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TAKING THE PULSE OF OUR PLANET FROM SPACE

EUMETSAT ECMWF EUSPA

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

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The FRM4SOC Phase 2 project

FRM4SOC (Phase 1) 2016 – 2019

- 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

@frm4soc

The Fiducial Reference Measurements (FRM)

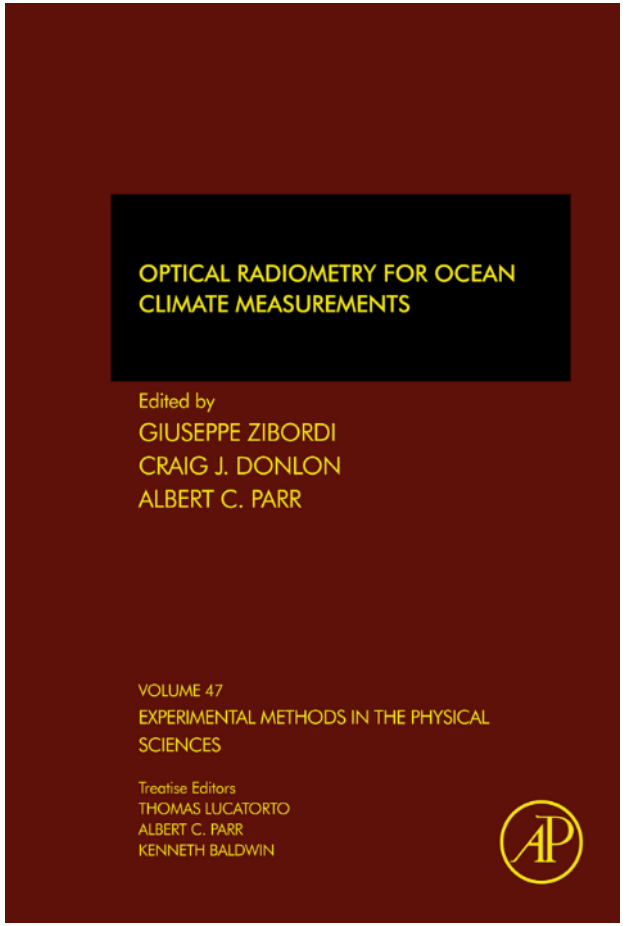
fi·du·cial ***(adj)*** *Regarded or employed as a standard of reference, as in surveying.*

[Latin *fīdūciālis*, *fīdūcia* – trust,confidence.]

In Earth Observation – a best estimate for the „ground truth“

The FRM must:

- have documented **traceability to SI units** (via an unbroken chain of calibrations and comparisons);
- be independent from the satellite retrieval process;
- be accompanied by a complete **estimate of uncertainty**, including contributions from all FRM instruments and all data acquisition and processing steps;
- follow **well-defined procedures**/community-wide management practices and;
- be openly available for independent scrutiny.



✓ Donlon, C.; Goryl, P. Fiducial Reference Measurements (FRM) for Sentinel-3. In Proceedings of the Sentinel-3 Validation Team (S3VT) Meeting, ESA/ESRIN, Frascati, Italy, 26–29 November 2013.

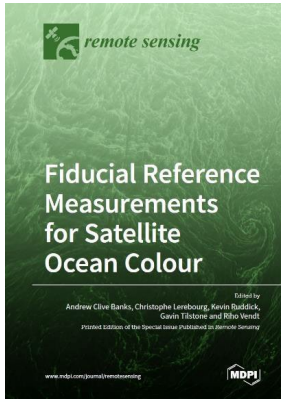
✓ Donlon, C.J.; Wimmer, W.; Robinson, I.; Fisher, G.; Ferlet, M.; Nightingale, T.; Bras, B. A., Second-Generation Blackbody System for the Calibration and Verification of Seagoing Infrared Radiometers. J. Atmospheric Ocean. Technol. 2014, 31, 1104–1127.

✓ G. Zibordi and C. J. Donlon, Chapters 3 and 5, vol. 47, G. Zibordi, C. J. Donlon, and A. C. Parr, Eds. Academic Press, 2014.

Goals of the FRM4SOC Phase 2

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

- FRM4SOC-2 is to build on the achievements of the first FRM4SOC study managed by ESA.
- Provide clear guidlines for obtaining FRM compliant data.
- Establish a network of radiometric measurements with the FRM certification (FRMOCnet).



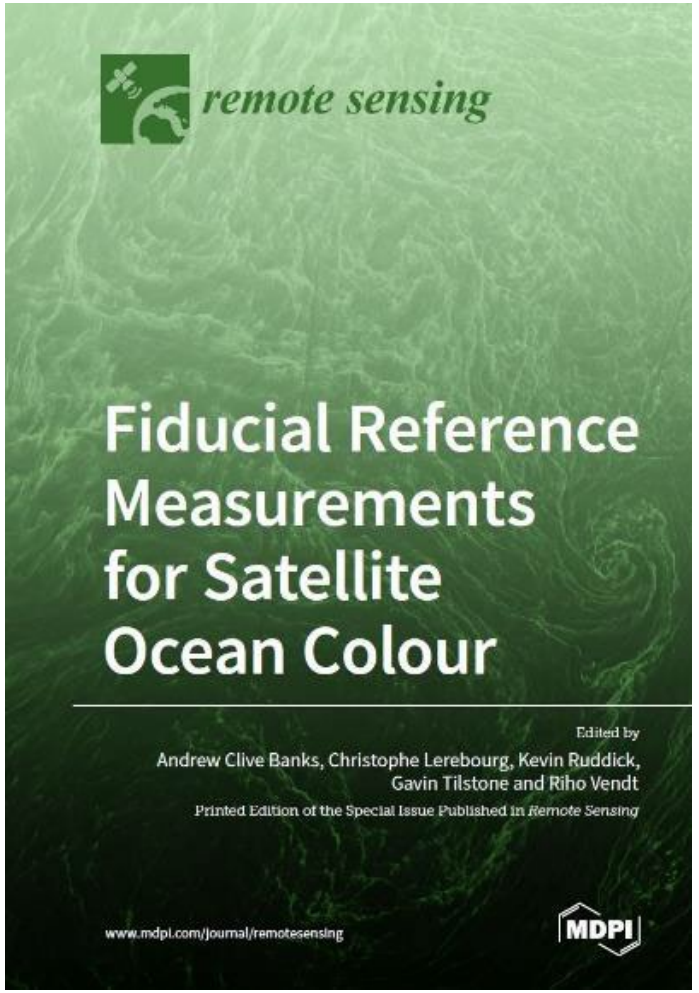
FRM4SOC

Identification of gaps in
- **traceability**,
- **calibration**,
- **characterization**,
- **uncertainty estimation**

FRM4SOC-2

Consolidate **FRM4SOC-1** focusing on
- **Operational** OCR cal/char guidelines.
- **Operational** (prescriptive) FRM procedures/protocols.
- **Engagement** of the **global** community.

Results from the FRM4SOC Phase-1



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

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Individual papers (web page of the special issue)

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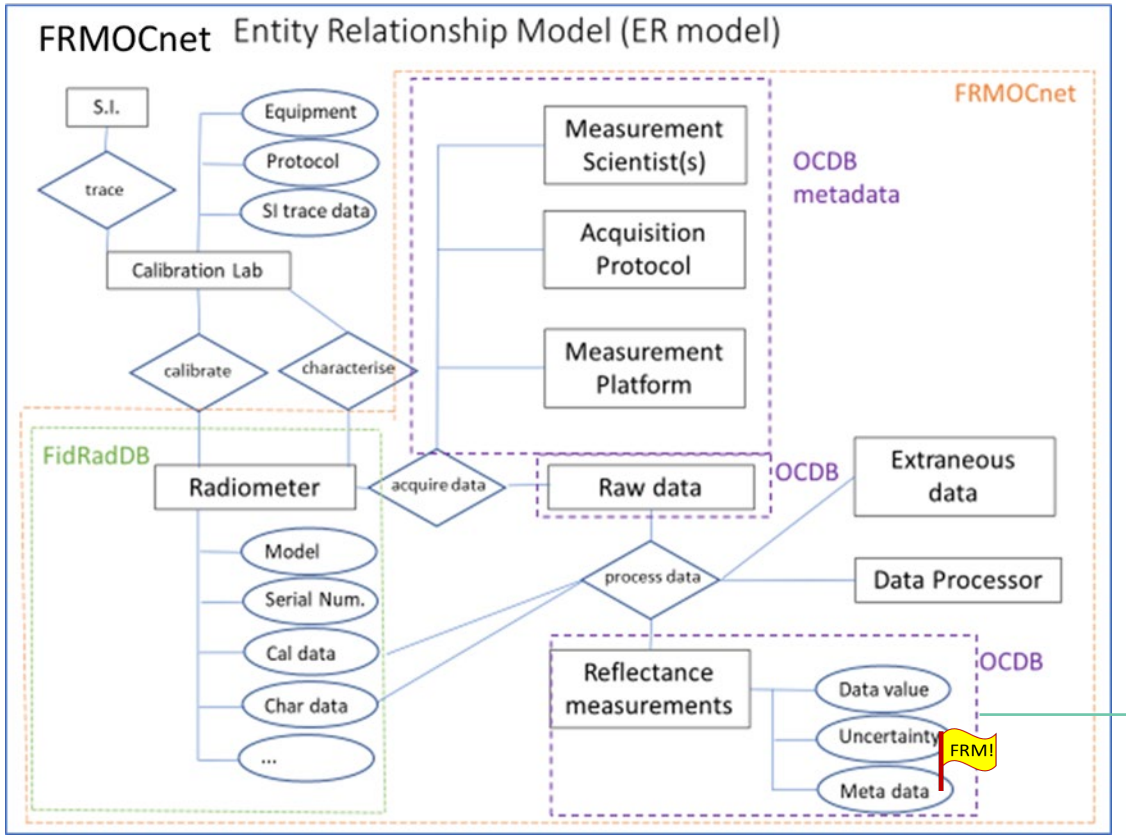
fiducial reference measurements for satellite ocean colour
FRM4SOC Phase-1

Network of radiometric measurements with the FRM certification (FRMOCnet)

museum
Royal Belgian Institute of Natural Sciences



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

OCR Calibration, Caracterisation

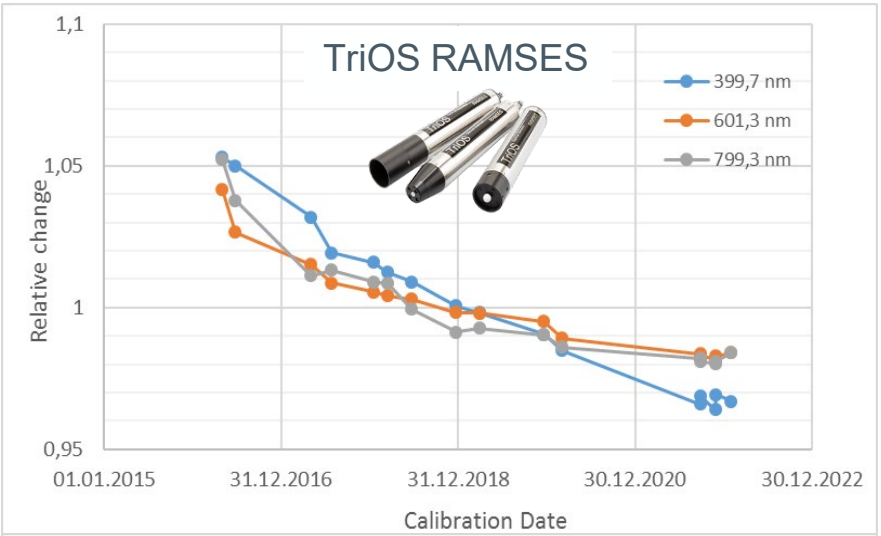
- Cal/Char plan

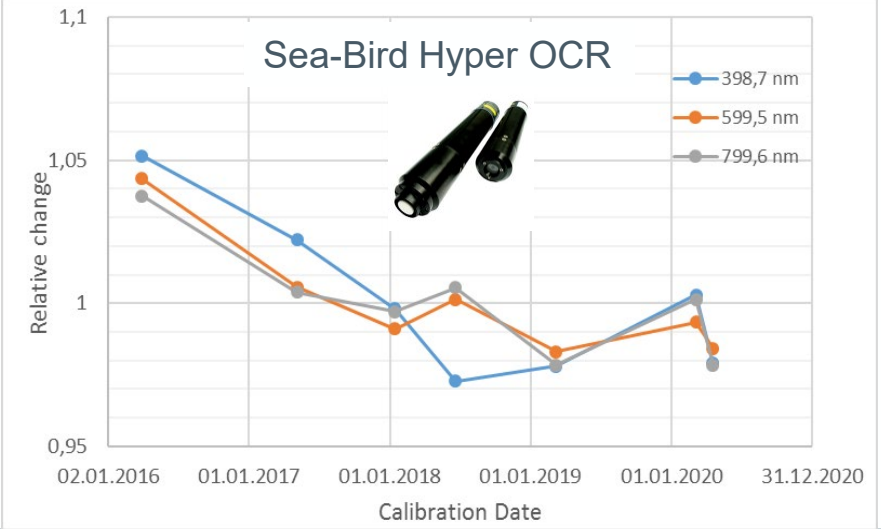
1. Absolute calibration for radiometric responsivity
2. Long term stability
3. Stray light and out of band response
4. Immersion factor (irradiance)
4b. Immersion factor (radiance)
5. Angular response of irradiance sensors in air
6. Response angle (FOV) of radiance sensors in air
7. Non-linearity
8. 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

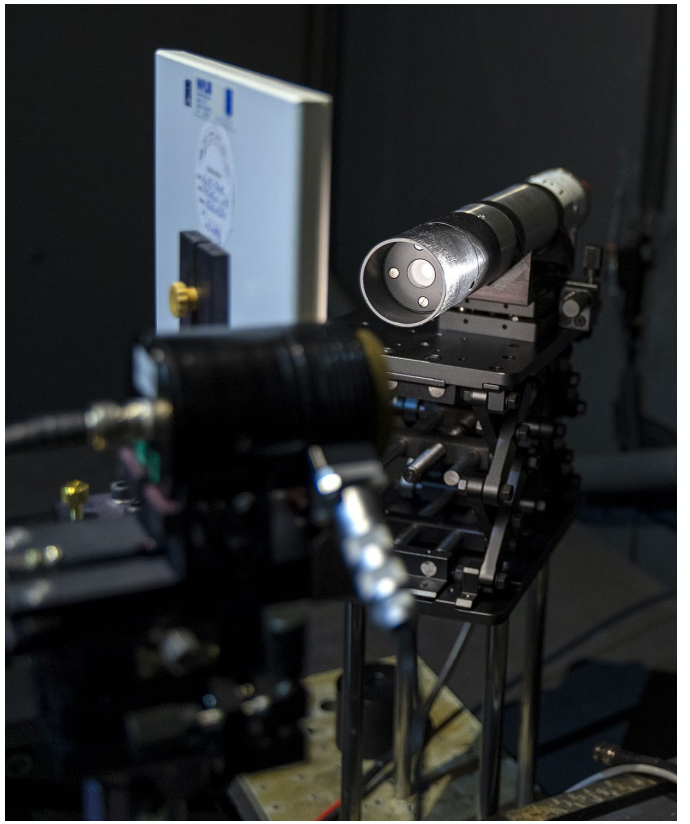
- Characterisation of instruments
- Guidelines for laboratories
- Laboratory comparison

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

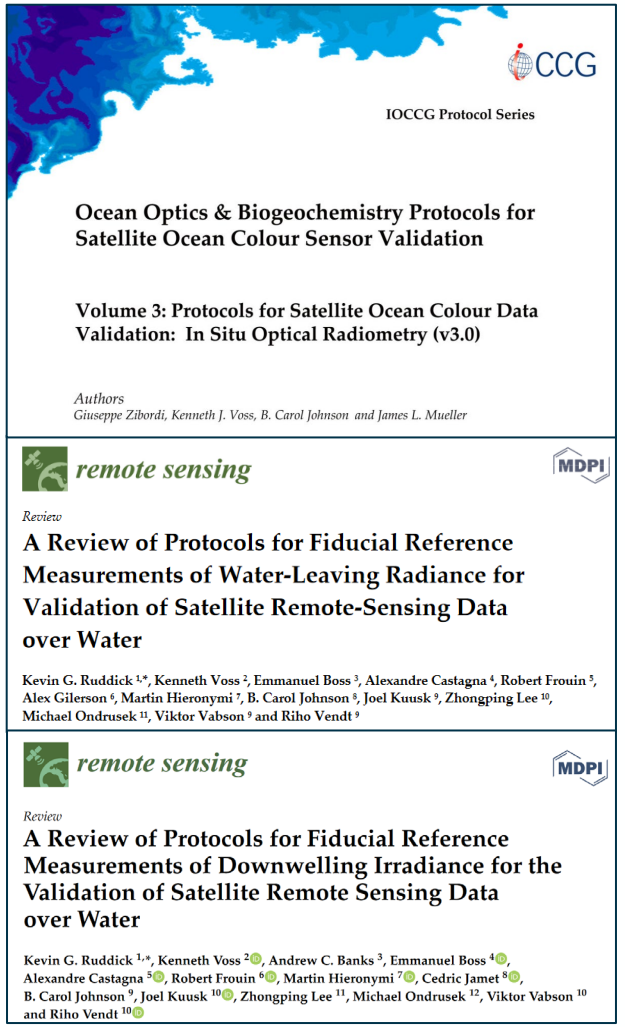
Examples of the calibration history







OCR FRM Procedures/Protocols

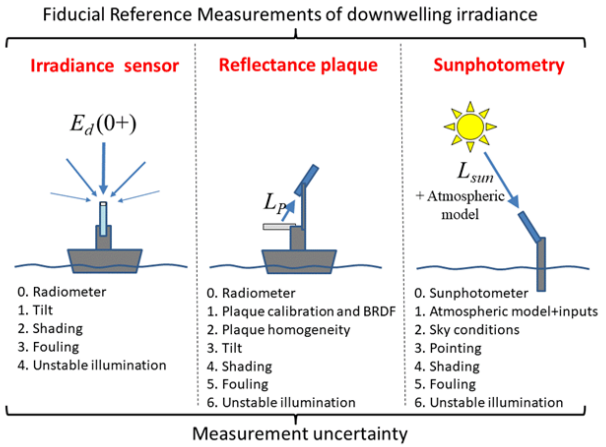


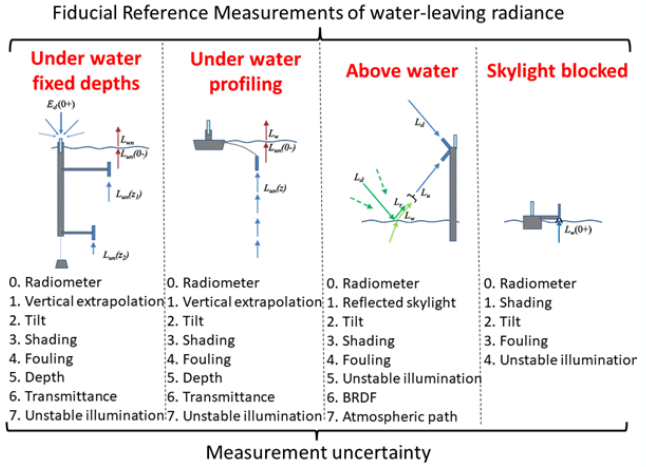
A Measurement Procedure for shipborne operation of the TriOS RAMSES and SeaBird/Satlantic HyperOCR radiometers to obtain Fiducial Reference Measurements (MPROC)

- Elaboration of the IOCCG and FRM4SOC-1 protocols
- In form of clear and prescriptive guidelines

Updates on

- Ancillary/complementary measurements
- Satellite/in-situ
  - viewing geometry difference
  - time differences
  - spatial difference
- Non-standard protocols for "complex waters"
- Good examples of complete uncertainty analysis following FRM4SOC principles





museum
Royal Belgian Institute of Natural Sciences

Community Processor (CP)

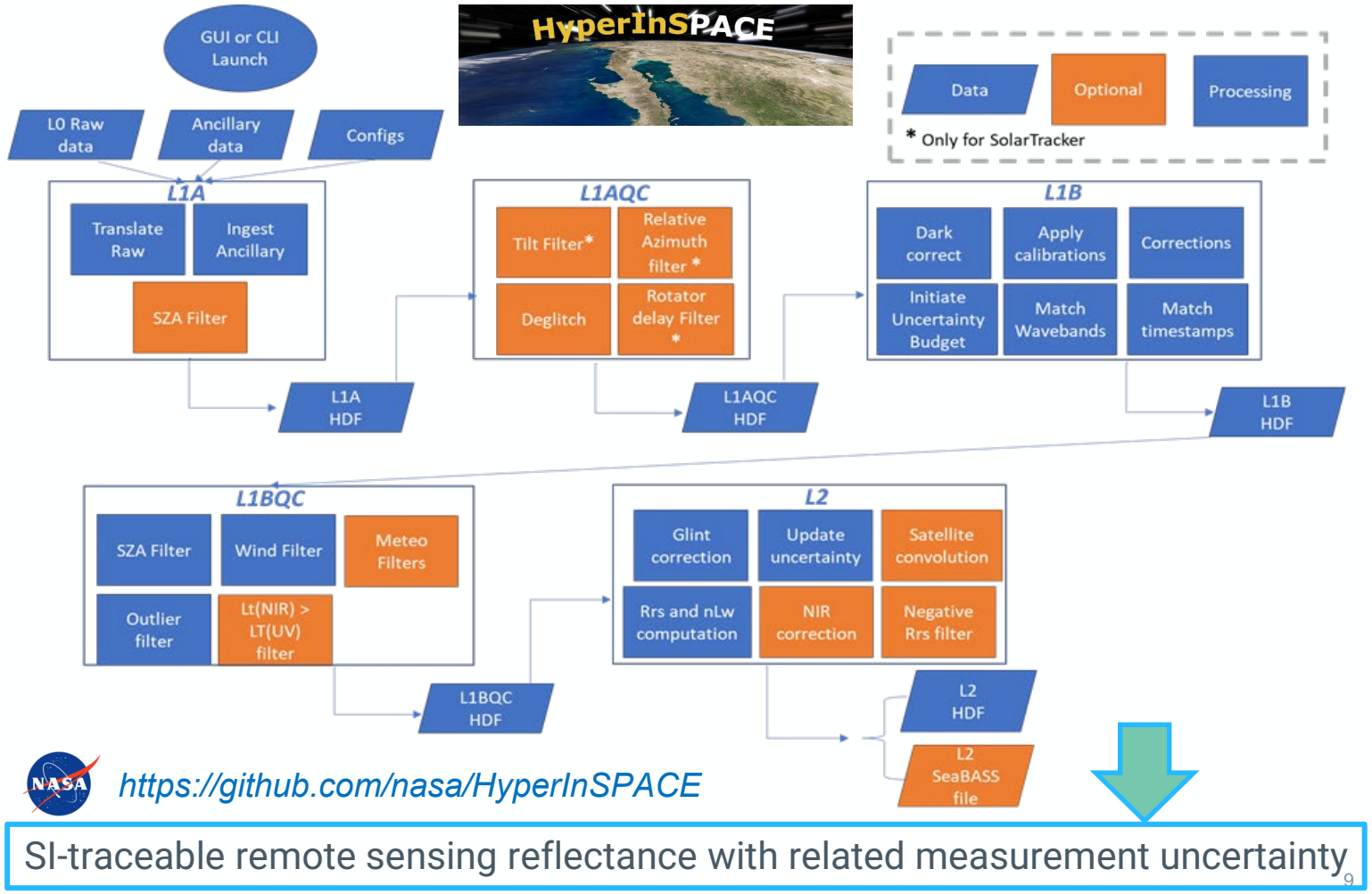
Community processor for in situ data processing and uncertainty budget calculation

Cooperation with NASA (HyperInSPACE)

- Currently supports
  Sea-Bird Scientific HyperSAS packages

Adding functionalitiy for:

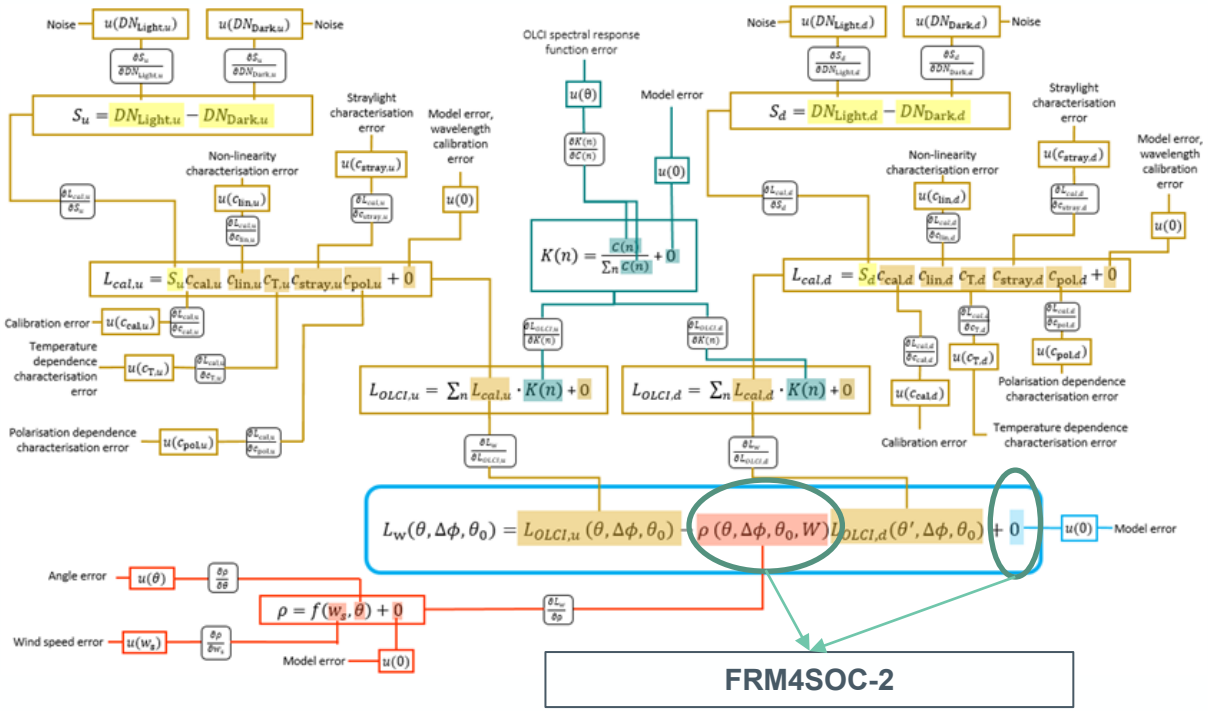
- TriOS RAMSES data;
- Corrections and uncertainties from OCR characterisation;
- Full end-to-end uncertainty calculation;
- Command Line Interface (CLI).



Uncertainty budgets

Elaboration of the FRM4SOC Phase 1 uncertainty budgets

- Develop end-to-end uncertainty budgets for
  - remote sensing reflectance,
  - fully normalised water-leaving radiance.
- Address uncertainty components
  not previously analysed in FRM4SOC Phase 1
  - e.g. environment effects (ambient temperature, sky radiance cosine error, polarisation, structure shading, sun-glint, wave focusing, etc.).
- Implementation of uncertainty calculations
  in the CP processing chain.
- Easy and practical guidelines for uncertainty calculation.



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

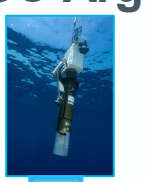
Ocean Colour In-Situ Database (OCDB)

Community Processor

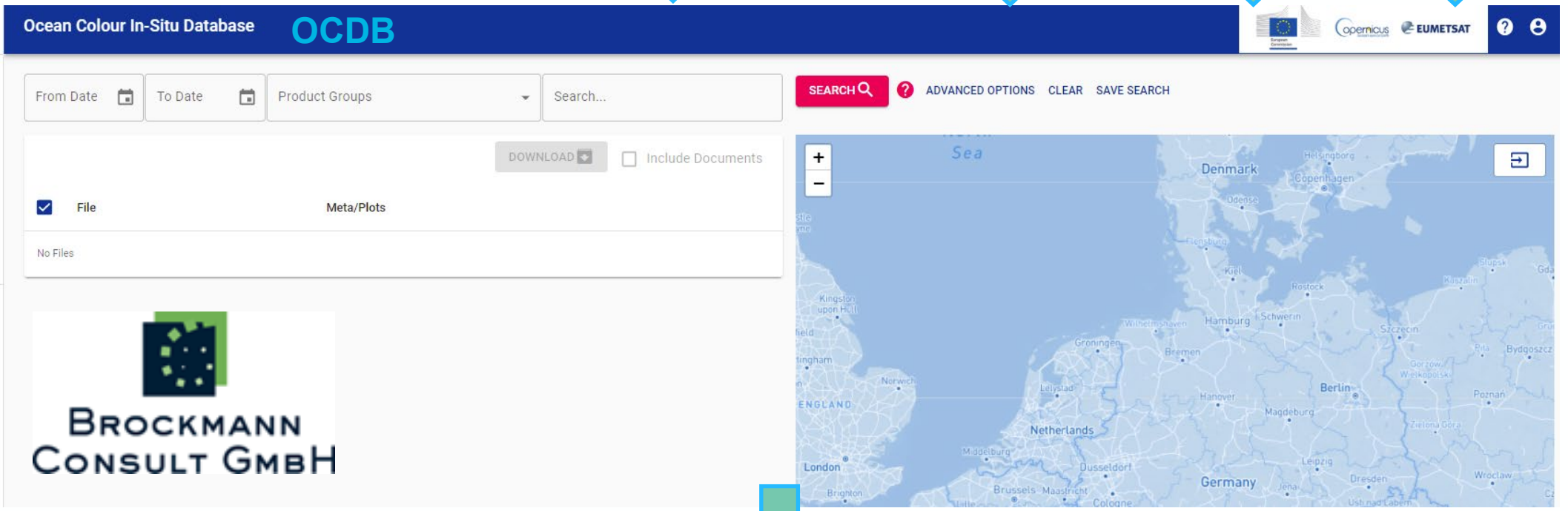
AERONET-OC

MOBY

BGC Argo



https://ocdb.eumetsat.int/



Data users

Field InterComparison Exercise

11-20 July 2022, at

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

Critical review, testing, and feedback on

- FRMOCnet;
- measurement protocols;
- Community processor;
- SI traceability;
- Application of instrument characterisation;
- Uncertainty budgets;
- Aimed uncertainty levels.

PML | Plymouth Marine Laboratory

Paricipating systems (7 institutes registered)
Above water: TRIOS RAMSES; TriOS RAMSES G2 sun tracker (SoRAD)
Hyper SAS with PySAS robot; HypSTAR

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

Water type: Optical Case 1 (clear open sea waters) 60% of the year (Zibordi et al., 2009b); 40% optical Case 2 (turbid coastal) depending on river discharge from the surrounding catchment.

Fiducial Reference Measurements
for Satellite Ocean Colour Phase 2

FRM4SOC-2
Project Workshop

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

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

unded by the European Union

Acknowledgements

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EUMETSAT

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