

**TERMS OF REFERENCE FOR THE CEOS
OCEAN COLOR RADIOMETRY VIRTUAL CONSTELLATION**

VERSION 1.0

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CONSTELLATION NAME: Ocean Color Radiometry Virtual Constellation (OCR-VC)

MISSION STATEMENT & OBJECTIVES

The OCR-VC exists to sustain a systematic capability to provide essential observations of ocean color radiometry from space in support of research, applications and services across all relevant spatial and temporal scales through international scientific and programmatic coordination.

Key scientific and societal *goals* supported by the OCR-VC include:

- understanding and predicting synoptic states and information for the global and coastal ocean related to biological, ecological and biogeochemical processes;
- monitoring and managing global and coastal (regional) water quality, living marine resources and other crucial ecosystem goods and services,
- understanding and predicting the impacts and feedbacks of climate variability and change on ocean biology, ecology, and chemistry.

The OCR-VC addresses the following *strategic objectives* towards these goals:

- Work to assure long-term continuity of OCR data through CEOS agency cooperation;
- Facilitate timely and easy access to OCR data, products and information;
- Foster best quality OCR data sets through international collaboration and coordination, scientific innovation, and rigor;
- Promote data harmonization through community standards and best practices;
- Support the next generation of satellite OCR practitioners and users, via outreach, capacity building and training activities;
- Advance development and use of OCR data and products for research, applications and services, satisfying and/or complementing key GEOSS, GCOS and GOOS requirements;
- Maintain a strong and mutually supportive relationship with relevant scientific bodies, in particular the International Ocean Colour Coordinating Group (IOCCG).

CHARACTERISATION OF THE MEASUREMENTS AND DATA COLLECTIONS WITHIN SCOPE

The OCR-VC includes a large number of satellite-derived geophysical properties within its scope. These include spectral remote sensing reflectances and radiances, concentrations of phytoplankton chlorophyll *a* and total suspended matter, diffuse attenuation coefficients for downward irradiance, inherent optical properties such as particle backscattering and absorption by colored dissolved organic matter, primary productivity, phytoplankton functional types, instantaneous and daily photosynthetically active radiation, and particulate inorganic carbon, among others.

As addressed further below, these remote sensing measurements are complemented by diverse in situ measurements for calibration/validation, quality control, and to provide more comprehensive geophysical information and context. In terms of data access, the primary repositories for data from space-based missions are presently defined and maintained by individual agencies, with

some in situ databases maintained for broader community use (e.g., SeaBASS: SeaWiFS Bio-optical Archive and Storage System).

CHARACTERISATION OF THE SPACE SEGMENT CONCERNED

The core missions that are presently the priority for coordination efforts by the OCR-VC include:

Current Priority: Nimbus-7 (CZCS, 1978-1986); ADEOS (OCTS, 1996-1997); OrbView-2 (SeaWiFS 1997-2010); Envisat (MERIS, 2002-2012); Aqua (MODIS, 2002-present); ADEOS-II (GLI, 2002-2003); COMS (GOCI, 2010-present); Suomi NPP (VIIRS, 2011-present)

Future Priority: Sentinel-3 series (OLCI); GCOM-C series (SGLI); GEO-KOMPSAT-2B (GOCI-II); JPSS series (VIIRS); PACE (OCI).

Data from other past, present and future missions are aimed for inclusion in the OCR-VC core space segment: IRS-P4 (OCM), Oceansat-2/3 (OCM-2/3), SABIA/Mar, COCTS and CZI (HY-1C/1D).

Toward this goal, the OCR-VC awaits full and timely data availability from these missions, calibration/validation information, and community quality assessment.

Efforts are underway to develop consistent time-series and merged ocean color data sets from the above missions, along with determination of uncertainties/error characterization. Assimilation of OCR data into forecast models is likewise an emerging focus.

The majority of the above missions relate to a visible to near-infrared discrete band set of global measurements of ocean color radiometry. These satellite observations are also completed by a suite of related *in situ* measurements for OCR calibration/validation as addressed further below. Further, OCR-VC activities will benefit from CEOS coordination across a much broader range of satellite missions, instruments and measurements, particularly for sea-surface temperature (SST), various meteorological (e.g., wind, pressure, water vapor) and ozone measurements used as ancillary inputs, as well as synoptic scatterometer, synthetic aperture radar et al. measurements.

ACTIVITIES, OUTCOMES, AND DELIVERABLES

1. Implementation of ocean color minimum mission requirements for global polar-orbiting sensors and data harmonization: Global ocean color data are being collected or are planned to be collected and openly distributed by historical, current, and planned ocean color missions as above. To enable a seamless multi-mission time series mandatory for most research, applications and services, including Essential Climate Variables (ECVs) as identified by GCOS, the IOCCG has established a minimum set of observational (instrument and mission) requirements for planned ocean color sensors (IOCCG Report #13, *Mission Requirements for Future Ocean-Colour Sensors*, 2012). A near-term deliverable in this regard is the review and assessment by CEOS agencies of existing & planned OCR missions relative to these requirements; the long-term goal is their consistent, uniform implementation.

2. Coordination for geostationary ocean color missions and facilitating coastal ecosystem research, applications and services using OCR data: Building on another recent OCR report (i.e., IOCCG Report #12, *Ocean-Colour Observations from a Geostationary Orbit*, 2012), the OCR-VC is working to facilitate and ultimately harmonize geostationary ocean color observations as well, although a full geostationary constellation will not be realized for the foreseeable future. In the interim, efforts will be made to improve quality and facilitate broader use of OCR data for coastal ecosystem research, applications and services, with best practices

demonstrated, and supporting GOOS and GEOSS requirements. An emerging thrust is in the area of remote sensing of coastal and inland water quality, with a working group in this area recently proposed to the IOCCG and awaiting implementation in 2014, with associated development of a GEO Water Quality Community of Practice, also anticipated in 2014.

3. Implementation of the INSITU-OCR: The OCR-VCs efforts will be supported by an essential, foundational initiative entitled **INSITU-OCR** (*International Network for Sensor InTercomparison and Uncertainty assessment for Ocean Colour Radiometry*). The INSITU-OCR initiative is working toward the development, validation and maintenance of consistent and accurate Ocean Color Radiometry data products from multiple missions, taking full advantage of existing OCR and other related activities (ECV et al.) within CEOS agencies and across the broader community (INSITU-OCR White Paper, 2012). This initiative also supports a multi-agency network consisting of sea-based measurements for use in space-based sensor system vicarious calibration, data product validation, and algorithm development. The INSITU-OCR represents a crucial need, as OCR-VC objectives cannot be realized without this essential (and non space-based) component. Near-term outcomes and actions are clearly articulated in the conclusions and recommendations of the white paper and need not be repeated here. One key near-term item under discussion by the IOCCG and OCR-VC member agencies is implementation of a core multi-agency INSITU-OCR office.

4. Implementation and coordination of an Ocean Color Radiometry satellite sensor calibration permanent task force: The IOCCG and the OCR-VC are exploring joint implementation of a standing task force to address technical issues of OCR sensor calibration, interfacing with WGCV/IVOS. Establishment of this satellite sensor calibration task force is a recommendation of the INSITU-OCR initiative and it follows an initial proposal submitted to IOCCG in 2013. The immediate action required is to identify the final terms of reference, membership et al. for this group, working toward its implementation in 2014 in coordination with, and sponsorship by, the appropriate parties.

5. Support for implementation of the GEO Blue Planet Task. Ocean color radiometry data, products and derived information represent primary inputs to the GEO Blue Planet task. In particular, OCR-VC output will specifically contribute to the following Blue Planet Components as identified in the revised Blue Planet Task White Paper (November 2013): Sustained Ocean Observations (e.g., OCR ECVs); Sustained Ecosystems and Food Security (e.g., ChloroGIN, harmful algal blooms); Ocean Forecasting (e.g., GOVST-MEAP Task Team); Services for the Coastal Zone (e.g., water quality monitoring service); Ocean Carbon and Climate (ECVs); and, Developing Capacity and Social Awareness (ChloroGIN). An OCR-VC action plan will be generated addressing the corresponding ocean color components in the updated blue Planet Task Plan.

	3-year horizon	5-years or more horizon
Space Segment	<ul style="list-style-type: none"> ▪ Develop a plan for essential OCR-VC space segment (polar and geo) that can meet OCR-VC goals and user and science requirements. The 2016 constellation will have several core elements in place, satisfying many user requirements (e.g., NPP, Sentinel-3, GCOM-C in orbit); key gaps will still exist however. 	<ul style="list-style-type: none"> • At least three geostationary ocean color sensors/missions on-orbit or approved for launch • Next generation polar ocean colour missions on launch horizon (e.g., with hyperspectral capabilities)
Ground Segment & Information Systems	<ul style="list-style-type: none"> • Make freely available and accessible in a timely manner historical, current and future OCR mission data from all CEOS member agencies. • Develop a catalogue of cal/val infrastructure and activities to help in cal/val planning, to identify risks and the needs for advancement, and to promote agency collaboration. • Update cal/val strategies et al. for operational missions, and associated support needs for coastal/inland applications & services. 	<ul style="list-style-type: none"> • Establish integrated, coordinated community access to all OCR sensor data and products (historical and future) through common, standardized distribution portals. • Develop new and improved cal/val strategies and capabilities for next generation (polar/geo) missions.
Products & Services	<ul style="list-style-type: none"> • Assure best quality global data sets in support of GCOS requirement for Ocean Colour ECVs as well as other applications and services (e.g. water leaving radiances; chlorophyll-a). • Fully implement the INSITU-OCR. • Promote broader use of OCR data in existing systems supporting marine/coastal ecosystem research, applications & services. Develop best practices for water quality and marine resource monitoring (supporting GOOS and GEOSS). 	<ul style="list-style-type: none"> • Agree on data harmonization in support of GCOS requirement for an Ocean Colour ECV and ECV continuity as well as for operational applications and services (e.g., water leaving radiances; chlorophyll-a). • Facilitate new & improved products (including OCR-derived proxies, indicators and merged products); new applications and services developed and implemented operationally (supporting GOOS and GEOSS requirements).

IMPLEMENTATION AND COORDINATION ISSUES TO BE ADDRESSED BY SIT:

A number of compelling issues to address in the context of the OCR-VC have been identified in community reports and other publications (e.g., IOCCG, GCOS, GOOS, GEOS). In this context, achievement of the OCR-VC objectives requires the following implementation and coordination issues be addressed by SIT:

1. SIT encouragement for CEOS agency implementation of the IOCCG Report 13 will be critical to the success of the OCR-VC and future OCR continuity and user engagement.

2. SIT endorsement for the formulation of a Water Quality Community of Practice, and subsequent development of a pathfinder activity for a global coastal and inland water quality monitoring service, to be developed under the auspices of GEO/GEOSS.
3. SIT encouragement for CEOS agency participation and support toward implementation of the INSITU-OCR.
4. CEOS agency endorsement of sensor calibration approaches advocated by OCR-VC.
5. SIT endorsement for the OCR-VC action plan to be generated addressing the ocean color components in the updated GEO Blue Planet Task Plan.
6. CEOS agency adoption of free, easy and timely access to and sharing of calibrated OCR data, as well as uncalibrated Level-0 or Level-1A data, calibration information and source/processing codes.
7. SIT encouragement for CEOS agency participation and support for sustained projects for calibration and validation of OCR data, and merging of OCR data across satellite sensors with determination of uncertainties/errors and SI traceability.

SCHEDULE:

Activity	Milestone	Target Date
Ocean color mission minimum requirements implementation and data harmonization	All CEOS agencies (as appropriate) respond to IOCCG Report #13 recommendations	May 2014
Facilitate coastal ecosystem research, applications, services using OCR data	Implementation of GEO Water Quality Community of Practice (WQ-COP)	July 2014
Implementation of the INSITU-OCR	Establish coordinating INSITU-OCR office	May 2015
Facilitate OCR sensor calibration	OCR sensor calibration task force initiated	September 2014
Support for implementation of the GEO Blue Planet Task	OCR-VC action plan for GEO Blue Planet components delivered	September 2014

MEMBERSHIP AND LEADERSHIP

Current Co-Leads are:

- NASA, Paula Bontempi (paula.bontempi@nasa.gov)
- NOAA, Paul DiGiacomo (Paul.DiGiacomo@noaa.gov)
- ESA, Peter Regner (Peter.Regner@esa.int)

This leadership group is supported by the IOCCG Chair (currently David Antoine), the IOCCG Executive Scientist (Venetia Stuart), and the other scientific and executive committee members of the IOCCG. The following CEOS agencies are actively involved in the OCR-VC:

- CNES, Juliette Lambin (Juliette.Lambin@cnes.fr)
- CSA, Yves Crevier (Yves.Crevier@asc-csa.gc.ca)
- EUMETSAT, Ewa Kwiatkowska (Ewa.Kwiatkowska@eumetsat.int)
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- KARI/KIOST, Joo-Hyung Ryu (jhryu@kiost.ac)

In addition, it is expected that other members of the research, applied and management communities will frequently participate in OCR-VC activities and support the constellation's projects, activities and implementation efforts.

RESOURCES:

The OCR-VC leverages existing IOCCG activities and contributions by IOCCG member agencies, and more generally leverages additional resources provided by these and other CEOS member agencies in support of diverse research, climate and user engagement activities.