relevant IOCCG WGs and Task Forces (e.g., WG on uncertainty, ocean colour satellite sensor calibration task force etc.). The project will undertake laboratory comparison exercises (open call) as well as field inter-comparison exercises. In February 2017 there will be an international workshop on vicarious adjustment of S-2 and S-3 instruments and an international ATM4SentinelFRM workshop will be held in Plymouth, UK (20-21 June 2017) as a forum for discussing the performance of S-1, S-2 and S-3.

Ewa Kwiatkowska noted that networks have been working best for validation e.g., AERONET. If a certain set of radiometers are commonly used by investigators they could be made into a network, as they will have a calibration history in community documentation, data will be collected in a community database, field protocols will be documented etc. A community processor could then be used, but this required funding as a first step. This is the direction that FRM4SOC is going.

5.0 OCR-VC Agency Updates

5.1 NASA Update on Current and Future Missions

Bryan Franz provided an update on NASA Ocean Biology Processing Group (OBPG) activities. Currently they are supporting calibration, validation, software development,

(re)processing, and data distribution for a multitude of active and heritage ocean colour missions and sensors. NASA has finished the reprocessing of all global missions, except for OLCI and MERIS (waiting for their reprocessing). The SeaWiFS/MODIS/VIIRS ocean colour data series will be two decades long this September. SeaWiFS and MODIS-A products are very similar up until 2012 due to consistent processing and calibration to MOBY, but the calibration of MODIS-A could not be trusted after 2012. NASA is working to resolve on-going issues with MODIS-A late-mission instrument calibration trends. There are also still some issues with VIIRS, and NASA is working to improve spectral relative issues with the temporal calibration of VIIRS that is impacting IOP trends. For $R_{rs}(\lambda)$ validation, all 3 sensors give the same level of agreement with *in situ* match-ups from SeaBASS. For the VIIRS instrument, there is a heavy reliance on AERONET-OC for radiometric validation as there is very little Chl validation data for VIIRS in SeaBASS.

Regarding OLCI support, OBPG is acquiring the full OLCI mission at Level-1B, through an ESA-NASA gateway, and distribution (mirror) of OLCI Level-1B via the ocean colour web portal is coming soon. Standard NASA ocean colour processing codes have been augmented to support OLCI. At some point NASA may be doing production/distribution of OLCI L2, but they do not have the mandate to do that currently.

Regarding GOCI support, OBPG is acquiring the full GOCI mission at Level-1B, through ongoing collaboration with KIOST. Level-1B (mirror) and Level-2 products (using NASA algorithms) are available via the NASA ocean colour web portal. Standard NASA ocean colour processing codes have been augmented to support GOCI.

OBPG is now moving into hyperspectral support, and the SeaDAS/L2gen code has been modified to support hyperspectral $R_{rs}(\lambda)$ retrieval. Future OBPG plans include MERIS reprocessing, then JPSS1-VIIRS processing and distribution (to be launched in September 2017), as well as future GCOM-C SGLI and Sentinel-2 processing capability, and PACE.

Paula Bontempi reported on the NASA PACE (Plankton, Aerosol, Cloud, ocean Ecosystem) mission, currently in Phase A and hopefully going to Phase B on 27 March 2017. PACE has two fundamental science goals: i) to extend key systematic ocean colour, aerosol, and cloud climate data records, and ii) to address new and emerging science questions using its advanced capabilities. PACE is a hyperspectral ocean colour instrument with 2-day global coverage at 1-km spatial resolution, with a possible multi-angle polarimeter. The mission is scheduled to be launched in the August 2022 timeframe. In response to a question from Simon Belanger, Paula noted that the proposed CSA COCI instrument would not be included on the PACE platform.

5.2 NOAA Ocean Colour Activities Including VIIRS

Paul DiGiacomo reported on NOAA "End-to-End" ocean colour activities including improved VIIRS calibration, NOAA multi-sensor Level 1 to L2 (MSL12) with two data streams (NRT and delayed mode, science quality, up to 15 d delay), quality monitoring, *in situ* calibration and validation (MOBY vicarious calibration, dedicated NOAA VIIRS cruises and AERONET-OC support) and data distribution (NOAA CoastWatch/ OceanWatch/ PolarWatch). NOAA is working on a MOBY technology refresh with a complete optics overhaul. The dedicated VIIRS Cal/Val cruises are now an annual event (three so far) with the next cruise planned for early next year.

With the cooperation of EUMETSAT, NOAA has established a multi-cast link (EUMETCAST) and is receiving S-2 and S-3 data routinely in NRT. NOAA is the primary distributor of S-3 OLCI ocean colour data from EUMETSAT to USA users.

Regarding data distribution, the NOAA CoastWatch/OceanWatch website and data portal has been revamped, with access to NRT and science quality L1, L2 and L3 multi-sensor ocean colour data (e.g., VIIRS, OLCI; granules and mapped products) as well as calibration/validation data and quality monitoring tools (e.g., OC View). Other complementary ocean remote sensing data are available there as well, including sea surface temperature, sea surface salinity, ocean surface vector winds, ocean surface topography et al. A PolarWatch data portal is also being developed as a partnership between NMFS and NESDIS that will focus on providing multi-sensor satellite data for Arctic and Antarctic waters. The AquaWatch GEO Water Quality Community of Practise was also mentioned, as well as the 3rd Blue Planet symposium (31 May – 2 June 2017). In conclusion, VIIRS-SNPP is capable of providing high-quality global ocean colour products in support of science research and operational applications. More *in situ* data are required for validation and improvement of VIIRS ocean colour products (VIIRS dedicated cruises, collaborations, etc.). VIIRS on the JPSS-1 platform is scheduled for Launch in 2017.

5.3 JAXA: GCOM-C/SGLI new developments

Hiroshi Murakami reported on new developments with the JAXA GCOM-C/SGLI mission, dedicated to the long-term observation of the radiation budget and global carbon cycle, and scheduled to be launched in December 2017. SGLI will have 250-m resolution and along-track slant-view polarization observation to improve land and coastal monitoring, and aerosol estimation. It will also have stable calibration with an on-board diffuser with monthly moon observation. SGLI final radiometric tests have been completed and they are now starting the final tests for the ground system. JAXA also flies the

meteorological geostationary satellite, Himawari, which routinely produces ocean colour, AOT, SST, PAR and UV products in NetCDF4 format.

5.4a KIOST: Progress in GOCI-II Development

Seongick Cho introduced the Korea Ocean Satellite Center (KOSC), the official GOCI operating agency assigned by the Korean government. GOCI-II user requirements were outlined and the specifications discussed: GOCI and GOCI-II are similar instruments, apart from the addition of 4 spectral bands for GOCI-II, which is also physically a bigger instrument (1.5 m vs. 1 m) with a smaller pixel size of the detector. The filter wheel of GOCI-II has an extra B9 filter in case of aging of the filter. Full disk imaging of GOCI-II is possible with 240 imaging slots (1 image per day or 2 x per day). The Test Readiness Review (TRR) should be completed in early February 2017.

5.4b Updates in GOCI Cal/Val Activities and Applications

Wonkook Kim reported on recent KIOST Cal/Val activities as well as research accomplishments and potential applications for GOCI/GOCI-II data. Field data have been collected from more than 500 stations. The major KORUS-OC field campaign (Korea-US Joint Field Campaign for Ocean Color) had many international participants (NASA, NOAA, NRL etc.). The cruise took place from May-June 2016 and covered 3 seas around the Korean peninsula, each with different optical characteristics, from oligotrophic to sediment loaded waters. More than 100 stations were sampled yielding 16 matchups with GOCI.

GOCI data can be used for a wide range of applications including spherical shell atmospheric correction, ocean front detection, HAB detection, floating green algae, tracking *Sargassum,* and developing forecasting models. There are also several atmospheric products including aerosol optical depth.

5.4c Current Status of GOCI-II Ground Systems (G2GS) Development

Hee-Jeong Han reported on the development status of the GOCI-II ground segment system. In future, KOSC will be located in Busan on the new campus of KIOST. GOCI-II will have more accurate spatial resolution with full-disk mode data than GOCI, as well as more frequent observations (10 times per day), 5 more bands (13 VIS/NIR bands) and a total of 26 products (vs. 13 for GOCI). The goal of the GOCI-II ground segment is to process and distribute data within 60 minutes of acquisition. They are developing a data processing system using parallel/distributed processing with a cloud service. By using this system, atmospheric correction is 17 times faster than a single core CPU. Basic

GOCI-II product algorithms will be developed using the additional bands, and some GOCI L2 product algorithms will be reused for GOCI-II with verification. GOCI-II is scheduled for launch in March 2019.

5.5 Update on Chinese Ocean Colour Missions

Xianqiang He provided an update on Chinese ocean colour missions: In the HY series, four ocean satellites have been launched producing typical products such as Chl, TSM and SST (HY-1B), or SST and SSW (HY-2A). Over the next 10 years 28 satellites will be launched by China, five of which will be dedicated to ocean colour. The HY-1C and HY-1D global missions are the successor to HY-1B (not global). They will carry three sensors: COCTS (the same as on HY-1B, 10 bands, 1.1 km resolution), CZI (4 bands, 50 m pixel resolution) and a UV imaging sensor (2 bands. 550 m resolution), and are scheduled to be launched in 2018.

HY-1E and HY-1F are the next generation polar orbiting satellites of the HY-1 series (HY-1E is experimental, HY-1F is operational). It will have 3 main payloads: a new Ocean Color and Temperature Scanner (500m resolution, 18 bands), a programmable Moderate Resolution Imaging Spectroradiometer (500m resolution, 16 bands – similar to MERIS) and a Coastal Zone Imager (20m resolution, 9 bands). These missions will be launched in 2021. Lastly, a geostationary OC mission will be launched in 2022 with a prototype of the geostationary ocean colour sensor (GOR, 10 bands from 412nm-1640nm; spatial resolution 250m for VIS/NIR; 1km for SWIR; hourly observation for 2500km x2500km). Field tests of the sensor have been carried out. They have also developed a RT model taking into account the Earth's curvature.

5.6 EUMETSAT Ocean Colour Services

Ewa Kwiatkowska reported on EUMETSAT OC services. EUMETSAT is hosting the Copernicus Marine Center which operates the satellites and processes and distributes the marine data. They are also responsible for the quality of the marine data service (Cal/Val and new products). Online data access is via CODA (Copernicus Online Data Access). Data can also be obtained via EUMETCAST (NRT via telecommunication satellites or via high speed internet) or data can be ordered from the EUMETSAT Data Centre (complete historical archive).

Sentinel-3A has undergone a 5 month commissioning phase and is now at the end of a 10-month ramp-up phase (review in mid-May) after which data delivery from S-3A will be operational. ESA and EUMETSAT have established a Sentinel-3 validation team (S3VT) of expert users to test data quality. The S3VT meeting will take place at ESA-

ESRIN from 15-17 February 2017, and part of the S-3A time series has been reprocessed in preparation for this meeting. Regarding public release of data, L1B NRT data was released on 20 Oct 2016. EUMETSAT is working towards public release of OLCI L2 products in May 2017. OLCI L1B products are of relatively good quality but there are still certain limitations (e.g., radiometric accuracy has a positive bias of 2-3%, possible instrument degradation). OLCI L2 ocean colour products are being improved. Improvements planned for the L2 OC public release include improvements in OLCI radiometric calibration and implementation of system vicarious calibration/vicarious gains.

EUMETSAT are conducting a variety of Cal/Val activities including system vicarious calibration, ongoing algorithm improvements, and new products are also planned. EUMETSAT would like to support the implementation of the INSITU-OCR White Paper through a proposed virtual project office and hands-on activities. EUMETSAT OC user support includes co-sponsoring and co-organization of IOCS-2017 (including Copernicus training session, student sponsorship, CMEMS side event and breakout sessions), the "Oceans from Space" Massive Open Online Course (MOOC) which attracted over 5,000 participants, and the Expert Exchange Workshop on the Copernicus Marine Data Stream (29-30 Nov 2016, Oostende, Belgium).

5.7 ESA Update on Sentinel-2 and Sentinel-3

Craig Donlon provided an overview of the EU Copernicus Programme, including the Sentinel-2 and S-3 missions (a total of 8 satellites that are OC capable). The Sentinel-2 mission consists of two spacecraft operating in twin configuration, carrying a multispectral instrument with 13 spectral bands (VIS, NIR & SWIR) at 10, 20 and 60 m spatial resolution (5 day revisit at the Equator with 2 satellites), with an ever increasing range of applications, including water quality. The primary S2 product is L1C top-of-atmosphere reflectances. A new L2A product is currently being prepared (bottom-of-atmosphere reflectances). S2 is not a marine sensor, but it acquires a lot of marine data – a 10 days revisit of all land masses will be reached Q1/2017. S2B launch is scheduled for 6 March

The Sentinel-3B Flight Acceptance Review is planned for Sep-Oct 2017 which is compatible with a launch scheduled for the end of November 2017. The current baseline orbit phasing between S3A and S3B is a 180° angle phase separation on the same orbital plane. It is proposed to set S3B in 140° phasing with S3A to optimise the constellation for OC and altimetry. Validation activities are well advanced and dedicated projects are in place to develop a culture of FRM validation. The Mission is responding to user needs and evolving to meet those needs.

5.8 CONAE: Current Status of SABIA/Mar Mission

Daniel Caruso provided an update of the Argentinian SABIA-Mar mission. The mission is primarily intended for determination of global and coastal (South America) chlorophyll-a concentrations and monitoring global and coastal water related parameters. Two satellites are planned: CONAE (Argentina) will take responsibility for SABIA-Mar-1 and INPE (Brazil) for number 2. Revisit times over the Equator will be 1-day with 2 satellites, but only 2-days with 1 satellite. The regional/coastal OC mission will have 200 m resolution for the measurement bands and 400 m for the atmospheric correction bands (global scenario 800 m). There is only one ground station in Argentina, but with another ground station they could provide 200 m globally). Products will include nLw, Chl, Kd, PAR, turbidity and SST. Data will be available free of charge, every two days. Three instruments will cover 17 bands from 412 nm – 11,800 nm. CONAE has taken most of IOCCG's recommendations on band selections into account.

The mission design allows for possible enhancement of the current global and coastal-regional imaging scenarios. SABIA-Mar-1 could offer ocean colour (200 meters) and thermal infrared images (400 meters) on a daily basis over other regions, besides South America, if another agency/organization provides X-band downlink capability through a suitable Ground Station, coordinated with the Main Control and Receiving Station located in Córdoba, Argentina. With only one Ground Station to download payload generated data, coverage is limited to a 2-day revisit. CONAE is performing *in situ* radiometric measurements around Argentina but they need to interact with other agencies to access data from other areas. SABIA-Mar-1 satellite launch is planned for September 2021, with SABIA-Mar 1 entering its operational phase at the start of 2022.

5.9 CNES: Ocean Colour Developments

David Antoine reported on the CNES ocean program on behalf of Philippe Escudier. Since the last IOCCG meeting Jason 3 is operational and CNES has supported Cal/Val for Sentinel-3A (altimetry and OLCI ocean colour). Unfortunately, the OCAPI mission (ocean colour from a geostationary orbit) proposed for the ESA 2016 EE9 announcement of opportunity was declared unsuccessful. The OCAPI concept was considered too mature for an Earth Explorer mission. CNES will support the inclusion of an OCAPI-type mission in the framework of the next phase of the Copernicus programme (timeframe 2030 or beyond). CNES is also considering collaboration with CONAE on the SABIA Mar mission. CNES supports OC science activities on a regular basis e.g., Cal/Val activities at Boussole. Satellite ocean colour has demonstrated the unique capability to monitor the biological

state of the ocean, but low Earth orbit satellite observations are limited in terms of revisit time. Geostationary orbit observation (e.g., OCAPI) is a key element of an OC monitoring system and can complement LEO observations. The high revisit frequency will allow the monitoring of rapidly changing phenomenon such as algae blooms. Copernicus is a good framework to implement such a concept to complement LEO observations. CNES supports such an initiative, to be discussed with European partners.

Paula Bontempi raised the issue of understanding the challenges of high temporal, high special resolution, satellite observations. What science /models are required that work better for 500 m resolution vs 1-km globally. The temporal resolution is easier to justify, but do we really need/want sub-mesoscale? Stephanie Dutkiewicz noted that is a need for high time and space resolution in both satellite products and models, although 500 m resolution would still not resolve sub-mesoscale features well enough (100 m appears ideal). Craig Donlon pointed out that high spatial data was required in coastal and inland areas. Current modellers find it difficult to use snap-shot information, but we should still strive for high resolution data e.g., S2, which contains an enormous amount of information. We should build a legacy data set today on the assumption that modelling capabilities will improve in the future.

5.10 ISRO Update on OCM-2/OCM-3

Prakash Chauhan reported on OC activities in India, via Skype. The Oceansat-2 OCM payload is working nominally, and has recorded 5 years of OC data around India and the globe. ISRO will continue to operate OCM for operational data dissemination, mainly in coastal and inland waters. OCM-2 L2 products are supported in HDF 4 format and can be displayed and processed in SeaDAS. ISRO has established an *in situ* database of APOs, IOPs and in-water constituents.

The future Oceansat-3 satellite will carry an OCM-3 instrument with 13 bands and an SST sensor, as well as a Ku-band scatterometer. A new bio-optics laboratory has been established at SAC/ISRO. The laboratory is equipped with state-of-the-art equipment such as High Performance Liquid Chromatography (HPLC), Total Organic Carbon Analyser (TOC), UV-VIS spectrophotometer, inverted microscope and hyperspectral radiometer to meet the *in situ* data requirements of OCM and future ISRO OC missions. Future EO satellite missions include Oceansat-3 (scheduled launch 2018-2019), and GISAT, as high resolution (50 m) geostationary satellite also scheduled for launch in 2018-2019. The Oceansat-3 OCM instrument will have 13 Channels in the 400-1010 nm range and 2 Channels around 11 and 12 µm for SST, with local area coverage at 360-m and global area coverage at 1-km (complete global coverage in 2 days). In response to a

question regarding the *in situ* validation database, it should not be a problem to bring the Chl data into another database such as SeaBASS or Mermaid.

5.11 ASI Hyperspectral Mission PRISMA

Lia Santoleri provided a programme overview of the Italian space agency (ASI) medium-resolution hyperspectral imaging PRISMA mission, scheduled for launch in 2018. The mission was initially designed as a national mission but now will provide global coverage. Application domains include quality of inland and coastal waters, biogeochemical monitoring of the Mediterranean Sea, carbon cycle monitoring and atmospheric characterization. The instrument will operate in the range 0.4 to 2.5 μm, and is optically integrated with a medium resolution Panchromatic camera operating in the spectral range 0.4-0.7 μm. The re-visit time will be less than 7 days. L2C products (geo-located at-surface reflectances) will include water reflectances, chlorophyll-a, total suspended matter and yellow substance concentration. The data policy is still under discussion, but likely PIs could submit an application to access the data. A combination of PRISM with S2 data would be very valuable.

6.0 INSITU-OCR Implementation

6.1 Progress towards implementation of INSITU-OCR Project Office

The Chair encouraged all agencies to become involved in the INSITU-OCR in order to implement the INSITU-OCR White Paper in a modular way. Offers had been received from EUMETSAT, ESA, NOAA and NASA to contribute towards a proposed "OCR-VC Project Office". EUMETSAT would like to establish an interoperable *in situ* database as well as multi-water type processing, and NASA would like to support updating the *in situ* protocols etc. A website could be established which could have a data serving capability as well as serving as a repository for a new series of living documents, covering a range of technical and applied matters. Jim Yoder suggested that such an office could also push recommendations from the IOCCG working groups.

Craig Donlon was opposed to this model since the IOCCG already had a project office responsible for international cooperation and coordination. Ewa pointed out that the project office should be distributed and virtual, with shared resources and activities. EUMETSAT is bound by procurement constraints so it can only contribute to this effort by funding an officer who would fulfil EUMETSAT duties and implement the OCR-VC activities. EUMETSAT could also contribute through research & development studies (issued through an ITT) with the funding going to European consortia. Initially the

proposed "office" could focus on fiducial reference measurements as well as on algorithms and products. Craig Donlon, along with Paul DiGiacomo, still disagreed about the need for a separate project office, and suggested that it could perhaps be implemented in the form of a "working group" within the bounds of IOCCG. He suggested that an implementation plan be prepared from the INSITU White Paper, with FRM4SOC being one small contributing project. Paula Bontempi commented that IOCCG needed to evolve to accommodate various agencies' requirements. After much heated debate there was consensus that a multi-agency "OCR Implementation Team (OCR-IT)" should be formed as a first approach, to prepare a rolling implementation plan for INSITU-OCR. Various activities/projects (e.g., ESA FRM4SOC, IOCCG protocols activity, IOCCG sensor calibration task force etc.) would contribute directly to the implementation. The power of this arrangement lies in the fact that this is a dedicated IOCCG activity that is closely linked to the CEOS OCR-VC. Agencies can contribute in any way they wish. The critical aspect is to ensure that there is a link between the requirements (INSITU-OCR White Paper) and the Agency funded activities.

David Antoine pointed out that the coordinating role is very important: if an implementation team such as this is formed, then each agency will decide what is best for their own purpose, so communal activities, such as development of a community processor, will not be addressed. It was agreed that there should be agency level activities as well as overarching synergistic activities which might require additional resources. Ewa agreed to proceed with the hiring of a junior OC remote sensing scientist at EUMETSAT (subject to EUMETSAT procurement constraints) to set up and coordinate the new "OCR-Implementation Team" (Chaired by Ewa Kwiatkowska with representatives from ESA, NASA, NOAA, EUMETSAT and CMEMS), under the auspices of OCR-VC. The team would prepare an implementation plan for INSITU-OCR and would also report back to SIT. Each year there should be an OCR-IT review.

Action 22/2: *Ewa Kwiatkowska, Paula Bontempi, Paul DiGiacomo and Craig Donlon to set up a telephone conference call to discuss the functioning of the new Ocean Colour Radiometry-Implementation Team (OCR-IT), and potential tasks for the new officer.*

6.2 Task force on ECV Assessment

David Antoine reported that there were several on-going activities generating ECVs but it was difficult to move forward with the Task Force with limited time and resources. It is unlikely that further progress would be made this year, and perhaps it was time to rethink the concept of the task force. It was agreed that the group could get together once per year to review efforts, but that the task force itself should be disbanded.

6.3 Linkages with GOOS and Ocean Colour

Paula Bontempi reviewed the role of GOOS, which is tasked with coordinating ocean observing capabilities. Three GOOS Expert Panels provide scientific oversight: i) Physics, ii) Biogeochemistry (BCG), and iii) Biology & Ecosystems. All panels are discussing the development of Essential Ocean Variables (EOVs), which are complementary to the Essential Climate Variables (ECVs) in support of the GCOS Implementation Plan. Recently the GOOS determined they wanted to include ocean colour as an EOV. Ocean colour currently sits under the BGC Panel although it also fits under the Biology & Ecosystems panel. The IOCCG recommended that the ocean colour ECV be included in both the Bio/Eco and BCG sub-panels, since ocean colour data span biological, ecological, and biogeochemical properties in the ocean. Paul DiGiacomo recommended that an IOCCG member regularly interact with GOOS to engage in a productive manner and ensure adequate expertise and communication. It was also agreed to charter a subgroup to revise, as needed, the ECVs for submission to GOOS as EOVs.

Action 22/3: *Paula Bontempi, Paul DiGiacomo and Lia Santoleri to set up a telephone conference call with Emmanuel Boss and Laura Lorenzoni regarding the ocean colour ECV: does it require updating, which GOOS panel(s) should ocean colour fall under, and what are the draft suggestions for GOOS EOVs? If necessary, send an official letter to Albert Fischer on behalf of IOCCG.*

6.4 New Lake ECV on Water Leaving Reflectance

Arnold Dekker reported that since the 2010 GCOS Implementation plan, a number of additional ECV products have been added to the Lakes ECV. These include Lake Surface Water Temperature, Lake Ice Coverage and Lake Water-Leaving Reflectance (Lake Colour). These products are amenable to satellite retrieval and efforts are already underway to build up substantial data records for these ECV products. Several space agencies (e.g. ESA CCI) and the Copernicus Global Land Service are planning to generate these products systematically, and dedicated databases will be available. The GEO AquaWatch group motivated to add an additional Lake ECV product called Lake Colour (Lake Water Leaving Reflectance) for extended data records. The wording in the GCOS Implementation Plan should be changed to include coastal and inland waters. There was some discussion about who should coordinate this: IOCCG, CEOS, GEO (AquaWatch and Blue Planet)? Arnold Dekker was tasked to submit an updated Lake ECV product consistent with the existing GCOS ocean colour ECV.

Action 22/4: *Paula Bontempi, Lia Santoleri and Paul DiGiacomo to send Arnold Dekker the current version of the Ocean Colour ECV's so AquaWatch can adapt these to inland water ECV's.*

Action 22/5: *Arnold Dekker to submit an updated Lake ECV product consistent with the existing GCOS ocean colour ECV.*

7.0 Ocean Colour Related Initiatives

7.1 Australian Ocean Colour Activities

Nick Hardman-Mountford reported on Australian ocean colour activities. Australia's regional Copernicus data access hub enhances access to S1, S2 and S3 data and facilitates collaboration between Australia, Europe and SE Asia. Data holding has been steadily increasing. The Australian geoscience DataCube project has been taken forward by CEOS and improves satellite data pre-processing – data is ingested into a cube infrastructure and then a new product can be easily generated. CSIRO has been working with Himawari-8 over the Great Barrier Reef and have developed robust algorithms for satellite-based assessment of water quality (eReefs project). Continuous above- and in-water optical measurements are collected off the IMOS Lucinda Jetty for coastal validation measurements – also linked to high-frequency satellite observations from Himawari-8. Funding has been secured to continue radiometric measurements under IMOS until June 2017, with an anticipated +5 years until 2022. Many of these OC validation activities support OLCI on S-3A. Overall, there is good performance of the operational atmospheric correction at this site. A radiometry inter-comparison task team was formed to improve consistency among IMOS radiometric measurements for validation of satellite products. This project could perhaps also contribute to the newly formed OCR-IT activity.

Another project is the Indian Ocean bio-optical profiling mooring off Perth for validation and analysis of OC satellite remote sensing observations, led by Curtin University. CSIRO and Curtin University are also trying to configure a "blue water" southern hemisphere vicarious calibration site because ocean/atmosphere conditions off Perth are quasi ideal for SVC. Another cruise in 2016 studied the bio-optics and biogeochemistry of the SW Pacific Ocean from Fiji to Hobart, also deploying Bio-Argo floats and included participation by NOAA for VIIRS validation. Furthermore, a Curtin University led project to undertake autonomous optical and radiometry measurements in the southern ocean, in support of ocean colour remote sensing validation and algorithm development, is spinning up. The "Antarctic Circumpolar Expedition" (ACE) Dec 2016 – Feb 2017

collected IOPs and radiometry *en route*, and other cruises are planned in the frame of the IIOE-2 (International Indian Ocean Expedition 2)

7.2 CEOS Feasibility Study for an Aquatic Ecosystem Imaging Spectrometer

Arnold Dekker reported on the outcome of an *ad hoc* CEOS WG examining the feasibility of designing an imaging spectrometer satellite mission focused on the biogeochemistry of inland, estuarine, deltaic and near coastal waters, as well as mapping macrophytes, macro-algae, sea grasses and coral reefs. These environments need higher spatial and spectral resolution than current and planned Earth observing sensors offer. The GEO Community of Practice, Aquawatch, suggested that alternative approaches, involving augmenting designs of spaceborne sensors for terrestrial and ocean colour applications to allow improved inland, near coastal waters and benthic applications, could offer an alternative pathway to addressing the same underlying science questions. Current OC sensors can cover about 40-60% of the World's lakes and coastal areas but this study is focussing on the remaining 40%, which requires increased spatial resolution, and perhaps adding a few extra spectral bands to Landsat or S2 to make them more useful for inland and coastal water quality. To measure optically active water constituents over large ranges, and also to discriminate bottom substrate through the water column, no specific multispectral band sets can do it all, so there is a strong indication that hyperspectral imaging spectrometry will be required. By augmenting planned land or ocean sensors spectrally or spatially is a cost-effective solution for observing aquatic ecosystems. The final report will be submitted to CEOS-SIT in April 2017.

7.3 Economic Valuation of Earth Science Data

Paula Bontempi reported on the economic valuation of Earth science data, using examples from a report by Bruce Wielicki (NASA Langley) examining the economic value of an advanced climate observing system. Science is an economic investment by the public. To quantify the economic value of climate science observations, a rigorous analysis is required to take into account the uncertainties in climate science, economic impacts and policy, but it is difficult to find real studies and estimates of this. Science value and economic frameworks are potentially valuable for strategic planning of the Earth observing system, as well as communicating what we do and its value to society. A combination of climate science and economics expertise is required to quantify the economic value of climate science and perform a risk benefit system analysis, which feeds into societal policy changes. Economists run simulations using the "Value of Information (VOI)" method to determine the return on investment for improved climate observations. Economics estimates have large uncertainties, but they can both increase or decrease the current economic VOI costs. Current global climate science research

investment are around $4 Billion U.S. per year. Further investments to triple this level to $12 Billion per year to build an international Climate Observing System would pay back ~ $50 for every $1 invested. The study concluded that a new climate observing system would be one of the most cost effective investments society could make to provide a stable economic future.

Paul DiGiacomo also spoke about recent activities within NOAA addressing the topic of socio-economic benefits and valuation of EO data, focusing on end user and societal benefit applications. In the case of ocean colour remote sensing, we have to think about a test-case scenario for economic impacts of our observations e.g., coastal zones, HABs, fisheries, economic impact of marine protected areas etc., but it is a daunting task to assess the economic valuation. Arnold Dekker mentioned the Australian study "The Value of EO from Space to Australia", which has a lot of interesting information. There are two types of economic impact: direct and employment. Tourism is a huge economic impact to consider.

Stewart Bernard cautioned about framing such an exercise entirely in a climate change context in light of changing political dispensations – rather use an ecosystem services context. Paula suggested it could be beneficial to focus on one topical area e.g., the value of a fishery on a global scale, or global carbon cycling. There is a lot of material regarding economic value of Copernicus from ~2010 onwards. Hubert Loisel pointed out that in terms of water quality, eutrophication has a big economic impact. Paula Bontempi agreed to talk with Bruce Wielicki regarding the economic valuation of ocean colour data and the direction the OC community could take, as well as obtain names of economists.

Action 22/6: *Paula Bontempi to contact Bruce Wielicki (NASA Langley) regarding the direction the OC community could take to perform an economic assessment of OC data.*

Paul DiGiacomo agreed to discuss with Emily Smail whether NOAA could coordinate a study on the economic value of ocean colour data, also potentially under the auspices of the GEO Blue Planet Initiative, and help assemble existing information on this topic.

Action 22/7: *Paul DiGiacomo to provide feedback in consultation with Emily Smail regarding leading a study on the economic value of ocean colour data under the auspices of the GEO Blue Planet Initiative.*

7.4 Global Biogeochemical Argo Update

Nick Hardman-Mountford provided an update on the Biogeochemical Argo (Bio-Argo) network, which provides vertical distribution of important ocean variables to study ocean biogeochemistry and carbon cycling. Planning for a global Bio-Argo network has begun and a draft implementation plan is out for comment. Such a network will help to answer many grand science challenges. Results of various studies using Bio-Argo data were presented highlighting the fact that Bio-Argo is a mature technology. IOCCG should consider how best to promote bio-optics on profiling floats, using floats for validation / SVC and perhaps having a task force on bio-optical profiling floats.

7.5 Summary of PFT Activities

Nick Hardman-Mountford gave a short update on PFT activities, on behalf of Taka Hirata. The satellite phytoplankton functional type algorithm intercomparison project is a voluntary group with four main goals: to produce a user guide, to compile an *in situ* measurement database, to undertake algorithm intercomparison, and to carry out algorithm validation. The first three goals have been accomplished and have resulted in peer-reviewed publications, the database is completed and always updated, and the group is currently focussing on algorithm validation.

8.0 International Ocean Colour Science Meeting 2017

8.1 Plans for IOCS-2017 Meeting

Stewart Bernard outlined the current schedule of the upcoming IOCS meeting, in which the Scientific Planning Committee tried to balance agency talks and science, with keynote speakers feeding into breakout workshops. One of the poster sessions had been removed but the Committee strongly advised on retaining the poster session, and also attempting to keep posters displayed the entire meeting. For the final session, Paul DiGiacomo recommended holding a Q & A session with all the agency representatives on the podium. It was suggested that the Chairs of each breakout session should provide a brief summary in Plenary (1 to 2 slides) of what their groups will discuss in their respective sessions. For the final session, the breakout chairs could also present the highest priority issues as a discussion starter for agency feedback. Craig Donlon, Ewa Kwiatkowska and Mark Dowell were tasked with planning the "Copernicus Plenary Session" at IOCS-2017.

Action 22/8: *Craig Donlon, Ewa Kwiatkowska and Mark Dowell to plan the Copernicus Plenary Session at IOCS-2017.*

For future IOCS meetings, it was recommended that the IOCCG provide the topics for breakout sessions and request people to chair them, rather than issue a call for breakout sessions. An offer had been received from China to host the IOCS-2019 meeting in Hangzhou, China. This offer would be discussed at the IOCCG Executive meeting.

9.0 Training and Capacity Building

9.1 IOCCG Capacity Building

Ewa Kwiatkowska gave a brief outline of the recent EUMETSAT Massive Open Online Course (MOOC) entitled "Oceans from Space" which addressed the whole system from scientific topics to data providers. Ocean colour was well represented with a large range of products and applications. The MOOC was aimed at an audience who may be using satellite data but who are not entirely familiar with the products or processing of data. A total of 5,738 people registered for the course, 57% of whom were active throughout the entire course. The initial feedback was extremely positive. For each module, participants watched 3-5 short videos, had links to other resources and material, answered simple quizzes and had a chance to interact with some data, and discussed what they had learned. EUMETSAT noted that it takes a lot of work to create the material and to follow the participants' discussions. EUMETSAT planned to re-run the course in 2017 making all the resources available on a stand-alone site for participants to learn from independently. An atmospheric composition MOOC was planned for 2018.

David Antoine then summarised 2016 IOCCG Summer Lecture Series. Over 140 applications had been received from students of 47 different nationalities, 22 of whom were chosen to attend the course (11 females, 11 males). It is not possible to physically accommodate more than about 20 students at LOV. The students received lectures from 17 distinguished research scientists on a wide variety of topics, including practical sessions in the laboratory. Around 80% of the cost of the course came from external sources and 20% from the recurrent IOCCG budget. All the lectures were video recorded and made available online, where they have been downloaded thousands of times by researchers from around the world. Next year, Villefranche will have a new building, entirely devoted to hosting students and visitors (56 persons), and equipped

with a conference room, so it may be possible to hold a course there in 2018. David would try to resume CNES support for the training course and evaluate the possibility of getting support from local entities such as the "Conseil Régional". A small contribution form students would also be considered. Stewart Bernard noted that a course such as this takes significant effort and David was commended for all the time and effort he had put in to making this course such a successful part of IOCCG capacity building efforts.

A proposal for a short OC online training course had been requested from Sam Lavender. David Antoine pointed out that a student would not gain extensive knowledge on a topic from such a short course but it could perhaps attract new people to use OC. Nick Hardman-Mountford supported Sam's proposal and noted that the company had the time, insight and expertise to prepare such a course. The challenge would be around the cost (IOCCG currently does not have the funds). The proposal would be further discussed in the IOCCG Executive meeting.

David Antoine agreed that the Summer Lecture Series should not be the only IOCCG training activity. Lia Santoleri noted that CMEMS also conducts short (1-day) training courses for users, many of whom come from the research community. Perhaps this could be part of the IOCCG capacity building strategy to attract people to use OC data. Lia Santoleri would provide further information.

10.0 Organisation and Membership

10.1 Joint CNR-ESA Hosting of IOCCG-23 in Rome 2018

Lia Santoleri presented a proposal to host the IOCCG-23 meeting at the CNR Headquarters in Rome, to be organised jointly by CNR and ESA. CNR Headquarters are located in the center of Rome center, 15 minutes' walk from Rome Central Station (Termini). From there, it is only 32 minutes to Rome's Fiumicino airport by train. CNR also has locations in Capri and Sicily, but the Committee decided the logistics were easier to hold the meeting in Rome. There are several hotels within walking distance from CNR Headquarters (e.g., Ateneo Garden Palace Hotel). Proposed dates are last week in February or first week in March (3-day Committee meeting, 1-day Executive meeting).

10.2 Proposals for Hosting IOCCG-24 in 2019

Hubert Loisel, together with Cedric Jamet, presented a proposal for hosting the IOCCG-24 meeting in Vietnam in 2019. The need for satellite observations for the management of coastal and inland waters has clearly been stated by Vietnamese authorities, and

there is increasing research on OC remote sensing, with many PhD students. Vietnam is also very affordable and most meeting participants will not require a visa. Currently there is effective collaboration between CNES and the Vietnam Academy of Science and Technology (VAST) as well as JAXA and VAST.

Two different options were presented for meeting location: either in Hanoï or Nha Trang. Hanoï is the capital of the country, the site of VAST, and direct flights are available from most major cities. The meeting will take place on the campus of VAST at University of Sciences and Technology (USTH). An outreach seminar could be organized for Master/PhD students. Regarding hotels, participants could either stay in the busy, but charming old town, or at Tây Hồ, a quiet location around a big lake north of Hanoï, which is closer to VAST. Side trips could be arranged for example, to Halong Bay (limestone islands). The other option was to hold the meeting in Nha Trang, at the Institute of Oceanography, but access is more difficult (no direct flights). The best time to hold the meeting is the beginning of March. This proposal would be further discussed in the Executive meeting.

10.3 Rotation of IOCCG Committee Members

Heidi Dierssen, Taka Hirata and Andrew Tyler were rotating off the Committee. The Chair noted that they had all put in a lot of effort and had helped out with several IOCCG initiatives which were very much appreciated. Stephanie Dutkiewicz was also rotating off the Committee but would still be invited to attend Committee meetings as Chair of the modelling WG. Fréd Melin will officially replace Giuseppe Zibordi as the JRC scientific member, and Wonkook Kim will officially replace Joo-Hyung Ryu as the KIOST scientific member – both were welcomed onto the Committee. Chuanmin Hu (University of South Florida) was nominated as a new IOCCG Scientific member. David Antoine would be officially stepping down as past-Chair, but he had an open invitation to attend all IOCCG future Committee meetings. His extensive and tireless contributions to IOCCG are greatly appreciated. David's initiatives over the years have had a tremendous impact on IOCCG's on-going activities, including the establishment of the extremely successful IOCCG Summer Lecture Series, and the International Ocean Colour Science meetings.

10.4 Handover of Chair

Stewart Bernard commented that it was a privilege and honour to serve as the IOCCG Chair for the past 3 years. The experience had been very rewarding - there are few communities like IOCCG. Stewart was presented with a token of appreciation from a local artist and thanked for the immense amount of work that he has done over the

years. Stewart then handed over the Chair to Cara Wilson (NOAA/NMFS). He believed that she would do a very good job in chairing the IOCCG Committee for the next 3 years.

Action: IOCCG-22 Committee Meeting

Perth, Australia, 7 - 9 February 2017

	Brief description	Status
22/1	Paul DiGiacomo to submit a list of names of potential reviewers for the IOCCG Water Quality report, including specific chapters they could review.	Open
22/2	Ewa Kwiatkowska, Paula Bontempi, Paul DiGiacomo and Craig Donlon and to set up a telephone conference call to discuss the functioning of the new Ocean Colour Radiometry-Implementation Team (OCR-IT), and potential tasks for the new officer.	On-going
22/3	Paula Bontempi, Paul DiGiacomo and Lia Santoleri to set up a telephone conference call with Emmanuel Boss and Laura Lorenzoni regarding the ocean colour ECV: does it require updating, which GOOS panel(s) should ocean colour fall under, and what are the draft suggestions for GOOS EOVs? If necessary, send an official letter to Albert Fischer on behalf of IOCCG.	Open
22/4	Paula Bontempi, Lia Santoleri and Paul DiGiacomo to send Arnold Dekker the current version of the Ocean Colour ECV's so AquaWatch can adapt these to inland water ECV's.	Open
22/5	Arnold Dekker to submit an updated Lake ECV product consistent with the existing GCOS ocean colour ECV.	Open
22/6	Paula Bontempi to contact Bruce Wielicki (NASA Langley) regarding the direction the OC community could take to perform an economic assessment of OC data.	On-going
22/7	Paul DiGiacomo to provide feedback in consultation with Emily Smail regarding leading a study on the economic value of ocean colour data under the auspices of the GEO Blue Planet Initiative.	Open
22/8	Craig Donlon, Ewa Kwiatkowska and Mark Dowell to plan the Copernicus Plenary Session for IOCS-2017.	Closed

Appendix I: LIST OF PARTICIPANTS

Perth, Australia, 7 - 9 February 2017

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
DiGiacomo, Paul	-	NOAA/NESDIS/STAR, USA
Donlon, Craig	-	ESA-ESTEC, Netherlands
Dutkiewicz, Stephanie	-	Massachusetts Institute of Technology, USA
Franz, Bryan	-	NASA Goddard Space Flight Center, USA
Hardman-Mountford, Nick	-	CSIRO, Australia
He, Xianqiang	-	Second Institute of Oceanography, China
Kim, Wonkook	-	KIOST, Korea
Kwiatkowska, Ewa	-	EUMETSAT, EU, Germany
Loisel, Hubert	-	ULCO, France
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
Yoder, James	-	Woods Hole Oceanographic Institution, USA

Invited Participants		**Affiliation**
Caruso, Daniel	-	CONAE, Argentina
Cho, Seongick	-	KIOST, Korea
Dekker, Arnold	-	CSIRO, Australia
Fearns, Peter	-	Curtin University, Australia
Han, Hee-Jeong	-	KIOST, Korea
Jamet, Cédric	-	Université du Littoral Côte d'Opale, France
Pan Delu	-	Second Institute of Oceanography, China
King, Edward	-	CSIRO, Australia
Lynch, Mervyn	-	Curtin University, Australia

Apologies		**Affiliation**
Agyekum, Kwame	-	University of Ghana, Ghana
Bergeron, Martin	-	CSA, Canada
Boss, Emmanuel	-	University of Maine, USA
Chauhan, Prakash	-	ISRO, India
Dierssen, Heidi	-	University of Connecticut Avery Point, USA
Dowell, Mark	-	Joint Research Centre, EU, Italy
Escudier, Philippe	-	CNES, France

Hirata, Takafumi	-	Hokkaido University, Japan
Kampel, Milton	-	INPE, Brazil
Park, Youngje	-	KIOST, Korea
Ryu, Joo-Hyung	-	KIOST, Korea
Tyler, Andrew	-	University of Stirling, UK