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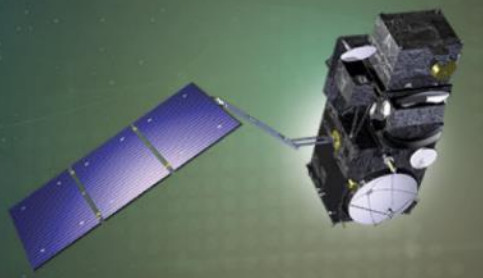


7th Sentinel-3 Validation Team Meeting 2022

18-20 October 2022 | ESA-ESRIN | Frascati (Rm), Italy

Fiducial Reference Measurements for Satellite Ocean Colour (FRM4SOC) Phase 2

Riho Vendt[1], Viktor Vabson[1], Krista Alikas[1], Ilmar Ansko[1], Joel Kuusk[1], Martin Ligi[1],Marine Bretagnon[2], Christophe Lerebourg[2], Alexis Deru[2], Carsten Brockmann[3], Uwe Lange[3], Sabine Embacher[3], Agnieszka Bialek[4], Ashley Ramsay[4], Gavin Tilstone[5],
Giorgio Dall'Olmo[5,6],Kevin Ruddick[7], Juan I. Gossn[8], Ewa Kwiatkowska[8]

[1]*University of Tartu,* [2]*ACRI-ST,* [3]*Brockmann Consult GmbH,* [4]*NPL,* [5]*PML,* [6]*OGS ,* [7]*RBINS,* [8]*EUMETSAT*

fiducial reference measurements for satellite ocean colour

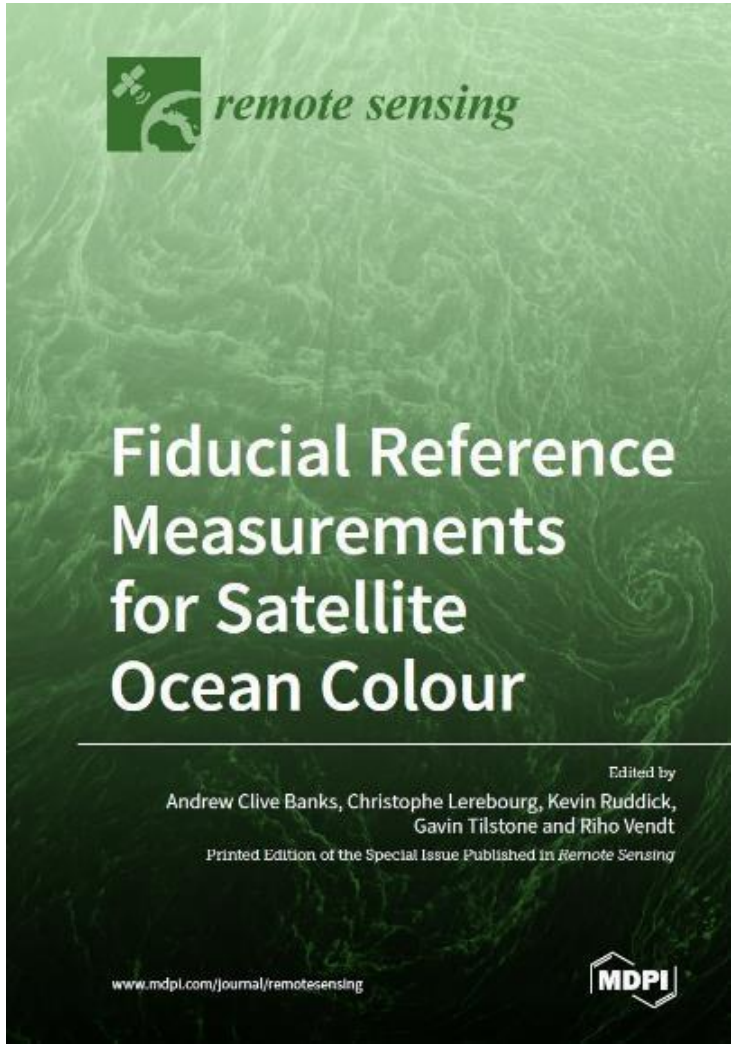
FRM4SOC (Phase 1) 2016 – 2019

- Initiated, funded and coordinated by ESA
- In a series of several other FRM projects
- *https://frm4soc.org*

FRM4SOC Phase 2

- Project kick-off 8 April 2021
- Funded by the EU and coordinated by EUMETSAT
- Project end March 2023 (24 months)
- Two optional 12 month extensions may be granted
- *https://frm4soc2.eumetsat.int/*

Funded by the European Union



Fiducial Reference Measurements for Satellite Ocean Colour

Andrew Clive Banks, Christophe Lerebourg, Kevin Ruddick, Gavin Tilstone and Riho Vendt (Eds.)

The results of the FRM4SOC project are published as a special issue of the MDPI journal Remote Sensing.

Open Access

Book (Hard Cover): ISBN 978-3-03943-064-2 (Hbk)
PDF: ISBN 978-3-03943-065-9 (PDF)
https://doi.org/10.3390/books978-3-03943-065-9

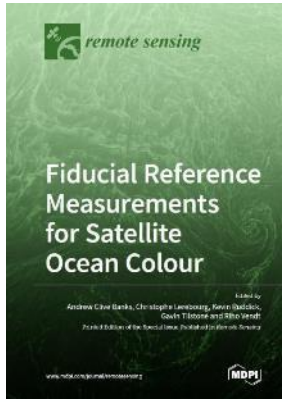
Individual papers (web page of the special issue)

fiducial reference measurements for satellite ocean colour
FRM4SOC Phase-1

Goals of the FRM4SOC Phase 2

Ensure the adoption of FRM principles across the Ocean Colour community.

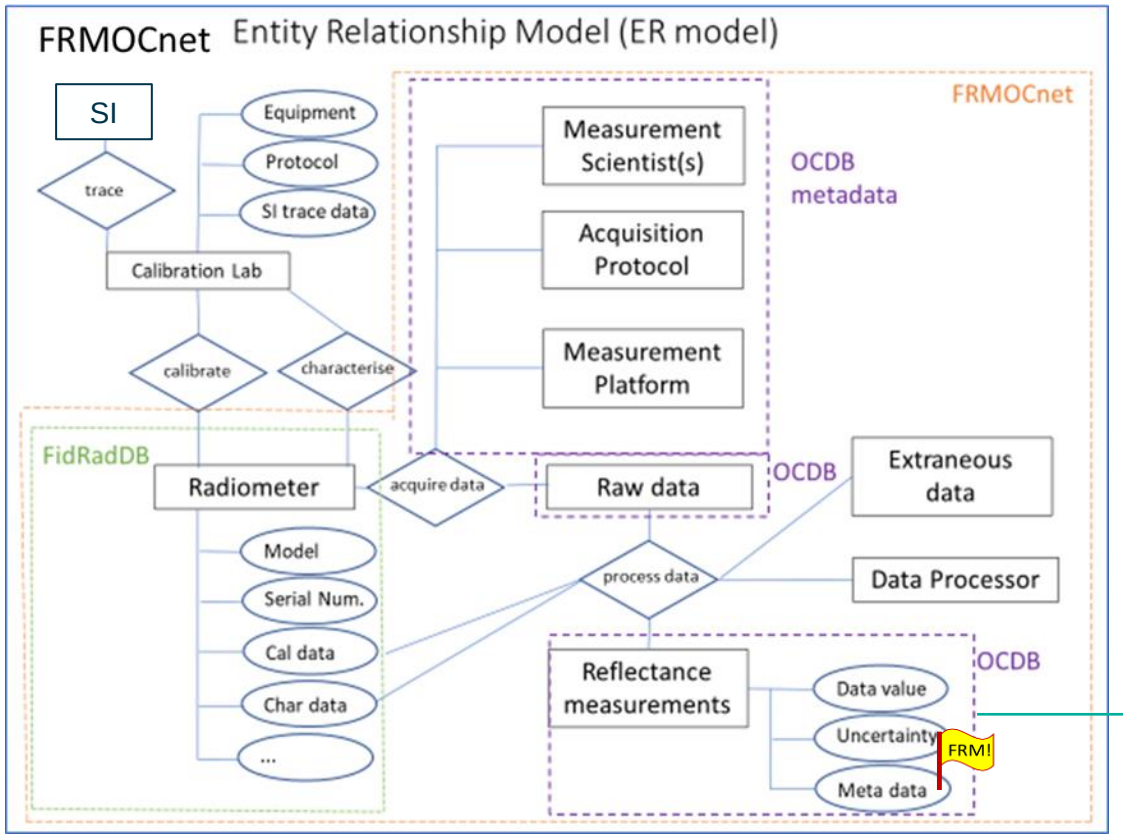
- FRM4SOC-2 builds on the outcomes from earlier studies in the field and the first FRM4SOC study managed by ESA
- Will establish a network of radiometric measurements with the FRM certification.



FRM4SOC	FRM4SOC-2
Identification of gaps in • **traceability**, • **calibration**, • **characterization**, • **uncertainty estimation**	Consolidate **FRM4SOC-1** focusing on • **Operational** OCR cal/char guidelines. • **Operational** (prescriptive) FRM procedures/protocols. • **Engagement** of the **global** community.

Guidelines to obtain FRMs must be clear and as straightforward as possible.

FRMOCnet (network of radiometric measurements with FRM certification)



USERS

FRM4SOC Phase 2
focus on two most common Ocean Colour Radiometer (OCR) types

museum
Royal Belgian Institute of Natural Sciences

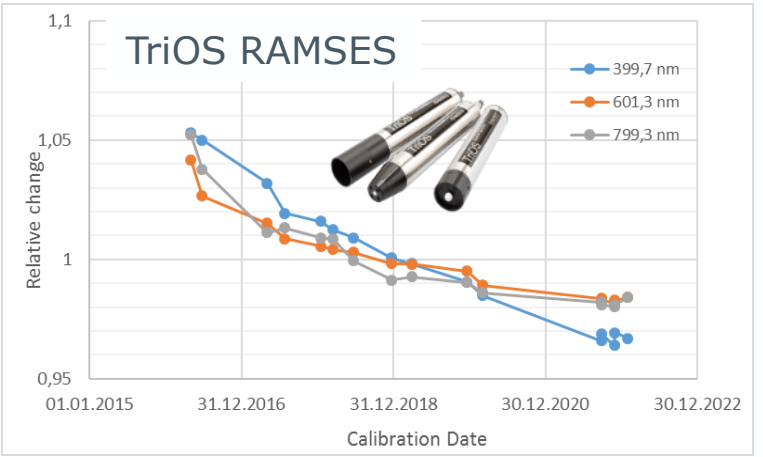
OCR Calibration and characterisation (Presentation following)

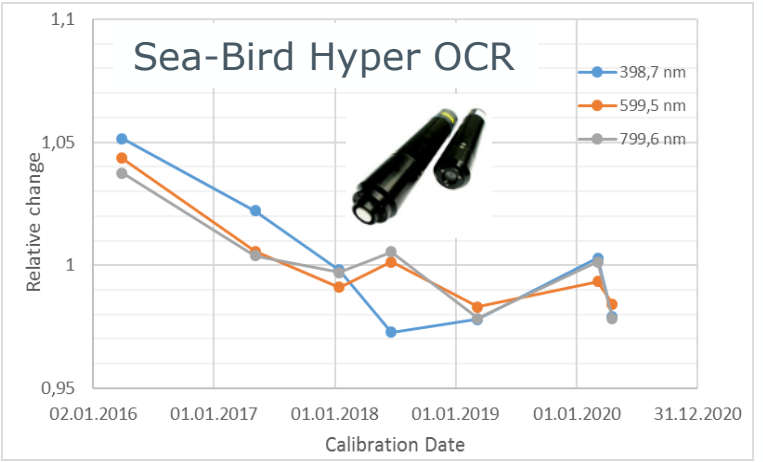
1. Absolute calibration for radiometric responsivity
2. Long term stability
3. Stray light and out of band response
4. Immersion factor (irradiance)
4b. Immersion factor (radiance)
5. Angular response of irradiance sensors in air
6. Response angle (FOV) of radiance sensors in air
7. Non-linearity
8. Accuracy of integration times
9. Dark signal
10. Thermal sensitivity
11. Polarisation sensitivity
12. Temporal response
13. Wavelength scale
14. Signal-to-noise ratio
15. Pressure effects

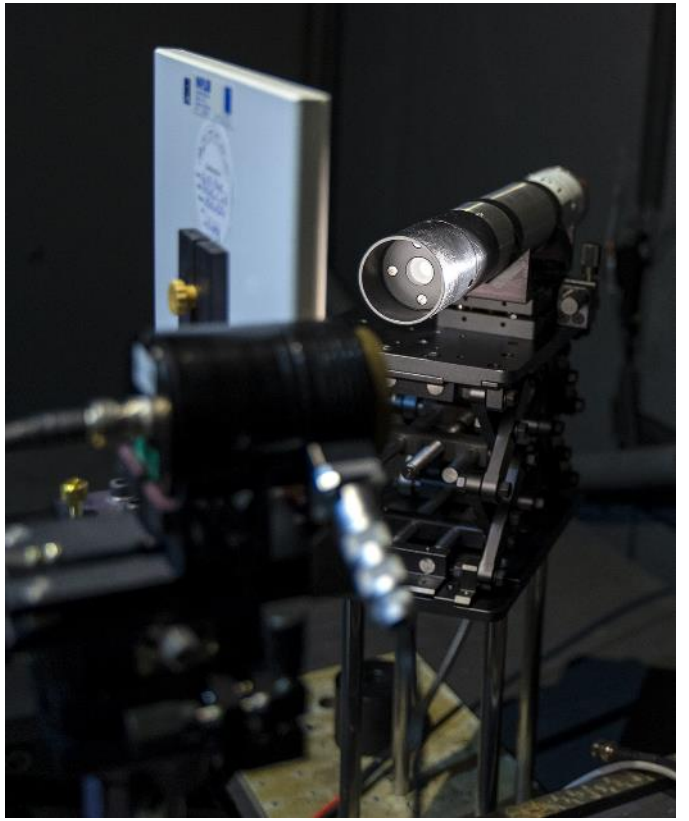
- Characterisation of instruments
- Guidelines for laboratories
- Laboratory comparison

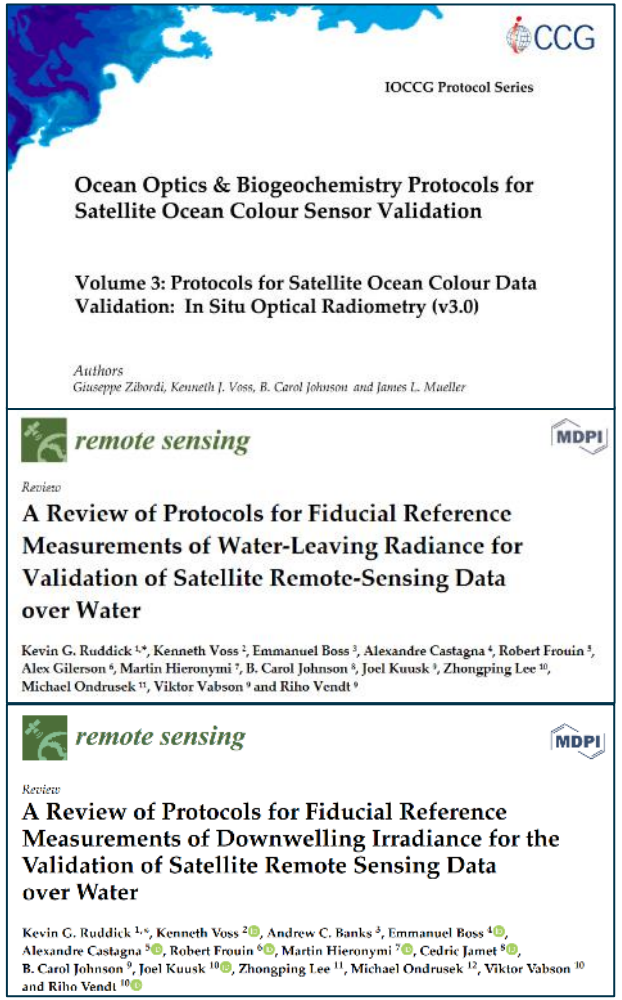
✓ IOCCG Protocol Series 2019
✓ Vabson, et al. 2019

Example of the calibration history








CCG

IOCCG Protocol Series

Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

Volume 3: Protocols for Satellite Ocean Colour Data Validation: In Situ Optical Radiometry (v3.0)

Authors
Giuseppe Zibordi, Kenneth J. Voss, B. Carol Johnson and James L. Mueller

remote sensing MDPI

Review

A Review of Protocols for Fiducial Reference Measurements of Water-Leaving Radiance for Validation of Satellite Remote-Sensing Data over Water

Kevin G. Ruddick [1,*], Kenneth Voss [2], Emmanuel Boss [3], Alexandre Castagna [4], Robert Frouin [5], Alex Gilerson [6], Martin Hieronymi [7], B. Carol Johnson [8], Joel Kuusk [9], Zhongping Lee [10], Michael Ondrusek [11], Viktor Vabson [9] and Riho Vendt [9]

remote sensing MDPI

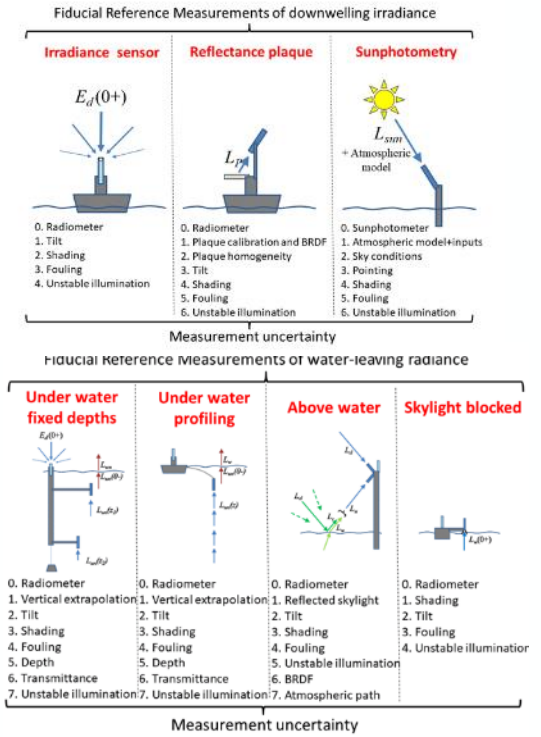
Review

A Review of Protocols for Fiducial Reference Measurements of Downwelling Irradiance for the Validation of Satellite Remote Sensing Data over Water

Kevin G. Ruddick [1,*], Kenneth Voss [2], Andrew C. Banks [3], Emmanuel Boss [4], Alexandre Castagna [5], Robert Frouin [6], Martin Hieronymi [7], Cedric Jamet [8], B. Carol Johnson [9], Joel Kuusk [10], Zhongping Lee [11], Michael Ondrusek [12], Viktor Vabson [10] and Riho Vendt [10]

A Measurement Procedure for shipborne operation of the TriOS RAMSES and SeaBird/Satlantic HyperOCR radiometers to obtain Fiducial Reference Measurements (MPROC)

- Elaboration of the IOCCG and FRM4SOC-1 protocols
- In form of clear and prescriptive guidelines
- Examples of complete uncertainty analysis following FRM principles



Terminology

OC Community
- NASA Ocean Optics Protocols
- IOCCG Protocols
- FRM4SOC Protocol Reviews

Metrological community / VIM
- Measurement principle
- Measurement method
- Measurement procedure

museum
Royal Belgian Institute of Natural Sciences

Community processor for in situ data processing and uncertainty budget calculation

Latest updates:

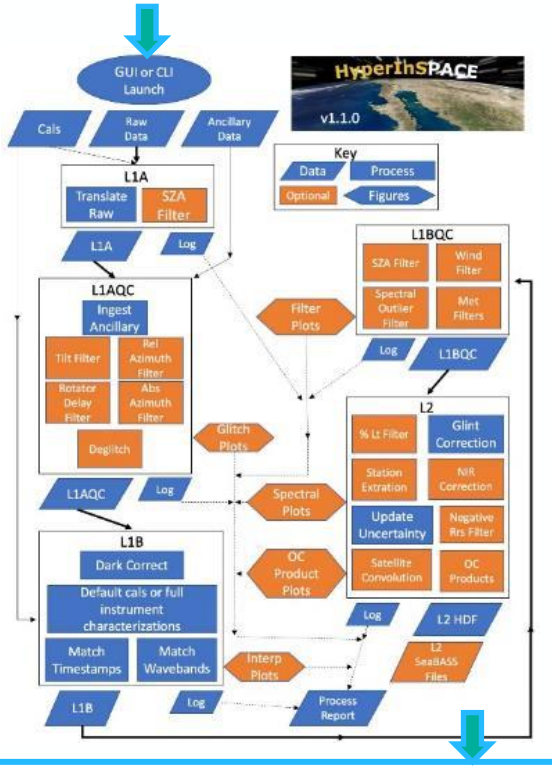
(Presentation following)

- Now 2 instruments supported:
  - Seabird HyperOCR (initally)
  - TriOS RAMSES (added)
- End-to-end uncertainty budget computation following GUM recommendation.
- GUI + CLI + batch processing under Linux.

https://github.com/nasa/HyperInSPACE

N. Vandenberg, M. Costa, Y. Coady and T. Agbaje, "PySciDON: A python scientific framework for development of ocean network applications," *2017 IEEE Pacific Rim Conference on Communications, Computers and Signal Processing (PACRIM)*, 2017, pp. 1-6,

SI traceable measurement data from calibrated and characterised radiometers

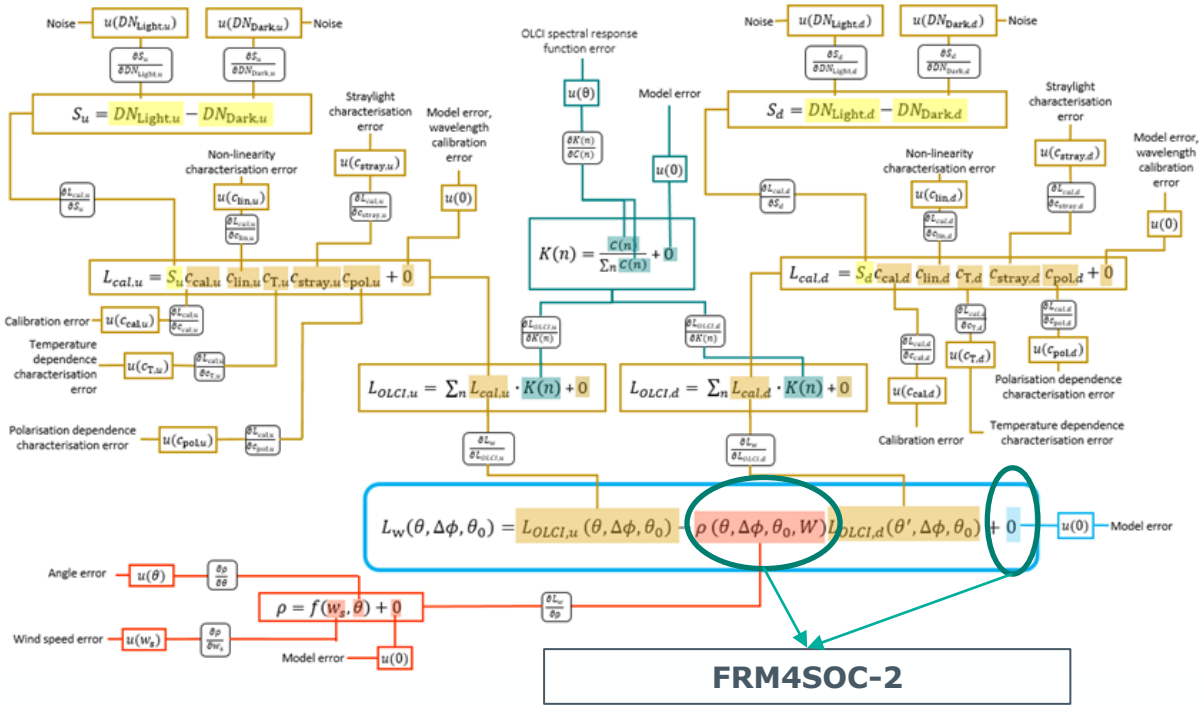


SI traceable remote sensing reflectance R_{rs} with related measurement uncertainty

Uncertainty budgets (Presentation following)

Elaboration of the FRM4SOC Phase 1 uncertainty budgets

- Developing end-to-end uncertainty budgets for
  - remote sensing reflectance,
  - fully normalised water-leaving radiance.
- Implementing uncertainty calculations in the CP processing chain.
- Providing easy and practical guidelines for uncertainty calculation.



Water leaving radiance uncertainty tree diagramm.
Adapted from (Bialek et al. 2020).

Ocean Colour In-Situ Database (OCDB) (Presentation yesterday)

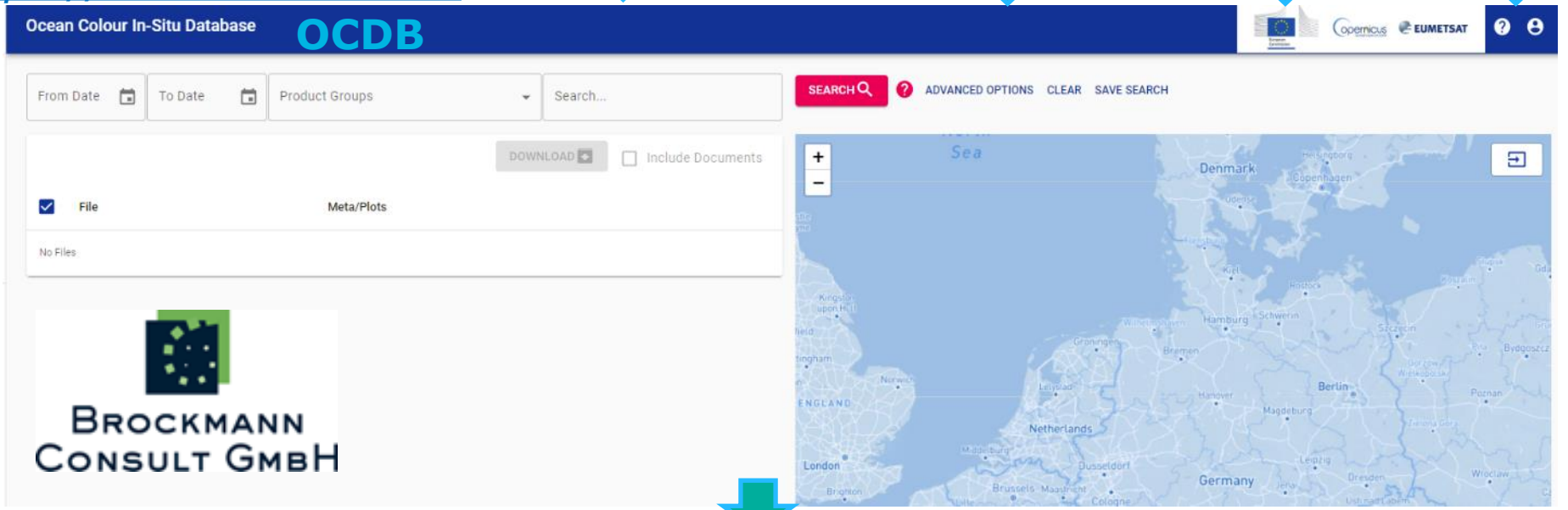
Community Processor

AERONET-OC

MOBY

BGC Argo

https://ocdb.eumetsat.in



Data users

Field InterComparison Exercise (FICE)

11-20 July 2022,

at Acqua Alta Oceanographic Tower (AAOT), Venice, Italy.

Comparison of L_i, L_t, L_w, E_d, R_{rs}, L_{wn}

Critical review, testing, and feedback on

- Measurement protocols/procedures
- Community processor
- FRMOCnet
- Application of instrument characterisation

Validation of

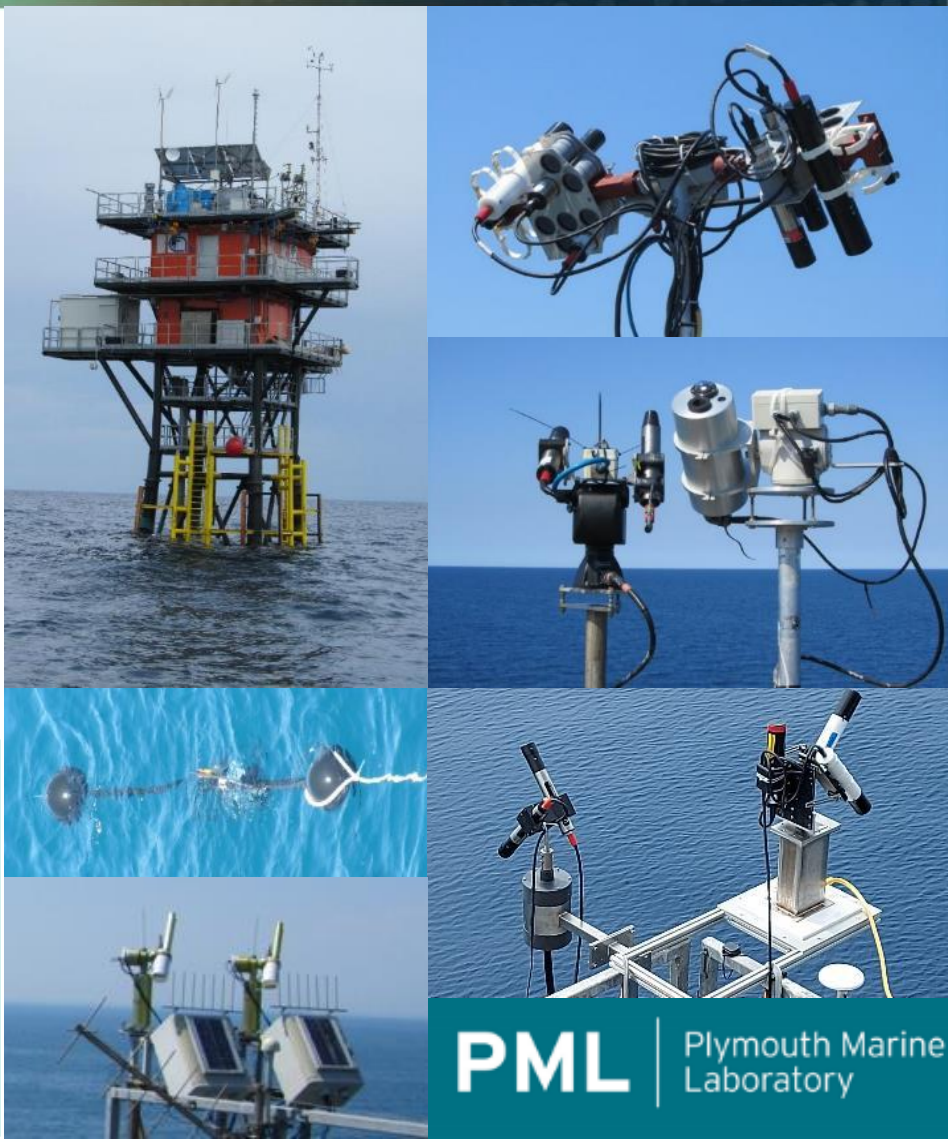
- SI traceability;
- Uncertainty budgets;
- Aimed uncertainty levels.

Participants: CNR-ISAC, Helmholtz Center Hereon, NASA, NOAA, PML, RBINS, UT

Instruments:

Above water: TRIOS RAMSES, TriOS RAMSES G2 sun tracker (SoRAD), Seabird HyperOCR HyperSAS with PySAS robot, HYPSTAR, PANTHYR.

In-water: Sea-Bird HyperPro II, TriOS RAMSES floating buoy.



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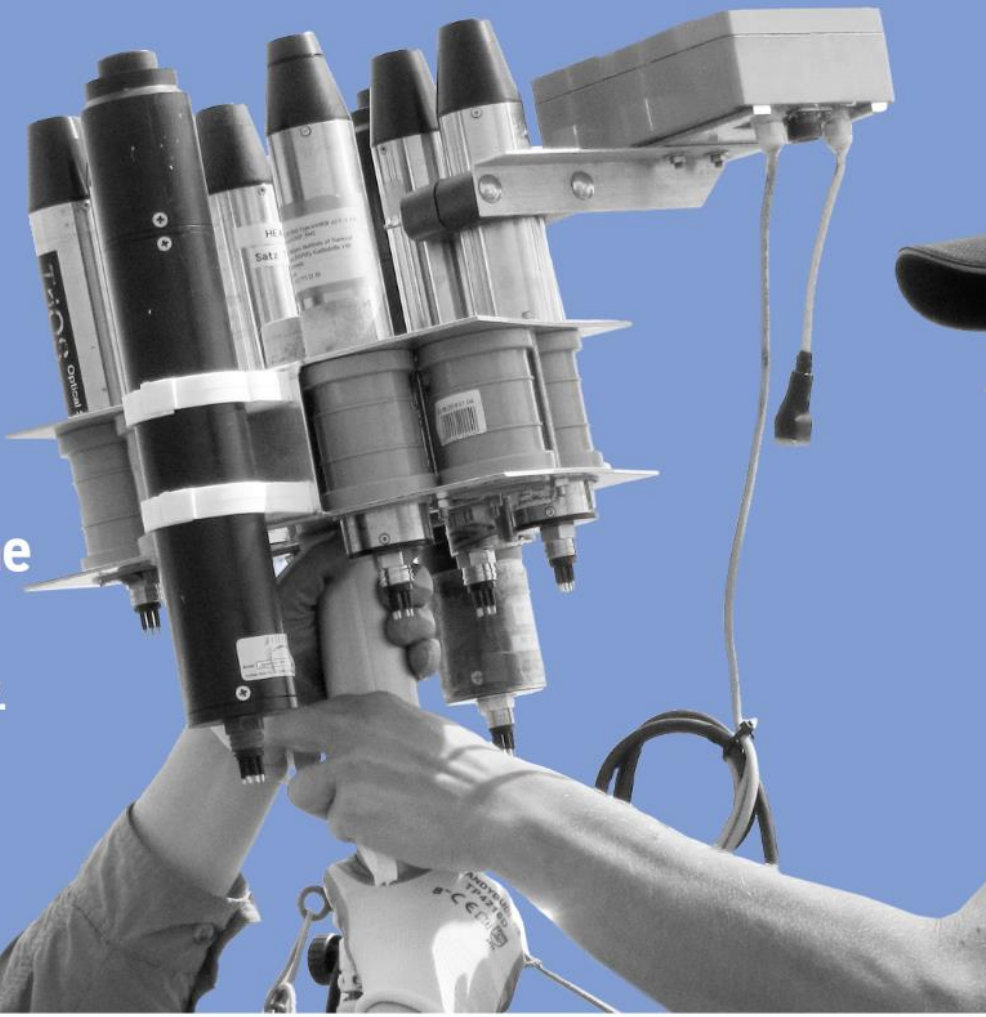
FRM4SOC-2 Project Workshop



Save the date! 5 – 7 December 2022 – Darmstadt/Online

Registration open at *https://frm4soc2.eumetsat.int/*

Consortium partners and project-related experts will attend physically.
You are invited to join either physically or online.
No registration fees will be charged.

Funded by the European Union