Overall Goal of IOCS Meetings

- To provide a forum for discussion on various topics and come up with recommendations/advice for IOCCG, the community and the space agencies
- To build and reinforce the voice of the global ocean colour community
- To promote international linkages amongst different communities
- To allow more people from the ocean colour community to be involved in IOCCG activities
- To help the IOCCG in its oversight role with respect to high-level discussions with space agencies

IOCS Meetings

- **2023 – Venue: USA/TBD**
- April 2019 – Busan, South Korea (~250 attendees from 29 different countries)
- May 2017 – Lisbon, Portugal (344 attendees from 41 different countries)
- June 2015 – San Francisco, USA (262 attendees from 29 different countries)
- May 2013 – Darmstadt, Germany (244 attendees from 36 different countries)

Next IOCS Meeting

- We want to restructure how we organize breakout sessions to generate recommendations. Considering setting up teams for breakout workshops community that would develop strawman recommendations *before* the meeting, which would be discussed and validated by the community at the meeting. This will require more pre-meeting planning.
- Two years is a relatively short timeframe for recommendations to change, and for the IOCCG, the community and the space agencies to uptake the recommendations.
- IOCCG will be transitioning to a new Coordinator with Venetia working part-time next year, moving towards retirement.
- Next IOCS meeting will be in 2023, probably somewhere in the USA.

IOCS-2019 Breakout Groups

- Open source scientific computing tools and resources
- Requirements for phytoplankton composition
- High temporal/spatial resolution applications
- Remote sensing of optically-complex and shallow waters
- Vicarious calibration and validation protocols
- Research to operations (R2O) applications
- Emerging new technologies for ocean colour research
- Satellite Sensor calibration
- Atmospheric correction under complex/extreme environments

By Thursday Evening

- One sentence on the ideal future capability and impact
- Three bullet points on key recommendations

By April 30th

- 1-2 page summery of breakout discussion
- List of key ***recommendations***

International Ocean Colour Science Meeting 2019

Advancing Global Ocean Colour Observations

Breakout Workshop #1

Scientific computing and the Open Source software revolution: how Ocean Colour Science can benefit

Co-chairs: Joaquín E. Chaves (NASA GSFC/SSAI), Erdem M. Karaköylü (NASA GSFC/SAIC), & Joel P. Scott (NASA GSFC/SAIC)

Summary: **'Open science' principles** and open source technologies are **promoting diversity, inclusion, & accessibility** to Ocean Colour Science, driving international collaboration, and encouraging transparency and reproducibility in research among the Ocean Colour Science community.

1. **Develop and publish a community 'open science' statement** to encourage making data, code, and software open and discoverable.
2. **Encourage international adoption of 'open science' policies and open source technologies** through existing training and education instances (e.g. – Ocean Optics class, EUMETSAT trainings, Cornell Ocean Satellite class, etc).
3. **Establish a code repository to exists as a live IOCCG report**, titled: Open Science Principles for Ocean Colour, to contain open source code and common Ocean Colour science workflows as a demo/place-to-start for learning open source technologies. (A workshop is recommended to set and define the scope of this repository.)

Breakout Group #2

Going beyond HPLC: Coming to rapid consensus on science requirements for assessing phytoplankton composition (PFT) from satellite imagery

Co-chairs: Astrid Bracher (AWI), Ryan Vandermeulen (NASA-GFSC), Stewart Bernard (CSIR)

Systematic analysis is needed to understand PFT signal across wide ranges of water types (biomass, IOP ranges) **using complete in-situ description of PFT and optimal IOPs,** including uncertainties, followed by an analogous RT study on the water leaving signal.

1. **Need for promoting, standardizing automated** imaging particle counters and flow cytometry to allow routine phytoplankton taxonomy resolving observations & key community metric products in addition to IOP, AOP & HPLC.
2. **Improve the translation of phytoplankton composition information from the different in-situ data source metrics into the IOP signal**, primarily through the use of IOP models.
3. **Enhance capabilities of phytoplankton composition IOP measurements** especially on the specific backscattering properties spectral slope, VSF, chi factors; recognizing shape/structure beyond sphere)

Breakout Group #3

High temporal and high spatial resolution applications

Co-Chairs: K. Turpie, W. Kim, A. Mannino, M. Tzortziou, C. Hu, Z-P Lee, A. Dekker, J. Ortiz, E. Hochberg, N. Pahlevan, J. Salisbury

- Science and end-user communities seeking high temporal, high spatial resolution, hyperspectral satellite observations (H4D, CEOS report, etc.). How is trade space resolved under current paradigm of ESA, NASA, and NOAA, that are focused on global missions?
- Given formal interactions with end-user groups, revisit time is the most critical aspect in the trade space. A constellation of ~ 30-m resolution sensors with Landsat-like radiometric performance and OLCI-like spectral coverage would serve a wide range of applications in inland and nearshore coastal waters.
- Inter-consistency in observations and products is challenging and require dedicated effort. We recommended that space agencies coordinate mission formulations, and pre-launch calibration to minimize potential difference in products.

Breakout Group #4

Remote sensing of optically complex and shallow waters

Expanded measurements and sharing (e.g., in situ Rrs in UV and NIR, VSF, hyperspectral b_b, highly-turbid, profiles, MLD, T, S‰, Lidar data, library of substrate reflectance and bottom depth, floating matters, etc.) are required for further understanding of all complex waters, and for algorithm development/refinement.

Co-Chairs: Zhongping Lee and Dirk Aurin

1. Complex waters are not restricted to coastal/inland/shallow waters; open-ocean waters are also complex.
2. Need to promote the application of IOPs, as it is the first-order inversion products from Rrs
3. Develop capacities, such as numerical tools for Lidar simulation or “super sites”, to obtain comprehensive and high-quality data to improve our understanding of “complex” waters.

Breakout Group #5

Vicarious Calibration and Validation Protocols

Co-chairs: Giuseppe Zibordi, Kenneth Voss, B. Carol Johnson

The goal of this session was to settle on a definition of protocols for constructing and analyzing matchup data bases for validation and system vicarious calibration (SVC).

1. While for some parameters there is agreement on how they should be defined protocols, there are several parameters for which there is either not a clear consensus. For example size of box (3x3, 5x5, 100x100) for satellite part of the matchup, and the permissible time lag between in-situ and satellite data, the number of SVC sites that are useful, and the qualities of those sites. Most likely these factors will depend on the situation so can't be defined.

2. It is not a settled subject so further work, and discussions in the community, are required to settle on a full definition of the protocol for both SVC and validation.

3. Documents will be circulated to try to achieve agreement on the parameters with the hope of settling the outstanding issues. We are thinking this would best be done as a white paper.

Breakout Group #6

Research to Operations (R2O) Applications

Where are the biggest gaps or obstacles in achieving fit-for-purpose OC data that meet the needs of operational users and how can we close these gaps and reduce obstacles?

Co-chairs: Veronica Lance (NOAA), Ewa Kwiatkowska (EUMETSAT)

1. **PRODUCTS**: Users want single consistent and stable product time series, long-term to NRT, merged from multiple instruments which are regionally adjusted to assure the highest quality, as well as anomaly products.

2. **TRAINING**: Need to actively engage with different type of users, provide on-line resources (guide for different applications e.g. fisheries, HABs, aquaculture), workshops, training, also opportunities for the OC community to engage with higher level users.

3. **IOCCG** could extend its tasks to lead the above activities to create a coordinated multi-agency approach and collaboration.

Breakout Group #7

Emerging New Technologies for ocean colour research

Co-chairs: Mike Twardowski, Griet Neukermans

Standardize VC for new radiometric platforms

- Individual global entities with emerging technology for radiometric systems for VC should all use “established (draft)” protocols of Zibordi and Voss.
- Need for International strategy for integration of all emerging technologies for VC of ocean colour satellites

Better spectral and angular scattering instrument and approaches

May need to consider a Centralized business-service model with complex technology that is emerging

CubeSat and pseudo-satellites for low-cost demonstration missions

Breakout Group #8

Ocean Color satellite sensor calibration

Chair: Gerhard Meister

This workshop provides a forum to exchange new approaches and recent results related to the calibration of ocean color satellite sensors, and provides the opportunity to discuss the focus of future calibration efforts.

1. (agencies): every mission should evaluate if lunar observations can be acquired at least infrequently (for gain corrections and straylight evaluation)

2. (agencies): every mission should evaluate if for a newly launched sensor, a tandem flight (preferably with a similarly or better calibrated sensor) is possible (a tandem flight is where one sensor follows the other in orbit closely) to evaluate calibration consistency

3. (agencies): the gain calibration trends should not contain discontinuities that are not clearly supported by calibration measurements (if erroneous discontinuities do occur, they should be replaced by continuous trends in a timely fashion)

Breakout Group #9

Atmospheric Correction under Complex/Extreme Environments

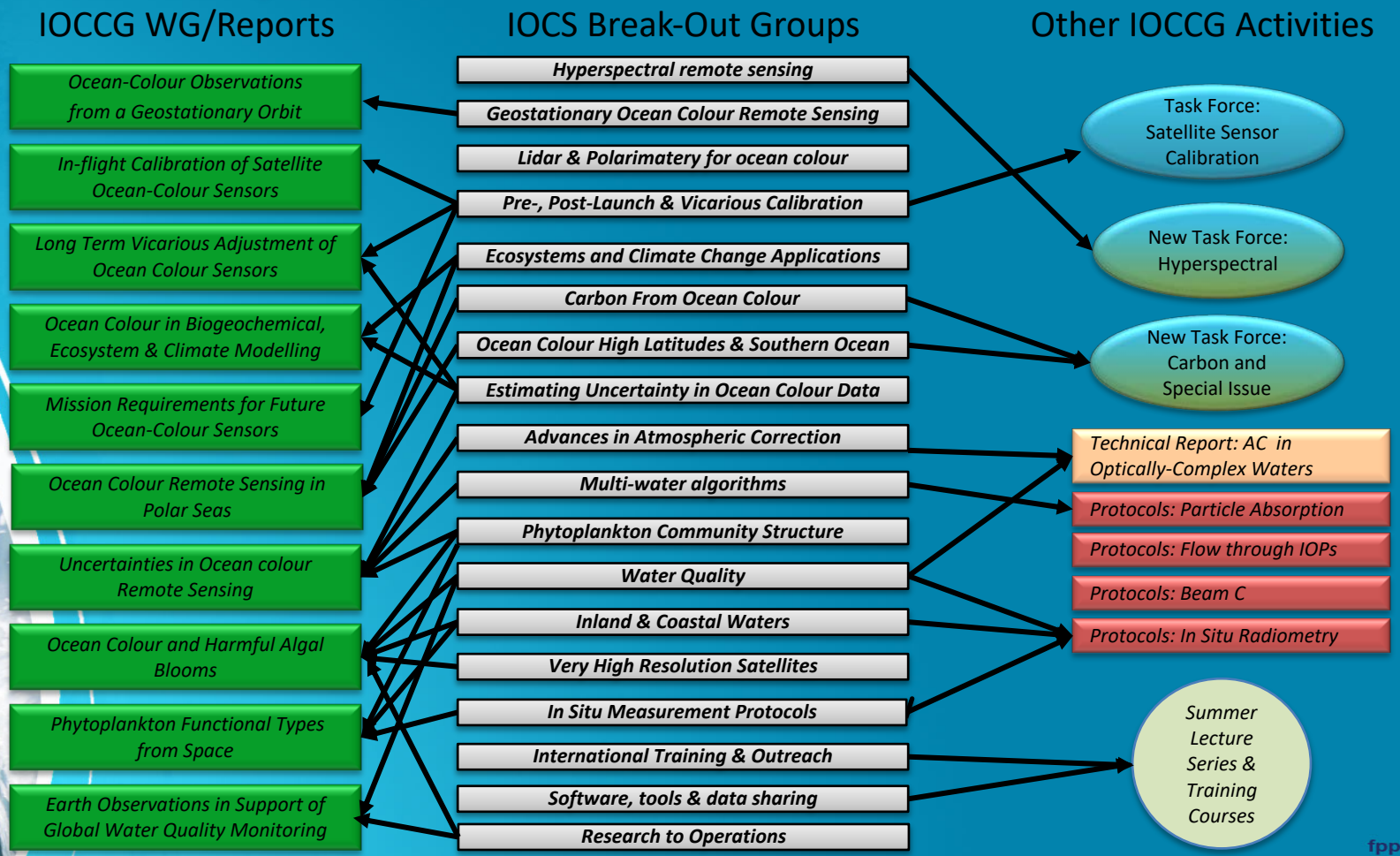
Chairs: Constant Mazeran, Amir Ibrahim, Robert Frouin

- Better understand the performance of existing algorithms with respect to their physical assumptions, modeling, and inversion techniques
- Encourage interdisciplinary collaboration between the modeling, atmospheric and the OC communities: numerical models, UV, LIDAR and multi-angle polarimetry to constrain the atmospheric correction
- Deriving uncertainties should be a requirement when developing algorithms. This includes characterizing the input L1b uncertainties.

2019 IOCS Breakout Recommendations IOCCG/Community Community Agency

BO1: Open Source Software 1. community 'open science' statement 2. Encourage adoption of 'open science' 3. Code repository	**BO2: PFT Requirements** 1. standardized IPCs & FC 2. improve PC data → IOP signal translation 3. enhance capabilities of PC IOP measurements	**BO3: High Temporal/Spatial Res** 1. A constellation of ~ 30-m resolution sensors 2. space agencies coordinate mission formulations to minimize differences
BO4: Optically-Complex & Shallow H_2Os 1. Promote the application of IOPs 2. Develop capacities, such as numerical tools for Lidar simulation or "super sites"	**BO5: Vicarious Cal/Val Protocols** 1. Define/Constrain protocols for satellite/in-situ match-up 2. Write white paper or Protocol Series	**BO6:R2O** 1. Products – global multi-water products 2. Training – community relevant 3. IOCCG Coordination of above
BO7: Emerging Technology 1. Standardize VC for new radiometric platforms 2. Better spectral and angular scattering instrument and approaches 3. CubeSat and pseudo-satellites	**BO8: Satellite Sensor Calibration** 1. Lunar observations 2. Fly in tandem flight 3. No discontinuities in gain calibration trends	**BO9: AC under Complex Environment** 1. Better understand performance of existing algorithms 2. Encourage interdisciplinary collaboration to constrain AC 3. Require deriving uncertainties when developing algorithms.

Relationship between IOCS break-outs and IOCCG activities



IOCS recommendations and agency/community take-up

IOCS Break-Out Groups

NASA: PACE and Earth Venture mission planning

EUMETSAT
- Copernicus Ocean Colour System Vicarious Calibration, e.g. FRM4SOC +
- OC-BPC approaches for the NIR-based clear water Atmospheric Correction
- Sentinel advances in phytoplankton fluorescence retrievals
- Spectral matching AC for Sentinel
- Sentinel IOP inversion in oceanic and inland surface waters
- Enhanced geostationary capabilities of MSG-3

CSA: Additional SWIR bands for COCI sensor

JAXA: GCOM-C Operational Applications

NOAA: CoastWatch implementation of IOCS 2013 R2O recommendations

Hyperspectral remote sensing

Geostationary Ocean Colour Remote Sensing

Lidar & Polarimatery for ocean colour

Pre-, Post-Launch & Vicarious Calibration

Ecosystems and Climate Change Applications

Carbon From Ocean Colour

Ocean Colour High Latitudes & Southern Ocean

Estimating Uncertainty in Ocean Colour Data

Advances in Atmospheric Correction

Multi-water algorithms

Phytoplankton Community Structure

Water Quality

Inland & Coastal Waters

Very High Resolution Satellites

In Situ Measurement Protocols

International Training & Outreach

Software, tools & data sharing

Research to Operations

Hyperspectral Task Force

KIOST: GOCI II mission planning

Carbon special issue

Carbon Task Force

ESA: CARBON + project

Additional satellite user training courses in Asia and Africa

New tools & processing capabilities for high resolution applications