International Network for Sensor InTercomparison and Uncertainty assessment for Ocean Colour Radiometry (INSITU-OCR)

working toward high accuracy and consistency of essential climate variables from multiple satellite ocean color missions

…a joint CEOS/IOCCG initiative…

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in collaboration with

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Background and Rationale

- The Ocean Color Radiometry - Virtual Constellation (OCR-VC), developed in the context of the Committee on Earth Observation Satellites (CEOS), aims at producing sustained data records of well calibrated and validated satellite ocean color radiometry to assess the impact of climate change in coastal and open sea waters.

- Within this framework, the *International Network for Sensor Inter-comparison and Uncertainty Assessment for Ocean Color Radiometry* (INSITU-OCR) initiative aims at integrating and rationalizing inter-agency efforts on satellite sensor inter-comparisons and uncertainty assessment for remote sensing products. Emphasis is placed on requirements addressing the generation of Ocean Color Essential Climate Variables (ECV) as proposed by the Global Climate Observing System (GCOS).

INSITU-OCR Evolution

- **January 2010**
  - *Proposal for an international SIMBIOS-like activity at IOCCG#15*
- **April 2010 – March 2011**
  - *Discussions and Side-Meetings including an introduction of INSITU-OCR to Space Agency Principles at the CEOS Plenary in Rio.*
- **November 2011**
  - *Working group formed*
- **February 2012**
  - *Workshop held at GSFC to draft the Report*
- **June 2012**
  - *White Paper*

INSITU-OCR White Paper

International Network for Sensor Inter-comparison and Uncertainty assessment for Ocean Color Radiometry (INSITU-OCR)

Working toward consistency and accuracy in the development of essential climate variables from multiple missions

Executive Summary

The Ocean Color Radiometry - Virtual Constellation (OCR-VC) developed in the context of the Committee on Earth Observation Satellites (CEOS), aims at producing sustained data records of well calibrated and validated satellite ocean color radiometry to assess the impact of climatic changes on coastal and open sea waters. Within this framework, the *International Network for Sensor Inter-comparison and Uncertainty Assessment for Ocean Color Radiometry* (INSITU-OCR) initiative aims at integrating and rationalizing inter-agency efforts on satellite sensor inter-comparisons and uncertainty assessment for remote sensing products with particular emphasis on requirements addressing the generation of Ocean Color Essential Climate Variables (ECV) as proposed by the Global Climate Observing System (GCOS). Under the guidance of the International Ocean Color Coordinating Group (IOCCG), representatives of Space Agencies and Institutions supporting INSITU-OCR agreed on a series of recommendations on activities critical to ensure high accuracy and consistency among products from present and future ocean color missions. Those recommendations, as consolidated here, call for thoughtful consideration by Space Agencies contributing to OCR-VC in view of achieving the final goal of developing consistent long-term Climate Data Records. Key recommendations address: i. space sensor radiometric calibration, characterization and temporal stability; ii. development and assessment of satellite products; iii. *in situ* data generation and handling; iv. information management and support. Special consideration is given to traceability, application and accessibility of the necessary *in situ* measurements, which are a fundamental element of any ocean color mission.

Agency Representatives

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Outcome

- Representatives of Space Agencies and Institutions supporting INSITU-OCR agreed on a series of recommendations on activities critical to ensure high accuracy and consistency among products from present and future ocean color missions.

- Recommendations fall under 4 categories:
  - *Space sensor radiometric calibration, characterization and temporal stability*
  - *Development and assessment of satellite products*
  - *In situ data generation and handling*
  - *Information management and support*

- These recommendations call for consideration by Space Agencies contributing to OCR-VC in view of achieving the final goal of producing consistent long-term Climate Data Records.

Calibration, characterization and temporal stability

- **Ensure comprehensive pre-launch sensor calibration & characterization**

  All satellite ocean color sensors should undergo a comprehensive pre-launch instrument calibration and characterization traceable to SI standards to ensure continuation of the current time-series of OC ECVs.

- **Provide open access to calibration and characterization data**

  Agencies should provide open access to the pre- and post-launch instrument calibration and characterization data for all ocean color sensors.

- **Establish a permanent working group on satellite sensor calibration**

  Experts from ocean color mission calibration teams should meet regularly to review calibration and characterization methodologies and results, cross-calibration studies, and address instrument issues.

- **Maintain at least one long-term vicarious calibration site**

  Maintain at least one long-term vicarious calibration site (but multiple sites are encouraged) with SI traceable radiometry pursuing the objective of producing and delivering highly accurate measurements collected under ideal measurement condition in a region representative of global ocean observations. Vicarious calibration should be reassessed whenever the instrument calibration or OCR retrieval algorithm is modified.

- **Support calibration teams**

  All agencies should consider that a fundamental requirement for the OCR-VC is to maintain support for the calibration team throughout the life of the mission.

- **Continuously assess and correct sensors degradation**

  All ocean color missions should have at least one suitable system to monitor the temporal degradation and episodic changes in sensitivity of the instrument. Additionally, Space Agencies should commit to support continuous assessment and correction for temporal changes in instrument radiometric performance, and to quantify uncertainty in the temporal calibration.

Development and Assessment of Satellite Products

- **Distribute calibrated and un-calibrated data**

  In addition to distribution of calibrated data (i.e., Level 1B), the Space Agencies should promote the distribution of un-calibrated data (e.g., Level-0 or Level-1A) and the sharing of tools necessary to apply the calibration and characterization information.

- **Support permanent working groups on algorithm topics**

  It is recommended that the Space Agencies support international working groups on OCR related algorithms and associated uncertainties. This is a fundamental step in view of achieving consensus on the most effective and consistent approach for multi-mission satellite application.

- **Enforce quantification of products uncertainties**

  Enforce quantification of uncertainties on a pixel-by-pixel basis in satellite OCR and derived products.

- **Promote the development of regional bio-optical algorithms**

  Promote programs for the development of regional bio-optical algorithms with emphasis on the definition of uncertainties and inter-regional merging of products. When existing data sets would not suit the purpose, new field programs should also be enforced for generating the required measurements.

- **Provide open access to source code for processing algorithms**

  It is recommended that the Space Agencies create the ability to process the data from their respective missions through a common set of algorithms and to make the source code for those algorithms open and available for review and implementation by others.

Development and Assessment of Satellite Products (cont.)

- **Establish and maintain long-term field measurement programs**

  Long-term measurement programs should be established and maintained beyond any individual mission. These should rely on consolidated instruments, calibration methods and measurement protocols. In situ data designated to support satellite ocean color validation programs should be globally and seasonally distributed, and cover a broad range of water types.

- **Encourage community validation protocols**

  The definition, implementation and application of common validation protocols should be strongly encouraged. This should translate into the construction of matchups using identical criteria as well as reporting results through identical statistical measures.

- **Generate Level-3 data products**

  It is recommended that Space Agencies produce data sets of global, binned (Level-3) OCR and derived products. The binning strategy and spatial/temporal resolution of these Level-3 ECV data sets should be identical, including the use of a unified naming convention.

- **Agree on inter-agency consistent ancillary data**

  It is recommended that the Space Agencies agree on the use of a consistent set of ancillary data sources for the production of ECVs from ocean color sensors.

In Situ Data

- **Improve traceability of *in situ* measurements**

  Funding agencies should enforce common calibration schemes and measurement protocols, and additionally unify processing schemes and quality assurance criteria to ensure consistency and traceability of in situ measurements to SI standards. Inter-comparison exercises should be considered as the means to enforce traceability by promoting state-of-art on instrument calibration, measurement methods, data processing, and quality assurance. Practical implementation of inter-comparisons may entail a series of round-robins on specific topics together with training opportunities.

- **Ensure continuous consolidation & update of measurement protocols**

  Measurement protocols should be consolidated as a result of a critical review and update of those currently documented in peer-review literature or already included in compilations produced by former programs. Consolidated protocols should then be published using modern communication methods.

- **Enforce the definition of uncertainty budgets**

  In situ data should be linked to uncertainty budgets determined in agreement with defined protocols and accounting for a comprehensive range of uncertainty sources. Ideally these uncertainty budgets should include contributions from calibration, processing, deployment restrictions, and environmental conditions.

- **Define and implement community quality assurance schemes**

  Define and implement quality assurance schemes for in situ data. These criteria should be specific for the different quantities and should take benefit of ancillary information provided with the data itself (e.g., cloud cover or sea state in the case of radiometric data), empirical thresholds, closure between inherent and apparent optical properties, models estimate.

In Situ Data (cont.)

- **Establish and maintain centralized repositories for *in situ* data**

  Centralized open access data repositories should be established, supported and maintained beyond any individual mission's life. Repositories should ideally have the capability of indexing data as a function of their fitness for specific applications (e.g., vicarious calibration, bio-optical modeling, and validation). Suitable mechanisms should be put in place to warrant data submission (e.g., requesting timely data delivery for field data produced within the framework of measurement programs funded by Space Agencies, or creating benefits like full processing and quality assurance of submitted data, or, where appropriate, convincingly recommending authors exploiting archived data to contact contributors and offer co-authorship).

- **Design and implement community processors for *in situ* data**

  Design, implement and apply community consensus processors for in situ data. This development should proceed through incremental steps, for instance by initially creating open access libraries and requesting manufacturers to adopt common (or user definable) data formats.

- **Agree on priority variables to be collected**

  A list of variables considered essential for satellite ocean color applications should be defined and considered with high priority by any field program.

- **Establish general coordination mechanisms for field campaigns**

  Establish a coordination mechanism to allow for a continuous exchange of information on forthcoming field activities to create opportunities for collaboration including instrument exchange, field training, inter-comparisons. The coordination should be instrumental in ensuring the collection of prioritized in situ variables meeting the basic needs for satellite ocean color applications.

Information Management and Support

- **Ensure accessibility and distribution of large data volumes**

  The entire archive of satellite data products should be freely and easily accessible in a timely manner. Space Agencies should enter into data sharing agreements so that the source data for all missions are provided to their partner Agencies as means of facilitating inter-mission comparisons, to provide mirror sites for improved user access to the data and to act as a data-loss risk reduction mechanism.

- **Establish processing capabilities for calibration & validation activities**

  Establish appropriately scaled processing system architectures and computer infrastructures to support substantial reprocessing for calibration and validation analyses, in addition to operational processing and regular re-processing.

- **Ensure accessibility to documentation**

  A minimum set of documentation on missions/data products should be made available. This should include documentation on the implementation of the instrument characterization and calibration and associated pre- and post-launch data, the relative spectral response functions for the instrument bands, and the derivation and validation of Ocean Color ECV algorithms.

- **Establish common data formats**

  It is recommended that a common data format be agreed upon for the storage of the satellite data produced by all Space Agencies. A good example is netCDF with CF compliant metadata. At a minimum, tools should be provided by the Space Agencies to allow users the ability to easily read the files – whatever the format.

- **Provide support for open source data processing and visualization**

  Space Agencies should support the development and distribution of open-source data processing and visualization software, including the source code used in the generation of mission Ocean Color ECVs.

Concluding Remarks

- The INSITU-OCR White Paper provides recommendations relevant to the production of long time-series of consistent and accurate Ocean Color Essential Climate Variables (ECVs) from multi-mission satellite ocean color data, in view of creating Climate Data Records (CDR).

- These recommendations are mostly addressed to Space Agencies contributing to the Ocean Color Radiometer – Virtual Constellation (OCR-VC).

- The range and complexity of activities required to thoroughly address the proposed recommendations entail an efficient coordination of inter-agency contributions (….. options include a central coordinating office with the main function of facilitating communication and merging information, and dedicated hands-on working groups to actively address specific issues).

Thank you!