Tuesday, November 14

2:30 - 5:00 **Breakout WS 1:** Beyond Chlorophyll-a

New trophic state indicators for optically complex waters

Chairs: Daniel Odermatt, Michael Sayers, Astrid Bracher

New remote sensing sensors and platforms, as well as improved understanding of observables such as phytoplankton fluorescence, are enabling new indicators for assessing trophic status or carbon fixation in aquatic environments. This includes, for example, the determination of primary production, different phytoplankton functional types, harmful algal blooms, carbon particle fractions, aggregated trophic mass or indirect estimates of nutrient availability. The specific potential uses, required methods, and reference data bases require clarification. By discussing these requirements, we aim to identify research priorities that can range from consensus protocols for fiducial measurements to robust algorithms for global applications.
With a brief introduction and three to four presentations, we hope to stimulate broad discussion of novel ecosystem indicators for optically complex waters that could complement established chlorophyll-a products. We will highlight the state-of-the-art and potential uses for each, but also address challenges and research gaps. The subsequent discussion will serve to identify research priorities regarding indicators as well as specific knowledge and data gaps.

Key questions:
• What potential trophic state indicators could complement or challenge the dominance of chlorophyll-a in satellite remote sensing?
• What is their technical feasibility and practical relevance in comparison to chlorophyll-a?
• What measures are required to verify their performance and advance their feasibility to global baseline products?

AGENDA

2:30 - 2:40 ***Introduction and goals***
(co-chair: D. Odermatt, Swiss Federal Institute of Aquatic Science and Technology, Eawag)

2:40 - 2:55 ***Quantitative indices and reporting products for tracking inland water algal bloom status and trends*** *(Caren Binding, Environment and Climate Change Canada)*

2:55 - 3:00 *Q&A*

3:00 - 3:15 ***Causal bloom research using EO satellites and hydrodynamic models***
(co-chair: D. Odermatt, Swiss Federal Institute of Aquatic Science)

3:15 - 3:20 *Q&A*

3:20 - 3:35 ***Remote Sensing Derived Primary Production Estimates for the World's Largest Lakes***
(co-chair: M. Sayers, Michigan Tech Research Institute)

3:35 - 3:40 *Q&A*

3:40 - 3:50 *Group discussion (co-chairs, all)*

3:50 - 4:00 *Coffee break*

4:00 - 4:15 ***Detection of phytoplankton groups in optically complex water: status, challenges and perspectives*** *(H. Xi, Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research)*

4:15 - 4:20 *Q&A*

4:20 - 4:35 ***Spatial and temporal changes in the presence of kelp forests: how can remote sensing help?***
(Maycira Costa, University of Victoria)

4:35 – 4:40 *Q&A*

4:40 - 5:00 *Summary and group discussion (co-chairs, all)*

Tuesday, November 14

2:30 - 5:00 **Breakout WS 2:** Remote sensing of aquatic litter and debris

Chairs: Madeline Cowell (Ball Aerospace) & Shungu Garaba (University of Oldenburg)

The breakout workshop will be coordinated and supported by the Task Force on Remote Sensing of Marine Litter and Debris. Discussion will be focussed on the state-of-the-art technology available for mapping and monitoring of floating and slightly submerged matter in all aquatic environments with a focus on anthropogenic waste as plastic litter, but considering also microalgae, sea snot, pollen, vegetation and other materials common in mixed accumulations. This will be presented from the angle of instrument technology, algorithms, datasets and applications. Interdisciplinary elements of the Task Force are going to be presented with the expected outcome of understanding end-user needs and capabilities of current remote sensing end-products relevant to monitoring aquatic litter. An expected outcome of the workshop is the identification of essential indicators that could be derived from operational remote sensing and would be relevant descriptors for the United Nations Sustainable Development Goals (e.g., Goal 6, Goal 14). The workshop will also highlight gap areas and recommend ways forward to better understand marine litter pollution using space-based technology and remote sensing in general.

Objectives:

- *Review results of the first two years of activities of the Task Force on Remote Sensing of Marine Litter & Debris (RSMLD).*
- *Consensus on future steps, including alignment of remote sensing products retrieved from Ocean Colour sensors and current in situ observations*
- *Considering the progress thus far, discuss, select priorities, and plan actions for the next 3 years.*

AGENDA

2:30 - 2:35 Introduction, motivation and goals of the session.

- Summarize milestones challenges and outlook
- Continue the conversation of next steps
- Promote engagement from the IOCS community

2:35 - 3:00 Status update from the IOCCG RSMLD Task Force

- What is and who are the IOCCG RSMLD Task Force
- Questions from the ESTEC Remote Sensing of Marine Litter (RSML) Workshop

3:00 - 3:45 Overview Talks (12 min talk, 2 min questions, 1 minute transition)

- Floating Matter overview – Shungu Garaba (Univ. Oldenburg)
- Technology Overview –Victor Martinez Vincente (PML)
- MARLISE Overview – Liesbeth De Keukelaere (VITO)

3:45 - 4:00 *Break + Open Discussion*

4:00 - 4:20 Outcomes of the ESTEC RSML Workshop Hosted Oct – Shungu and Maddie

- Summary from the questions posed at the workshop
- Next steps and actions

4:20 - 4:45 Panel Discussion + Open Discussion

- What is missing?
- Engage

4:45 - 5:00 Summary and Group Discussion

Tuesday, November 14

2:30 - 5:00 **Breakout WS 3:** Inventory of current ocean colour mission validation activities

Chairs: Lachlan McKinna (NASA GSFC/GO2Q), Jeremy Werdell (NASA Goddard Space Flight Center)

There are multiple international ocean color missions on-orbit and in-formulation (e.g., GCOM-C, Senitel-3A/B, VIIRS, PACE). Each mission has its own dedicated validation program to ascertain data product quality and provide confidence to the user community. Successful validation programs are key to ascertain if prescribed mission requirements are met. There are currently multiple validation programs run concurrently throughout the world with data stored in various data repositories.

As the collective international ocean color community has not met in-person for several years, this workshop aims to take an inventory of current validation activities to identify potential gaps/opportunities and learn how we might assist each other. For example, there may be measurements or instruments that some groups require that could be resolved by a collaboration. There are also a number of novel technologies, including hyperspectral sensors, and sampling strategies being deployed such as rapid sampling and in-water autonomous platforms. The data richness of these approaches lends themselves well to validation, however, the capabilities and benefits may not be broadly familiar.

In this workshop we are interested in taking stock of what activities are occurring in the near-term with a focus on biogeochemical measurements (e.g., HPLC, POC, PIC, Kd), apparent optical properties (AOPs, Kd), and inherent optical properties (IOPs). We hope to identify: (i) gaps in validation campaigns, (ii) geographic domains being sampled, (iii) new technologies, (iv) innovative sampling strategies, and (v) areas where we can collaborate and/or share resources to achieve collective objectives.

Key Questions

- *What is the current state of international validation programs?*
- *What current gaps and opportunities exist?*
- *Where can we collaborate/share resources for mutual benefit?*

AGENDA

2:30 - 2:45 Introduction and goals (McKinna, Werdell)

2:45 – 3:45 Survey of activities and needs by agency/organization (e.g., NASA, NOAA, ESA, EUMETSAT, CSIRO, JAXA, KOSC/KORDI, others)

3:45 – 4:00 Coffee break

4:00 – 5:00 QA and interactive discussion (moderated by McKinna, Werdell)

Wednesday, November 15

2:30 - 5:00 **Breakout WS 4:** Global carbon budget for the land to ocean aquatic continuum (LOAC) from remote sensing

Co-chairs: Hubert Loisel & Claudia Giardino

The assessment of the respective contributions of inland waters (streams, rivers and floodplains, lakes and reservoirs) and coastal waters (estuaries, marshes, mangroves, shelves) in the global carbon budget require a synergistic approach for these very complex and various environments, including in situ observations, models, and remote sensing. In this context, observations from satellite platforms play a central role, providing temporal and spatial coverage.

Objectives

• Identify the main advances and limitations in the satellite assessment of aquatic carbon over the inland and oceanic (coastal) waters
• Exchange on best practices from the two communities for the space retrieval of carbon related parameters
• Identify priority actions over the next decade for the monitoring of the carbon pools and fluxes for the land to ocean aquatic continuum (LOAC) from remote sensing.

Key questions

• Which components of the carbon cycle, with their degree of uncertainties, can (and cannot) be estimated from remote sensing for inland and coastal aquatic environments?
• What are the common or different challenges in the estimation of the carbon pools and fluxes for the land to ocean aquatic continuum from space?
• How do we merge community practices along the continuum across varied consistency between products, temporal dynamics and spatial scales?
• How can we address the vertical dimension (lidar, models, in situ observatories, etc)?

AGENDA

2:30 - 2:50 Introduction to the session (Hubert Loisel, Claudia Giardino)

2:50 - 3:00 Mapping lake carbon from space (Tiit Kutser)

3:00 - 3:10 Observe dissolved organic carbon in global lakes: current status and challenges (Dalin Jiang)

3:10 - 3:25 Current and future capabilities and challenges in quantifying DOC and POC concentrations, stocks and lateral fluxes across estuaries and coastal ocean waters (Antonio Mannino).

3:25 - 3:30 Coffee Break

3:30 - 5:00 Discussion

Wednesday, November 15

2:30 - 5:00 **Breakout WS 5:** The Value of Ocean Color for the Benefit of Society: status and change in water quality and ecosystems

Co-chairs: Merrie Beth Neely (GEO AquaWatch), Veronica Lance (NOAA), Emily Smail (GEO BluePlanet)

How do we enhance the value of ocean color to applications for the benefit of society? While the world's oceans are characterized by their relative inaccessibility, satellite observations provide both focused and synoptic views of this expansive realm. Though we are arguably data rich, a challenge still remains to ease the conceptualization and synthesis of data for the purposes of user accessibility and decision making. In this session, we explore how to leverage new capabilities in technology and algorithm development, while simultaneously working to help provide end-users with actionable knowledge, not simply data. In the age of open science, advanced institutional capacity should be exploited to maximize data accessibility, increase visualization, and create tools to better help our communities learn from and connect with data streams that impact their lives. We intend to probe the workshop participants for stories of successes and failures in this endeavor, and establish priorities for increasing the widespread usability of information derived from ocean color and associated synergistic measurements.

Objectives:
• Increasing the science community's awareness of state and local user needs and barriers to Earth Observations for water quality monitoring.
• To produce a refined set of recommendations to space (and companion) agencies for providing data, information and knowledge.

Key Questions
• What are the challenges and proven successes in understanding and exploiting ocean color for their applications and decision making (e.g., indicator products vs data products?)
• What do users expect for data interoperability, uncertainty reporting,
• What current gaps exist within user needs? (e.g., desires for cross-platform blended observational capabilities? desires of water quality managers?)

Deliverable(s): *List of ocean and/or water quality product requirementsdata needs to inform agencies for new satellite sensor technology on upcoming missions, or capacity building, or training needs, or product development.*

AGENDA

2:35 - 3:40 **Ocean Panel Discussion**
Juan Ignacio Gossn, EUMETSAT;

Emily Smail, GEO BluePlanet Executive Director;

Maria Tzortziou, Martin and Michele Cohen Endowed Professor of Environmental Sciences, Center for Discovery and Innovation, Lab: Earth & Atmospheric Science Dept. CUNY CREST, The City College of New York and the CUNY Graduate Center

Audience Q&A

3:40 - 3:45 *Break*

3:45 - 4:55 **Water Quality Panel Discussion**
Megan Hunnicutt, GIS Lead, Office of Agricultural Water Policy, FL Dept of Ag and Consumer Svcs;

Stacie Flood, South Florida Water Management District's Coastal Ecosystems Section;

Andrew Kamerosky, Applied Ecology, Inc consultant for Brevard County, FL

Audience Q&A

Wednesday, November 15

2:30 - 5:00 **Breakout WS 6:** Ocean Colour Satellite Sensor Calibration

Chair: Gerhard Meister (NASA)

This session is a meeting of the IOCCG Task Force on Ocean Colour Satellite Sensor Calibration. The Task Force is composed of Space Agency calibration and characterization experts. The Task Force presents recent advances and challenges in the pre-launch and on-orbit calibration of ocean colour satellite sensors. The task force focuses on the delivery of highly accurate top-of-atmosphere radiance (or reflectance) products based on direct instrument calibrations. To note, the application of system vicarious gains or water-leaving radiance specific issues are not within the scope of the Task Force. The session will be structured as follows: presentations by calibration experts (with a length of about 10-15 minutes) will be followed by discussion among all the session participants. We expect to have at least 5 presentations in this session. At the end of the session, we will reserve time to discuss future activities of the Task Force.

Objectives
One of the main objectives of this session will be the review of the results of the pre-launch calibration of the Ocean Color Instrument on the PACE mission, which is scheduled to launch early 2024. The other main objective will be calibration issues of current ocean colour satellite sensors such as GOCI-II, MODIS, OLCI, SGLI, and VIIRS. The third main objective of this session will be the development of new ocean colour satellite sensors, such as A-OLCI Next Generation, and the associated instrument design and calibration challenges as well as discussions around the new TSIS solar irradiance spectrum.

Thursday, November 16

2:30 - 5:00 **Breakout WS 7:** Priority list of marine biodiversity metrics to observe from space

Chairs: Victor, Martinez Vicente (PML), Frank Muller-Karger (U. South Florida), Alice Soccodato (EMBRC)

Essential Ocean Variables (EOVs) are a fundamental framework to develop time series and maps of interoperable physical, biological and ecological observations. From these, Essential Biodiversity Variables (EBV), which include specific indicators for different levels of the ecosystem, have been developed and are useful to inform policy and advance biodiversity and ecosystem research. There is an expectation that EOVs and EBVs can serve as indicators to measure progress toward sustainable development and biological diversity targets of international agreements (i.e. the Global Biodiversity Framework or GBF of the Convention on Biological Diversity, the Sustainable Development Goals, the UNFCCC). The UN Decade of Ocean Science for Sustainable Development (The Ocean Decade) is an opportunity to advance these observations. Marine Life 2030 is a Program of the Ocean Decade that helps highlight relevant indicator work. The aim of the workshop is to advance the use of remote sensing products to generate EOV and EBV products, and specifically to identify practical indicators to develop for national and international use.

Objectives:
- *Identify the remote sensing products relevant to generate EOV, EBV, and indicators*
- *To discuss and produce a preliminary ranked list of remote sensing products and requirements*
- *To highlight gaps and possible EOV/EBV that could be developed in the future*

Primary Aim of the session:
To identify indicators (at EBV, Essential Biodiversity Variables) that may be derived from ocean colour and ancillary measurements to address national and international management and science needs for marine biodiversity

Secondary aim:
Map the relevance of those indicators to high level policy
- *CBD Goals and Targets / 30x30 (Kunming-Montreal), connectivity, High Seas Treaty*
- *relevance to SDGs, Ocean Decade challenges*
- *relevance to carbon monitoring*

Output
A plan for a paper and the skeleton for it, summarizing the conclusions and recommendations from the workshop

AGENDA

2:30 - 2:45 Introduction to the session:
Common understanding of what are EOV, ECV, and EBV, and movement towards indicators (Frank Muller-Karger)

2:45 – 3:00 Phytoplankton EOV: EBV class community composition (Asrtid Bracher)

3:00 – 3:15 Various EOV: EBV class ecosystem structure (Maria Kavanaugh Oregon State U, Gabriel Reygondeau U. of British Columbia)

3:15 - 3:30 Seagrass cover and composition as an Essential Ocean Variable (EOV): Measurement and data management standards (Heidi Dierssen U. Connecticut)

3:45 - 4:00 Linkages with models to produce status/trends/forecast indicators (Camila Serra Pompei MIT)

4:00 - 4:45 Discussion

4:45 - 5:00 Summary and next steps (Chairs)

Thursday, November 16

2:30 - 5:00 **Breakout WS 8:** Achieving long-term consistency in cross-sensor ocean color data products

Co-Chairs: Brian Barnes, Frédéric Mélin, Kelsey Bisson

Detecting long-term trends in satellite observations, including those influenced by climate change, requires timescales typically much longer than that of an individual sensor or sensor series. While 'marathon' missions (lasting > 20 years; e.g., MODIS) may offer some ability to address long-term science questions, dedicated calibration activities are required to achieve and maintain ocean color radiometry (OCR) consistency, even for a single sensor. Substantial effort is required to ensure continuity of the multi-sensor ocean color record, and to reduce uncertainties when combining data across platforms. Indeed, numerous sensor-specific attributes (e.g., band placement and spatial resolution) and prevailing geometric characteristics (e.g., orbital elements and optical path geometries, with consequences on BRDF correction) may individually or synergistically contribute to cross-sensor discrepancies that show non-random spatial and temporal variations.

Consideration of these factors is required when merging data from disparate instrument series, as well as from sensors of the same series. Recently characterized seasonal biases in OCR datasets further complicate within- and cross-sensor consistency. Additionally, higher resolution sensors are increasingly becoming integral to monitoring of coastal and in-land aquatic systems, and present unique intercalibration challenges, while some thinking may be required to optimally relate upcoming hyperspectral data to the existing multi-spectral data records. When assessing cross-sensor consistency using co-located and coincident data from multiple sensors, tandem orbital phases provide the optimal conditions for determination of radiometric consistency, while intersecting orbits allow for more geometric-based continuity assessment. Cross-sensor continuity can also be investigated by comparing multiple satellite sensors to the same in situ dataset(s). In either case, such assessments require accounting for uncertainties of the satellite products (and in situ data).

In this breakout workshop, invited presentations will establish the current knowledge base and moderated discussions will explore cross-sensor continuity, including underlying causes for discrepancies, reporting best practices, potential remediation, and implications for our ability to address long-term science questions with OCR.

Objectives

• Solicit feedback from the ocean color community on existing knowledge gaps and their likely relative importance.
• Encourage prioritization of cross-sensor assessments and open publication of results accounting for sensor uncertainties.
• Stimulate the development of approaches to correct identified discrepancies.

Key Questions

• Which sensor attributes / geometry characteristics are most critical to address when combining data from different sources? How do identified seasonal biases in OCR datasets affect cross- sensor dataset consistency?
• To what extent do cross-sensor discrepancies diminish our ability to assess long-term (climate scale) issues? Are uncertainties associated with time series characterized enough to assess long-term issues?
• Should the community advocate for 'marathon' missions (i.e., 20+ year expected life), or can merged products sufficiently capture relevant climatic trends? What criteria should be required to consider a merged-sensor dataset capable of detecting long-term trends?

CALL FOR CONTRIBUTIONS

The chairs invite contributions from the ocean color community to enhance discussions within this workshop. Interested workshop participants are encouraged to submit a 1-slide presentation responding to any of the listed key questions.

*Please email responses to Brian Barnes (bbarnes4@usf.edu) by **12 November**.*

Thursday, November 16

2:30 - 5:00 **Breakout WS 9:** Lidar applications for ocean color

Co-chairs: Peng Chen (Second Institute of Oceanography), Davide Dionisi (CNR), Cédric Jamet (LOG/ULCO)

Active remote sensing of global ocean plankton properties presents a renewed opportunity for overcoming some of the major limitations of passive ocean color data that have challenged the community for decades. Passive remote sensing of ocean color observations has revolutionized our understanding of global plankton ecosystems and provide multi-spectral retrievals at many advantages: multiple wavelength bands, good spatial resolution (300-1000 meters) and on high repetitive cycles (~2 days). However, the ocean color signal is limited to the very near surface layer, provides no information on plankton vertical structure, is extremely limited in polar regions, suffers from cloud cover and absorbing aerosols, and provides no information on day-night changes in plankton properties. Active remote sensing can address some of these challenges and would provide an exceptional complement to passive observations.

This Breakout Session will only focus on Lidar (Light detection and ranging) as this active remote sensing technique can provide ocean retrievals under thin clouds, between holes in broken clouds, and throughout the polar annual cycle. Lidar measurements can also retrieve plankton vertical structure and information on day-night changes. In the last decade, lidar systems applied to ocean color have reached maturity thanks to field deployments of multiple airborne and in-situ sensors and to recent studies using lidar measurements from atmospheric satellite missions to obtain significant scientific results in the ocean color field. These advances make the transition to an ocean-optimized satellite system foreseeable in the next generation of missions.

Objectives
The goal of the breakout session is to showcase what has been done so far with lidar through examples of successes in the field and from airborne, in-situ and satellite active sensors and to discuss potential avenues for further advances for ocean applications. Additionally, the session will delve into the features that a future ocean-optimized Lidar should possess, such as blue laser, High-Spectral Resolution Lidar, among others. A main focus will be in the instrumentation part, on how to develop in-situ lidar for monitoring bio-optical biogeochemical parameters from ships.

Key Questions
- *How to get a 3D and diel observation of the ocean color?*
- *What are the currently available technologies and what are the potential technologies for the future?*
- *How can active measurements be used to validate and improve passive ocean color retrieval algorithms?*
- *What are the community requirements and willingness to use lidar techniques ?*

AGENDA

2:30 - 2:35 Introduction (Cédric Jamet)

2:35-2:50 Current international initiatives and collaborations (Cédric Jamet)

2:50 - 3:10 The CALIGOLA and PROTEO space-borne lidar missions (Davide Dionisi)

3:10 - 3:30 Overview of the ocean capabilities of the space-borne lidars: CALIOP and ATLAS (Yongxiang Hu, NASA Langley)

3:30 –3:50 Overview of the in-situ oceanic profiling lidar (Peng Chen/Dong Liu)

3:50 –4:45 Discussions

4:45 - 5:00 Wrap-up and Recommendations