# Laboratory exercise LCE-2 in the framework of FRM4SOC

FRM4SOC

*https://frm4soc.org*

*Riho Vendt (TO)*

# 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

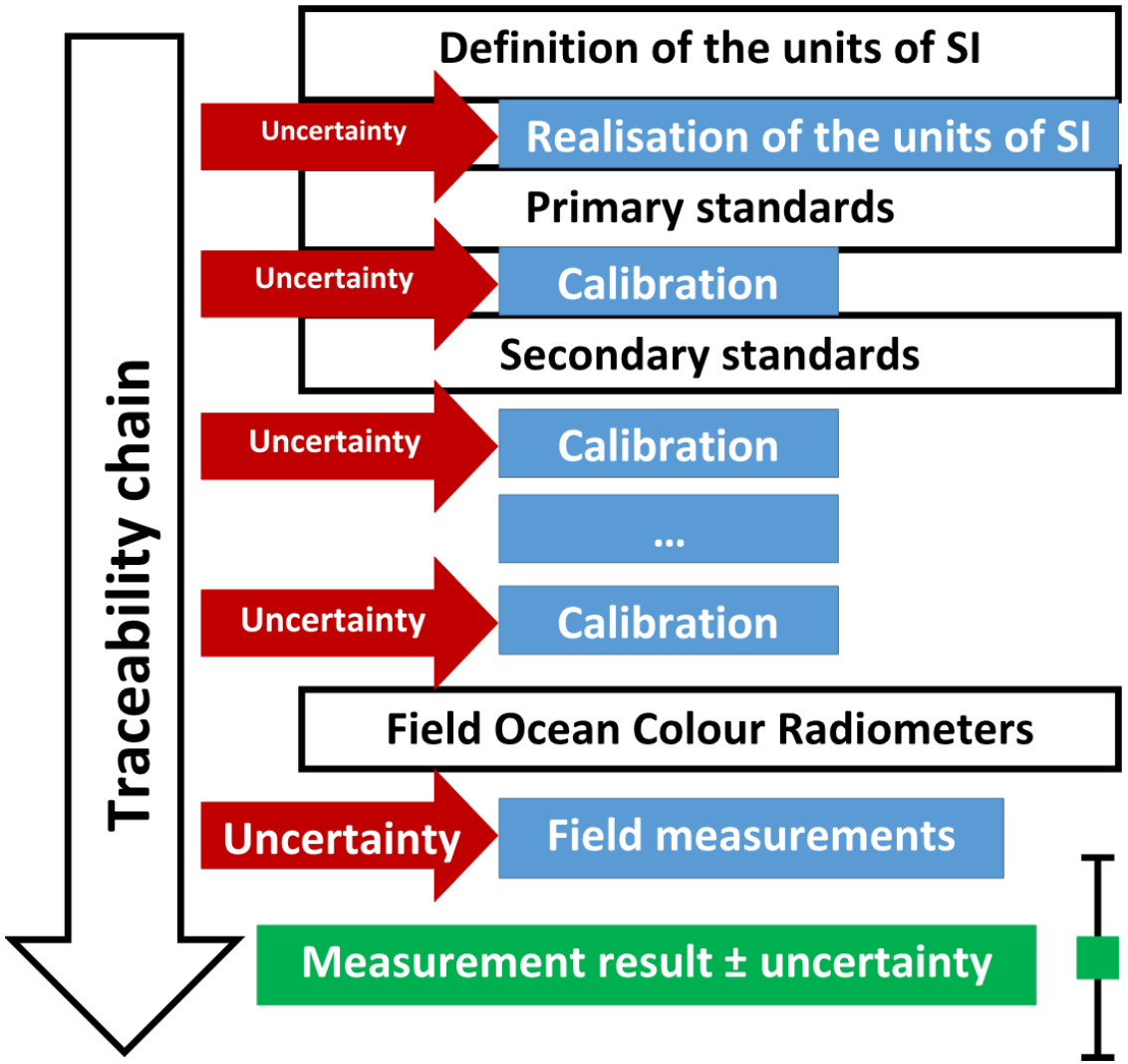
- have documented **traceability to SI** (calibration, comparison);
- be **independent from the satellite retrieval process**;
- have evaluated **uncertainty budgets** for all FRM instruments and measurements procedures available and maintained;
- defined and adhered **protocols/community-wide management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

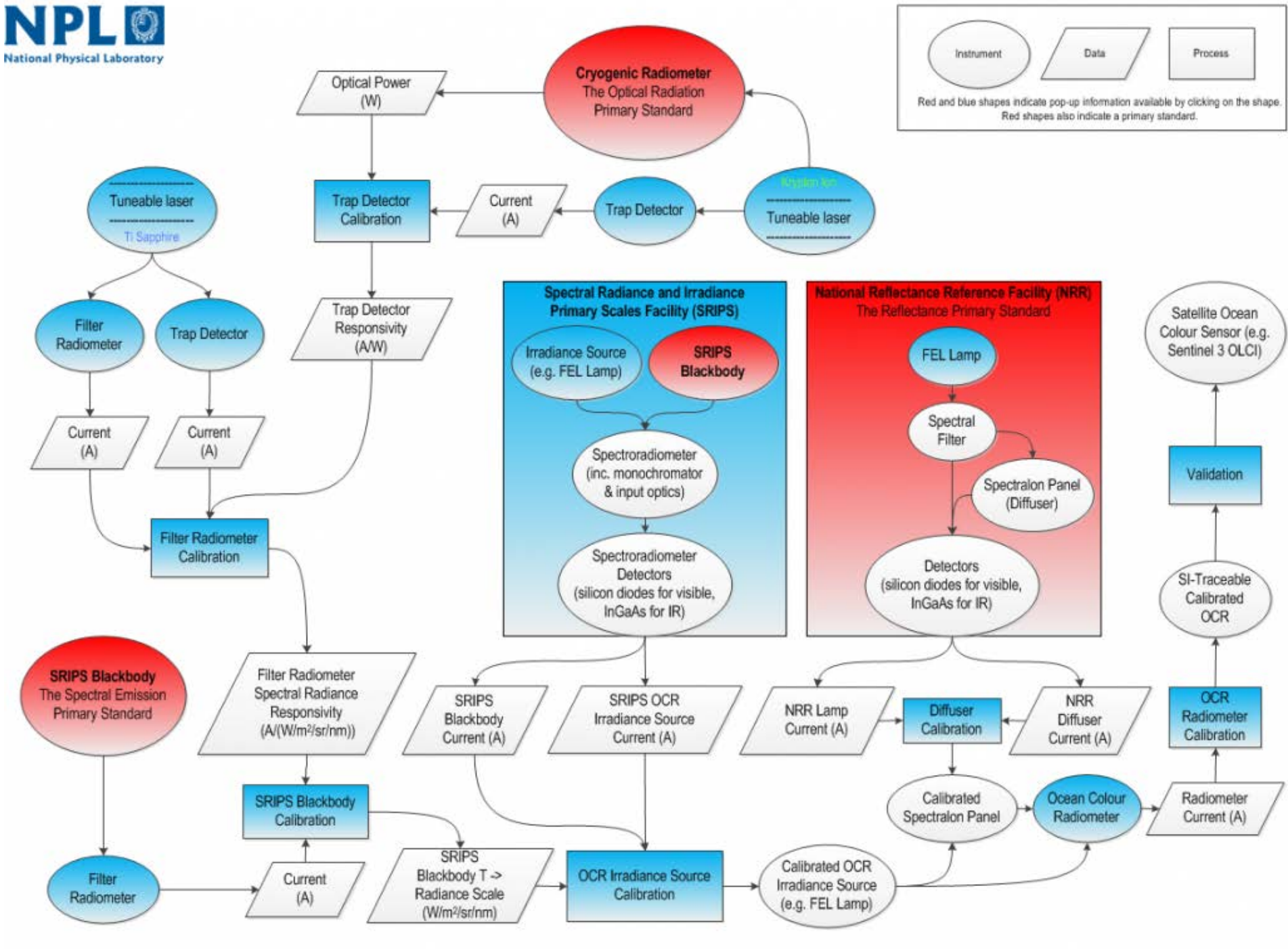
# Objectives of FRM4SOC

- 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

fiducial reference measurements for satellite ocean colour

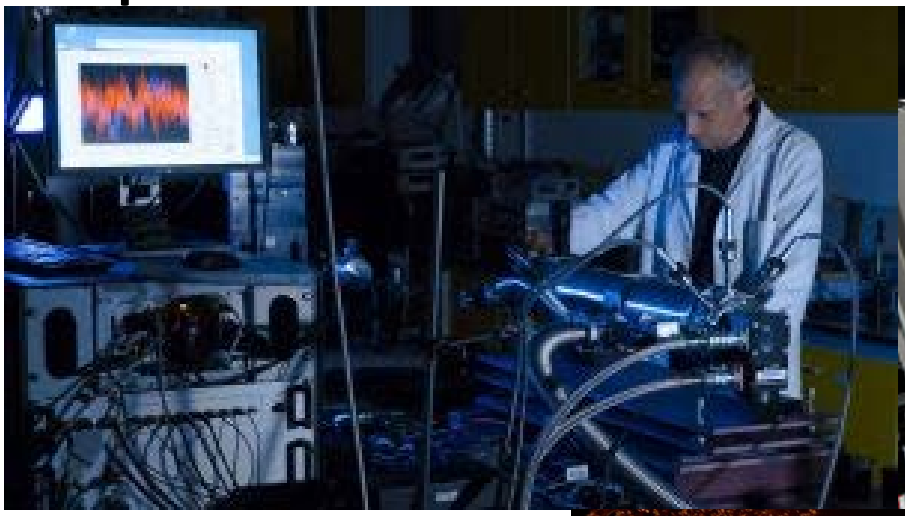
| |
|---|
| WKP – 1 Workshop on vicarious adjustment |
| OCR FRM Description, Measurement Procedures and Protocols |
| LCE-1 Verification of reference irradiance and radiance sources |
| **LCE-2** Verification of OC radiometer calibration |
| **FICE –** OC Field Inter-comparison experiments |
| Compilation of uncertainty budgets |

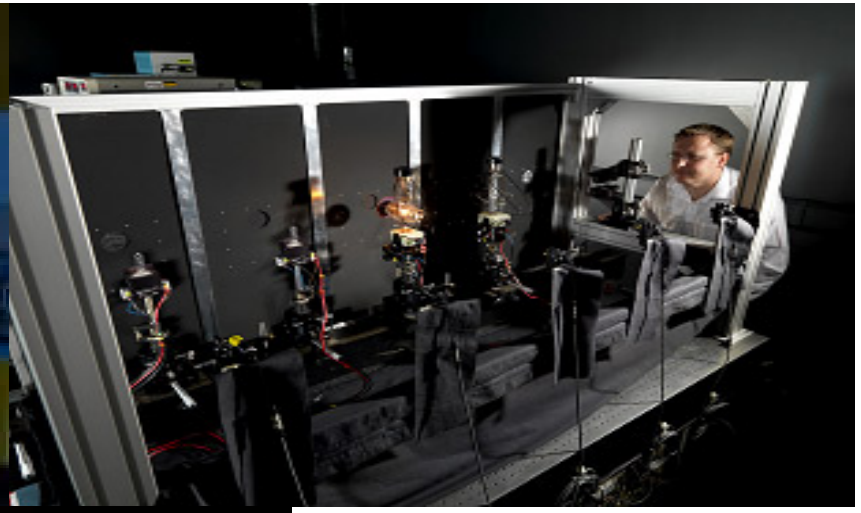

Traceability chain
Definition of the units of SI
Uncertainty
Realisation of the units of SI
Primary standards
Uncertainty
Calibration
Secondary standards
Uncertainty
Calibration
...
Uncertainty
Calibration
Field Ocean Colour Radiometers
Uncertainty
Field measurements
Measurement result ± uncertainty

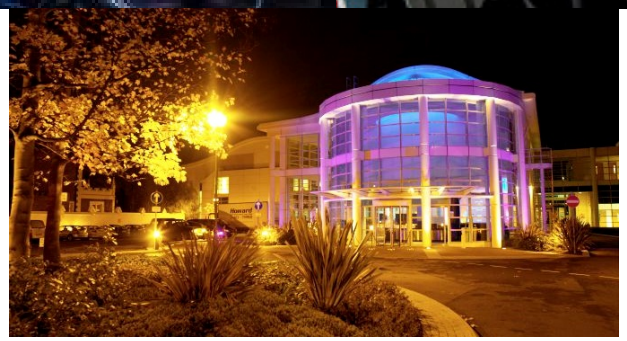

NPL
National Physical Laboratory
Instrument
Data
Process
Red and blue shapes indicate pop-up information available by clicking on the shape.
Red shapes also indicate a primary standard.
Cryogenic Radiometer
The Optical Radiation
Primary Standard
Optical Power
(W)
Krypton Ion
Tuneable laser
Trap Detector
Current
(A)
Trap Detector
Calibration
Tuneable laser
Ti Sapphire
Filter
Radiometer
Trap Detector
Current
(A)
Current
(A)
Trap Detector
Responsivity
(A/W)
Filter Radiometer
Calibration
Spectral Radiance and Irradiance
Primary Scales Facility (SRIPS)
Irradiance Source
(e.g. FEL Lamp)
SRIPS
Blackbody
Spectroradiometer
(inc. monochromator
& input optics)
Spectroradiometer
Detectors
(silicon diodes for visible,
InGaAs for IR)
National Reflectance Reference Facility (NRR)
The Reflectance Primary Standard
FEL Lamp
Spectral
Filter
Spectralon Panel
(Diffuser)
Detectors
(silicon diodes for visible,
InGaAs for IR)
Satellite Ocean
Colour Sensor (e.g.
Sentinel 3 OLCI)
Validation
SI-Traceable
Calibrated
OCR
OCR
Radiometer
Calibration
SRIPS Blackbody
The Spectral Emission
Primary Standard
Filter Radiometer
Spectral Radiance
Responsivity
(A/(W/m²/sr/nm))
SRIPS
Blackbody
Current (A)
SRIPS OCR
Irradiance Source
Current (A)
NRR Lamp
Current (A)
Diffuser
Calibration
NRR
Diffuser
Current (A)
SRIPS Blackbody
Calibration
Calibrated
Spectralon Panel
Ocean Colour
Radiometer
Radiometer
Current (A)
Filter
Radiometer
Current
(A)
SRIPS
Blackbody T ->
Radiance Scale
(W/m²/sr/nm)
OCR Irradiance Source
Calibration
Calibrated OCR
Irradiance Source
(e.g. FEL Lamp)

# LCE-1 3 – 7 April 2017 at NPL, Teddington, UK

## Comparison of Reference Irradiance and Radiance Sources at NPL

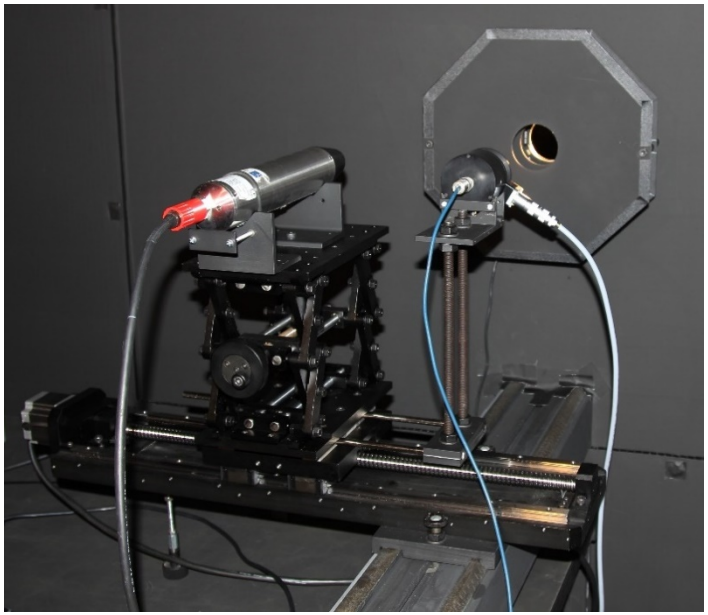




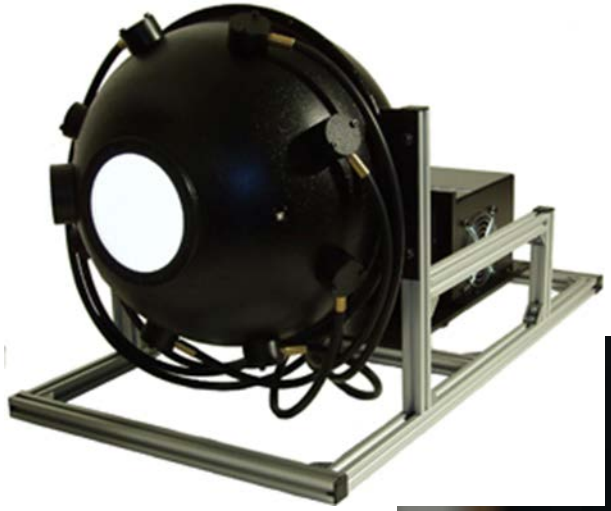


# LCE-2 8 – 13 May 2017 at TO, Tõravere, Estonia

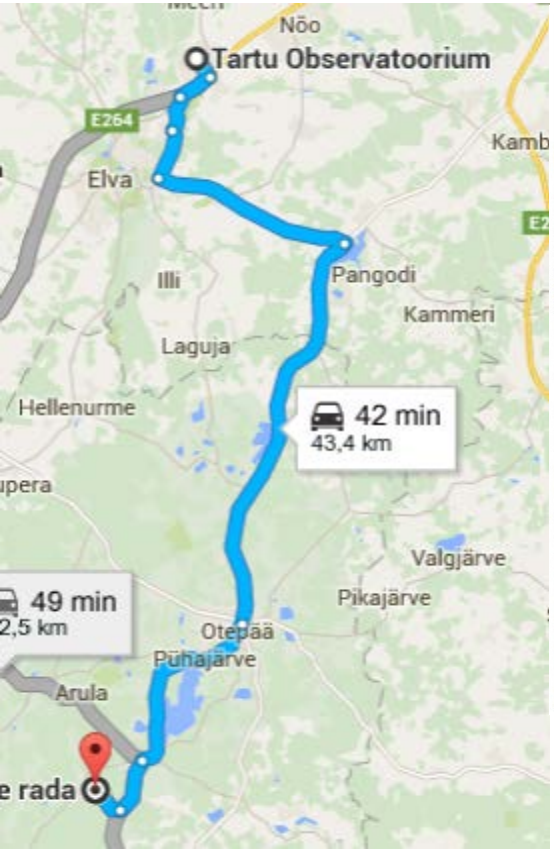
1. TO calibrates all participating radiometers



2. Participants measure the targets under controlled laboratory conditions



# **LCE-2** outdoor intercomparison - Lake Kääriku, 8 – 13 May 2017



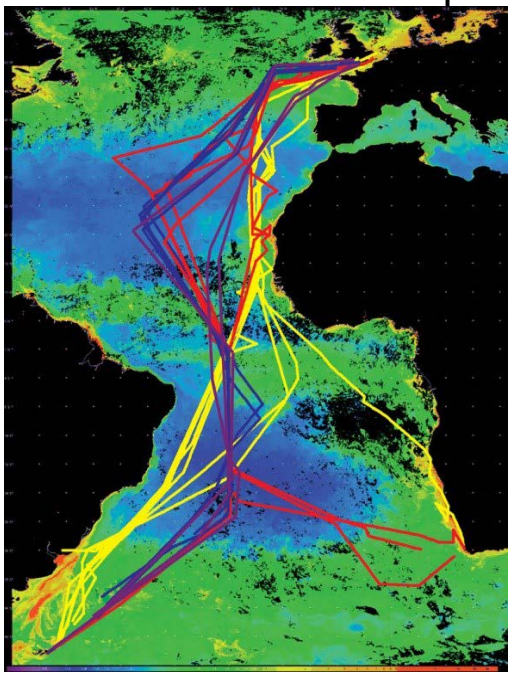



**FICE experiments will be conducted on two platforms** which have a long history of satellite ocean colour validation and development during NASA and ESA missions (O'Reilly et al. 1998; Zibordi et al. 2006).

**1.** The **<u>Acqua Alta Oceanographic Tower</u> (AAOT),** Gulf of Venice, Italy.
8 days, in **July *2018*** .

Purpose built steel tower with instrument house platform to conduct optical measurements under stable conditions to tilt and roll and illumination geometry.

**2.** The **<u>Atlantic Meridional Transect</u> (AMT)**
27. ***Sept-Oct 2017***.
AMT cruises are conducted between UK & South Atlantic on a NERC ship.



AMT passes through a wide range of environmental conditions and biogeochemical provinces.

# Uncertainty Budgets


| UNCERTAINITY COMPONENTS | SELECTED SPECTRAL BANDS OF THE SENTINEL 3 OLCI SENSOR | | | |
|---|---|---|---|---|
| | 400 nm | 442.5 nm | 490 nm | 560 nm |
| FEL standard lamp irradiance | 0.78 % | 0.61 % | 0.61 % | 0.61 % |
| Interpolation of irradiance | 0.2 % | 0.2 % | 0.2 % | 0.2 % |
| Lamp ageing | 0.28 % | 0.28 % | 0.28 % | 0.28 % |
| Shunt | 0.002 % | 0.002 % | 0.002 % | 0.002 % |
| Lamp current | 0.15 % | 0.15 % | 0.15 % | 0.15 % |
| Distance lamp - sensor | 0.08 % | 0.08 % | 0.08 % | 0.08 % |
| Alignment of lamp position | 0.1 % | 0.1 % | 0.1 % | 0.1 % |
| Alignment of radiometer | 0.1 % | 0.1 % | 0.1 % | 0.1 % |
| Temperature variability | 0.1 % | 0.1 % | 0.1 % | 0.1 % |
| Expanded uncertainity, k=2 | 1.5 % | 1.5 % | 1.5 % | 1.5 % |

Wavelength λ [nm]

Deriving a full uncertainty budget for the laboratory calibration exercises:

- **Will follow the GUM – Guide to the expression of Uncertainty in Measurement**
  - ✓ The foremost authority and guide to the expression and calculation of uncertainty in measurement science
  - ✓ Written by the JCGM and BIPM

http://www.bipm.org/en/publications/guides/gum.html

# Contact information and updates


*frm4soc.org*

*riho.vendt@to.ee*

*craig.donlon@esa.int*


*#frm4soc*