IOCCG-21 Committee Meeting
Santa Monica College, USA, 1 – 3 March 2016

MINUTES

1.0 Welcome and Opening Session

1.1 Welcome and Introductory Remarks

The Chairman, Stewart Bernard, opened the meeting and thanked everyone for travelling to Santa Monica. Paul DiGIacomo welcomed the Committee on behalf of NASA and NOAA and informed them that Prof Baghdasarian, from Santa Monica College, was the host of the meeting, and thanked the college for their support. Paula Bontempi welcomed everyone to the USA on behalf of NASA, and invited input from the new members about the direction IOCCG should head in the future, as far as scientific planning goes. She noted that IOCCG has evolved over the years, there is an enormous breadth of accomplishments, and the number of space agency members has tripled.

Prof. Garen Baghdasarian warmly welcomed the diverse group of participants, on behalf of Santa Monica College. He noted that Santa Monica College is also very diverse with over 33,000 students from 116 countries. He appreciated the fact that certain IOCCG members had volunteered to give lectures to the students and was excited to hear about work they are doing.

New Committee members for 2016 were officially welcomed including Kwame Agyekum, Emmanuel Boss, Bryan Franz, Xianqiang He, Hubert Loisel, Rosalia Santoleri and Craig Donlon (Sentinel-3 Mission Scientist, replacing Peter Regner from ESA). The Chair invited a brief tour de table for participants to introduce themselves. The list of participants is provided as an Annex to the minutes.

1.2 Adoption of IOCCG-21 Agenda

The IOCCG-21 agenda was adopted after moving agenda item 4.1 ahead by 1 hour.

1.3 Adoption of Minutes from IOCCG-20 and Status of Actions

The minutes of IOCCG-20 were approved by consensus. The Chairman summarised the status of actions from the 20th Committee meeting, which had either been completed, or would be addressed further during the meeting.

- *Action 20/1:* Vittorio Brando and Suzanne Craig submitted a re-scoped proposal, to be addressed under Agenda item 3.2.
- *Action 20/2:* At the Executive meeting in San Francisco it was agreed that there was no point in writing another letter regarding funding of validation activities as the

Commission is fully cognisant of what is required, but they cannot add additional funding at this stage.

- *Action 20/3:* Craig Donlon chaired a panel discussion at IOCS-2015.
- *Action 20/4:* Paul DiGiacomo invited Samantha Simmons (co-chair of the GOOS Biology and Ecosystem panel) to the IOCS-2015 to interact with the ocean colour community. Furthermore, Stewart Bernard and Lia Santoleri are currently serving on the GOOS Science Steering Committee.
- *Action 20/5:* Stephanie Dutkiewicz attended the GOV MEAP-TT workshop in Halifax.
- *Action 20/6:* The new modelling working group will be presented under agenda item 2.5.
- *Action 20/7:* EUMETSAT will discuss new demonstration products under agenda item 4.4
- *Action 20/8:* Links to ocean colour data sets have been updated on the IOCCG website.
- *Action 20/9:* Timelines and specifications of current and planned ocean colour sensors have been updated on the IOCCG website.
- *Action 20/10:* Paul DiGiacomo attended the SIT-30 meeting in Paris (March 2015)
- *Action 20/11:* Bryan Franz and David Antoine are the new co-chairs of the ECV Task Force.
- *Action 20/12:* Jim Yoder's ECV presentation is now on the IOCCG website.
- *Action 20/13:* Developments of the INSITU-OCR will be discussed under item 5.7
- *Action 20/14:* IOCCG has sent a letter to KIOST/KARI (Director General Shin-Hee Cho) expressing appreciation for GOCI data and for the rapid development of the missions
- *Action 20/15:* IOCCG is coordinating with EUMETSAT regarding joint capacity building efforts – to be discussed under agenda item 8.2
- *Action 20/16:* Available ocean colour training courses have been updated on the web.
- *Action 20/17:* An EOS article on the IOCS-2105 meeting was published on 11 January 2016.
- *Action 20/18:* Dates and venue for IOCCG-21 finalized.

2.0 Status of IOCCG Working Groups

2.1 Earth Observations in Support of Global Water Quality Monitoring

Steven Greb reported on the IOCCG water quality working group, which had been very active with regular meetings and conference calls. The overarching objectives of the working group are to assess current knowledge regarding coastal and inland water quality and associated use of remote sensing data, to assess existing and identify new space-based and *in situ* observing capabilities, to identify supporting research and development activities, and to identify best practices and new and improved data streams and products. There is also a user engagement and outreach component. The group has already produced a rough draft report, with most

chapters nearly complete – the goal is to submit the final report to the IOCCG in time for the IOCCG Executive meeting in October. The report framework centers on three audiences with three different time scales. For the short time frame (0-1 year) the focus is on societal infrastructure and end users/managers (stewardship, how to get water quality products, real time monitoring etc.). For the mid-range (1-5 years) the focus is more on science and the sensors/satellite signal. For the long range the focus is on technical infrastructure assets and user support programs. Meeting participants were requested to provide feedback on the draft report, in terms of general direction, key omissions, suggestions for complementary additions, entities to engage etc. Comments and suggestions should be submitted to Paul DiGiacomo and Steve Greb by the end of March/early April.

ACTION 21/1: *IOCCG-21 participants to provide feedback on the draft water quality report to Paul DiGiacomo and Steve Greb by mid-April 2016.*

2.2 GEOHAB/IOCCG Harmful Algal Bloom Working Group

Stewart Bernard reported on the GEOHAB/IOCCG working group, which will provide communication between the HAB and ocean colour communities. He outlined the various chapters of the report, about 60% of which have been completed. Case studies compare retrieval of the same organism in different locations, as well as ecologically disruptive blooms and various types of toxic blooms. The critical element in terms of retrieving phytoplankton functionality is atmospheric correction, especially at low biomass. The real value of ocean colour remote sensing lies in detecting high biomass blooms. Sophisticated regional algorithms can only be used in high biomass, Case-1 systems: FLH-type algorithms are used in most other areas. SCOR (GEOHAB) has offered to provide funding for a small workshop to prepare material for the outstanding chapters (including Sentinel-2 applications) and to produce a final draft report ready for review. A close to final draft report should be ready by the end of this year. Mark Dowell agreed to approach JRC regarding printing of the HAB report.

2.3 Atmospheric Correction in Coastal Waters Working Group

Cédric Jamet summarized the progress of the Atmospheric Correction working group, which aims to inter-compare and evaluate existing atmospheric correction algorithms over turbid waters. The challenge is to understand the advantages and limitations of each algorithm and their performance under certain atmospheric and oceanic conditions. The group is only focussing on algorithms that deal with non-zero NIR water-leaving radiances, and will not address shallow waters, but will examine adjacency effects. The group is only focussing on MODIS-Aqua (not MERIS, as ESA has a similar project on extreme Case-2 waters).

Many atmospheric correction algorithms have been developed over the past 10 years based on several different approaches. The working group will examine 12 algorithms in 5 different categories, to understand advantages and limitations of each, using three different databases (classic match-up, simulated dataset for sensitivity studies, and satellite images). Where possible, all algorithms are implemented in SeaDAS for consistency. The group is currently analysing the results of the synthetic and *in situ* datasets, and compiling the satellite dataset. The redaction of the report is scheduled for the end of the year. Stewart Bernard suggested that the group focus on the differences between this report and Report 10. There was a lot of discussion about whether this report was an update or addendum to Report 10, but it was agreed that it represented a complementary and updated version of Report 10. There was also a high degree of complementarity with the proposal submitted by Craig and Brando (item 3.2).

2.4 Uncertainties in Ocean Colour Remote Sensing Working Group

Giuseppe Zibordi reported on the status of the uncertainties working group, on behalf of Frédéric Mélin. A breakout session at IOCS-2015 reviewed the methods for quantifying uncertainties for R_{rs} and derived products and developed a set of recommendations which will be included in the report. A working group meeting was also held after the IOCS meeting to review the Terms of Reference, revise the outline of the report and identify the contributions and leads for the various chapters. The ToR to "develop and compile a data set to test uncertainty and out-of-scope algorithms" was removed. The current outline of the report was discussed including the various approaches used to determine R_{rs} uncertainties. It was anticipated that the final draft report would be ready by September 2016.

2.5 Ocean Colour in Biogeochemical, Ecosystem and Climate Modelling

Stephanie Dutkiewicz briefed the committee on the new IOCCG modelling working group which has a new title: "The Role of Ocean Colour in Biogeochemical, Ecosystem and Climate Modelling". The group had just held their first meeting in New Orleans (19-20 February 2016) where they reviewed the Terms of Reference, received talks from all participants, and discussed the draft outline of the report. The report will address regional (coastal) models and global (climate change) models, as well as data assimilation. Chapter 3, on Ocean Colour Products, was seen to be a critical chapter, and Chapter 4 was seen as a bridge linking model output and ocean colour products. Reflectance products are more useful for ocean colour scientists, but carbon is a better currency for modellers. Chapter 7 will include models driven by ocean colour e.g., habitat, HABs, food webs, sea grasses. Heidi Dierssen suggested that this chapter be removed as there was too much to define, and also Stewart Bernard was already addressing HABs. The final chapter will provide a summary and will synthesize all the recommendations.

The group plans to hold several meetings of opportunity, as well as a breakout session at IOCS-2017 before finalising the report in November 2017. Lia Santoleri pointed out that much of this work was being done at CMEMS under Copernicus – she would give Stephanie a point of contact at CMEMS.

3.0 Proposals for new IOCCG Working Groups and Initiatives

3.1 Issues Related to Airborne and Remote Sensing Hyperspectral Data

Emmanuel Boss presented a proposal for a new working group entitled "Hyperspectral Measurements of Water Constituents", submitted by Cecile Rousseaux. The Terms of Reference will address the current status of aircraft and satellite hyperspectral remote sensing and what can be done better with hyperspectral measurements that cannot be done with multispectral measurements. Hubert Loisel pointed out that full hyperspectral measurements were very costly. Stewart Bernard noted that it was important to gain a better understanding of the signal and IOP variations. Many participants thought that it might be too early for this proposal as the PACE Science Team was addressing similar issues, and many new papers would be coming out. This proposal would be further discussed at the IOCCG Executive meeting.

3.2 Algorithm Selection for Optically-Complex Waters

Susanne Craig presented a proposal (via Skype) for a new working submitted in conjunction with Vittorio Brando, entitled "Guidelines for Algorithm Selection for Optically-Complex Waters". There are many approaches for retrieving IOPs and/or water constituents (e.g., semi-analytical, neural networks, empirical) but no universal algorithm or approach. This report aims to develop a framework to guide algorithm implementation for optically-complex waters by developing a deeper understanding of an algorithm's strengths and weaknesses. The Terms of Reference include identifying current algorithms suitable for use in optically-complex waters, characterising the underlying principles of each algorithm type, developing a set of evaluation metrics to identify best-performing algorithms, examining the potential of multi-water type processing approaches, and formulating guidelines for algorithm selection. The group will not perform an intercomparison of algorithms. Paul DiGiacomo pointed out that this was a fairly technical report so would not be a resource for non-specialists. Andrew Tyler informed the group that the GloboLakes project was already doing a lot of the work described and they would be happy to contribute (Peter Hunter nominated). This proposal would be further discussed by the Executive Committee.

3.3 Supporting and Enhancing Access to Earth Observation Data

Clarissa Anderson presented a proposal (to be submitted to NASA) to create a database of experts to facilitate data and information exchange between Earth science experts and non-academic entities, in support of critical conservation or socioeconomic issues. Key partners include Future Earth – Coasts (formerly LOICZ), International Association of Impact Assessment (IAIA). Fondation pour la Protection de la Biodiversité Marine (FoProBim – in Haiti), Center for Biological Diversity, World Resources Institute and Google Earth Engine. Future partners will include ESA, CEOS, UN Convention on Biological Diversity and IPBES. The database architecture will consist of a self-populating database of remote sensing experts and social scientists, sorted by topics, with a number of search fields. A possible role of IOCCG could be hosting the database and engaging with experts in remote sensing of ocean colour. Craig Donlon pointed out that many tools do this kind of networking already, e.g., Ocean Expert, a global directory containing information on individuals involved in all aspects of marine and freshwater research and management. It is intended as a tool for scientists, policy makers and anyone who needs to contact a marine or freshwater professional. It was pointed out that the Anderson proposal also intends to encourage people to engage in projects, and not just create links. Paul Di Giacomo suggested that they also try to bring in the GEO Blue Planet initiative. The Committee resolved to wait for the outcome of her proposal before making any further decisions.

3.4 Should IOCCG Perform an Economic Value Assessment of the Global OC Constellation

Stewart Bernard presented some ideas on performing an economic assessment of the value of the global ocean colour constellation. The oceans have significant economic value and many agencies require economic justification before building a sensor etc. Would it be useful to produce a short paper estimating the global economic value of ocean colour radiometry across all domains (oceanic, climate change, carbon fluxes, ecosystem services in coastal and inland waters)? The "value of information approach" could be used, e.g., information is worth ~1% of the value of the resource. Examples of several existing studies from U.S.A., India, Europe and Australia were presented. This is an emerging area of importance to social science, and members agreed that it would be extremely valuable, but would also be very expensive to do well, since an economist would have to be involved. Some were sceptical about the calculations. Craig Donlon circulated a document for information entitled "*The Socio-Economic Benefits of GMES*" (Report 39, November 2011) by the European Space Policy Institute (http://www.espi.or.at/images/stories/dokumente/studies/ESP_Report_39.pdf).

One option could be to provide a few application examples highlighting some case studies with an estimate of the global value of the resource and the impact of climate change/HABs etc.

Paul DiGiacomo suggested preparing a one-page scoping paper outlining what we are trying to accomplish, and then identify an economist. Paula Bontempi cautioned that this type of exercise is often done incorrectly by policy people, and there was also the possibility that our best intended output could be used negatively. Paul DiGiacomo and Stewart Bernard agreed to take the lead on preparing a one-page scoping document, to be followed by further Executive evaluation of costs, benefits and any liabilities of publishing the full study.

ACTION 21/2: *Paul DiGiacomo and Stewart Bernard to prepare a one-page scoping document on performing an economic assessment of the value of the ocean colour radiometry-virtual constellation, to be followed by further Executive evaluation of costs, benefits and any liabilities of publishing the full study.*

4.0 Agency Reports on New/Emerging Initiatives

4.1 NASA Update on Current and Future Missions

Paula Bontempi provided an update on current and future NASA missions. SeaDAS implementation is underway for OLCI data, with a processing capability from Level-1B with NASA algorithms. Display/analysis of standard ESA products should be automatic, since SeaDAS is now built on BEAM architecture. OBPG will acquire the full OLCI mission at Level-1B through the ESA-NASA gateway. NASA is planning to distribute both Level-1B (mirror) and likely NASA Level-2 data via the ocean color web portal (but awaiting mandate from EOSDIS/ESDIS).

A multi-mission ocean colour reprocessing has been carried out to improve interoperability and sustainability of the product suite by adopting modern data formats, standards, and conventions and incorporating calibration and algorithm updates. CZCS, OCTS, VIIRS, MODIS-Aqua and SeaWiFS have been completed. MODIS-Terra and MERIS are still in progress. The long term continuity of climatology is consistent across the sensors so there is confidence in the changes made to data products. NASA is in the process of redeveloping the VIIRS Level-0 to Level-1 and GEO process to switch the data source from NOAA IDPS to NASA EDOS. They will also include a Level-1A product for distribution of uncalibrated radiances.

Regarding the PACE mission, the primary science objectives are to understand and quantify global aerosol and cloud dynamics, ocean biogeochemical cycling, and ecosystem function, and to extend key Earth system data records on global ocean ecology, ocean biogeochemistry, clouds, and aerosols. Launch readiness is 2022. Three projects were selected to address the vicarious calibration approach and instrumentation competition – the final reports are due in 2017. PACE applications White Papers are also available on the web. The project is exploring

the inclusion of a polarimeter. Other capabilities under study include a high spatial resolution (~100 m) spectroradiometer to study coastal/inland ecosystems, support for NASA Earth Venture class instruments, and direct broadcast communications capabilities.

4.2 NOAA Ocean Colour Activities

Paul DiGiacomo provided an update on NOAA ocean-colour activities, on behalf of the NOAA ocean colour coordinating group (NOCCG). NOAA is contributing to almost all components of the INSITU-OCR and also carries out end-to end ocean colour processing for VIIRS: Multi-Sensor Level-1 to Level-2 (MSL12) is the official VIIRS OC processing system with eight standard products as well as experimental products (e.g., IOPs, PAR). There are two data streams: NRT (official data) and science quality (delayed mode, reprocessed every 2-3 years). The full mission VIIRS Science Quality (reprocessed) global dataset will be available in mid-2016.

NOAA is carrying out a tech refresh for MOBY which should be completed by the end of next year. NOAA also carries out dedicated annual VIIRS cal/val cruises with international, interagency, and academic collaboration. NOAA has signed a bi-lateral agreement with the EU to be the primary distributor of Sentinel-3 OLCI ocean colour data from EUMETSAT to US users. Examples were given of other colour activities within NOAA e.g., HAB forecasting, CoastWatch/OceanWatch, Coral Reef Watch etc. In summary, NOAA is actively working to improve L0 to L1 VIIRS data. VIIRS ocean colour products are now comparable to, or better than, those from MODIS-Aqua. NOAA is also co-hosting the GEO Blue Planet Secretariat in partnership with CSIRO, as a contribution to the CEOS Blue Planet Initiative.

4.3 ESA's Sentinel-2 and Sentinel-3 Missions

Craig Donlon provided an overview and status report of ESA's Sentinel-2 and Sentinel-3 missions. He outlined the various components of Copernicus, a user-driven programme of services for environment and security, and a source of information for policymakers, industry, scientists, business and the public. ESA is coordinating the space component, and JRC the services component.

An overview was provided of the Sentinel-2 mission, carrying the MultiSpectral Instrument (MSI) which has 13 spectral bands, a spatial resolution of 10/20/60 m and a wide swath of 290 km. It is designed for land, but if one pixel falls within the coastal zone the entire scene is downloaded, so a large quantity of coastal data is available (e.g., all of the Mediterranean Sea). The data policy is open and free. Each image is ~4 GB so ESA is looking at ways of bringing the users to the data. Sentinel-2B will be launched later this year. Data from first few months of

acquisitions are looking very good and the signal-to-noise is also very good. The images provide incredible detail and will provide a revolution for coastal zone applications.

The Sentinel-3A mission was launched on 16 February 2016 (S-3B will likely be launched in 2018). It is an operational mission in low Earth orbit. Full performance will be achieved with two satellites in orbit (S-3A and S-3B). It has an optical payload, OLCI (Ocean and Land Colour Instrument) and SLSTR (Sea and Land Surface Temperature Radiometer) as well as a topography payload. With two satellites, the revisit will be every ~2 days. OLCI has 21 spectral bands and 300 m acquisition over land and oceans. OLCI has a higher spectral resolution than all previous sensors which is important for atmospheric correction, complex coastal waters and phytoplankton functional types, but there is still consistency with MERIS, facilitating merging (no need to do band-shifting to establish inter-sensor biases). Reference sets of core products will be released to the validation team during the commissioning phase. In addition, sample core products will be released to all users as early as possible for familiarisation.

Tri-party agreements between ESA, EUMETSAT and EU share operations of the missions. Sentinel data can be accessed online at http://scihub.copernicus.eu. The Sentinel-3 Toolbox can be used for visualisation and processing of Sentinel-3 OLCI and SLSTR data and other optical data.

4.4 EUMETSAT OC Services, S-3 Multi-water Demonstration Product

Ewa Kwiatkowska reviewed EUMETSAT ocean colour services. EUMETSAT hosts the marine centre and will take over flight operations from ESA (currently there is a 5 month commissioning phase for Sentinel-3). There will be a mid-term check point, after which data will start flowing to authorised users as early as May 2016, depending on the green light from the commissioning team. EUMETSAT will take over the marine ground segment. There is a joint EUMETSAT-ESA mission performance framework with a joint Sentinel-3 Validation Team (S3VT) and Sentinel-3 Quality Working Groups. The S3VT is based on a rolling call, which is continuously open. S3VT provides independent validation evidence for S-3 cal/val, and members receive early access to S-3 data and some internal products. The S3VT ocean colour implementation plan recommendations are in line with recommendations from INSITU-OCR. Therefore concrete INSITU-OCR advances will at the same time benefit S3VT-OC, particularly those related to the *in situ* data provision standards, formats, processing, inter-operable databases, and measurement protocols. Product development for S-3 is currently under discussion with Copernicus Marine Environment Monitoring Service (CMEMS), including the development of vicarious calibration infrastructure for Copernicus. There will be an open ITT for EUMETSAT to write the requirements documents, along with a peer-review process. The EUMETSAT group will work closely with IOCCG and NASA groups. Development of a multi-

water product is also in the plan, initially as a 1-year study. There are three ways of accessing data: i) EUMETCast (main method of disseminating NRT data), ii) Online Data Access (rolling archive of 1 month of data supporting ftp/http access) and iii) EUMETSAT Data Center (complete historical archive of all EUMETSAT data including S-3 marine data). EUMETCast is currently disseminating S-3 dummy data sets. EUMETCast terrestrial connections are now established with NOAA/NESDIS/STAR and with National Computational Infrastructure in Australia.

4.5 CNES: Ocean Colour Developments

Thierry Carlier gave an update on major CNES ocean developments, on behalf of Philippe Escudier who was unable to attend the meeting. Since the last IOCCG meeting, Jason-3 (altimetry) and Sentinel-3A had been successfully launched. CNES supports cal/val for altimetry and OLCI. CNES also provides science support for the SWOT science team as well as continuous support of science activities related to space activities through Tosca AO (e.g., cal/val activities at Boussole). Recommendations from COSPACE (a government-industry committee for space programs) include recommendations for improvement by a factor of ten in ocean colour time resolution (i.e., geostationary observations to complement LEO). The OCAPI Program is a short term priority for CNES Earth observation program. A proposal will be submitted to the new Earth Explorer Mission EE-9 program by mid June 2016, by David Antoine. In this concept ESA will lead the program. In parallel, technical documents are being prepared for instrument design. The instrument must be compatible with a commercial telecommunication host satellite (to reduce launch cost) and must meet financial requirements. Potential flight opportunities have launch readiness around 2023/2024. The OCAPI program should be incorporated in a global geostationary virtual constellation (minimum of 3 satellites required positioned at coordinated locations with a common set of mission definition elements). IOCCG members indicated strong support for the proposal to ESA.

4.6 KIOST Update on GOCI and II Missions

Joo-Hyung Ryu provided an update on the geostationary GOCI mission, which is still quite stable after 6 years on orbit. The GOCI data processing software (GDPS) has been updated and shows improved results in R_{rs} matchp comparisons. Every year massive red/green/brown tides are detected with GOCI imagery (floating *Sargassum horneri*, outbreaks of harmful *C. polykrikoide*s). Several field campaigns and stationary observations were carried out for GOCI cal/val in the East/Japan Sea, including measurements from the ESOOB buoy. This year there are plans for an 18-day Korea-US joint field campaign (KORUS-OC).

The GOCI-II instrument will have 13 VIS/NIR bands for atmospheric correction, PFT identification and HAB detection. The reference local area (RLA) will be captured every hour (10 times/day) and the full disk (FD) once per day. GOCI-II should be ready for launch in 2019. The Integrated Data Processing System for GOCI-II aims to complete the whole process, from satellite data reception, to correction, processing and distribution, within 1 hour (GOCI currently takes 2 hours). The public sector will be relocated from Ansan to Busan in 2017.

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

5.1 Status of CEOS OCR-VC

Paula Bontempi provided an update on the OCR virtual constellation (VC) activities and actions. The VC coordinates the different activities of the space agencies and is currently co-chaired by Paula Bontempi (NASA), Paul DiGiacomo (NOAA) and Craig Donlon (ESA). The OCR-VC is moving forward with the Blue Planet implementation plan and IOCCG agencies are willing to contribute to all Blue Planet components. Furthermore, a water quality community of practise has been implemented, the agency mapping exercise has been completed and will be discussed at the CEOS SIT meeting in Frascati (April 2016), and Ewa Kwiatkowska has developed a formal relationship with the CEOS WGCV (they will review and endorse relevant IOCCG cal/val recommendations). Following the agency infrastructure mapping exercise, IOCCG will use agency *in situ* calibration and validation asset information to identify priority needs and gaps in infrastructure that agencies could collectively address, and will work with CEOS to address these in a collective manner. An example of the implementation of the INSITU-OCR beyond heritage capabilities includes NASA supporting three new projects (2014-2017) in the areas of the vicarious calibration instrumentation for future ocean colour missions, and ESA introducing the concept of Fiducial Reference Measurements (FRM) into its work for satellite calibration and validation. Additionally, all agencies will be asked to contribute towards the "protocols activity" (i.e., an open opportunity to share information regarding *in situ* instrumentation for calibration and validation protocols, led by NASA).

OCR-VC issues for CEOS Plenary include ready access to L0 or L1A data (an item of significant concern for the OCR-VC). CEOS-SIT, at the OCR-VC's request, sent out a letter in July 2015 to those agencies that (plan to) have ocean colour missions, requesting they consider distribution of Level 0 and Level 1A mission data. Formal replies were (only) received from ESA and NOAA (note that NASA already fulfills this requirement), and via email from CNES. The NOAA and CNES responses were in the affirmative regarding access to these data; ESA indicated there was no plan or resources to deliver these data – but there is pressing interest from the community

for this level of data. OCR-VC requested that this general issue be discussed during the CEOS Plenary to advance free, open, routine and timely data exchange of these data.

5.2 Task Force on ECV Assessment

David Antoine advised participants that he and Bryan Franz had been too busy to make any progress over past year, so there was nothing to report regarding the IOCCG task force on Essential Climate Variables. Various programs are generating these ECVs and the group intends to apply for grants to compare the different approaches, in order to develop the most consistent products.

5.3 Task Force on Satellite Sensor Calibration

Ewa Kwiatkowska provided an update on the IOCCG Task force on satellite sensor calibration. The task force was established following a recommendation from the INSITU-OCR White Paper and focuses on calibration needs specifically for ocean colour measurements. The task force has held splinter sessions at the biennial IOCS meetings and also held side-meetings at other large meetings, and encourages inter-agency collaboration. CEOS WGCV initially believed it was inappropriate to have a task group on satellite sensor calibration which is specific to an end application, since, in their view, calibration and validation are generic problems (especially pre-flight and on-board calibration). The IOCCG argument was that ocean colour requires highly stringent uncertainties which drive calibration requirements, design of instrumentation, and mission operations. The IOCCG task force works with unique issues and needs specific answers in time scales that are hard to achieve in more generic discussions. It was reconfirmed that the calibration task force will remain affiliated under IOCCG/OCR-VC. It was also agreed that the IOCCG task force will have a close relationship with CEOS WGCV, a permanent seat on WGCV, and a standing invitation to attend the plenaries. The next WGCV meeting will take place in Canberra Australia (14-18 March 2016). Nick Hardman-Mountford suggested that Thomas Schroeder from CSIRO could represent the ocean colour sensor calibration task force at this meeting. WGCV/IVOS also agreed to review IOCCG OCR-VC cal/val documentation including the INSITU-OCR White Paper and IOCCG Report 13, and they will prepare a formal response. WGCV/IVOS and the IOCCG Calibration Task Force will jointly develop concrete areas of cooperation. CEOS WGCV is planning a workshop on satellite sensor calibration and characterization (pre-launch and on-orbit) with participation from industry as well as agencies and cal/val experts (late 2016/early 2017) – the IOCCG calibration task force plans to attend.

5.4 *In situ* Protocols Coordination Activity

Paula Bontempi provided an update on the "*In situ* protocols coordination activity". There had been no progress over the past year as Jeremy Werdell is now Project Scientist for the PACE mission, but NASA can commit to re-initiating the activity this year. The goal is to form a standing committee to catalogue information related to *in situ* measurement protocols in order to reduce redundancies in efforts, collaboratively fill gaps, and target new opportunities to move the community forward. The committee would be composed of individuals with access to information about institutional activities and funding opportunities, not necessarily protocol practitioners. The IOCCG Web site could provide a clearinghouse of protocol information. Additional components of this group could include guidance on *in situ* data formats, standards for metadata and standardization of databases (beginning with SeaBASS).

The NASA OBB field program support office is undertaking an update of ocean optics protocols. The completed protocols documents should be released by Summer/Fall 2016 (particle absorbance, CDOM absorbance, *in situ* sensor absorbance-attenuation and backscatter protocols). There is also field work in support of the protocol activity.

5.5 Updating Measurement Protocols: Proposed IOCCG Technical Publication Series

Emmanuel Boss put forward a suggestion to produce an "IOCCG Technical Publication Series" to publish the protocols on the IOCCG website, by and for the international community, rather than being seen as "NASA protocols". Regular updates could be posted on-line. The Committee agreed that this was a perfect action for the IOCCG under INSITU-OCR, since the protocols group has a wide geographic distribution and is not perceived as being driven by NASA. The protocols could be peer-reviewed and should have a digital object identifier (DOI). One suggestion was that IOCCG should open up more to the community and advertise meetings to discuss these issues.

5.6 INSITU-OCR Mapping Exercise: Gap Analysis, Community AOP/IOP Processor

Stewart Bernard presented a recap of the INSITU-OCR model, which has been difficult to implement. The "agency mapping" exercise included consideration of available and planned international agency assets and resources for OCR cal/val. Agencies were requested to identify resources to support the INSITU-OCR, and IOCCG subsequently identified gaps in infrastructure that agencies could collectively address. Key items to focus on include development and assessment of satellite products (multi-water type processing, a new generation of PFT products etc.) plus *in situ* data generation and handling, including the NASA group effort on

protocols, the potential IOCCG protocol publications (see above) and developing a community processor for *in situ* data. A community processor would improve traceability by having centrally-curated instrument inventories and calibration data. Application of standardised processing and error calculations would reduce uncertainty. An ambitious AOP/IOP Community Processor would be an end-to-end processing and archiving system requiring substantial resources for scoping, development and dedicated ongoing operations. The benefits are traceability, uncertainty estimates, quality assurance and common formats for archiving, providing a substantial improvement in data quality and utility with little overhead for the community. A "lightweight" processor would have a community code base requiring moderate resources for scoping and development, with minimal ongoing maintenance, and would provide detailed best error estimates (and perhaps quality assurance). The general consensus was that it would be an extremely useful asset for the OC community to move forward. One of the main challenges is continuity over many years (long-term time series), and also community buy in. There was some discussion about the importance of articulating the benefits and the task at hand, and also the pros and cons of establishing, for example, an instrument pool.

Regarding INSITU-OCR, the highest priority for all agencies is to develop vicarious calibration infrastructure. This was highlighted as a critical need. Craig Donlon reported that ESA will run an open invitation workshop to discuss long term vicarious "adjustment" in Europe. Funding was also available for international participation – agency members were requested to submit a point of contact to Craig Donlon.

ACTION 21/3: *Craig Donlon to plan an open workshop on long term vicarious "adjustment". All agency members requested to submit a point of contact to Craig Donlon.*

The deliverable from the workshop will likely be a technical report - the workshop will establish the requirements for *in situ* measurements in support of vicarious calibration by consensus. Paul DiGiacomo suggested that sustained continuity of vicarious calibration also be discussed at the workshop. It would be useful to document what technology is required for calibration and validation and to reach consensus on a minimum set of requirements or priorities for calibration/validation. The joint vicarious calibration plan should come out of the ESA workshop, so there should be a basic consensus on way forward.

Ewa Kwiatkowska indicated that EUMETSAT might have some resources for an international OCR-VC project office. The vision is to have a full time project officer who could tackle issues such as sourcing funding and managing the envisioned OCR-VC activities, possibly starting with the development of a community processor, or helping to draft the requirements for a vicarious calibration strategy. It was agreed that since this is a community initiative, the IOCCG would

draft the terms of reference and scope for an international project office and circulate for review. NASA and NOAA would be willing to put in some funding as well. All agencies and members were requested to submit a shortlist of priorities to be addressed by the international OCR-VC project office (e.g., open access to *in situ* data) as well as their highest project office priorities.

ACTION 21/4: *All IOCCG Committee members to submit to the IOCCG Chair a shortlist of priorities to be addressed by the proposed international OCR-VC project office, as well as their highest project office priorities.*

5.7 Copernicus Marine Environment Monitoring Service

Rosalia Santoleri informed the committee about the Copernicus Marine Environment Monitoring Service (CMEMS) for ocean colour – the only marine service for Copernicus. CMEMS provides regular and systematic reference information on the physical state and dynamics of the ocean and marine ecosystems for the global ocean and the European regional seas. The system is operational and provides near real time products (daily, hourly), forecasts (2 - 10 days) and reanalysis (10 - 45 years). There are over 6000 registered users who access data every day. Within this framework is the Ocean Colour Thematic Assembly Center (OC-TAC). The OC-TAC operates the European ocean colour component within the CMEMS, bridging the gap between space agencies, and providing ocean colour data and added-value information not available from space agencies. The OC-TAC generates and delivers L3 and L4 NRT, DT, reprocessed products (REP – based on OC-CCI) and INDICES covering the CMEMS regions (global, Arctic, Baltic, North Atlantic, Mediterranean and Black Sea), plus a European Sea (EUR) product combining the individual regional products. CNR leads the OC-TAC which has 3 production units (ACRI, CNR, PML) and one dissemination unit (CNR). They also have a mandate to produce specific data for assimilation in bio-geochemical models (two models assimilate ocean colour data in NRT). Data quality information is provided to users by the Quality Information Document (QUID). Soon OLCI data will be ingested in NRT by the CMEMS OC-TAC to produce global daily L3 and L4 multi-sensor OC fields, as well as daily L3 global OC OLCI fields, and daily NRT L3 and L4 regional products for the European Seas. Quality control of NRT products is based on climatology. CMEMS also carries out cross-cutting activities such as training, communication and outreach.

6.0 International Ocean Colour Science Meeting 2017

6.1 Plans for 2017 IOCS meeting

Ewa Kwiatkowska presented the European proposal for the organization of the 2017 International Ocean Colour Science meeting, jointly submitted by EUMETSAT and ESA, with the support of the European Commission (Copernicus). The 2017 meeting will celebrate the beginning of the operational, sustained ocean colour data stream from the EC's Copernicus programme, from both Sentinel-2 and Sentinel-3 missions. The meeting will take place from 15 to 19 May 2017, in the Feira International Exhibition and Congress Centre (http://www.fil.pt) in Lisbon, Portugal with local support from Instituto Português do Mar e da Atmosfera (IPMA). IOCS-2017 can gain high visibility from local and national authorities. It was proposed to extend the meeting to 4 days to minimize the number of parallel sessions, and to accommodate extra programmes. The meeting will have the usual IOCS format with additional emphasis on Copernicus. The European contribution to the agenda will include an opening Key Note speech from a prominent European scientist, a half-day Copernicus plenary session, four breakout sessions plus a 1-day training session after the meeting. A scientific programme committee will be established and will include the usual broad international member participation plus one EC, two ESA and two EUMETSAT members. An organising committee (EUMETSAT, ESA, IOCCG and IPMA), will also be established with support from the team from the first IOCS meeting. Suggestions from previous meetings are to have fewer parallel sessions, more time for discussions in breakout sessions, shorter agency talks, and more time for poster sessions. One suggestion was that agencies should also provide display booths with additional information on their missions, as the agency talks were seen as being very important for IOCS.

Historically the IOCS meetings have not charged a registration fee to ensure that IOCS is perceived as a community building activity and an IOCCG service to the community, and not a conference. On the other hand, a registration fee will help boost meeting finances will to force commitment when people register. Coffee breaks, an icebreaker event and a gala dinner will be offered free of charge, but no lunches will be provided. The costs will be shared between EC, EUMETSAT, ESA and IOCCG - other sponsors are highly encouraged.

David Antoine pointed out that the logic of meeting was to have a working meeting with small focussed, parallel sessions. Small groups provide a better forum for discussion, and in principle these sessions should not be filled with talks, but should allow time for discussions. For the IOCS-2017 meeting there will be a limit on the number of sessions a person can chair (one session per person), the maximum number of talks per session (3 to 4 talks), and there will also be a template for the final deliverable. Session chairs must provide an abstract and a set of key

questions to be addressed. The talks will be overview-type talks, and the keynotes will provoke discussion at a general level. It was important that the IOCS-2017 meeting be seen as an IOCCG meeting (and not ESA/EUMETSAT meeting). The NASA OCRT meeting will also take place at IOCS-2017, as in previous years.

Breakout sessions should address big questions such as vicarious calibration, or ecological forecasting, to help progress our community. Session leaders will be encouraged to write a short background document (~1 page) and pose 3 questions related to the topic. A speaker could then address each question followed by a discussion. Several names were discussed as potential keynote speakers. It was also recommended that the 2019 IOCS meeting could be a hosted jointly by KIOST and JAXA, and be held in Japan.

6.2 IOCS-2017 Discussion

A range of potential topics for parallel breakout workshops at IOCS-2017 were discussed including marine forecasting and ocean colour/ecosystem modelling, merging different resolution data (e.g., Sentinel-3/2/Landsat), atmospheric correction of Landsat and S-2 for coastal areas, inland water sessions, PFTs (and validation), Sentinel-2 applications for water quality, biogeochemical Argo, carbon cycling, Earth observation and modelling/data assimilation, air-sea fluxes, new technology for ocean colour remote sensing (e.g., hyperspectral, polarisation), remote sensing in coastal waters (multi sensor), oil and gas, coral reefs and health, detecting regime shifts, biodiversity, and new *in situ* techniques for validation. Each proposal will require a short abstract plus a list of questions to be addressed. One recommendation was for each breakout workshop to have an introduction with a few key talks and then, if feasible, small groups can break out from within the session and came back at the end for a larger group discussion. This would be considered, depending on the availability of breakout rooms at the conference facility. It was agreed that the IOCCG should prepare a draft call for proposals for IOCS breakout workshops which can be circulated to the Committee for comment.

ACTION 21/5: *IOCCG Project Office to prepare a draft call for proposals for IOCS parallel workshops and circulate to Committee for comment.*

It was noted that the IOCS meeting should also serve the agencies so that they are aware of community recommendations regarding what they should invest in – most recommendations should advance the goals of the IOCCG.

7.0 Other Ocean Colour Related Initiatives

7.1 Australian Ocean Colour Activities

Nick Hardman-Mountford briefed the Committee on ocean colour activities in Australia. The Australian government has signed an agreement with the EC to provide a regional Copernicus data hub for the region. This will facilitate collaboration between Australia, Europe and inhabitants of the SE Asia-South Pacific region in exploitation of Earth observation data. Bio-optical data from the Integrated Marine Observing System (IMOS) is used for validation, and includes the Lucinda Jetty Coastal Observatory (LJCO). This facility, located at the end of a 6-km long jetty in Great Barrier Reef coastal waters, provides validation support for various ocean colour missions by acquiring continuous atmospheric and in-water optical measurements that are complemented with filtration analysis on a fortnightly basis. The site is currently the only AERONET-OC station in the southern hemisphere. Funding for the Observatory is likely to discontinue in June 2016. Letters of support for the facility are appreciated and should be directed to Thomas.Schroeder@csiro.au. Biogeochemical-Argo is also used for validation through a joint project with India. There are plans for a bio-optical cruise and float deployment in June 2016. David Antoine is funded to do bio-optics and ocean colour remote sensing in the southern ocean in support of OC validation and algorithm development. There will also be opportunities to take measurements on the Antarctic Circumpolar Expedition (ACE) from December 2016 to February 2017. Other proposed research voyages include the R/V Investigator in the frame of the International Indian Ocean Expedition 2 (IIOE-2) in 2018 and 2019. Other initiatives include the e-reefs marine water quality dashboard and routine monitoring of dredge plumes from space.

7.2 GloboLakes Update: Algorithm Assessment across a Range of Optical Water Types

Andrew Tyler provided an update of the U.K. GloboLakes program, which aims to develop an operational system for remote sensing of lakes, as well as understanding the ecological status of lakes around the world. The challenge is to derive water quality from space. GloboLakes is a consortium of researchers from 6 different UK universities/research institutes and includes EO scientists as well as lake ecologists, ecosystem modellers and statisticians. The group has collected water quality and temperature data for ~1,000 lakes globally. These lakes have a high diversity in lake optical properties and no single in-water algorithm will have global applicability - a dynamic selection of in-water algorithms is required. Research campaigns on UK and European lakes include inter-comparing biogeochemical algorithms as well as carrying out an inter-comparison of *in situ* radiometric measurements (effects of instruments, methods and

protocols on data comparability). The Limnades database has data from almost 1,500 lakes and radiometric data from ~4,000 stations, used for testing algorithms.

A series of clustering techniques has been used to cluster spectral characteristics, yielding 13 spectral clusters across the entire data set, ranging from very clear to highly turbid waters. The clusters have been used to test published algorithms which were then re-parameterised for each optical water type using the Limnades database. Re-tuning per cluster produces more accurate results than a standard algorithm. The four top performing algorithms are all based on the reflectance band ratio 708/665 nm, which is the optimal independent variable for describing Chla. The next step is to apply the same approach to MERIS match-up data to test atmospheric correction.

7.3 Biogeochemical Argo: Developments towards a Global Network

Emmanuel Boss discussed developments towards a global network of Bio-Argo floats, as discussed in Chapter 8 of IOCCG Report 11 (2011), as well as the goal of using floats for vicarious calibration of ocean colour sensors. In order to obtain accurate radiance measurements in space, the sensor system needs to be calibrated with Earth-based measurements. This is currently being done with MOBY and BOUSSOLE. It takes ~40 high quality matchups to set the gains at the appropriate accuracy, which took 2-3 years for SeaWiFS using MOBY data. Float-based sensors could potentially shorten this time, if uncertainties of float based measurements are small enough and are known. A global biogeochemical profiling Argo network would enable a widely distributed observing system. Floats and satellite ocean colour share key biogeochemical variables for matchups and validation i.e., Chla, b_{bp} (POC), Kd and CDOM. The benefits of such a coupled approach are that OC satellites only "see" 1/5 of the euphotic layer - profiling floats would bring the vertical dimension as well as observations under cloud cover or no light conditions, whereas remote sensing provides extrapolation to the global ocean. Planning for a biogeochemical Argo network has begun (first meeting in Villefranche, January 2016) and the draft implementation plan is being written. The target array size is ~1,000 floats, each equipped with O_2/pH/NO_3- chemical sensors, chlorophyll fluorescence, optical backscatter, and downwelling radiance sensors.

7.4 Supporting Coastal States in West Africa with Access to EO Data

Kwame Agyekum informed the Committee about supporting fisheries management in West Africa using Earth observation. MESA (Monitoring for Environment and Security in Africa) is designed to provide information and support decision-making/planning by enhancing access to, and exploitation of, relevant EO data. Around 3 million people are employed in the fishing

industry in the Gulf of Guinea. With the help of EUMETSAT, they are generating and disseminating products to 19 countries including Potential Fishing Zone (PFZ) maps overlaid with fishing vessel traffic, ocean colour and SST fronts, Mecator forecast products, monitoring and forecast of ocean conditions (waves, currents, altimetry, etc.). The PFZ service, when operational, will provide fisheries managers with information on fishing activities flagged to their country or in their territorial waters. It provides the probability of finding fish using the optimal range of environmental conditions for each species e.g., certain species are often associated with upwelling regions. Currently they are using SST and SSH but not ocean colour (too cloudy).

The monitoring and forecast service is designed for managers and fishermen to promote safe navigation at sea for the ~9,000 artisanal canoes and the 400 operational semi-industrial vessels. A daily bulletin of biological conditions at sea is generated and sent to fishermen via SMS. The tracks of fishing vessels can be monitored with ABSEA transponders. Currently the small fishing vessels (canoes) are being encouraged to install them.

8.0 Training and Capacity Building

8.1 Plans for 3rd IOCCG Summer Lecture Series

David Antoine outlined plans for the 3rd IOCCG Summer Lecture Series which will take place in Villefranche-sur-Mer from 18 - 31 July 2016. Around 15 distinguished lecturers will provide lectures on IOPs, AOPs, atmospheric correction etc. along with practical sessions. The LOV lab can only accommodate 20 students. The course will be sponsored by IOCCG, CNES, OCB, SCOR, EUMETSAT and the French Consortium. Emmanuel Boss pointed out that he would conduct the Ocean Optics class at the University of Maine next year, but they could only accept a limited number of foreign students, since the course is funded by NASA. Stephanie Dutkiewicz volunteered to serve on the evaluation committee to help select the final 20 students.

8.2 EUMETSAT Training Efforts

Ewa Kwiatkowska provided an overview of EUMETSAT's capacity building efforts. EUMETSAT is an operational space agency with a mandate in meteorological, climate and environmental data services with the objective to support the user community through user data services, forums, and help desk. EUMETSAT provides strategic support to Africa to ensure data access and help develop capacity to use the data. EUMETSAT is involved in several EU-Africa projects (PUMA, AMESD and MESA) and intends to extend the African support with ocean colour within the

Copernicus/EC framework. Some early achievements are DevCoCast (disseminates environmental added-value data, both *in situ* and satellite, from various sources in Africa), and the EAMNet projects (a network linking EO information providers, user networks and centres of excellence in Europe and Africa).

EUMETSAT offers a wide variety of training activities: classroom, online asynchronous, online synchronous (real-time). Christine Träger-Chatterjee is currently developing user training concepts for Copernicus Marine Data and will cooperate with IOCCG regarding training activities. They will hold a workshop entitled "Expert Exchange on EUMETSAT's Copernicus Marine Data Stream" as well as a Massive Open Online Course (MOOC). The workshop will take place at IOCD in Oostende, Belgium from 29 – 30 November 2016 and will promote the Copernicus Marine Data Stream (CMDS), focussing on ocean colour, SST and altimeter products. The workshop's goal is to identify users of the data, applications, and training needs of the user groups in order to specifically tailor the training activities. The information on the CMDS will be provided, as well as a chance to talk to product experts to identify product requirements for further development. IOCCG, GHRSST and OSTST will be invited to participate along with representatives of research institutes, government agencies etc. The workshop will be preceded by an online interaction to provide information about the CMDS and its products (geophysical variables, retrieval process, accuracy of the products, data format etc.). The subsequent face-to-face workshop in Oostende will include introductory talks as well as splinter groups on the various CMDS products with a focus on the potential applications and the associated needs to which EUMETSAT's training activities should be tailored.

The objectives of the MOOC are to increase awareness of the applications and impacts of Copernicus marine data. It will be a joint outreach/communication and training activity with CMEMS involvement. The free and open online course will take place in October 2016 (once L2 Sentinel-3 data are available) and will run for 5 weeks. The content will be developed by a service provider. Input from remote sensing experts and ocean scientists (including CMEMS) will be required. Craig Donlon provided a link for the ESA MOOC on "Monitoring Climate from Space" (futurelearn.com/courses/climate-from-space) as an example of how a MOOC can work.

8.3 Discussion on IOCCG Capacity Building Initiatives, Including Online Courses

Heidi Dierssen led a discussion on the way forward for IOCCG capacity building initiatives. There are two different types of MOOCS: 1) an interactive course with lectures (which can be recorded), homework, deadlines, often graded, and specific times when the students can engage with the lecturers and ask questions, generally free, but can be set up to get credits, and 2) a tutorial type course, similar to the ESA courses, where students go online and work at

their own pace, often doing small assignments. The latter might be easier to develop and may be a place to start. Craig Donlon pointed out that the MOOCS were very expensive to develop but could perhaps be done in partnership with an education establishment or through a university. The IOCCG turns away more than 120 students for each training course, so it would be good to offer them something else. It would also help with the Summer Lecture Series if the students could take the course beforehand and be graded.

Other ideas were to use the Ocean Optics work book as a resource, or the PowerPoints/videos from the Summer Lecture Series. Emmanuel Boss pointed out that hands-on training was also very important e.g., how to operate a radiometer. A YouTube video could be used to demonstrate - people revising the ocean optics protocols could be approached to prepare such online demonstration videos. Heidi Dierssen agreed to prepare a proposal/discussion points regarding online training courses.

ACTION 21/6: *Heidi Dierssen to prepare a proposal for IOCCG online training courses and circulate to Committee members for comment.*

9.0 Developing a New IOCCG Website

9.1 Status of New IOCCG Website

Venetia Stuart presented the outline of the new IOCCG website (available at http://ioccgdev.org/). Comments and suggestions were welcomed from the Committee. Everyone agreed that the current website requires updating. Issues to take into consideration included no moving images, ease of updating, incorporating phytoplankton in the background, ease of reading etc.

10.0 Agency Updates on New/ Emerging Initiatives (contd.)

10.1 CONAE: SABIA/Mar Mission

Robert Frouin provided an update of the status of the SABIA/Mar mission on behalf of Daniel Caruso who was unable to attend the meeting. The first mission concept was a Brazil/Argentina mission with two satellites (global 800 m resolution and coastal 200 m resolution) to obtain information for studies related to primary productivity of ocean and coastal ecosystems, the carbon cycle, marine habitats and management of fishery resources and water quality. Standard products will include normalised water leaving radiance, Chl-a, Kd(490), turbidity and

SST. The proposed 18 bands were reviewed, and feedback on band placement was requested, especially the spectral bands located at 705 and 710 nm (for vegetation-red edge and fluorescence baseline), and the 10 nm spectral band located at 765 nm (for aerosol altitude). Comments about which bands of the MAC should also have polarization capability were also welcome (this is only possible for 2 bands). Robert Frouin agreed to consolidate all comments and send them to David Caruso.

ACTION 21/7: *Comments requested on band placement of SABIA-Mar mission instruments. Robert Frouin to consolidate all comments and forward to David Caruso.*

Four cameras are required to cover the 18 spectral bands (VIS-NIR, NIR-SWIR, TIR and MAC). The global mission scenario system is designed to cover 120^{o} in latitude with VIS-NIR imaging during daylight. The regional scenario will cover South America (land) and its coastal regions during the day with TIR imaging at night. A Cooperation Agreement between CONAE and AEB (Brazil) was signed for the Preliminary Design Phase (Phase B) to be developed by the end of 2015, but because of budgetary constraints at AEB, Phase B is now being developed by CONAE alone, with a Mission PDR scheduled for April 2016. The initial roles and responsibilities have been modified accordingly, with the SABIA-Mar-1 satellite under CONAE responsibility and SABIA-Mar-2 under AEB, since the SABIA-Mar-1 satellite alone satisfies Argentina's needs (scheduled for launch late 2019). All data and products will be available through the web, free of charge. CONAE needs close international cooperation for cal/val. The instrument has an on board calibration system and lunar calibration.

10.2 Highlights of Chinese OC Missions

Xianqiang He provided highlights of the Chinese ocean colour missions. Over the next 10 years about 70 Earth observing satellites will be launched, including oceanic, meteorological and land & environment satellites. There are four series of Chinese ocean (HY) satellite missions including the HY-1 series for ocean colour (two satellites have been launched, HY-1B in 2007 but still in orbit), the HY-2 series for ocean dynamics, the HY-3 series for high spatial resolution ocean monitoring, and the HY-4 geostationary series (high temporal resolution). The Chinese ocean color and temperature scanner (COCTS) is the payload on HY-1A and -1B, which are experimental satellites with limited global observing capacity. HY-1C and -1D will be operational missions, probably launched in 2018 (morning and afternoon satellites). They will have global observing capacity and will be able to avoid sun glint. Each will carry three sensors: COCTS (10 bands), CZI (4 bands, wider swaths) and UICS (an ultraviolet imager for high turbidity waters). In turbid waters, water-leaving radiance in the UV may be negligible compared to that in the VIS

or NIR. The UV bands can be used to estimate aerosol scattering radiance instead of the traditional near-infrared bands.

The HY-4 series of geostationary satellites for ocean colour and SAR will be launched around 2020 to 2025. These satellites could be used, for example, to examine the diurnal variability and displacement of turbidity fronts and mapping of tidal currents. An information system of ocean satellites for monitoring CO_2 flux has also been developed. The Ocean Colour Remote Sensing group in Hangzhou expressed their desire to host another IOCCG meeting in Hangzhou.

10.3 JAXA: GCOM-C/SGLI New Developments

Taka Hirata provided an update on the JAXA GCOM-C/SGLI mission, on behalf of Hiroshi Murakami who was unable to attend the meeting. JAXA will launch GCOM-C in 2017. There will be three satellites in the series: GCOM-C, GCOM-C2 and GCOM-C3, all carrying the SGLI sensor with visible and NIR bands, and a polarization sensor with three angles and 1000 km swath. The spatial resolution is 250 m or 1-km (for polarisation). It will have a stable calibration with an on-board diffuser with monthly moon observation. Proto-flight tests of the GCOM-C satellite-system are on-going in JAXA Tsukuba Space Center. Radiometric tests have been carried out using integrating spheres to characterize the SGLI radiometric performances. Preliminary results of SNR meet the specification with some margin. Algorithms for most products have been developed through international collaboration. CDOM absorption will be a standard product with accuracy requirements. For research (evaluation) products e.g., PFTs, net primary production and red tide, the accuracy is not well defined.

Information was also presented on the JAXA geostationary meteorological satellite (GMS) series "Himawari-8". The data have been open to the public since 31 August 2015. SST, aerosol, PAR and ocean colour can be derived using GCOM-C algorithms. The Advanced Himawari Imager (AHI) has 1-km spatial resolution and a high frequency of measurements which show a good agreement with MODIS Chla in the summer (the SNR is lower in the winter due to a large solar zenith angle).

10.4 ISRO Update on OCM-2/OCM-3

David Antoine gave an update on Oceansat-3 and ocean colour applications in India on behalf of Prakash Chauhan who was unable to attend. Oceansat-1 was launched in 1999, Oceansat-2 in 2009 and now there are plans to launch the global Oceansat-3 mission in 2018, plus the geostationary GISAT mission in 2016/2017. Oceansat-2 is still operational after 6 years in orbit, and the OCM payload is working nominally. A wide range of ocean colour activities are being

undertaken in India, from scientific research to applications, especially those related to fisheries (e.g., using marine GIS for finding essential fish habitat). *In situ* data are being collected in collaboration with other national institutes and universities, and all measurements and analyses are done following standard ocean optics protocols. The Oceansat-3 mission will carry the OCM-3 instrument with 13 bands in the 400 - 1010 nm range, and two around 11 and 12 μm for SST. New bands are at 556 nm (for *Trichodesmium*/phycoerythrin detection), 681 and 710 nm (chlorophyll fluorescence) and 1010 nm (atmospheric correction over coastal waters). Questions regarding the mission can be relayed to Prakash Chauhan.

11.0 Organisation and Membership

11.1 Hosting IOCCG-22 in Perth 2017

Nick Hardman-Mountford presented a proposal to host the IOCCG-22 meeting in Perth, Australia. There were four potential venue options:

1. University of Western Australia - CSIRO is moving to the new Indian Ocean Marine Research Centre on campus. Conference facilities and accommodation available on site.
2. Fraser's Restaurant and Conference Facility, Kings Park - bushland park location, accommodation in West Perth / Perth City.
3. Cottesloe Beach - iconic beach location (hotel only has 13 rooms, but others nearby), range of cafes and restaurants, a little way out of the city (35 min from airport).
4. Rottnest Island – retreat location, not scoped (will add travel time).

The consensus was to hold the meeting in Cottesloe Beach from 7-9 February 2017. Nick would make further enquiries. Cara Wilson commented that outreach activities should be encouraged. It is important to talk to local people to teach them about ocean colour.

11.2 Proposals/Suggestions for Hosting IOCCG-23 (2018)

There was a suggestion for ESA and CNR to jointly host the next meeting, either at ESA in Frascati, or in Rome at the CNR Headquarters. The consensus was to hold the meeting in Rome in 2018.

11.3 Rotation of IOCCG Officers

Several IOCCG Committee members were scheduled to rotate off the committee. Suggestions for new members were requested. It was also necessary to nominate a new Chair since

Stewart would be stepping down at the end of the next meeting. The Committee was informed that Cara Wilson had been approached, and she had agreed to take over as Chair after the IOCCG-22 meeting.

Paul DiGiacomo also raised the issue of rotation of OCR-VC chairs (must be nominated from the agencies). Duties would include reporting to SIT, attending CEOS plenaries, and supporting WGIS and WGCV. Ewa Kwiatkowska indicated that she would be willing to step up as OCR-VC co-chair to elevate the status of ocean colour within EUMETSAT. Paula Bontempi agreed to step down.

10.4 Closing comments

Stewart Bernard thanked the participants for a very interesting and dynamic meeting, and for all the highly engaged contributions.

Actions – IOCCG-21 Committee Meeting

Santa Monica, CA, USA, 1-3 March, 2016

	Brief description	Status
21/1	IOCCG-21 participants to provide feedback on the draft water quality report to Paul DiGiacomo and Steve Greb by mid-April 2016.	Open
21/2	Paul DiGiacomo and Stewart Bernard to prepare a one-page scoping document on performing an economic assessment of the value of the ocean colour radiometry-virtual constellation, to be followed by further Executive evaluation of costs, benefits and any liabilities of publishing the full study.	Open
21/3	Craig Donlon to plan an open workshop on long term vicarious "adjustment". All agency members requested to submit a point of contact to Craig Donlon.	Open
21/4	All IOCCG Committee members to submit to the IOCCG Chair a shortlist of priorities to be addressed by the proposed international OCR-VC project office.	Open
21/5	IOCCG Project Office to prepare a draft call for proposals for IOCS parallel workshops and circulate to Committee for comment.	Closed
21/6	Heidi Dierssen to prepare a proposal for IOCCG online training courses and circulate to Committee members for comment.	Open
21/7	Comments requested on band placement of SABIA-Mar mission instruments. Robert Frouin to consolidate all comments and forward to David Caruso.	Closed

Appendix I: LIST OF PARTICIPANTS

Santa Monica, CA, USA (1-3 March, 2016)

IOCCG Members		**Affiliation**
Agyekum, Kwame	-	University of Ghana, Ghana
Antoine, David (Past-Chair)	-	LOV, Villefranche, France/ Curtin University, Australia
Bernard, Stewart (Chair)	-	CSIR, South Africa
Bontempi, Paula	-	NASA HQ, USA
Boss, Emmanuel	-	University of Maine, USA
Dierssen, Heidi	-	University of Connecticut Avery Point, USA
DiGiacomo, Paul	-	NOAA/NESDIS/STAR, USA
Donlon, Craig	-	ESA-ESTEC, Netherlands
Dutkiewicz, Stephanie	-	Massachusetts Institute of Technology, USA
Hardman-Mountford, Nick	-	CSIRO, Australia
He, Xianqiang	-	Second Institute of Oceanography, China
Hirata, Takafumi	-	Hokkaido University, Japan
Kwiatkowska, Ewa	-	EUMETSAT, EU, Germany
Loisel, Hubert	-	ULCO, France/Space Technology Inst., Vietnam
Ryu, Joo-Hyung	-	KIOST, Korea
Santoleri, Rosalia	-	ISAC-CNR, Italy
Stuart, Venetia	-	IOCCG Project Office, BIO, Canada
Tyler, Andrew	-	University of Stirling, UK
Wilson, Cara	-	NOAA/NMFS, USA
Yoder, James	-	Woods Hole Oceanographic Institution, USA
Zibordi, Giuseppe	-	Joint Research Centre, EU, Italy

Invited Participants		**Affiliation**
Carlier, Thierry	-	CNES, France
Frouin, Robert	-	Scripps Institution of Oceanography, USA
Greb, Steven	-	Wisconsin Department of Natural Resources, USA
Jamet, Cédric	-	Université du Littoral Côte d'Opale, France
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