IOCCG Annual Report to SCOR

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The International Ocean-Colour Co-ordinating Group (IOCCG) was established in 1996 to promote communication and co-operation between the space agencies and the ocean-colour user community. IOCCG is an Affiliated Program of SCOR, and an Associate member of CEOS (Committee on Earth Observation Satellites). The IOCCG has a wide-ranging mandate addressing technological and scientific issues through its scientific working groups and task forces, promoting capacity building through advanced training courses, and helping to ensure continuity and quality of the ocean-colour data stream though the CEOS Ocean Colour Radiometry-Virtual Constellation (OCR-VC) and Ocean Colour Radiometry-Implementation Team (OCR-IT). SCOR has been instrumental in helping the IOCCG secure funding from NASA for the IOCCG program, and also helps to support students from developing countries to attend IOCCG training courses and/or the International Ocean Colour Science (IOCS) meetings. The group is currently chaired by Cara Wilson (NOAA, USA), and the IOCCG Project Office is located at the Bedford Institute of Oceanography, Canada, staffed by Project Coordinator, Venetia Stuart.

1. IOCCG Scientific Working Groups

IOCCG scientific working groups are established to investigate various aspects of ocean colour science, technology and its applications. The working groups are relatively short-lived (2-4 years), and publish their findings in the IOCCG Report Series upon completion. Over the past year, two IOCCG scientific working groups have completed their deliberations and published their findings as IOCCG reports, and two other working groups are in various stages of completion.

The IOCCG Report Series all have an ISBN assignments as well as a digital object identifier (doi) provided by OceanBestPractises (OBP). Electronic versions of the reports are available through the IOCCG website, as well as the OBP Repository maintained by the International Oceanographic Data and Information Exchange (IODE) of UNESCO-IOC. Hardcopies are also mailed out free of charge. IOCCG reports are widely cited and are in high demand throughout the world, providing appropriate advice to space agencies, scientists and managers, as well as serving as a useful teaching aid for students. The two new IOCCG Reports, as well as the status of the two ongoing working groups are indicated below.

1.1 IOCCG Report 18 (2019). Uncertainties in Ocean Colour Remote Sensing, *e*dited by Frédéric Mélin (EC Joint Research Centre), published by the International Ocean Colour Coordinating Group, Dartmouth, Canada. http://dx.doi.org/10.25607/OBP-696IO

This report summarizes the state of knowledge on uncertainties related to ocean colour products and proposes recommendations to achieve progress on how uncertainties should be routinely quantified and distributed by the space agencies. A physical measurement is incomplete and meaningless unless accompanied by a statement of estimated uncertainty. Historically, ocean colour products have been distributed without estimates of uncertainty, and the community has had to rely on comparisons with *in situ* data to assess its products. This report reviews the various sources contributing to uncertainties in ocean colour data, from top-of-atmosphere (TOA) data to gridded products. It also describes how the uncertainties propagate through data processing, and proposes the best techniques to provide uncertainty estimates, as well as requirements for different applications of ocean colour data (e.g., numerical biogeochemical modeling, climate research, phenology studies, fisheries applications etc.).

The report also provides a series recommendations aimed at distributing fully documented uncertainty estimates and reducing the uncertainties associated with ocean colour products, with a final objective of ensuring traceability of ocean colour products to appropriate SI (International System of Units) standards. These include improving the statement of uncertainty requirements for missions or project deliverables, providing full documentation and source codes for the whole processing chain, and distribution of non-calibrated TOA data, amongst others. This report was recently printed by the EC Joint Research Centre (JRC) and will be distributed free of charge to all subscribers.

1.2 IOCCG Report 19 (2020). Synergy between Ocean Colour and Biogeochemical/Ecosystem Models, edited by Stephanie Dutkiewicz (MIT, USA), IOCCG Report Series, No. 19, International Ocean Colour Coordinating Group, Dartmouth, Canada. http://dx.doi.org/10.25607/OBP-711

The overall goal of this working group was to bridge the gap between the ocean colour community and the biogeochemical/climate numerical modelling communities by providing a better understanding of ocean colour products, the different types of models available, and the mismatches to model outputs. Models, *in situ* observations, and ocean colour products are different tools that can each be used to understand ecological and biogeochemical processes in the ocean. However, each provides a different "measurement" inhibiting straightforward inter-comparison.

Numerical modellers are frequent users of ocean colour products, but many modellers need better information about using satellite data. This report demonstrates that ocean colour products are uniquely important for model evaluation and data assimilation, and that models can also be useful for the ocean colour community by emphasizing the strength that can come from a more synergistic use of ocean colour and model products. Recommendations in the report encourage agencies to provide additional information alongside satellite products to help modellers make informed choices and interpretations. This report was recently printed by the Second Institute of Oceanography, China, and will be distributed free of charge to all subscribers.

1.3 IOCCG Working Group on Harmful Algal Blooms (Chair: Stewart Bernard, CSIR, South Africa).

Harmful algal blooms (HABs) and eutrophication events have had a significant global impact over the past few years. The frequency of these events, and the geographic extent of toxic/harmful algal blooms have been increasing globally. This joint working group between the IOCCG and the GlobalHAB programme of IOC-SCOR was established to produce a comprehensive guide to ocean colour remote sensing of HABs, summarising the state of knowledge and demonstrating the suitability of various ocean colour approaches through case studies from different ecosystems, as well as operational HAB applications. The primary focus areas are the technical difficulties of using ocean colour remote sensing in optically-complex coastal waters, and the need to understand the limitations of ocean colour for deriving phytoplankton community composition.

Recommendations form an important part of the report and include agency focussed sensor aspects (NIR bands, hyperspectral), as well as the importance of atmospheric correction. For intense blooms, Rayleigh-corrected reflectance can be used to determine Chl-a thus circumventing atmospheric correction problems associated with turbid waters and the correction of aerosol absorption. The group found that ocean colour remote sensing is effective in detecting high biomass blooms, but does not work well for low biomass blooms, so examples of indirect approaches are also shown. It is anticipated that the report will be published by the end of 2020.

1.4 IOCCG Working Group on "Evaluation of Atmospheric Correction over Turbid Waters" (Chair: Cédric Jamet, LOG, Wimereux, France).

Atmospheric correction is vital to obtain accurate ocean colour radiometry measurements, e.g., remote sensing reflectance. This process is more complicated in optically complex waters, especially turbid waters found in coastal environments. The goal of this working group is to provide an comprehensive evaluation of the most common atmospheric correction algorithms used over turbid waters, as well as to provide guidance to end-users on how and where to use specific atmospheric correction algorithms. A total of nine atmospheric correction algorithms are being evaluated using a simulated dataset for sensitivity studies.

This report is more technical than a traditional IOCCG report, so the IOCCG Committee suggested that it be published as an IOCCG Technical Report, as it deals primarily with methodology. It is anticipated that this report will be the first in the new "IOCCG Technical Report Series" and will likely be published this year, or early next year.

2.0 IOCCG Scientific Task Forces

In addition to the short-lived scientific working groups, the IOCCG also has a semi-permanent Task Force on *Satellite Sensor Calibration*, to help facilitate inter-agency collaboration on an ongoing basis. Under

this inter-agency framework, calibration experts from various space agencies meet regularly to exchange ideas, information and data.

The IOCCG also has plans to form another Task Force to bring together experts specializing in hyperspectral remote-sensing methods for aquatic ecosystems. This Task Force could provide clarity on ocean requirements and specifications to help determine where hyperspectral remote sensing offers serious quantitative advantages to multispectral remote sensing. It could also provide recommendations on how to develop global databases that merge hyperspectral optics and phytoplankton group composition to support the next generation of hyperspectral satellites for assessing phytoplankton biodiversity.

3.0 IOCCG Protocol Series

The IOCCG established the IOCCG Protocol Series to publish peer-reviewed Ocean Optics and Biogeochemistry Protocols online. *In situ* optical and biogeochemical in- and above-water measurements are critical for calibration and validation of satellite ocean colour radiometry data products, and for refinement of ocean colour algorithms. Over the past few years NASA and IOCCG have sponsored several international workshops with the aim of updating and developing new community consensus protocols for ocean colour sensor validation. These new protocols are posted on the IOCCG webpage for a period of time for testing, public comment and review, before they are accepted as international reference standards. Two new protocols were recently published by the IOCCG (see below) and are available on the IOCCG website.

3.1 **Protocols for Satellite Ocean Colour Data Validation: In Situ Optical Radiometry** (Vol. 3.0, December 2019)

This document provides protocols for the collection, processing and quality assurance of *in situ* measurements of the apparent optical properties of natural water for the validation of satellite radiometric products. In addition to a general introduction on Elements of Marine Optical Radiometry Data and Analysis, the document addresses Radiometer Specifications, Calibration and Characterization of Optical Radiometers, In-water Radiometry Measurements and Data Analysis, and Above-water Radiometry Measurements and Data Analysis. The protocols put emphasis only on measurements performed during clear sky conditions, which are most relevant for the validation of satellite ocean colour data products.

3.2 **Inherent Optical Property Measurements and Protocols: Best Practices for the Collection and Processing of Ship-Based Underway Flow-Through Optical Data** (Vol. 4.0, November 2019)

Optical data can be collected using the flow-through systems installed on research vessels and ships of opportunity taking advantage of the availability of seawater pumped into the vessel. These “in-line” or “underway” systems are able to provide data at spatial resolutions on the order of 10 to 100 m. As the number of research groups making these measurements grows, there is a need to provide coordinated

data collection and processing protocols to standardize methodology and data quality. This report discusses the essential issues associated with in-line data collection, provides recommendations on best practices for collection and processing data, and provides details on available software.

4.0 Capacity Building

4.1 Training Course in Hangzhou, China

In October 2019 the IOCCG coordinated an international ocean colour remote sensing training course in Hangzhou, China, in conjunction with EUMETSAT and the Second Institute of Oceanography, China. A total of 20 trainees from seven different countries participated in the course, which lasted for one week. The key objective of this training was to help early career scientists to download, analyze and visualize data from the EUMETSAT Copernicus Marine Data Stream (Sentinel-3 OLCI data) as well as the Chinese HY-1C ocean colour mission. Participants also learnt how to use the Marine Satellite Data Online Analysis Platform (SatCO2) for environmental monitoring and scientific research, including water quality monitoring, red tide detection, and marine carbon cycling/climate change investigations. SCOR sponsored the return airfare of four students (from Thailand, Indonesia, India and Bangladesh), which is greatly appreciated.

4.2 IOCCG Summer Lecture Series

The fifth IOCCG Summer Lecture Series is scheduled to take place at the Laboratoire d'Océanographie de Villefranche (LOV, France) from 22 June – 3 July 2020. The course will be dedicated to high-level training in bio-optics and ocean colour remote sensing, and will focus on current critical issues in ocean colour science. A total of 112 applications were received, the majority of which were of excellent quality, making for a very competitive field. The final 24 students selected come from 16 different countries, and represent 17 different nationalities. All students have been notified about the success of their applications, but in light of the COVID-19 pandemic, the IOCCG may have to cancel the course (the LOV lab is currently closed, and there are global travel restrictions). A final decision will be made on 29 May 2020, and all students will be informed of the situation. Should the course be cancelled, IOCCG will consider various options (conducting the course remotely with live on-line discussion sessions, finding another date when the lecturers are available etc.).

5.0 IOCCG Committee Meetings

The IOCCG Committee meets once a year to coordinate the activities of the group as a whole, discuss plans for the year ahead and review the progress of the various working groups. The Executive Committee also meets to approve the budget for the coming year. This year, the annual IOCCG-25 Committee meeting was scheduled to take place from 27–29 March 2020 in Tokyo, Japan hosted by the Japan Aerospace Exploration Agency (JAXA). Because of the COVID-19 pandemic, the meeting had to be cancelled. There are tentative plans to hold a small IOCCG Executive meeting in conjunction with the

Ocean Optics meeting in Virginia, USA (24-30 October 2020), as well as conducting several teleconferences with various groups to discuss pressing matters. The next full IOCCG Committee meeting is scheduled to take place in early February 2021.

6.0 IOCCG Membership (2020)

The IOCCG Committee consists of members drawn from space agencies as well as the scientific ocean-colour community. Rotation of members is being implemented according to a roster, but is currently the same as for 2019, due to cancellation of the Committee meeting. The IOCCG Executive Committee consists of all representatives from the sponsoring agencies, plus the IOCCG Chair and past-Chair.

Bernard, Stewart (past Chair)	-	CSIR, South Africa
Bontempi, Paula	-	NASA HQ, USA
Boss, Emmanuel	-	University of Maine, USA
Brando, Vittorio	-	CNR-ISMAR, Italy
Chauhan, Prakash	-	ISRO, India
Ciotti, Aurea	-	Universidade de São Paulo, Brazil
Devred, Emmanuel	-	Bedford Institute of Oceanography, Canada
Dogliotti, Ana	-	IAFE/CONICET, Argentina
Franz, Bryan	-	NASA GSFC, USA
Giardino, Claudia	-	CNR-IREA, Italy
Giugni, Laurent	-	CSA, Canada
He, Xianqiang	-	Second Institute of Oceanography, China
Hu, Chuanmin	-	University of South Florida, USA
Kampel, Milton	-	INPE, Brazil
Kim, Wonkook	-	Pusan National University, South Korea
Kwiatkowska, Ewa	-	EUMETSAT, EU, Germany
Lifermann, Anne	-	CNES, France
Loisel, Hubert	-	Université du Littoral, France
Malthus, Tim	-	CSIRO, Australia
Mélin, Frédéric	-	EU Joint Research Center, Italy
Murakami, Hiroshi	-	JAXA EORC, Japan
Rio, Marie-Hélène	-	ESA/ESRIN, Italy
Ryu, Joo-Hyung	-	KIOST, South Korea
Wang, Menghua	-	NOAA/NESDIS/STAR, USA
Wilson, Cara (Chair)	-	NOAA/NMFS, USA

7.0 IOCCG Sponsors

The IOCCG is sponsored and supported by contributions from various national space agencies and other

organisations listed below:

- Canadian Space Agency (CSA)
- Centre National d'Etudes Spatiales (CNES, France)
- Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia)
- Department of Fisheries and Oceans (Bedford Institute of Oceanography, Canada)
- European Space Agency (ESA)
- European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)
- National Institute for Space Research (INPE, Brazil)
- Indian Space Research Organisation (ISRO)
- Japan Aerospace Exploration Agency (JAXA),
- Joint Research Centre (JRC, EC)
- Korea Institute of Ocean Science and Technology (KIOST)
- National Aeronautics and Space Administration (NASA, USA)
- National Oceanic and Atmospheric Administration (NOAA, USA)
- Scientific Committee on Oceanic Research (SCOR)

The Bedford Institute of Oceanography (Canada) provides in-kind support, providing office space and informatics support, while SCOR provides infrastructure support to IOCCG and manages the NASA funds.

The affiliation to SCOR is critical for the IOCCG in that it provides an avenue for obtaining funding from US agencies such as NASA, which would be impossible without this affiliation. SCOR's support of students from developing countries to attend IOCCG training courses or the IOCS meetings is also gratefully acknowledged.