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

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IOCCG Report 13: Mission Requirements for Future Ocean-Colour Sensors

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IOCCG Report of "In-flight Calibration of Satellite Ocean-Colour Sensors

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Section R1.4 Vicarious calibration

(from INSITU-OCR White Paper)

Current target for absolute calibration uncertainty of satellite ocean color sensors is 0.5%. This stringent value is justified by the high accuracy requirements established for utilizing satellite ocean color products in climate and operational investigations. Such a level of accuracy can be achieved with vicarious calibration: the adjustment of pre-launch calibration coefficients using top-of-atmosphere (TOA) radiance predicted from *in situ* measurements through modeling of atmospheric radiative processes. The objective of vicarious calibration is the minimization of combined uncertainties resulting from satellite absolute pre-launch calibration and from the specific models/algorithms applied for determining primary radiometric products (e.g., normalized water-leaving radiance spectra) from TOA radiance. Vicarious calibration should be performed using *in situ* radiometry ideally performed with dedicated systems (e.g., MOBY- or BOUSSOLE-like) ensuring a high degree of accuracy and with full traceability to SI standards. The vicarious calibration site should be selected in a region where variability and complexity of the atmospheric and oceanic optical properties are low, to minimize additional sources of error due to temporal and spatial sampling differences between the satellite observation and the in situ measurement. Multiple vicarious calibration sites may offer additional information and alternative sources of data, however, these sites should be equivalent in terms of measurement accuracy, traceability and observation conditions (e.g., different complexities of the atmosphere might lead to inaccurate determinations of the aerosol type and consequently to the determination of substantially different adjustment factors for the pre-launch calibration coefficients).

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Recommendation (from INSITU-OCR white paper)

• Maintain at least one long-term vicarious calibration site with SI traceable radiometry pursuing the objective of producing and delivering highly accurate measurements collected under ideal measurement condition (e.g., spatial homogeneity, known aerosol and marine optical properties) in a region representative of global ocean observations.

• Multiple sites are encouraged, but their equivalence in performance is fundamental. It is essential that a rigorous metrology be established at each measurement site in view of assuring measurement traceability.

• Because of this, inter-comparisons of each relevant component of the vicarious calibration process should be encouraged and differences thoroughly investigated. Within such a context the adoption of a commonly agreed vicarious calibration approach, supported by sharing of processing modules, would enhance inter-mission consistency of radiometric products.

• Vicarious calibration should be reassessed whenever the instrument calibration or OCR retrieval algorithm is modified, and uncertainties on the derived gains should also be reported to support the determination of OCR uncertainties.

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• Instruments that provide **hyperspectral** water-leaving radiance spectra (e.g., MOBY) can be used for deriving water-leaving radiance data accounting for the effect of sensor spectral responses (in-band and out-of-band). Such data can be used for vicarious calibration for all satellite ocean color sensors, as radiance values for the specific band-passes the ocean color sensors can be obtained.

• The uncertainty of the *in situ* measurements is an important aspect of the vicarious calibration. The MOBY has provided uncertainties on the order of ~3%, BOUSSOLE about 6%. Uncertainties below **5%** are required to meet the ambitious goals outlined in this report.

• For the NIR bands, an additional set of assumptions are employed. The satellite data is not compared to *in situ* radiance measurements, rather regions are selected where the assumption of negligible water-leaving radiances in the NIR can be made and there exists a high degree of fidelity in the knowledge about the actual (or typical) atmospheric (i.e., aerosols) constituents.

• In order to achieve high accuracy in VC gains (~0.1%), the determination of the vicarious coefficients must be made carefully, avoiding measurements where instrument or algorithm uncertainties are high (e.g., data affected by straylight; geometries with high polarization sensitivity, etc.). In addition, it is important to have a sufficient number of samples. Given these constraints, the creation and operation of a vicarious calibration data facility is a resource intensive task. It is important that any ocean color mission has a well-defined strategy for obtaining the *in situ* data necessary for vicarious calibration.

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