Fiducial Reference Measurements for Satellite Ocean Colour

FRM4SOC

https://frm4soc.org

04. October 2018, NPL, Teddington

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Fiducial Reference Measurements

- the suite of independent ground measurements
- that provide the maximum scientific utility/return on investment for a satellite mission
- by delivering, to users, the required confidence in data products,
- in the form of independent validation results and satellite measurement uncertainty estimation,
- over the duration of the mission.

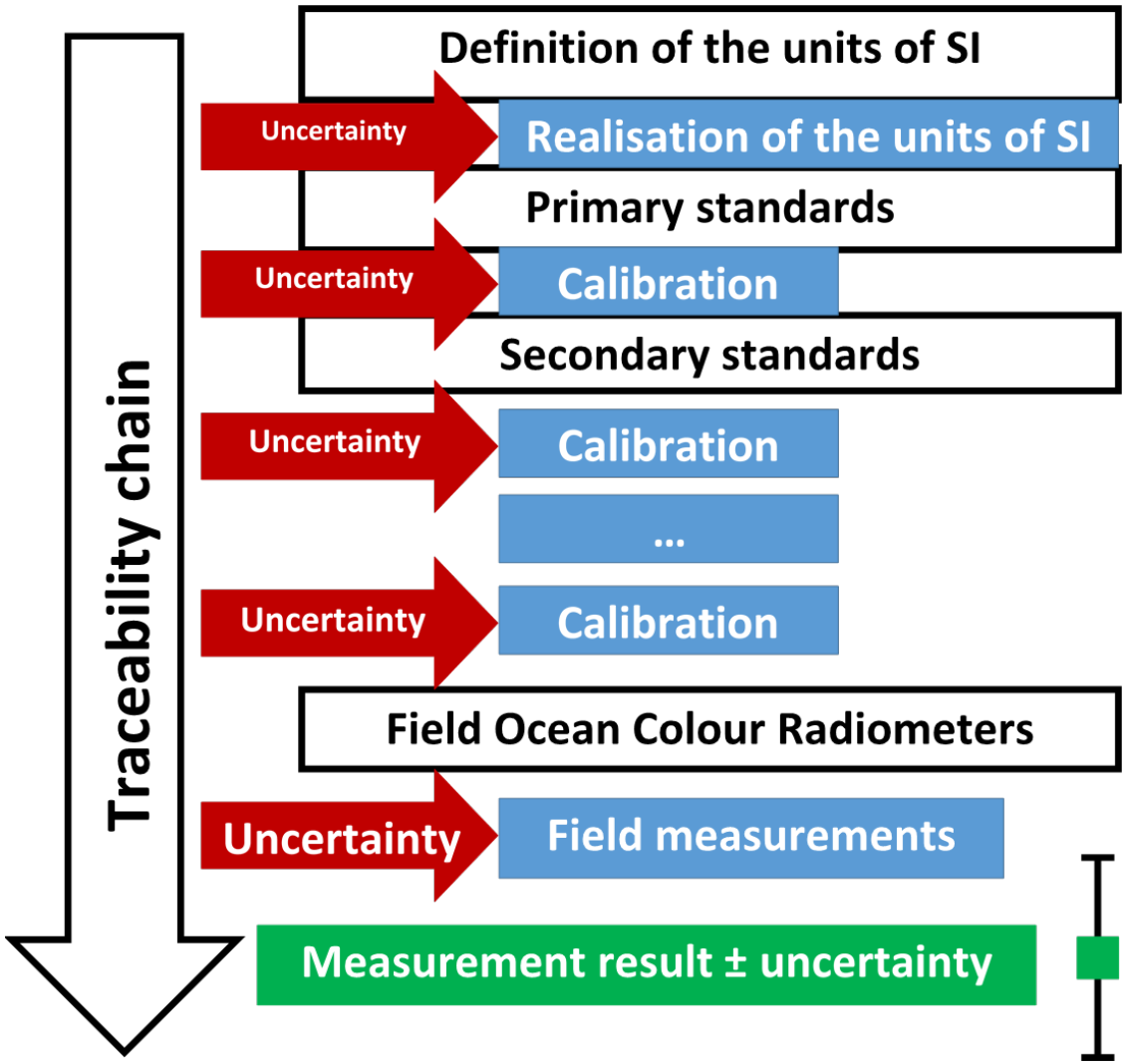
C. J. Donlon, P. J. Minnett, N. Fox, W. Wimmer, “Chapter 5.2 - Strategies for the Laboratory and Field Deployment of Ship-Borne Fiducial Reference Thermal Infrared Radiometers in Support of Satellite-Derived Sea Surface Temperature Climate Data Records,” in *Optical Radiometry for Ocean Climate Measurements*, vol. 47, Academic Press, 2014, pp. 557–604.

The FR Measurements must

- have documented **traceability to SI** (calibration, comparison);
- be **independent from the satellite retrieval process**;
- have evaluated **uncertainty budgets** for all FRM instruments and measurements procedures available and maintained;
- defined and adhered **protocols/community-wide management practices** (measurement, processing, archive, documents etc.);
- be openly and freely available for independent scrutiny.

Objectives of FRM4SOC

- Establish and maintain **SI traceability** of ground-based FRM for satellite Ocean Colour Radiometry with relevant **uncertainty budgets**
- Set up the **protocols** for an international ongoing reference measurement system for the validation of satellite ocean colour.
- Support that the ESA Sentinel satellite measurements of ocean colour (MSI on Sentinel 2 and OLCI on Sentinel 3) are of the highest quality possible


Traceability chain
Definition of the units of SI
Uncertainty
Realisation of the units of SI
Primary standards
Uncertainty
Calibration
Secondary standards
Uncertainty
Calibration
...
Uncertainty
Calibration
Field Ocean Colour Radiometers
Uncertainty
Field measurements
Measurement result ± uncertainty

fiducial reference measurements for satellite ocean colour

WKP – 1 Workshop on vicarious adjustment

OCR FRM Description, Measurement Procedures and Protocols Properties of the **OC Radiometers**.

LCE-1 Verification of reference irradiance and radiance sources

LCE-2 Verification of OC radiometer performance

Compilation of end-to-end uncertainty budgets

FICE – OC Field Inter-comparison experiments

fiducial reference measurements for satellite ocean colour

CEOS

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Workshop on Vicarious Infrastructure

https://frm4soc.org

FRM4SOC > Events > Workshop on Vicarious Infrastructure

Under water view of the four BOUSSOLE instrumented arms. Courtesy of CNRS/LOV.

European Space Agency

organized an international workshop

Options for future European satellite OCR vicarious adjustment infrastructure for the Sentinel-3 OLCI and Sentinel-2 MSI series

on 21 – 23 February 2017 ESA/ESRIN, Frascati, Italy

Gallery I List of participants I Presentations you will find under Agenda

D-240 Proceedings of WKP-1 (PROC-1) Report of the international workshop

Agenda

Workshop will be held from 21 – 23 February 2017 in Magellan room in ESRIN.

DAY 1 – Tue, 21 February 2017

Time	Session
9:00	**Session 1 – Introduction/Workshop objectives (Chair C. Lerebourg & M. Lewis)**
	Why this workshop and why at this particular moment. Review of satellite constellation (timeline). C. Donlon (pdf)
	Definition of the system vicarious calibration requirements for the EC's Copernicus programme. E. Kwiatkowska (pdf)
	Review of historical and contemporary approaches for vicarious adjustment, general requirements. D.

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REPORT: Measurement Requirements and Protocols when Operating FRM OCR for Satellite Validation

REPORT: A Review of Commonly used FRM OC Radiometers used for Satellite OCR Validation”

- The first round table seminar with manufacturers of Ocean Colour Radiometers was held on 6-th September 2017 at ESTEC.
- It would be beneficial to continue this initiative and establish an OCR forum in a form of series of seminars.

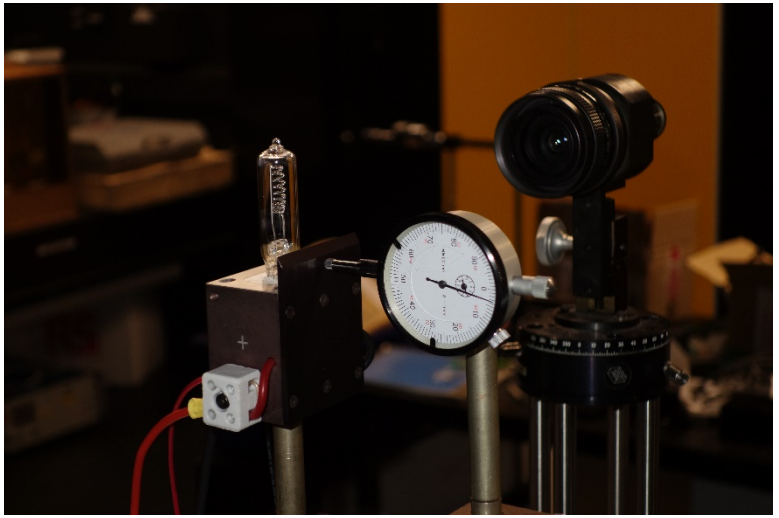
Uncertainty Budgets

for Fiducial Reference Measurement Ocean Colour Radiometers

- Uncertainty Budgets of FRM4SOC Fiducial Reference Measurement (FRM) Ocean Colour Radiometer (OCR) systems used to Validate Satellite OCR products”
  - Follows the Guide to the expression of Uncertainty in Measurement (GUM).
- Comparison is a validation of evaluated uncertainty budgets

LCE-1

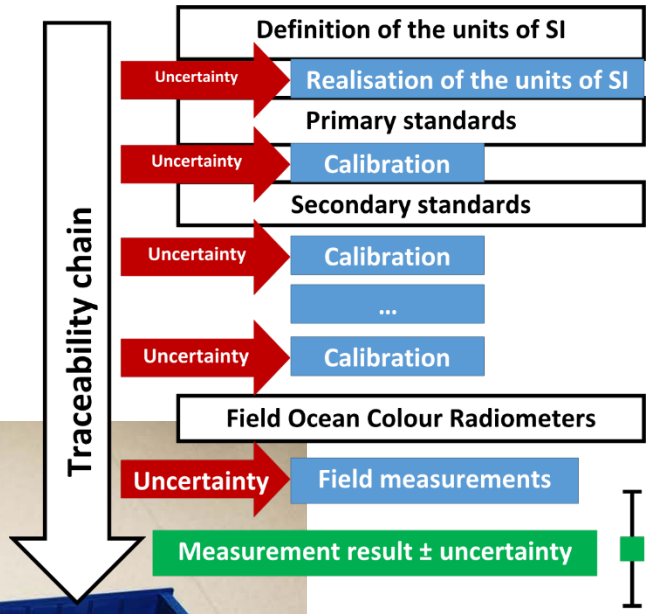
3 – 7 April 2017
at NPL, Teddington, UK
Comparison of Reference Irradiance Sources



Participants
National Physical Laboratory, UK
Tartu Observatory, Estonia
European Commission – DG Joint Research Centre
Laboratoire d'Océanographie de Villefranche, France
Satlantic, Canada Sea Bird Scientific
Cimel Electronique S.A.S., France
In-situ Marine Optics, Australia
Commonwealth Scientific and Industrial Research Organisation, Australia
Norsk Institutt for Vannforskning, Norway
Natural Environment Research Council's Field Spectroscopy Facility, UK
National Oceanic and Atmospheric Administration, USA
Remote Sensing Technology Institute, Deutsches Zentrum für Luft und Raumfahrt, Germany

Calibration of radiometers

TO calibrated all participating radiometers prior to each comparison exercise.



LCE-2, 8 – 13 May 2017 at TO, Tõravere, Estonia

13 organisations from 8 countries

ESA
TO (EE), pilot
AWI (DE)
CIMA (PT)
Cimel (FR)
CNR (IT)
HZG (DE)
NPL (UK)
PML (UK)
RBINS (BE)
Satlantic (CA)
UT (EE)
UVIC (CA)

LCE-2, 8 – 13 May 2017 at TO, Tõravere, Estonia

Participants measured the targets under controlled laboratory conditions

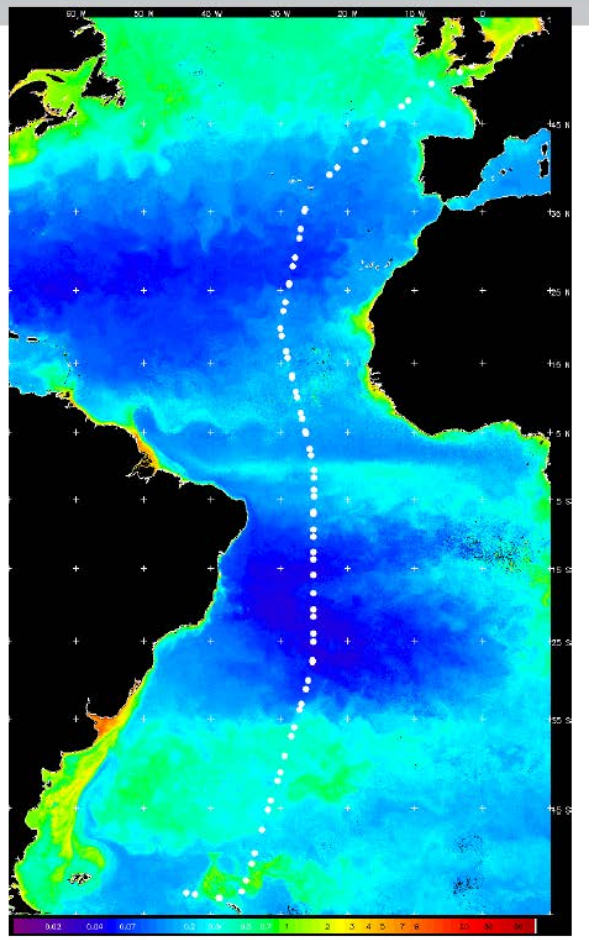
LCE-2, 8 – 13 May 2017 at Lake Kääriku, Estonia

Similar comparison in outdoor conditions.

fiducial reference measurements for satellite ocean colour

PML | Plymouth Marine Laboratory FICE-AMT: Update.

Personnel joined ship: **18 Sept 2017.**
Sailed from Southampton: **23 Sept 17.**
RBINS & TO Azores: **29 Sept 17.**
Disembark Falkland Islands: **5 Nov.**
Equipment return to UK: **Jan 2018.**



VIIRS CI composite 19 Sept – 9 Nov 2017.

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FICE Acqua Alta Oceanographic Tower (AAOT)

Gulf of Venice, Italy.

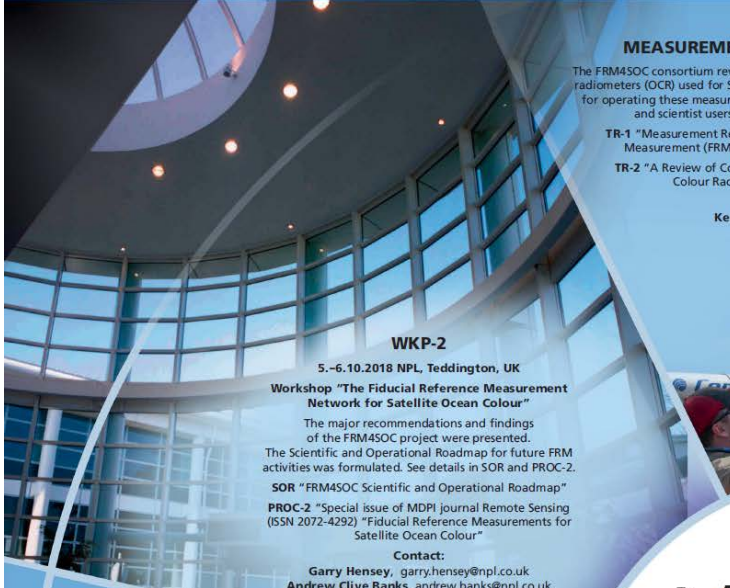
8-18 July 2018.

1. Martin Ligi	University of Tartu, Tartu Observatory, Estonia
2. Martin Hieronymi	Institute for Coastal Research (HZG), Germany
3. Davide D'Alimonte	Institute - CIMA U. Algarve, Portugal
4. Astrid Bracher	Alfred-Wegener-Institute Helmholtz Center for Polar and Marine Research, Germany
5. Maycira Costa	University of Victoria, Canada
6. Kevin Ruddick	RBINS, Belgium
7. Matthew Beck	RBINS, Belgium
8. Giorgio Dall'Olmo	Plymouth Marine Laboratory, UK
9. Gavin Tilstone	Plymouth Marine Laboratory, UK
10. Vincenzo Vellucci	LOV, France
11. Tania Casal	ESA
12. Dieter Vansteenwegen	Flemish Marine Institute (VLIZ), Belgium

FRM4SOC Final Workshop

The Future of Fiducial Reference Measurements for Satellite Ocean Colour

National Physical Laboratory (NPL)
Teddington, London, UK.
4. - 5. October 2018



WKP-2

5.–6.10.2018 NPL, Teddington, UK

Workshop "The Fiducial Reference Measurement Network for Satellite Ocean Colour"

The major recommendations and findings of the FRM4SOC project were presented. The Scientific and Operational Roadmap for future FRM activities was formulated. See details in SOR and PROC-2.

SOR "FRM4SOC Scientific and Operational Roadmap"

PROC-2 "Special issue of MDPI journal Remote Sensing (ISSN 2072-4292) "Fiducial Reference Measurements for Satellite Ocean Colour"

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Andrew Clive Banks, andrew.banks@npl.co.uk

MEASUREMENT REQUIREMENTS AND PROTOCOLS

The FRM4SOC consortium reviewed common fiducial reference measurement (FRM) ocean colour radiometers (OCR) used for Satellite OCR validation and worked out requirements and protocols for operating these measurements. The reports were discussed with instrument manufactures and scientist users to arrive at final consensus. See details in TR-1 and TR-2.

TR-1 "Measurement Requirements and Protocols when Operating Fiducial Reference Measurement (FRM) Ocean Colour Radiometers (OCR) for Satellite Validation"

TR-2 "A Review of Commonly used Fiducial Reference Measurement (FRM) Ocean Colour Radiometers (OCR) used for Satellite OCR Validation"

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WKP-1

21.–23.02.2017 ESA/ESRIN, Frascati, Italy

Workshop "Options for future European satellite OCR vicarious adjustment infrastructure for the Sentinel-3 OLCI and Sentinel-2 MSI series"

Consensus on the way forward to ensure the highest Copernicus Ocean Colour products quality through System Vicarious Calibration was reached. See details in PROC-1 and TR-10.

PROC-1 "Proceedings of the international workshop on system vicarious calibration"

TR 10 "Requirements and recommendations for infrastructure required for the long-term vicarious adjustment of the Sentinel-3 OLCI and Sentinel-2 MSI A/B/C and D instruments"

Contact:
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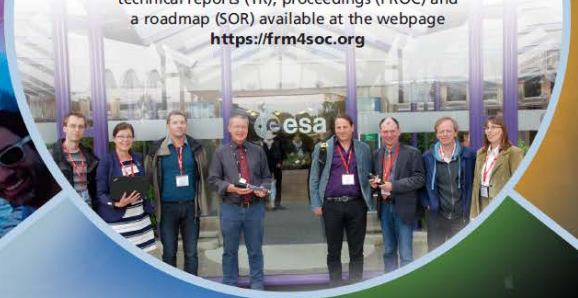
→ ACHIEVEMENTS

The FRM4SOC consortium organized a set of events to establish and maintain SI traceability of Fiducial Reference Measurements for satellite ocean colour radiometry. The results and findings of these activities were formulated in technical reports (TR), proceedings (PROC) and a roadmap (SOR) available at the webpage **https://frm4soc.org**



FICE AAOT

9.–19.07.2018 Gulf of Venice, Italy

Fiducial Inter-Comparison Experiment for Sentinel-3 at the Acqua Alta Oceanographic Tower (AAOT)

An inter-comparison was conducted at the AAOT to assess differences between eight measurement systems. The preliminary results show that for Ed(0+, lambda), Lsky(Lambda) and Lt(Lambda) there was generally good agreement with differences of <5% between institutes. Differences were greater for Rrs. See details in TR-8 and TR-9.

Contact: Gavin Tilstone, ghti@pml.ac.uk

LCE-1

3.–7.04.2017 NPL, Teddington, UK

SI-traceable laboratory comparison experiment for FRM OCR. Verification of reference irradiance and radiance sources.

NPL led international comparisons of (a) irradiance sources and (b) the radiance measurement capability of laboratories that calibrate ocean colour radiometers. The irradiance comparison was held at NPL using the Spectral Radiance and Irradiance Primary Scales (SRIPS) facility and the radiance comparison via am international round robin using transfer radiometers. See details in TR-3a, TR-3b and TR-4.

TR-3a,b "Protocols and Procedures to Verify the Performance of Reference Irradiance (a) and Radiance (b) Sources used by Fiducial Reference Measurement Ocean Colour Radiometers for Satellite Validation"

TR-4 "Results from the First FRM4SOC Reference Radiance and Irradiance Source Verification Laboratory Calibration Experiment Campaign"

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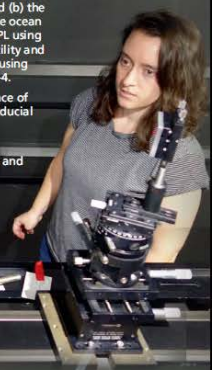

FICE AMT

20.09.–04.11.2017
Atlantic Meridional Transect 27

Fiducial Inter-Comparison Experiment at the Atlantic Meridional Transect (AMT)

FICE AMT was conducted on the Atlantic Meridional Transect 27 during which PML, RBINS, and UT compared above water radiometer measurements. See details in TR-8 and TR-9.

TR-8 "Protocols and Procedures for Field Inter-Comparisons of Fiducial Reference Measurement (FRM) Field Ocean Colour Radiometers (OCR) used for Satellite Validation"

TR-9 "Results from the First FRM4SOC Field Inter-Comparison Experiment (FICE) of Ocean Colour Radiometers"

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LCE-2

8.–13.05.2017 TO, Tõravere, Estonia

SI-traceable Laboratory Intercomparison Experiment to verify the performance of FRM field OCR

The LCE-2 exercise consisted SI-traceable radiometric calibration of participating radiance and irradiance spectroradiometers followed by indoor and outdoor intercomparison. The agreement between all the sensors was good in the indoor intercomparison, but the variability between the sensors increased two (radiance) to five (irradiance) times when natural targets such as sky and water were measured in outdoor conditions. See details in TR-5 and TR-6.

TR-5 "Protocols and Procedures to Verify the Performance of Fiducial Reference Measurement (FRM) Field Ocean Colour Radiometers (OCR) used for Satellite Validation"

TR-6 "Results from the First FRM4SOC Field Ocean Colour Radiometer Verification Round Robin Campaign"

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Scientific Operational Roadmap

Panel Discussion Session

Towards FRM for all validation of satellite ocean colour data – a scientific roadmap

Chair: C. Donlon & T. Casal

Contact information and updates

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European Union
Regional Development Fund

Investing in your future

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Tartu Observatory

Plymouth Marine Laboratory

National Physical Laboratory