Copernicus FICE 2025

Training on
In situ Ocean Colour Above-Water Radiometry towards Satellite Validation

EUMETSAT welcomes you to Copernicus FICE 2025

Juan Gossn, Ewa Kwiatkowska and Hayley Evers-King
EUMETSAT

6-20 July 2025
Venice, Italy

Why are we here today?

A chain of reasons:

1. We are here to improve the quality of **Ocean Colour observations** from space

2. To improve **Ocean Colour observations** we must validate them with **field measurements**

3. Our **field measurements** must be acquired with **trustworthy instruments, protocols, procedures, QA/QC, etc…**

4. To **trust** our measurements and use them for **validation of OC satellite products**, we must **understand them (our geophysical measurand, our instrument, our practices before, during and after the field)** and make field measurements follow **internationally agreed practices**

- This event is part of a project (**FRM4SOC - 2, Fiducial Reference Measurements for Satellite Ocean Colour – Phase 2**) that is **advancing our knowledge on OC field radiometry** but also helping the **community** to arrive to these agreed practices.

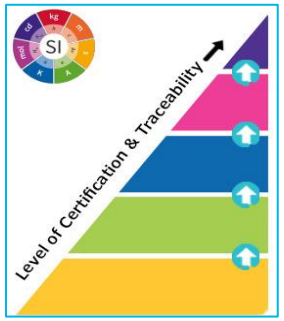
This **training** is a key element to fulfil FRM4SOC's major goal:
Promote FRM principles across the Ocean Colour community

Why are we here today?

What are **Fiducial Reference Measurements** (FRMs)?

*A suite of **independent**, **fully characterised**, and **traceable** (to a **community agreed reference**, ideally **SI**) measurements of a **satellite relevant measurand**, tailored specifically to address the **calibration/validation needs** of a **class of satellite borne sensors**, and following the guidelines outlined by the GEO/CEOS Quality Assurance framework for Earth Observation (QA4EO)*

[Goryl *et al.* 2023]



$$u_c^2(y) = \sum_{i=1}^{N} \left(\frac{\partial f}{\partial x_i}\right)^2 u^2(x_i) + 2\sum_{i=1}^{N-1}\sum_{j=i+1}^{N} \frac{\partial f}{\partial x_i}\frac{\partial f}{\partial x_j} u(x_i, x_j)$$

CEOS Committee on Earth Observation Satellites

This **training** is a key element to fulfil FRM4SOC's major goal:
Promote FRM principles across the Ocean Colour community

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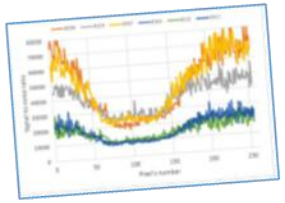
FRM4SOC2 resources, guidelines, tools

copernicus.eumetsat.int

https://frm4soc2.eumetsat.int/

\+ …



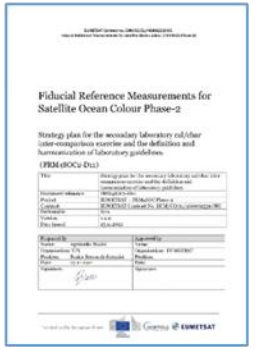
1. **Field radiometer classes** to conform to the FRMOCnet standards

2. **Full characterisation** of batches of field radiometers and a service of free calibrations and rentals of fully calibrated/characterised instruments

3. **Community guidelines** on radiometer cal/char standards and FRM certification

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

4. Radiometer cal/char **guidelines for laboratories**, international lab exercises and continuous communication with manufacturers and users


Fiducial Reference Measurements for Satellite Ocean Colour Phase-2

Strategy plan for the secondary laboratory cal/char inter-comparison exercise and the definition and harmonization of laboratory guidelines.

5. In situ **measurement procedures**, specific to the radiometer classes, and recommendations that complement those in the IOCCG protocols

6. **HyperCP community processor** for hyperspectral above-water radiometric measurements, extension of use cases

https://github.com/nasa/HyperCP/tree/master

7. Complete **end-to-end uncertainty budget** included in HyperCP, thoroughly documented and clear to users

8. Maintenance of Ocean Colour **In-Situ Database** OCDB, Fiducial Radiometer Data Base FidRadDB and promotion of their use

https://ocdb.eumetsat.int/

9. **Review, test and promote**: field comparisons, training, international workshops, feedback from experts

fiducial reference measurements for satellite ocean colour

https://frm4soc2.eumetsat.int

Promoting the adoption of FRM principles across the community

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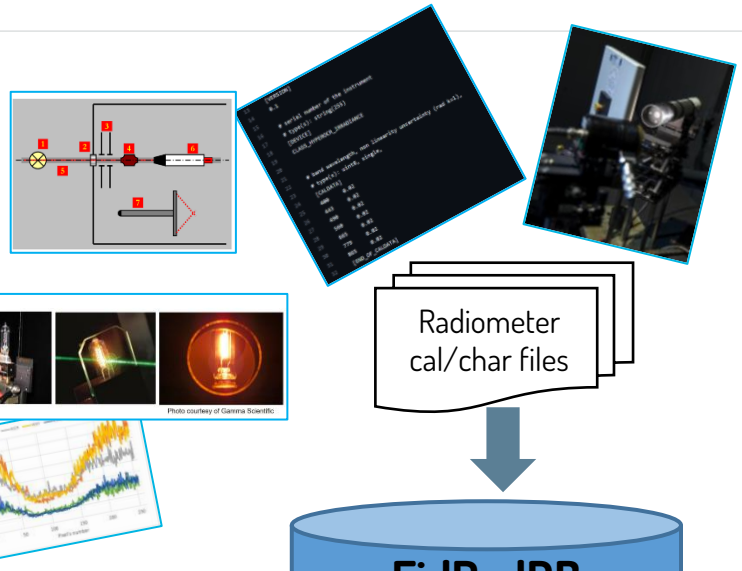
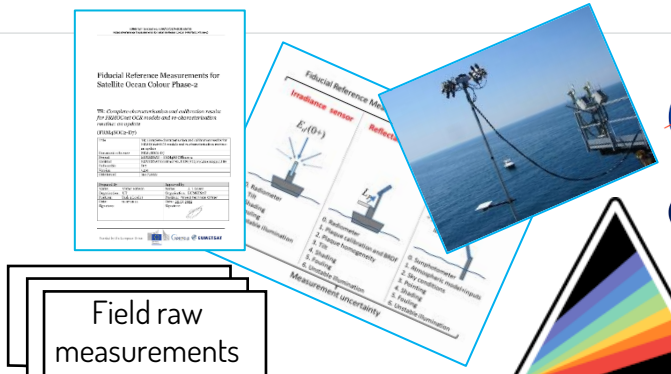
FRMOCnet: A network of radiometric measurements with the FRM quality



Radiometer cal/char files



Field raw measurements

copernicus.eumetsat.int

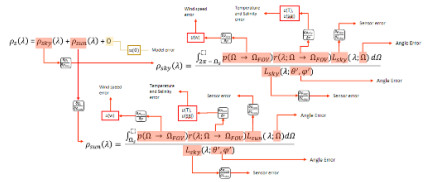
Gybe

University of Victoria

EUMETSAT

THE UNIVERSITY OF MAINE

HyperCP



NPL

ACRI ST

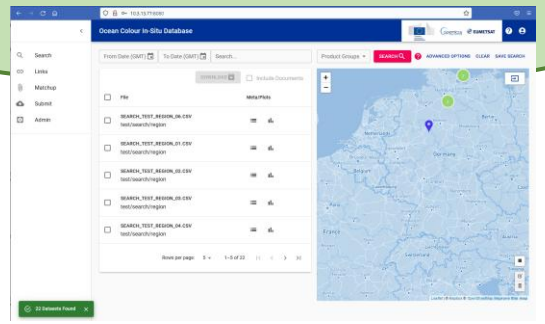
MORGAN STATE UNIVERSITY

Copernicus Europe's eyes on Earth

FidRadDB
Radiometer calibration and characterisation files

HyperCP
- Process hyper AWR (SeaBird, TriOS)
- Obtain Rrs, nLw, OC parameters + uncertainties
- Determine FRM quality

OC Data Base
- other OC related insitu data
- AWR measurements (FRM and non-FRM)



SeaBASS files

SeaBASS files

HDF files

Inter-operable

SeaBASS
seabass.gsfc.nasa.gov

NASA

OCDB
https://ocdb.eumetsat.int

EUMETSAT

ThoMaS
- Perform match-ups with satellite data
- Assessment of the uncertainty budget of the match-up process

FRM for Ocean Colour: Other efforts

The development and implementation of the FRM principles is an incremental process.
FRM4SOC phase 2 is built on the decades of work done previously by several teams worldwide.

FRM4SOC (Phase 1)

Fiducial Reference Measurements for Satellite Ocean Colour

Fiducial Reference Measurements for Satellite Ocean Colour (FRM4SOC)

by Andrew Clive Banks [1,*], Riho Vendt [2], Krista Alikas [2], Agnieszka Bialek [3], Joel Kuusk [2], Christophe Lerebourg [4], Kevin Ruddick [5], Gavin Tilstone [6], Viktor Vabson [2], Craig Donlon [7] and Tania Casal [7]

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]

remote sensing — MDPI

Article

Example of Monte Carlo Method Uncertainty Evaluation for Above-Water Ocean Colour Radiometry

Agnieszka Bialek [1,*], Sarah Douglas [1], Joel Kuusk [2], Ilmar Ansko [2], Viktor Vabson [2], Riho Vendt [2] and Tânia Casal [3]

remote sensing — MDPI

Article

Field Intercomparison of Radiometer Measurements for Ocean Colour Validation

Gavin Tilstone [1,*], Giorgio Dall'Olmo [1,2], Martin Hieronymi [3], Kevin Ruddick [4], Matthew Beck [4], Martin Ligi [5], Maycira Costa [6], Davide D'Alimonte [7], Vincenzo Vellucci [8], Dieter Vansteenwegen [9], Astrid Bracher [10], Sonja Wiegmann [10], Joel Kuusk [5], Viktor Vabson [5], Ilmar Ansko [5], Riho Vendt [5], Craig Donlon [11] and Tânia Casal [11]

remote sensing

Article

Comparison of Above-Water Seabird and TriOS Radiometers along an Atlantic Meridional Transect

Krista Alikas [1,*], Viktor Vabson [1], Ilmar Ansko [1], Gavin H. Tilstone [2], Giorgio Dall'Olmo [2], Francesco Nencioli [2], Riho Vendt [1], Craig Donlon [3] and Tania Casal [3]

remote sensing — MDPI

Article

Field Intercomparison of Radiometers Used for Satellite Validation in the 400–900 nm Range

Viktor Vabson [1,*], Joel Kuusk [1], Ilmar Ansko [1], Riho Vendt [1], Krista Alikas [1], Kevin Ruddick [2], Ave Ansper [1], Mariano Bresciani [3], Henning Burmester [4], Maycira Costa [5], Davide D'Alimonte [6], Giorgio Dall'Olmo [7,8], Bahaiddin Damiri [9], Tilman Dinter [10], Claudia Giardino [3], Kersti Kangro [1], Martin Ligi [1], Birgot Paavel [11], Gavin Tilstone [7], Ronnie Van Dommelen [12], Sonja Wiegmann [10], Astrid Bracher [10], Craig Donlon [13] and Tânia Casal [13]

SIRREX

SeaWiFS Intercalibration Round-Robin **Experiment**

NASA Technical Reports Server (NTRS)

IOCCG

International Ocean Colour Coordinating Group

IOCCG Ocean Optics & Biogeochemistry Protocols for Satellite Ocean Colour Sensor Validation

- Volume 1.0 - Inherent Optical Property Measurements and Protocols: Absorption Coefficient (November 2018)
- Volume 2.0 - Beam Transmission and Attenuation Coefficients: Instruments, Characterization, Field Measurements and Data Analysis Protocols (April 2019)
- Volume 3.0 - Protocols for Satellite Ocean Color Data Validation: In situ Optical Radiometry (December 2019)
- Volume 4.0 - Inherent Optical Property Measurements and Protocols: Best Practices for the Collection and Processing of Ship-Based Underway Flow-Through Optical Data (November 2019)
- Volume 5.0: Measurement Protocol of Absorption by Chromophoric Dissolved Organic Matter (CDOM) and Other Dissolved Materials (DRAFT)
- Volume 6.0: Particulate Organic Matter Sampling and Measurement Protocols: Consensus Towards Future Ocean Color Missions (August 2021)
- Volume 7.0: Aquatic Primary Productivity Field Protocols for Satellite Validation and Model Synthesis (September 2022)
- Noteworthy and Supplemental Topics on Ocean Colour Radiometry Protocols (DRAFT)

+ other studies belonging to other initiatives

Non-linear response of a class of hyper-spectral radiometers

Marco Talone and Giuseppe Zibordi

Immersion Factor of In-Water Radiance Sensors: Assessment for a Class of Radiometers

Giuseppe Zibordi

Principles of Optical Radiometry and Measurement Uncertainty

B. Carol Johnson, [1,*] Howard Yoon, [1] Joseph P. Rice, [1] Albert C. Parr [1,2]

[1] Sensor Science Division, National Institute of Standards and Technology, Gaithersburg, MD, USA; [2] Space Dynamics Laboratory, Utah State University, Logan, UT, USA

Polarimetric characteristics of a class of hyperspectral radiometers

Marco Talone* and Giuseppe Zibordi

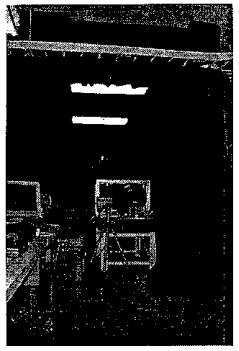
Assessment of AERONET-OC L_{WN} uncertainties

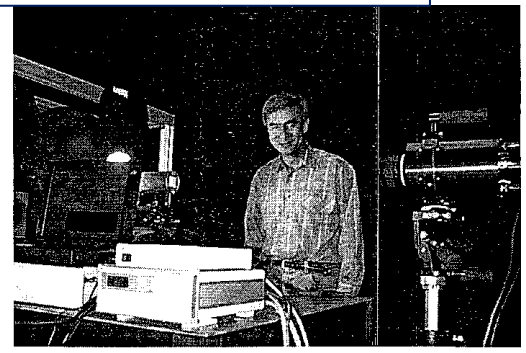
Mathias Gergely and Giuseppe Zibordi

European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra, Italy

SIMRIC

The SIMBIOS Radiometric Intercomparison

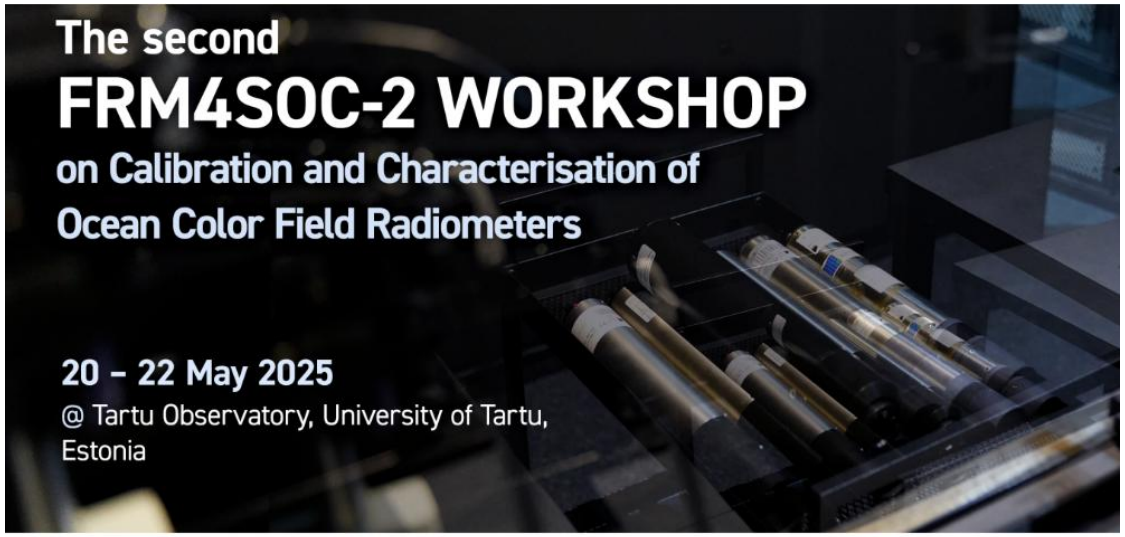


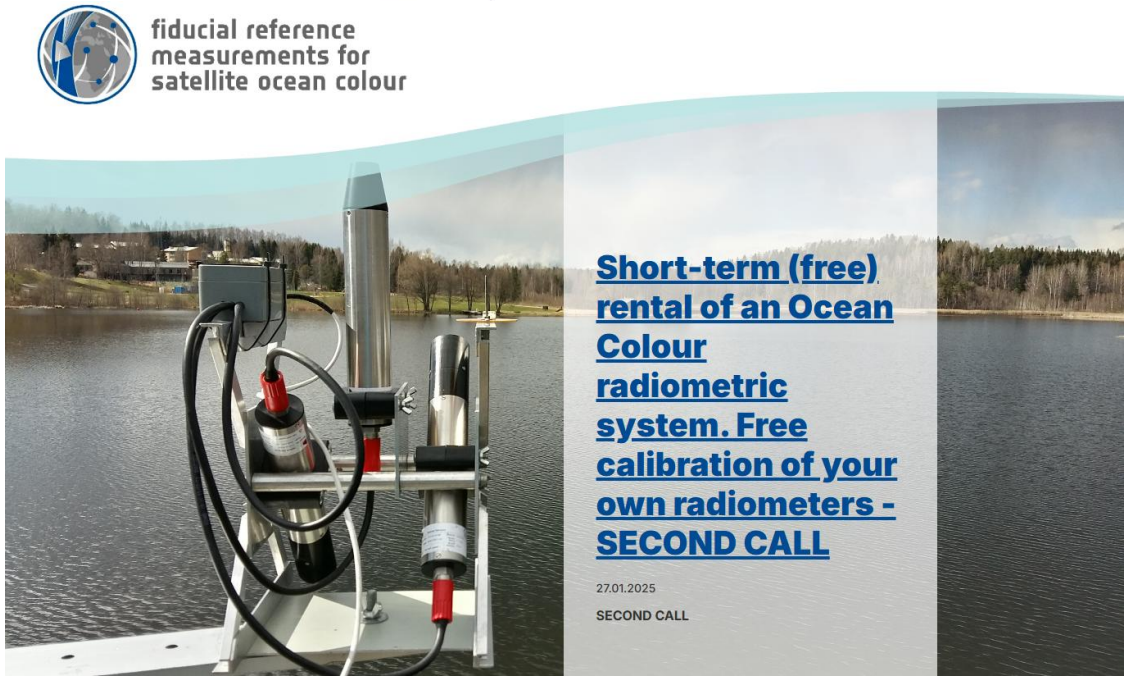


FRM4SOC2 community services

copernicus.eumetsat.int

https://frm4soc2.eumetsat.int/





Being in FICE 2025: A unique opportunity!

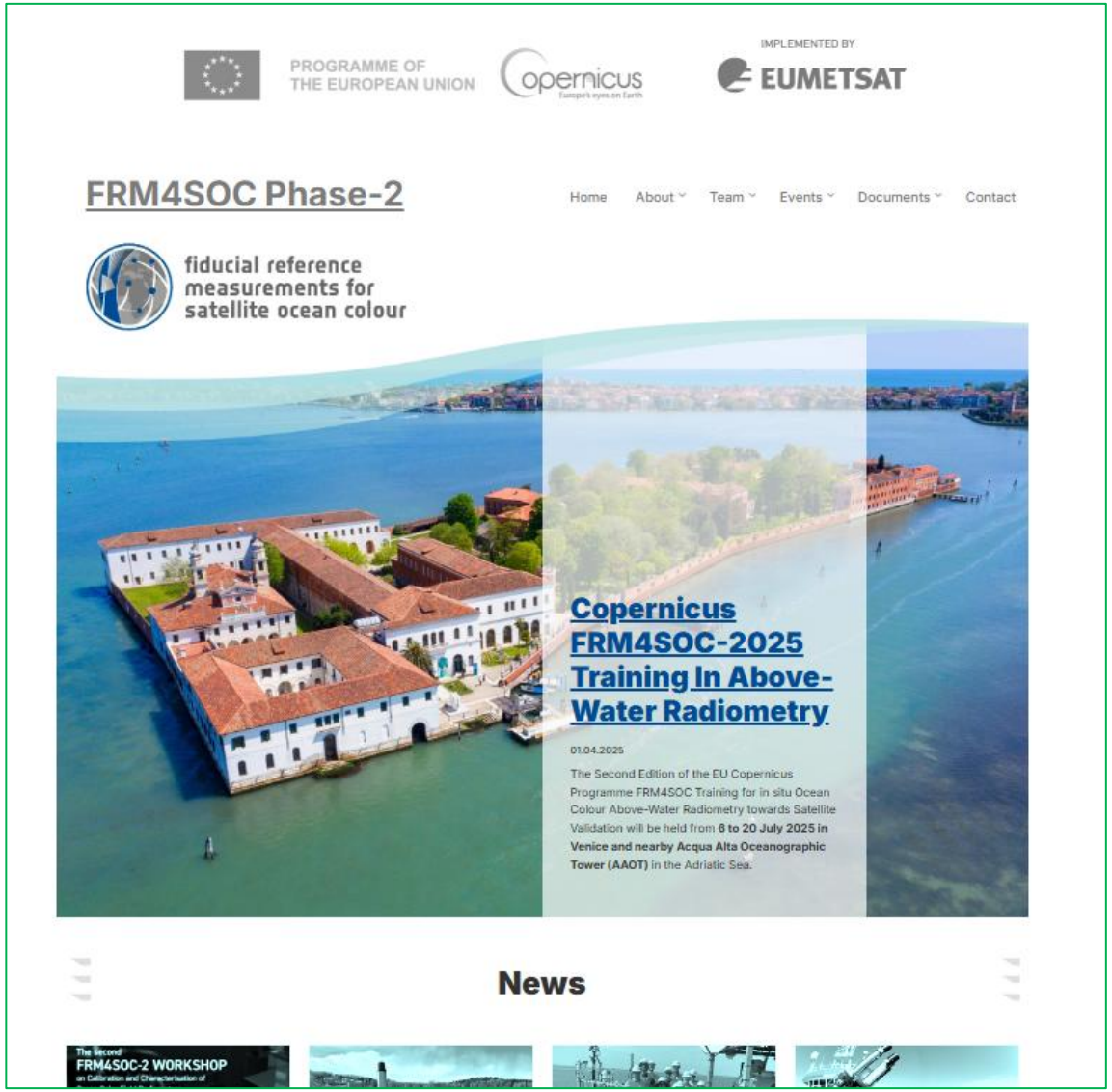
- Unique chance to learn from top experts in **Ocean Colour (OC) radiometry** about the complexity of the **physical processes during field measurements**, evaluate the impact of several **uncertainty sources**, and experience a **live demonstration** on how to apply measurement protocols and procedures correctly in the field.

Dealing with radiometers in the field is not an easy task.

- We will discuss the **challenges in collecting high-quality measurements** and understand their **uncertainties**.
- We will provide **community tools** developed partly within our project to process raw outputs from radiometers to measurement results with metrologically sound uncertainty estimates for performing satellite matchups.

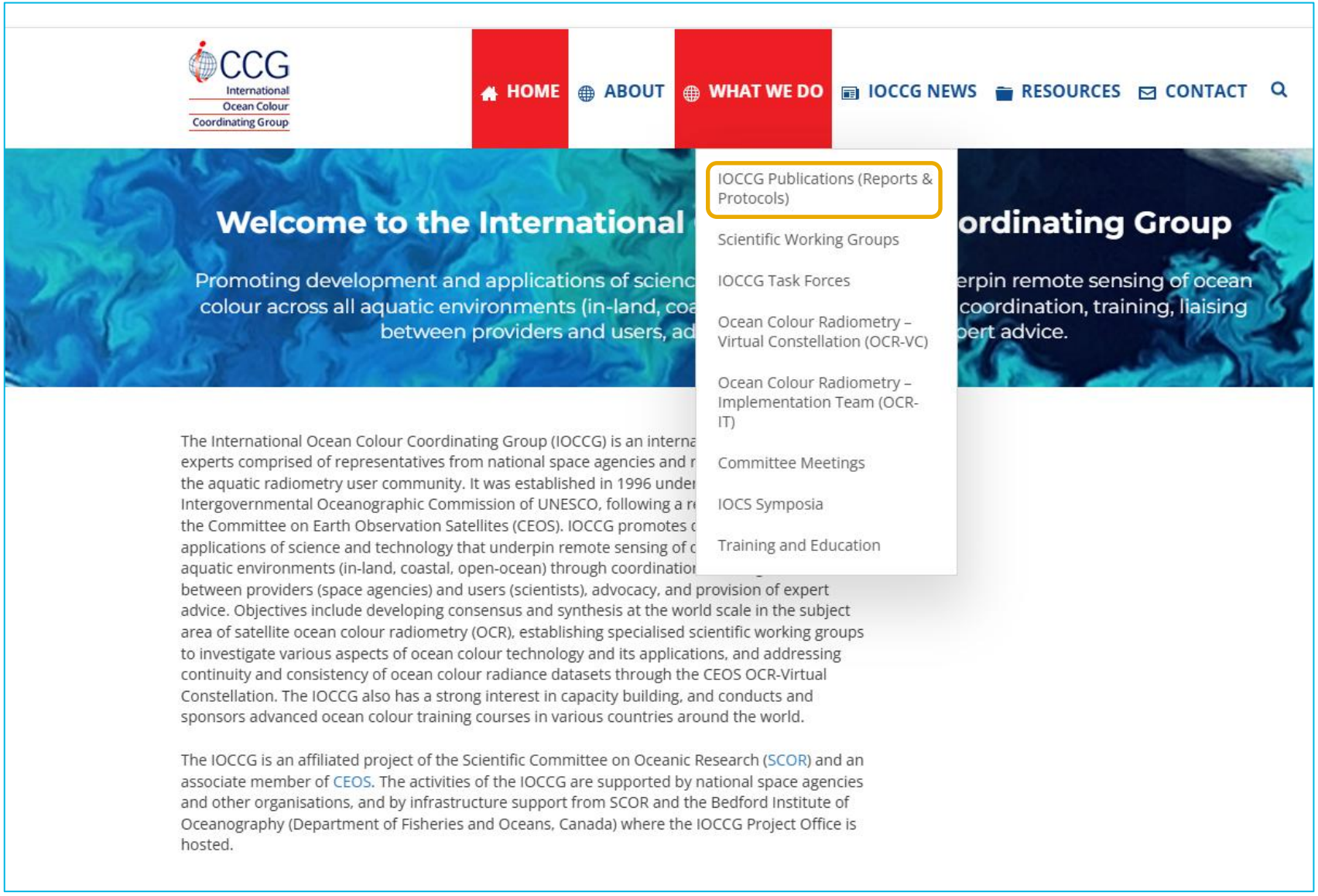
Resources: FRM4SOC-2 website

copernicus.eumetsat.int



https://frm4soc2.eumetsat.int

Resources: IOCCG website



https://ioccg.org

Who are EUMETSAT?

The European Organisation for the Exploitation of Meteorological Satellites

- Located in Darmstadt, Germany
- Founded in 1986, consists of 30 member states
- Two mandates:
  - Weather and Climate data for member states
  - Additional capabilities with EU and beyond:
    - Copernicus programme

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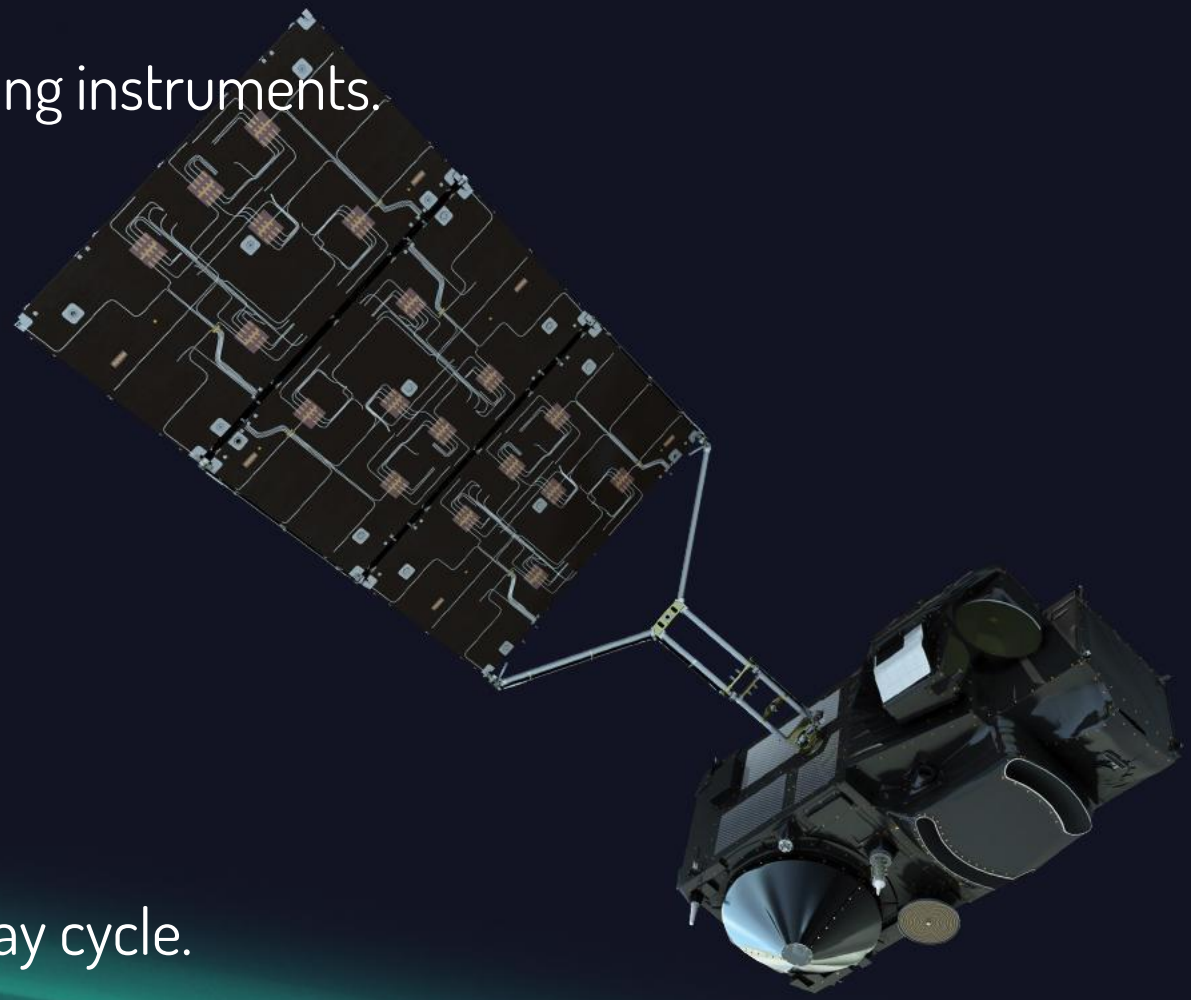
IMPLEMENTED BY EUMETSAT

EUMETSAT missions for marine – current and future

Marine missions: Sentinel-3 mission and configuration

- The “blue” sentinel; suite of ocean observing instruments.
- Main objectives: acquire sea-surface topography, sea surface temperature and ocean colour data.
- Constellation of two platforms:
  - Sentinel-3A launched February 2016
  - Sentinel-3B launched April 2018
  - Sentinel-3C planned mid-2026
- Sun-synchronous 98.65° polar orbit, 27 day cycle.
- Near global coverage; <2 day revisit (optical) & <1 day (thermal)



Marine missions: Sentinel-3 operations and data distribution

- EUMETSAT operates the satellite & provides the marine data stream at level-1 and level-2
- Supports the generation of level-3 and level-4 products by the Copernicus Marine Service (primary user)
- Operational and reprocessed data made directly available to users via the EUMETSAT Data Store
- Redistributed (and used) by NOAA
- Atmospheric products also available through EUMETSAT
- Land products available through ESA

Your EUMETSAT instructors in FICE

Dr Hayley Evers-King (EUMESAT): Lead Marine Applications Expert, User Support and Climate Division

Hayley provides user support and training on ocean applications of satellite data, and manages feedback between user(s) and operational satellite agencies. She has worked throughout the satellite data value chain; from the validation of satellite sensor measurements, to algorithm and application development. She is a keen programmer and a passionate science communicator. Prior to her current role, Hayley worked for 5 years as a Marine Earth Observation Scientist at Plymouth Marine Laboratory. She obtained a PhD in ocean colour remote sensing from the University of Cape Town, South Africa in 2014.

Dr Juan Ignacio Gossn (EUMETSAT): Remote Sensing Scientist; Ocean Colour

Juan Gossn was born in 1990 in San Isidro, Argentina. He is a remote sensing scientist specializing in Ocean Colour remote sensing. With a background in Physics from the University of Buenos Aires, he obtained his Ph.D. from the Argentinean Institute of Astronomy and Space Physics (IAFE – CONICET/UBA), focusing on the extremely turbid waters of Río de la Plata. In 2021, he joined EUMETSAT's Ocean Colour Services team, where he contributes to the improvement of operational ocean colour products through the analysis of in situ data and managing scientific studies.

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More information: User Support and Training Resources

copernicus.eumetsat.int

EUMETSAT Helpdesk

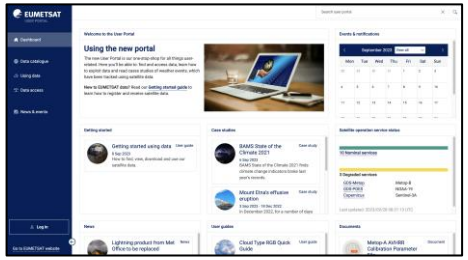
OPS@eumetsat.int

Contact the EUMETSAT helpdesk with any questions about EUMETSAT data products or services

EUMETSAT User Support Resources

User portal (first release!)

Copernicus & mandatory missions Data access



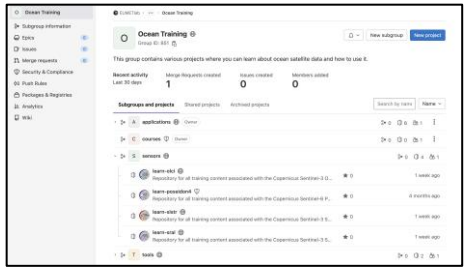
Courses

moodle

Code distribution

CONDA

GitLab

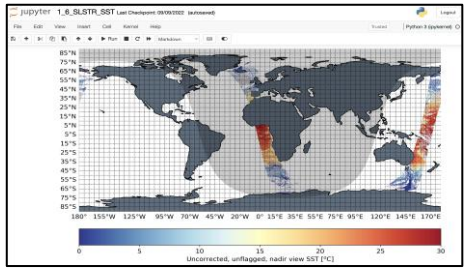


Video tutorials

YouTube

Jupyter Notebooks

jupyter

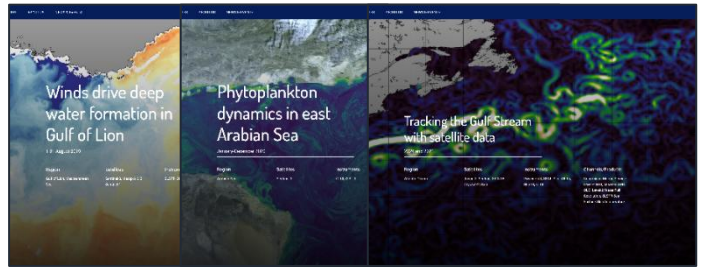


Cloud services

binder

WEkEO

Case studies



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