Summary Recommendations from IOCS Splinter Sessions

Recommendations from the Splinter Session on Advances in Atmospheric Correction of Satellite Ocean Colour Imagery (Chairs: Robert Frouin, Sean Bailey and Cedric Jamet)

1. Cloud screening (small clouds, shadows) should be linked to atmospheric correction.
2. Absorption by hydrosols in the NIR needs to be determined for very turbid waters. Better bio-optical models are needed in the NIR.
3. Planned sensors should complement spectral measurements from UV to SWIR with multi-angular and multi-polarized instruments.
4. Efforts should be made by space agencies to make the new techniques more visible and accessible, e.g., via inter-comparison activities, implementation in SeaDAS etc.
5. Parallel processing lines with standard and improved schemes may help users understand advantages and limitations of individual techniques, define the quality of final products, and allow for continuity.
6. Synergy between instruments/missions should be considered, in particular OLCI (visible NIR) and SLSTR (SWIR) (1b or 1c co-registered).
7. New techniques suggest sensors should not saturate over Sun glint and clouds, and that it may not be necessary to tilt them, but strategy should keep continuity while allowing improvements based on gained knowledge.
8. Aerosol altitude is an essential variable to compute atmospheric effects at ocean colour wavelengths, especially in the presence of absorbing aerosols, and efforts should be made to determine this variable in future ocean colour missions. Measuring NO_2 is definitely needed to perform accurate atmospheric correction in the coastal zone.
9. Aerosol model determination (size distribution, index of refraction) is useful to at least constrain the ill-posed inverse ocean-colour problem, but errors may be too large to compute the perturbing signal with sufficient accuracy, i.e., it is desirable to estimate the perturbing signal more directly. Yet aerosol information is required for studies of aerosol/ocean interactions (e.g., iron fertilization).

Recommendations from the Splinter Session on Geostationary Ocean Colour Radiometry (Chairs: Antonio Mannino, Joo-Hyung Ryu and Kevin Ruddick)

1. Broader distribution and application of GOCI data is recommended to demonstrate the utility of geostationary ocean colour radiometry data.

2. Additional activities on geostationary ocean colour radiometry are needed to inform the IOCS community, other scientists, managers and public on the utility of such observations through:
   - sessions at future meetings (IOCS, Ocean Optics, AGU, EGU, etc.);
   - articles in various publications (IOCCG newsletter, EOS, peer-review articles, etc.)
3. More extensive discussions on geostationary ocean colour radiometry are required to:
   - address and consider solutions to issues of atmospheric correction and BRDF;
   - consider novel products and applications;
   - discuss how to engage users both on research and applications and;
   - discuss how the community can advocate for such missions.

Recommendations from the Splinter Session on Multi-Agency Data Sharing (Chair: Mark Higgins)

1. When using data from MERMAID (MERIS Matchup In-situ Database) in publications, the Principal Investigators of *in situ* data should always be contacted for approval, be offered co-authorship and acknowledged.
2. Collaboratively identify and resolve bottlenecks to free and open exchanges of source data and software (satellite and *in situ*).
3. Space agencies should continue the pursuit and support of international multi-agency collaborations.
4. Researchers should archive satellite data sets used in publications. The agencies are not responsible for keeping older versions once the data has been reprocessed.
5. The user community should get together to discuss standardisation of metadata.
6. Space agencies/data providers should commit to providing global Level-3 composites of ocean colour climate variables to facilitate sensor intercomparison and global biogeochemical modeling and research.

Recommendations from the Splinter Session on Operational Ocean Colour Data in Support of Research, Applications and Services (Chairs: Ewa Kwiatkowska and Stewart Bernard)

1. The quality of operational ocean colour data is of critical importance. Operational agencies should develop and maintain infrastructure and scientific and technical activities to ensure that the accuracy and long-term stability requirements are met globally and across regions.
2. Assure data continuity and sustainability of product delivery. Distribute NRT data as well as consistent long-term time series of ocean colour observations.
3. Produce and distribute Level-3 data.

4. Ensure that operational capabilities are achieved soon after launch and enable early data access to marine service and cal/val users, even if the data are not yet well calibrated.
5. Provide open source modular software that matches the operational processor and that can be run in batch mode on local user computers; preferably multi-mission software.
6. Provide all data online for downloading (instead of a limited rolling archive).
7. Expand the core product suite; keep algorithms state-of-the-art.
8. Consolidate ocean colour requirements for services, ecosystem and management applications.
9. Create a framework within which the wider international community can collaborate through permanent working groups on specific topics identified by the IOCCG/IOCS meeting and the stakeholder community.

Recommendations from the Splinter Session on In Situ Measurement Protocol Revision for Cal/Val (Chairs: Giulietta Fargion and Jean-Paul Huot)

1. *In situ* measurement protocols should not be revised by a single investigator but through an international community effort spanning multiple universities and space agencies e.g. under the IOCCG umbrella.
2. Some support for protocol development should be secured from various agencies (NASA, ESA, EUMESAT, etc.).
3. Participants agreed on the following workshops to revise the protocols (ranked highest to lowest) and possible workshop leads:
    - Inherent Optical Properties (IOPs): E. Boss, D. Röttgers (lab particle abs), N. Nelson (lab CDOM abs), M. Twardowski, E. Rehm (code) and other TBD;
    - Apparent Optical Properties (AOPs): G. Zibordi (not confirmed), K. Voss, E. Rehm (code) and others TBD;
    - Particle sizes: M. Twardowski and others;
    - Carbon stocks and rates: A. Mannino, H. Sosik, G. Mitchell (bacteria), B. Balch (PIC) and others;
    - Bio-fouling and deployment modes: no identified leads.

Recommendations from Splinter Session on International Training & Outreach (Chair: Mark Higgins)

1. More online / distance resources are required.
2. Training on software and tools to support use of VIIRS and OLCI data, as well as other new missions, is strongly recommended.

3. EUMETSAT's role in training may be best focused on the operational users and potentially those involved in the management / decision making processes.
4. Wikipedia can be used for outreach and information provision, to provide more information on ocean colour and ocean-colour training.
5. Outreach activities aimed at the policy/decision making level are also recommended.
6. In the future to explore the value, and practicalities of competencies and certification.

Recommendations from the Splinter Session on System Vicarious Calibration (Chairs: Giuseppe Zibordi and Jeremy Werdell)

1. The current VIS and NIR method for system vicarious calibration of satellite ocean color sensors, which rely on the vicarious calibration of VIS bands with respect to NIR bands with the application of highly accurate *in situ* VIS data, is considered a robust approach over clear waters and should be considered for the forthcoming missions.

2. The importance of involving National Reference Laboratories in the characterization of field radiometers and SI traceability of measurements is essential. Still, the evaluation of new *in situ* platforms (i.e., gliders, AWS, …), in addition to existing bio-optical buoys, is recommended.

3. The analysis of legacy constraints for *in situ* measurements and sites supporting system vicarious calibration suggests that spatial homogeneity of the measurement site(s) is an essential requirement. The constraint on the aerosol optical thickness lower than 0.1 in the visible could be likely "relaxed" as long as the atmospheric conditions are well characterized. It is additionally recommended that the availability of supplementary atmospheric measurements at the vicarious measurement site(s) (e.g., vertical characterizations of the atmospheric components) are of potential aid to system vicarious calibration.

4. The use of commercial systems to support system vicarious calibration imposes the generation of *in situ* traceable measurements through fully characterized hyperspectral systems. This requires comprehensive characterizations of commercial hyperspectral systems whose performances often need thorough verification.

5. The standardization of system vicarious calibration is a necessary strategy for the generation of CDRs from multiple satellite instruments. Current system vicarious calibration exercises involving NASA and ESA sensors appear to indicate that the lack of standardization between institutions (not only for the system vicarious calibration process) may lead to significant differences in derived satellite data products not compatible with the creation of CDRs from independent missions. However, standardization using current technologies should consider that forthcoming advanced

systems like PACE may benefit from additional measurement capabilities (e.g., polarization) with respect to current space sensors.

6. The short time available for the Splinter Session on System Vicarious Calibration has not provided the capability to comprehensively address all specific elements of relevance for the forthcoming satellite ocean color missions. It is then expected that results from the Splinter Session are the start for additional international actions aiming at detailing specific requirements and methods for System Vicarious Calibration of new missions like PACE and Sentinel-3.

Recommendations from the Splinter Session on Climate Variables and Long Term Trends (Chairs: Jim Yoder, Mark Dowell and Stephanie Dutkiewicz)

1. Calculation of uncertainties, including bias, in the time series of ocean-colour products is vitally important. Space agencies should ensure resources are made available to support these developments.
2. Interactions between climate modellers and ocean-colour scientists are essential to ensure that the ocean-colour time-series and models are appropriately used in describing and understanding the optical properties and signatures within the oceans.

Recommendations from the Splinter Session on Phytoplankton Community Structure from Ocean Colour (Chairs: Astrid Bracher and Taka Hirata)

1. Agencies should support PFT algorithm development, validation and intercomparisons as well as activities to merge different techniques and multi-mission data sets, in order to develop a new "standard product" of ocean colour.
2. The development of PFT methods (including radiative transfer modelling to hyperspectral data sets) should be supported with relevant *in situ* measurements from ships, gliders and buoys.
3. Simultaneous collection of *in situ* HPLC pigments, other PFT parameters which identify size, groups and functions (e.g. size-fractionated Chla, particle size distribution etc.) and optical data are essential for validating PFTs from current and upcoming satellite missions.
4. The validation of HPLC-PFT data sets should be supported by all agencies: a single method may not be globally applicable.
5. Optical and pigment methods used to discriminate PFTs should be linked for a better understanding of actual community structure using imaging flow cytometry and

genetics. Better methods to allocate cellular carbon across the PFT categories should be defined.

Recommendations from the Splinter Session on Satellite Data File Formats and Tools for Easy Science Exploitation (Chairs: Carsten Brockmann, Bryan Franz and Simon Elliot)

1. All space agencies should adopt the netCDF4/CF format for their ocean-colour data.
2. Space agencies should continue to support the existing line of data processing, analysis and exploitation tools (i.e. SeaDAS, BEAM and ODESA), and continue them for future sensors. This should include further development as well as training of users.
3. Space agencies should support large volume, batch data access and download (e.g., through established means such as ftp/http), as well as more targeted access through protocols such as THREDDS/OpenDAP.
4. Regarding data distribution, the ocean-colour community is requested to provide concrete and justified requirements to EUMETSAT so that the distribution of Sentinel 3 data through EUMETCAST can be properly dimensioned.

Recommendations from the Splinter Session on Satellite Instrument Pre- and Post-Launch Calibration (Chairs: Gerhard Meister and Bertrand Fougnie)

1. Calibration teams from each of the current and future ocean-colour sensor are encouraged to join the international collaborative effort GSICS (Global Space-based Intercalibration System) to help intercalibrate TOA radiances for different low Earth orbit sensors.
2. It is strongly recommended that a permanent calibration task force be established to share expertise and information on instrument calibration and characterization. It should be supported by space agencies and should have close interaction with the extended ocean-colour community. It could be established either under the CEOS-IVOS framework, or the IOCCG/INSITU-OCR.