European Commission

fiducial reference measurements for satellite ocean colour

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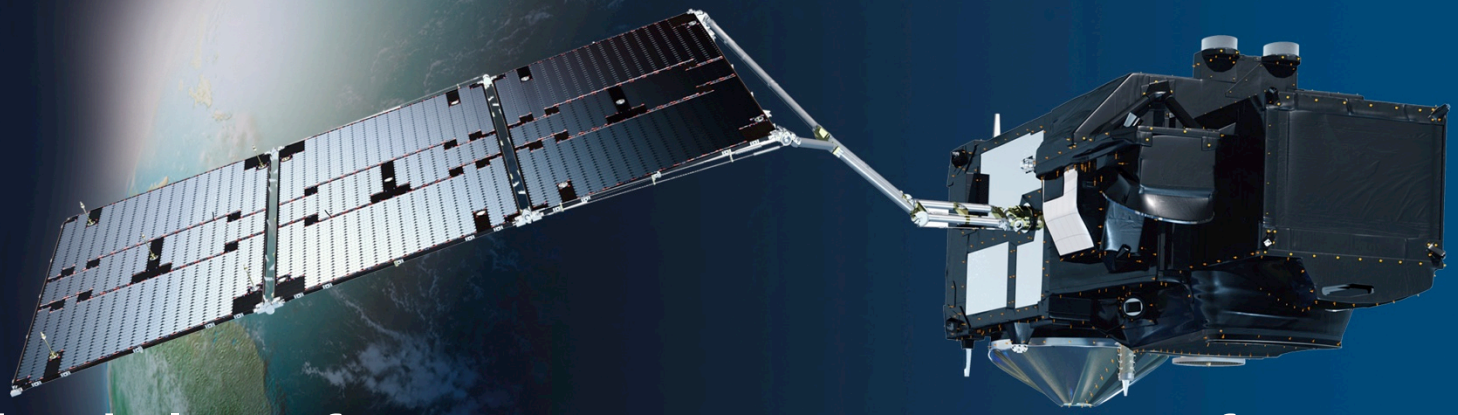
European Space Agency



Fiducial Reference Measurements for Satellite Ocean Colour (FRM4SOC)

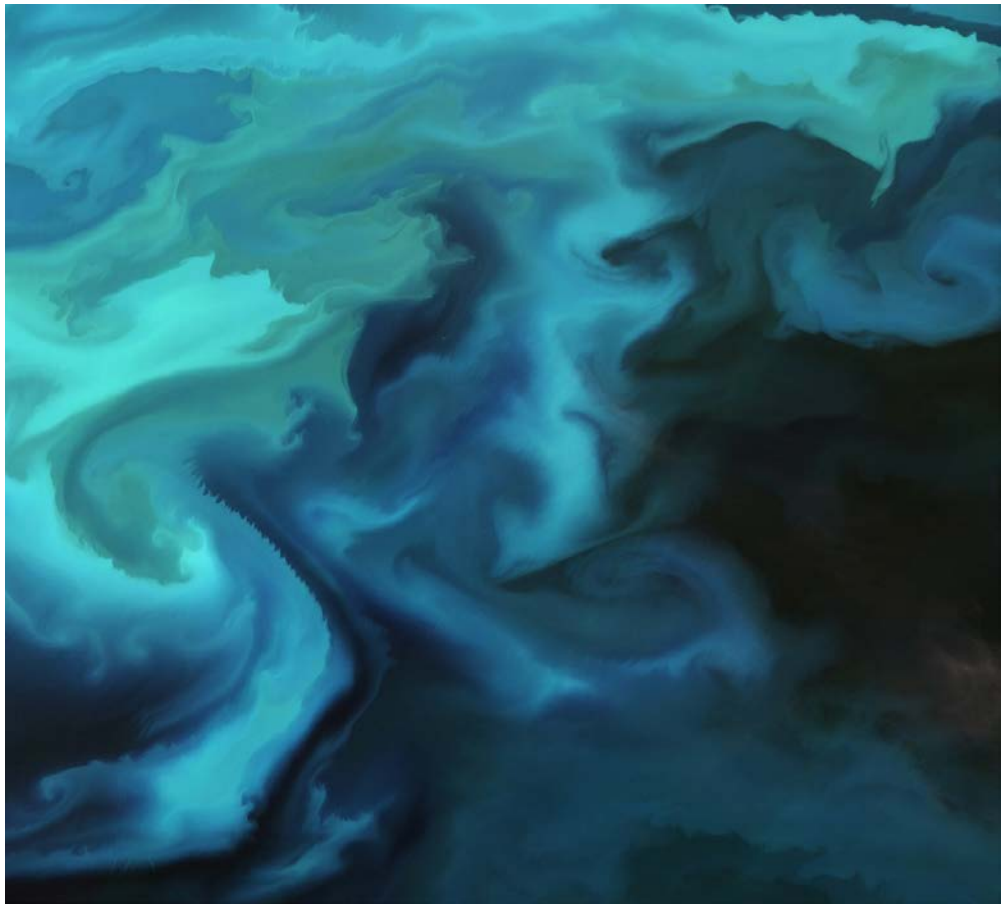
Craig Donlon and Tania Casal
European Space Agency, ESTEC, Noordwijk, The Netherlands

P. Goryll, J. Nieke, M. Rast, A. Straume, T. Fehr, M. Drinkwater, D. Schuttemeyer

Overview

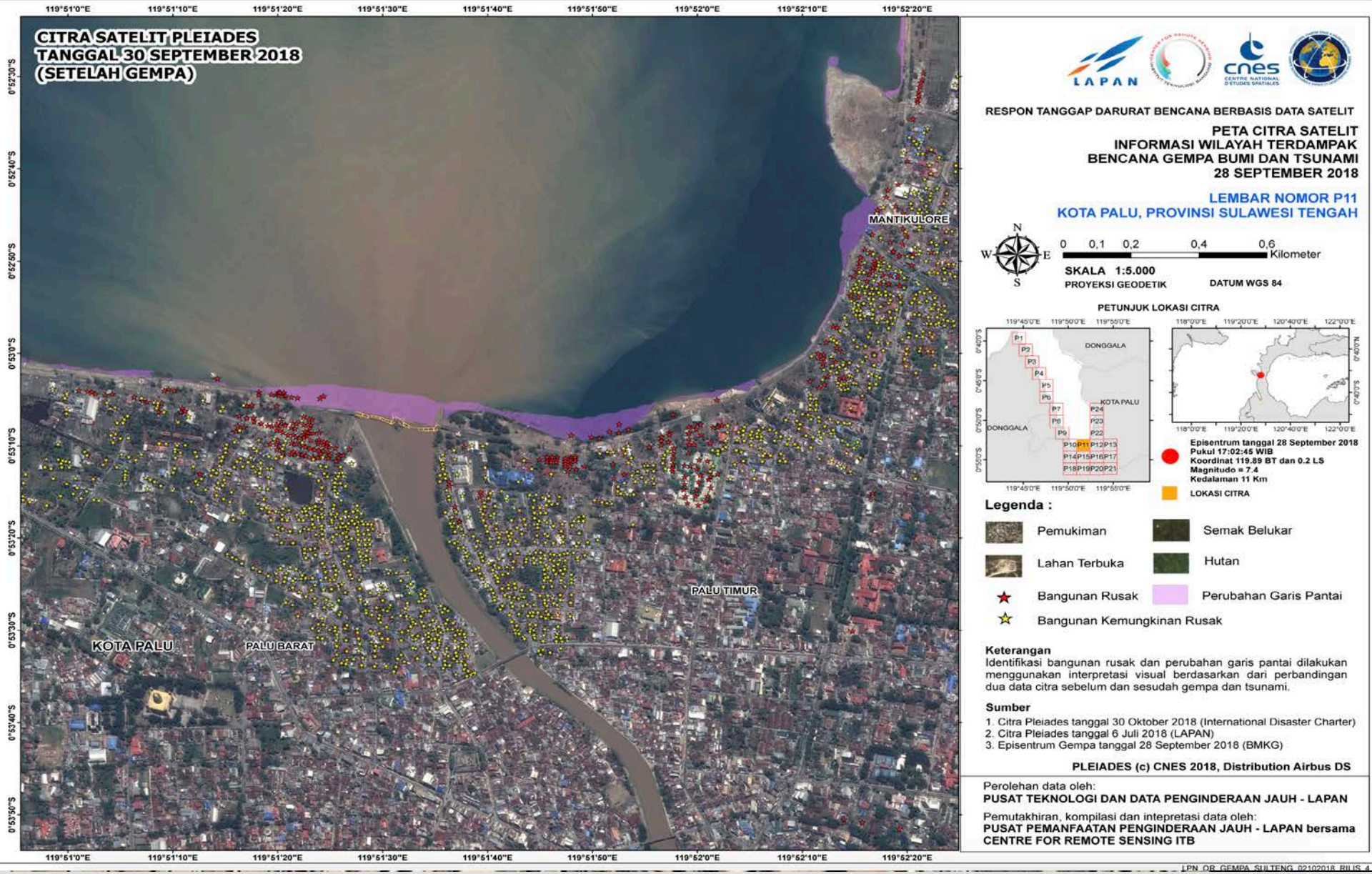
- What's the problem?
- Fiducial Reference Measurements
- FRM4SOC
- Future perspectives

fiducial reference measurements for satellite ocean colour

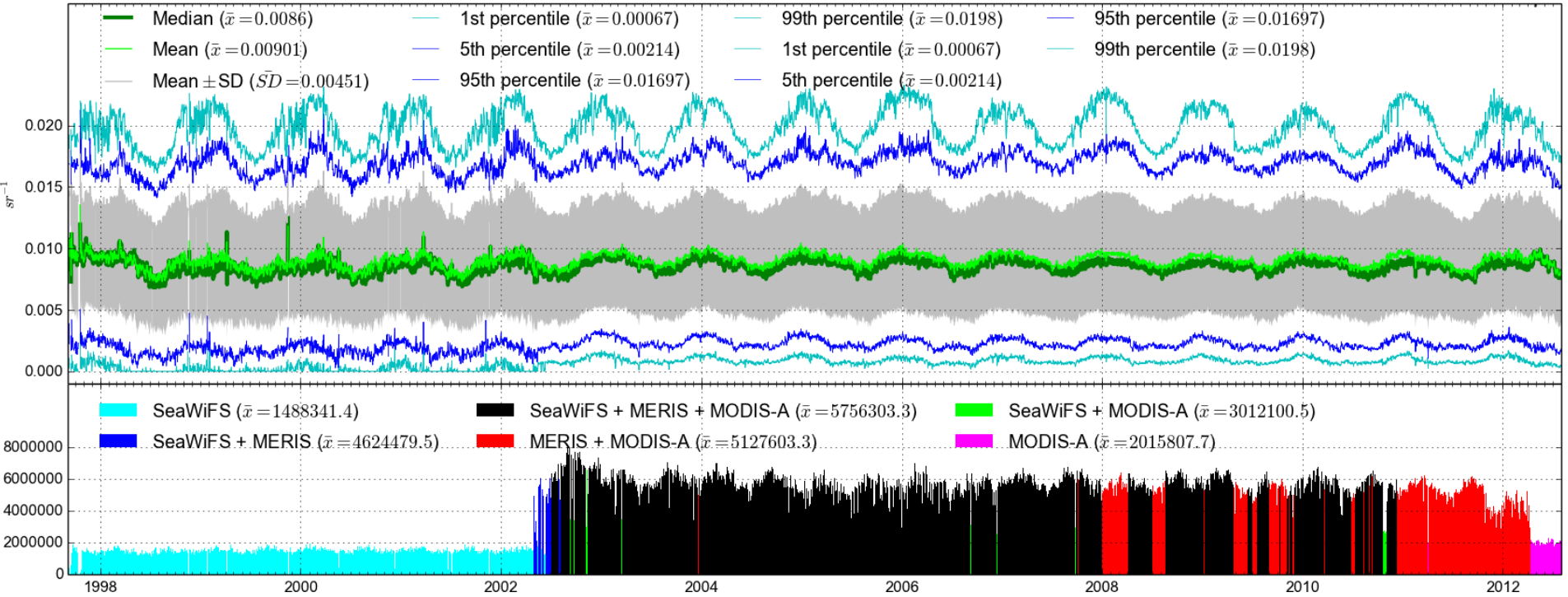


Earth Observation Envelope Programme

Ocean Colour Radiometry: Science and Society



OCR Time Series: Daily coverage: gaps in daily coverage with single sensor



(Credit: OC_cci, S. Sathyendranath)

- Need two to three sensors to minimise gaps in daily coverage, and to reduce noise
- Promise of Sentinel: at least two sensors in constellation mode when Sentinel 3A and 3B are in orbit
- Current status: OC-CCI time series reliant solely on old sensor MODIS-A. VIIRS under evaluation.

Impact of sea level rise

climate change initiative

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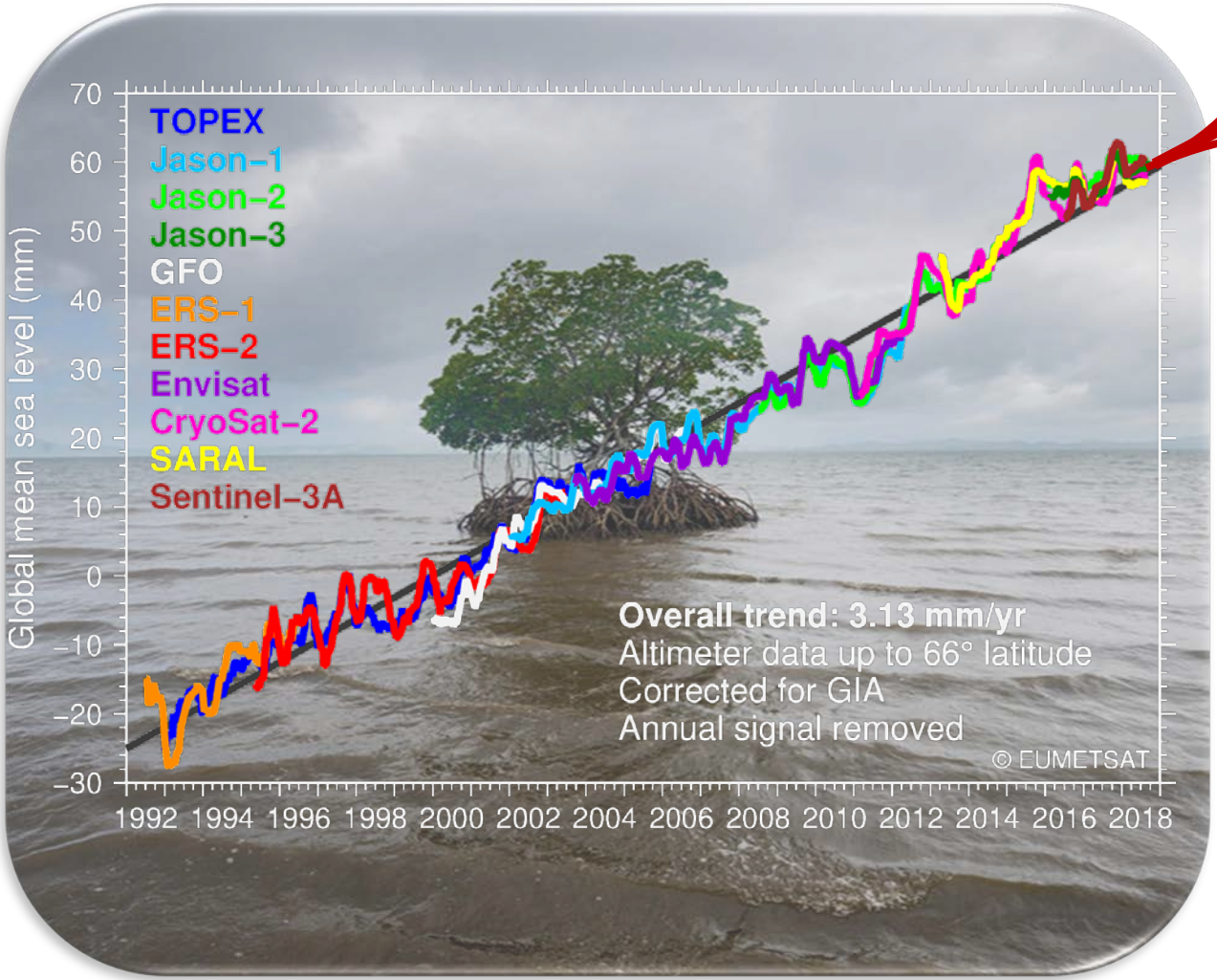
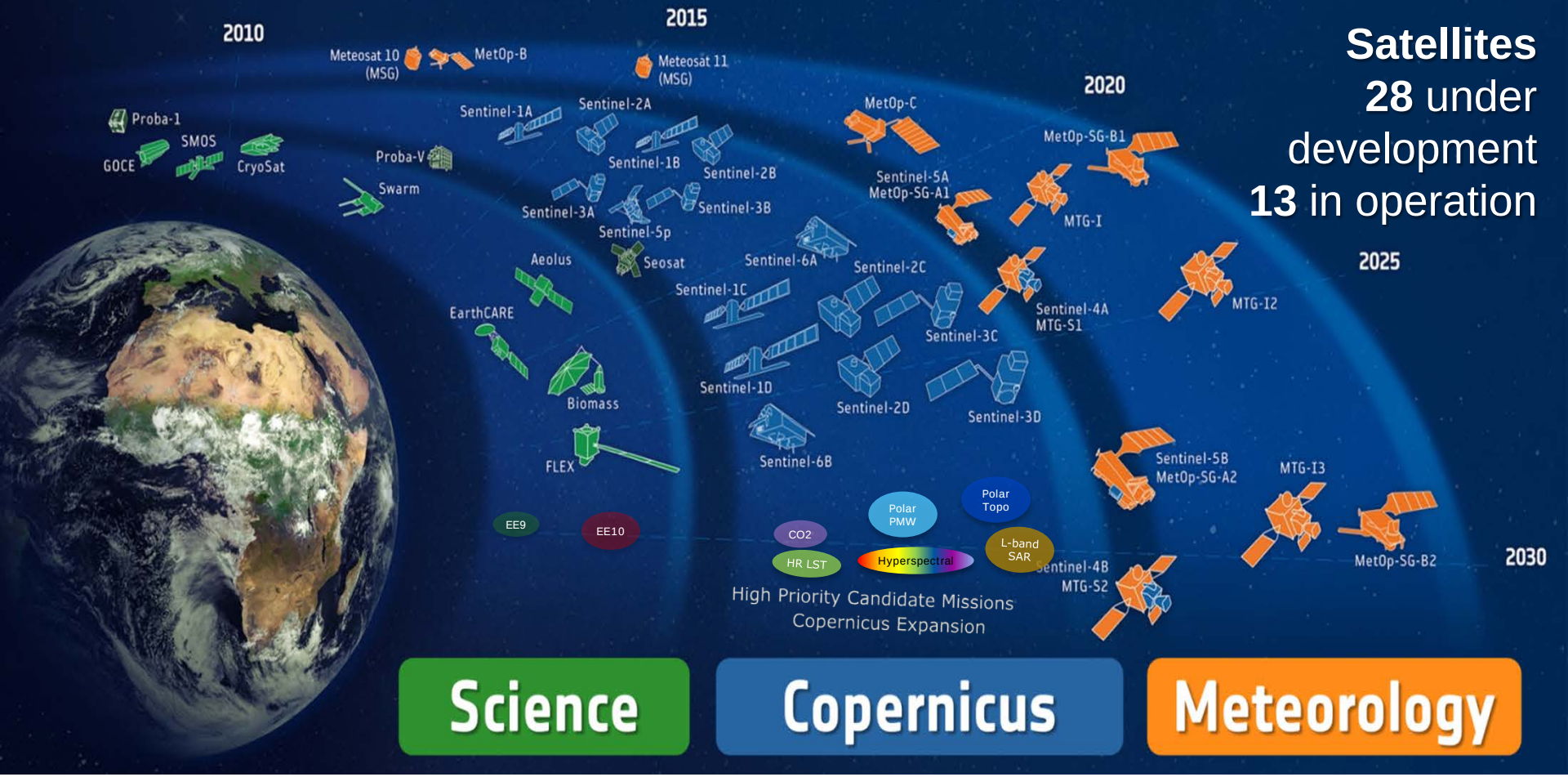


ocean colour cci

ESA-DEVELOPED EARTH OBSERVATION MISSIONS



Satellites
28 under development
13 in operation

Copernicus Sentinel Status

S-1	S-2	S-3	S-4	S-5P	S-5	S-6
						
Radar	High Res. Optical	Medium		tmospheric hemistry (LEO)	Atmospheric Chemistry (LEO)	Altimetry
A 3 Apr. 2014	A 23 Jun. 2015			2017	A 2021	A 2020
B 25 Apr. 2016	B 6 Mar. 2017				B 2027	B 2025
C 2022/23	C 2022/23				C > 2027	
D > 2022/23	D > 2022/23	D > 2023				

Sentinel-5P Launched 13 October, 2017

Sentinel-3B Launched 25 April, 2018

Band Set of OLCI&MSI in the Visible and the Near Infra-Red

(Credit: OC_cci, S. Sathyendranath)

- Higher spectral resolution than all previous sensors: Important for atmospheric correction, complex coastal waters, phytoplankton types
- Consistency with MERIS: facilitates merging (no need to do band-shifting to establish inter-sensor biases)

Copernicus Expansion: High Priority Candidate Missions (HPCM)

- **Potential** Copernicus High Priority Candidate Missions (HPCM) under discussion include:
    1. **Anthropogenic CO2 monitoring** Mission
    2. **High spatial-temporal resolution land surface temperature** (LST) monitoring mission (including coastal areas)
    3. **Passive microwave imaging radiometry** mission
    4. **Polar ice and snow topography** mission
    5. **Hyper-spectral imaging** mission (including coastal areas)
    6. **L-band SAR** mission

- **ESA Phase A/B1 studies for all HPCM all in progress**
- **The EC process of user needs and prioritisation is on-going and will continue in parallel**
- **Final selection of HPCM specific characteristics (e.g. spectral choice, number of satellites etc.) will be determined at the end of Phase A/B1**

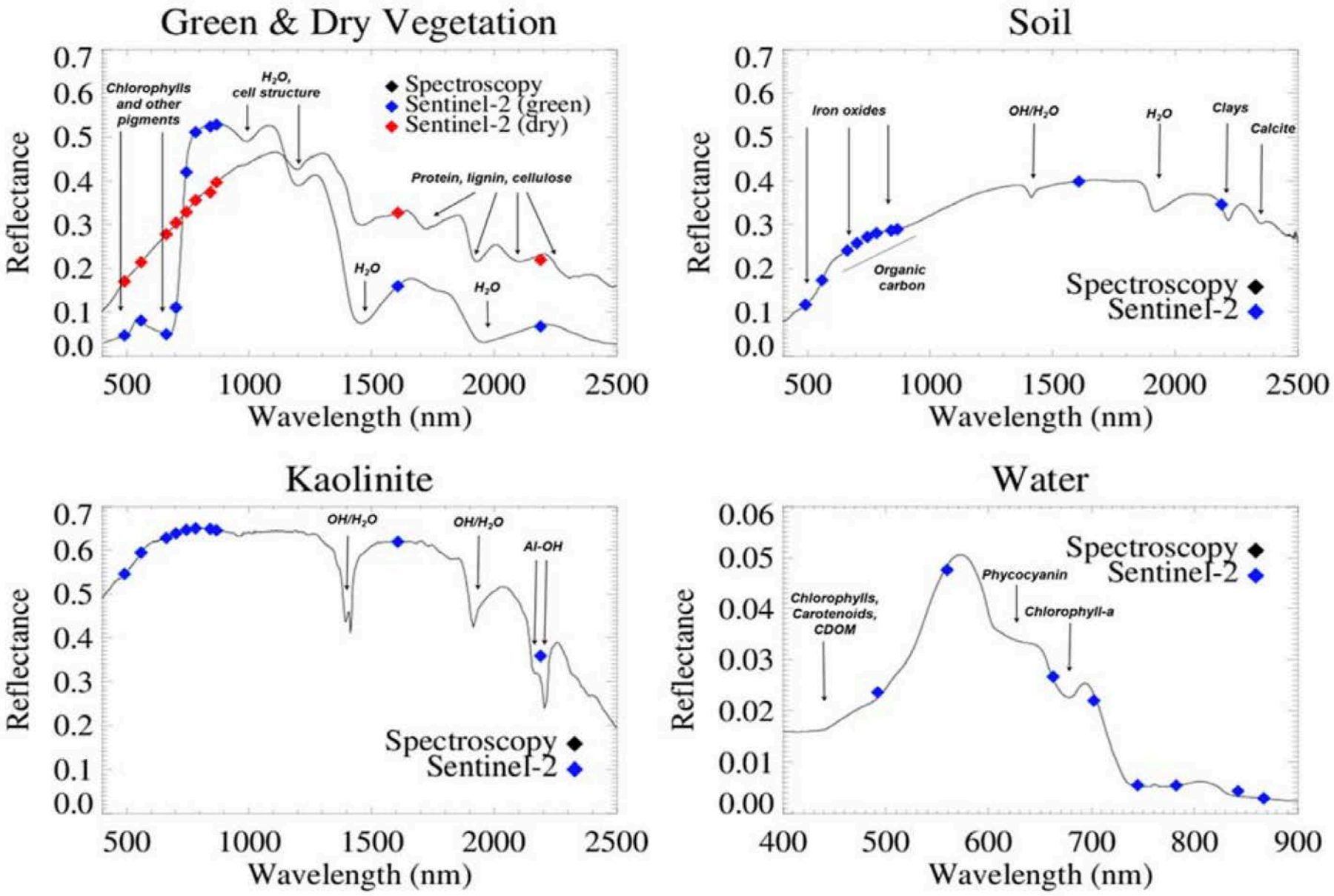
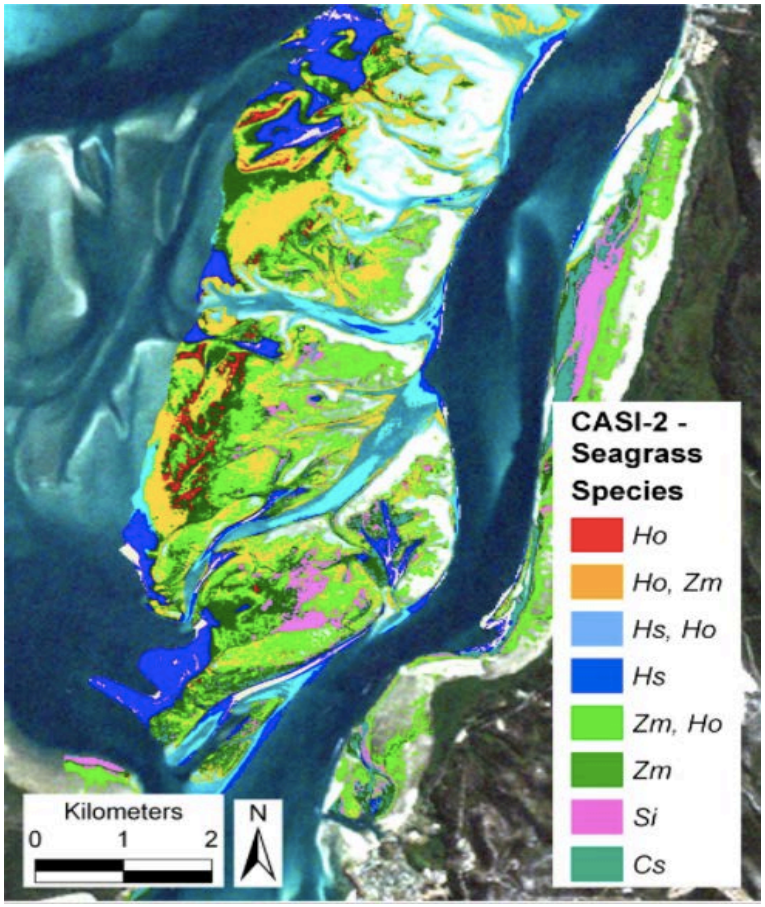


Figure 2-1 Reflectance spectra for different Earth surface materials at high spectral resolution and resampled to the spectral response of the multispectral instrument onboard Sentinel-2

For inland water bodies and coastal zones CHIME is expected to provide:

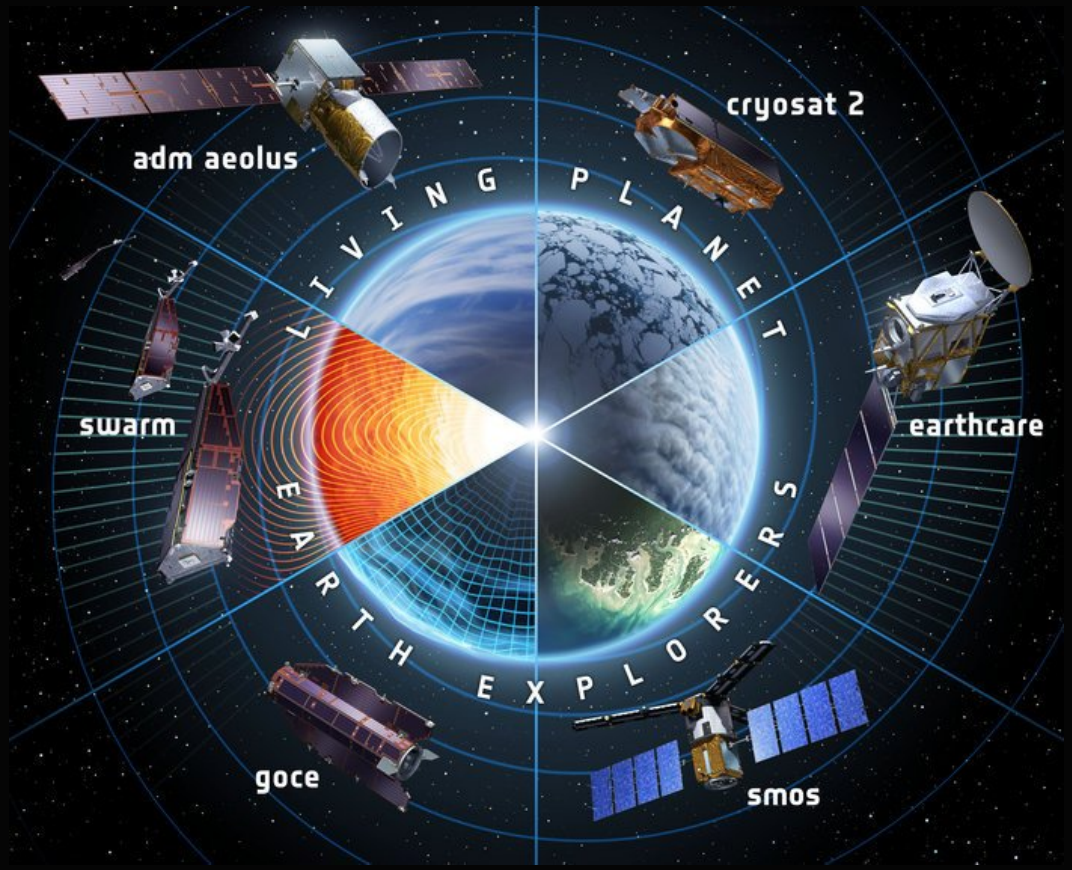
- more accurate turbidity and transparency measures
- chlorophyll, suspended matter and coloured dissolved organic matter concentration
- particle size distributions
- phytoplankton types and pigments
- harmful algal blooms
- distinguishing sources of suspended and coloured dissolved matter
- estimating water depth
- mapping heterogeneous substrates and cover types.

wavelength (nm)	Width (nm)	Lref W (W/sr/m2/micron)	SNR W after spectral/spatial binning
400	15	62.95	2188
412.5	10	74.14	2061
442.5	10	65.61	1811
490	10	51.21	1541
510	10	44.39	1488
560	10	31.49	1280
753.5	10	10.33	605
778.75	15	9.18	812



Relevance for monitoring rivers & lakes as required by the EU Water Framework Directive and Bathing Water Directive.

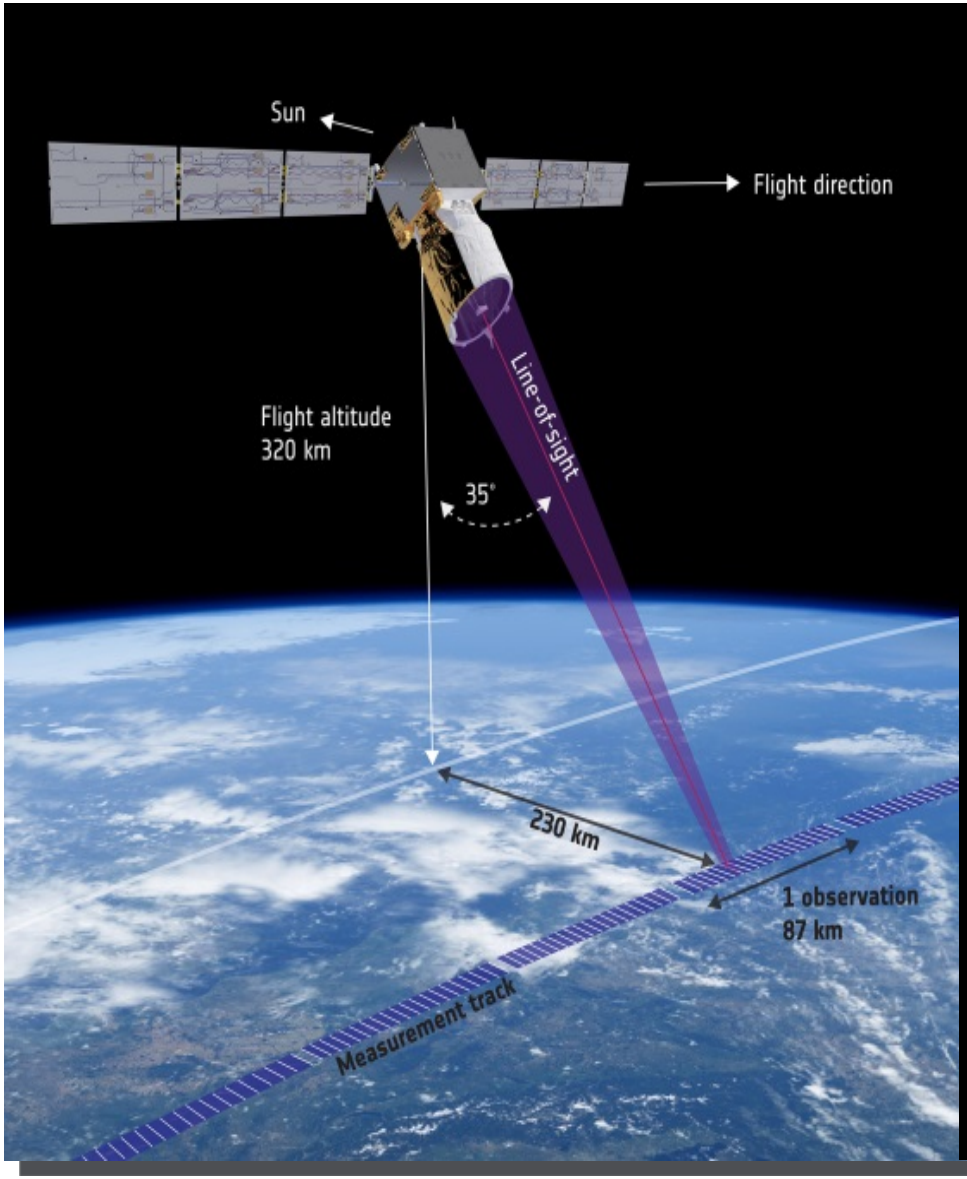
Science Missions: Earth Explorers



GOCE	2009 – 2013
SMOS	2009 – Present
CryoSat	2010 – Present
Swarm	2013 – Present
Aeolus	22 August 2018
EarthCARE	2020/21
Biomass	2022
FLEX	2022
EE9 (SKIM/ FORUM)	2025
EE10	2028

http://www.esa.int/aeolus

Aeolus measurement principle



- Direct detection UV Doppler Wind Lidar (355 nm), 80mJ laser output, 50 Hz, 2 receiver channels
- Mie receiver to determine winds from aerosol & cloud backscatter (Fizeau)
- Rayleigh receiver to determine winds from molecular backscatter (Double edge Fabry-Perrot)
- The line-of-sight (LOS) points 35º from nadir to capture profiles of single component horizontal wind (LOS wind is projected to HLOS)
- Pointing orthogonal to the ground track to remove contribution from satellite velocity
- Ground return used for attitude correction and instrument calibration

Coming soon: Aeolus+Innovation (Aeolus+I)

- Call for ideas for new observation products, new science exploitation and/or applications of Aeolus data

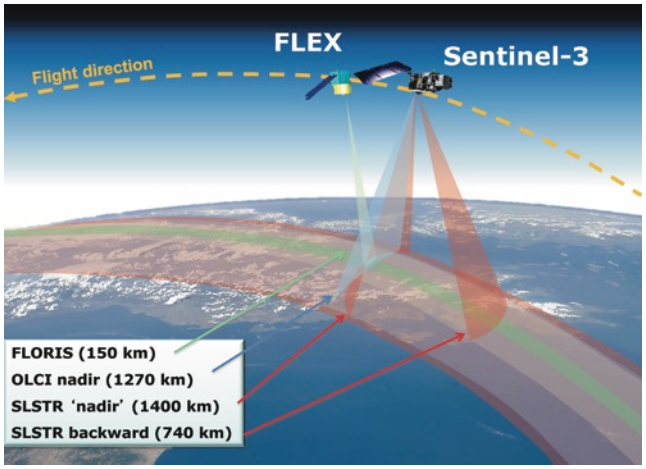
- **Is there sub-surface volume backscattering and can it be exploited?**
    - difficult to describe this contribution, because of the uncertainty of the seawater optical properties (Li et al, 2010)?
- Max 7 independent small studies (around 100 kEuro each)
- Exploitation of the ocean surface return, or links between atmosphere (wind and/or aerosol) and ocean applications could be suggested
- **ITT in preparation, release on EMITS expected soon**

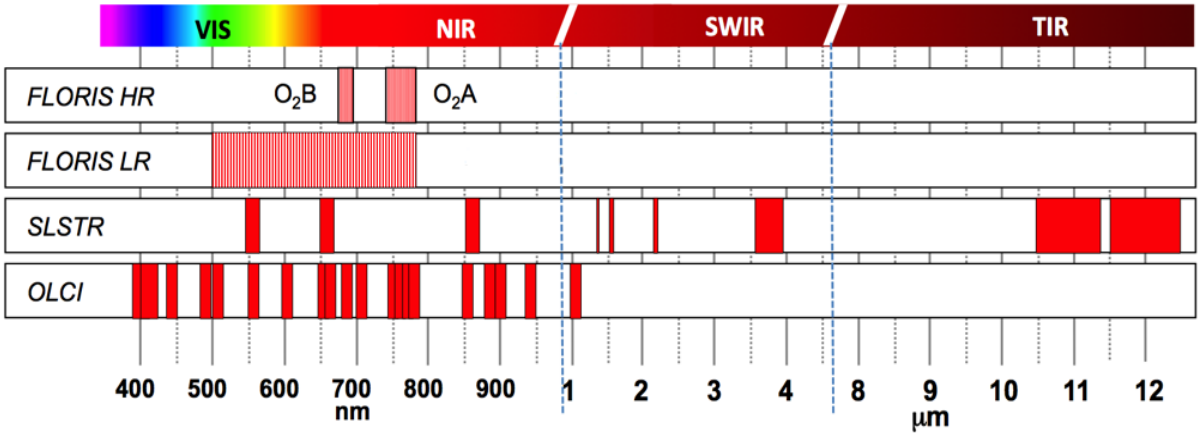
ESA's EARTH EXPLORER 8 – "Hyperspectal" FLEX Mission

Tandem Mission Concept with Sentinel-3:

- 5-30 sec temporal collocation with OLCI
- 300 × 300 m² spatial resolution
- 150 km swath width

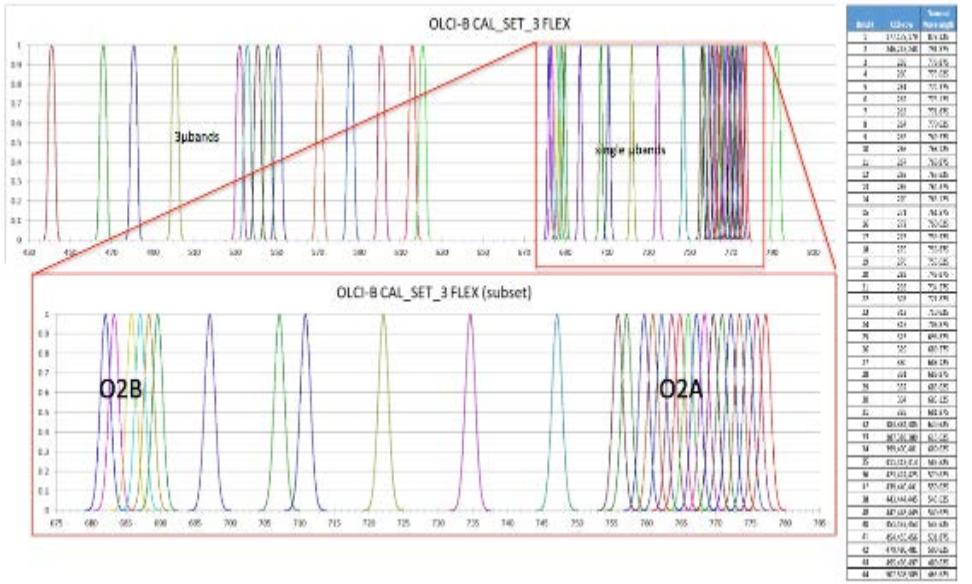
- 500 – 780 nm spectral coverage
- 0.3 – 2 nm spectral sampling intervals

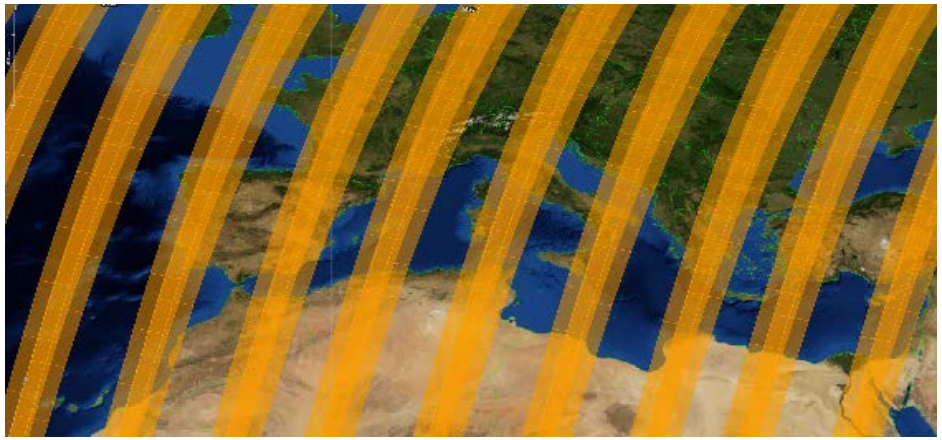




S3B OLCI Hyperspectral: e 2018 field activities

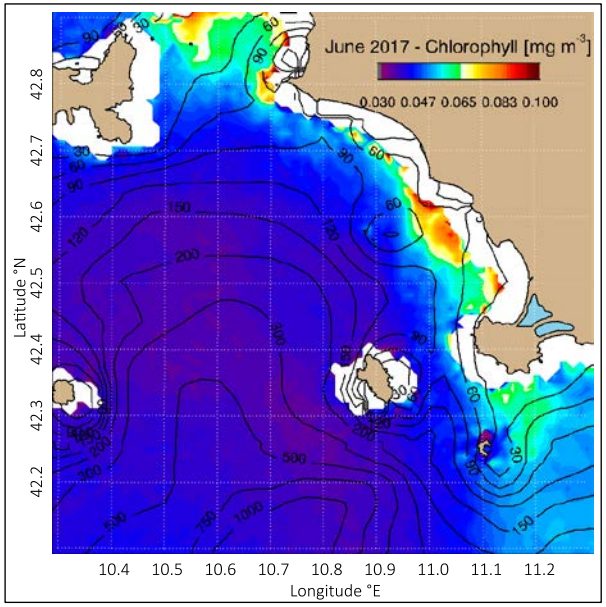
- Reprogrammed overpass of Sentinel-3B in June and July 2018 during comissioning phase
- 43 microbands accessible
- AVIRIS-NG (NASA) in Europe during the same time period (arranged by Uni Zurich)
- APEX being available in the time period (arranged by Uni Zurich)





Italy Mediterranean

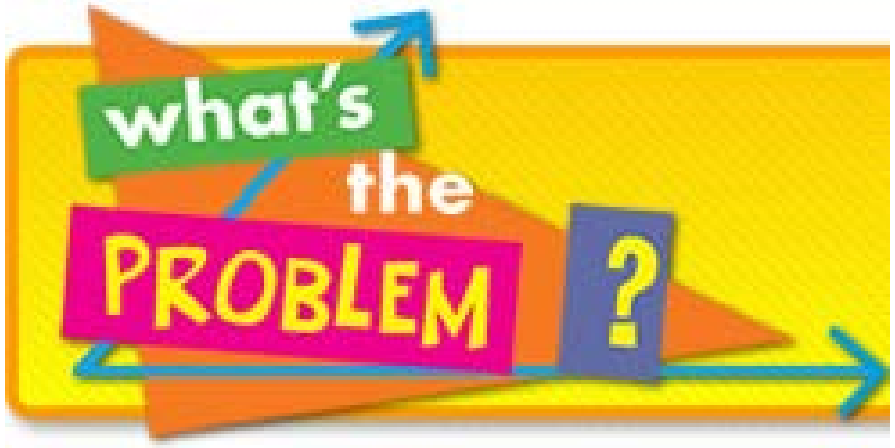
- Synchronized measurements of Fluorescence installed on a research vessel, *HyPlant*, and Sentinel-3B between June 4th and 8th in the costal area of Livorno and Rome
- Radiometric data acquisition over the Mediterranean sea (in synchrony with boat measurements of water AOP/IOP and constituents (CNR, Italy))
- Flight lines along a gradient of river run-off, which generally causes some algae bloom



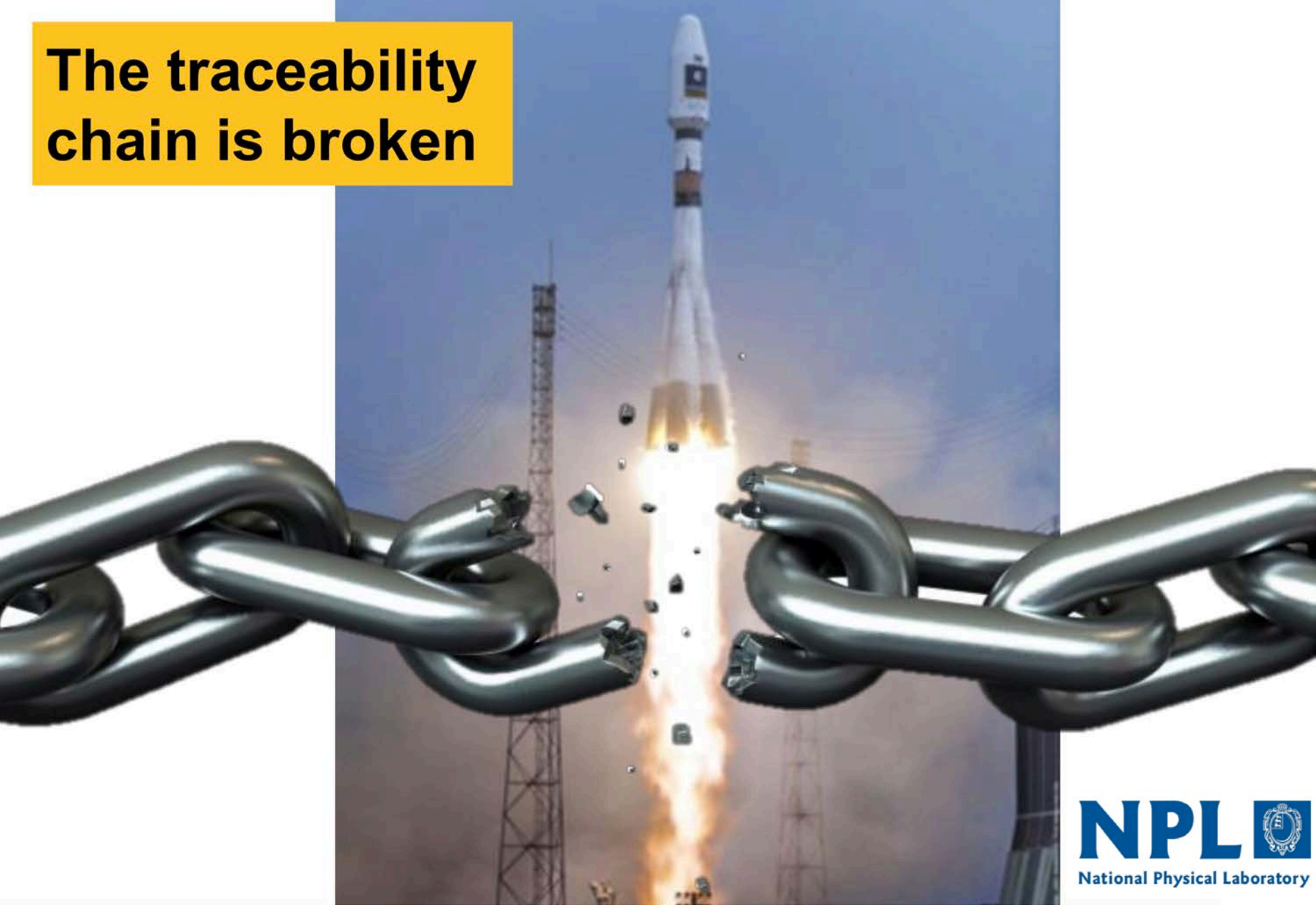
Testing Sentinel-2B MSI for straylight…

Pre-flight testing Sentinel-2B

Sentinel-3B and Tandem phase


what's
the
PROBLEM
?

The traceability chain is broken



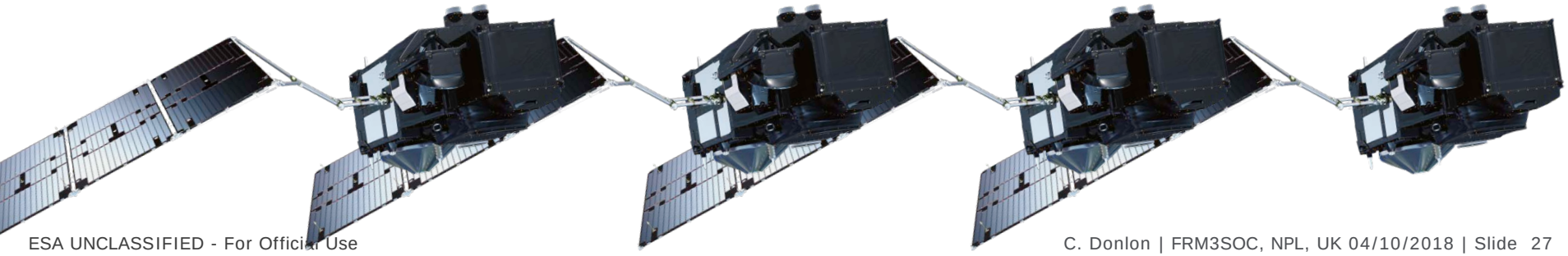
NPL National Physical Laboratory

How…

- How good ***is*** your data?
- **What is the uncertainty?**
- How can you be sure that you actually measure what you think you do?
- How did you make the measurement?
- Are we all happy with your approach?
- How did you check your instruments?
- How well calibrated is your instrument?
- How can the European Space Agency trust your data?

The importance of validation and verification

- Sentinel-3 A/B cost ~450MEuro
- Each payload instrument is an accurate and precise scientific instrument
- Maintaining quality is all about a regular stream of verification and validation data that can be used to check mission and product performance
- Verification and validation data shall be of an equal and ideally a better quality than anything else
- **We cannot do this without fundamental traceability and uncertainty budgets for all ground measurements used**
- **Why should we validate Sentinel-3 with substandard data?**



Multi-satellite missions…

- **The S2 & S3 missions include 4 satellites**
- Even though S2/3A and S2/3B are practically identical in design, ***it is anticipated that differences in performance of payload instruments will exist***
- It is essential that **relative (absolute) bias between S2/3A/B/C/D instruments are known properly** for Climate Data Record construction
- **FRM are required throughout the multi-mission time series**

Validation of EO measurements

A validation program includes different complementary approaches to produce consolidated and confident validation results.

- **Validation against precise Fiducial Reference Measurements (FRM): few points but precise,**
- **Validation against widespread in-situ: more points less precise,**
- **Validation against others sources: inter-satellite comparison,**
- **Validation against models: data assimilation rejection statistics, integrated model analyses…,**
- **Validation using Level 3 data (i.e. merged data): statistical comparison between various Level 3 from various sensors constitutes an extremely useful tool (mean, median, sd, bias, RMS…. for selected zones, transects, latitudinal bands, seasonal trends…) for a cross-validation of the products,**
- **Validation using monitoring tools: statistics, trend, systematic quality control, etc.**

All the components are important and necessary;

The first point (FRM) is of particular importance because it gives a reference properly characterised and traceable to standard on which the Validation results can be anchored.

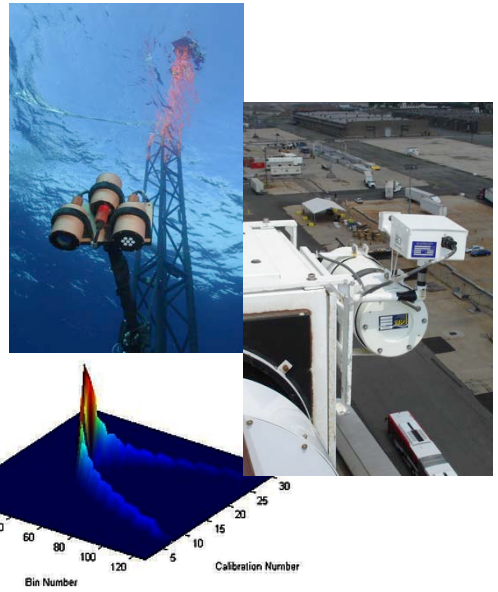
Fiducial Reference Measurements (FRM)

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

[Late Latin fdcilis, from Latin fdcia, *trust*, from fdere, *to trust*; seebheidh- in Indo-European roots.]

What's wrong with *in situ*?

- It means everything to the uneducated
- It's not tangible to a funding agency
- It is not precise enough to argue for a validation program



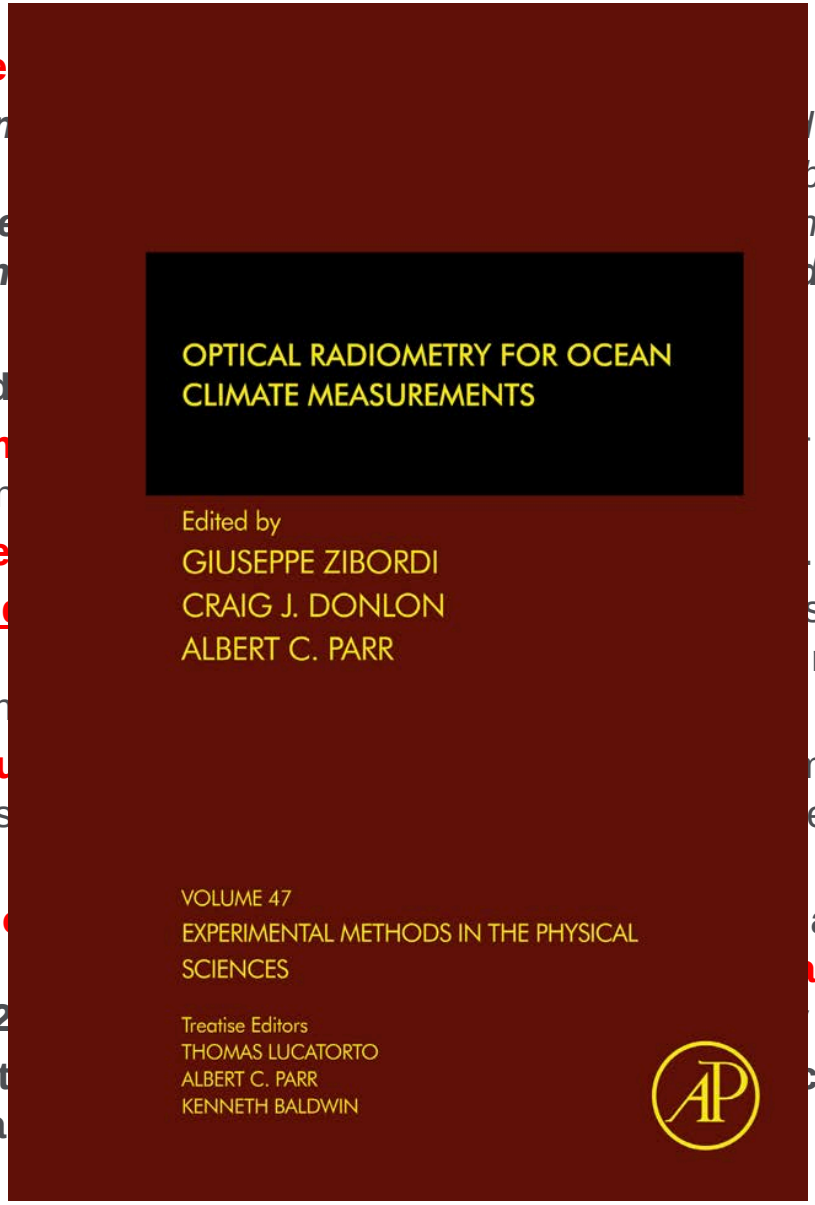
FRM are:

- Linked to Cal/Val plan activities
- Based on specific requirements
- Forward thinking – long-term vision
- Building on the existing capability
- Have an inclusive approach: FRM are not Mission specific (e.g. S3A, B, C, D… S2A, B, C, D…all need ocean colour FRM…, All Altimeters need transponders for range calibration – and Sigma0…)

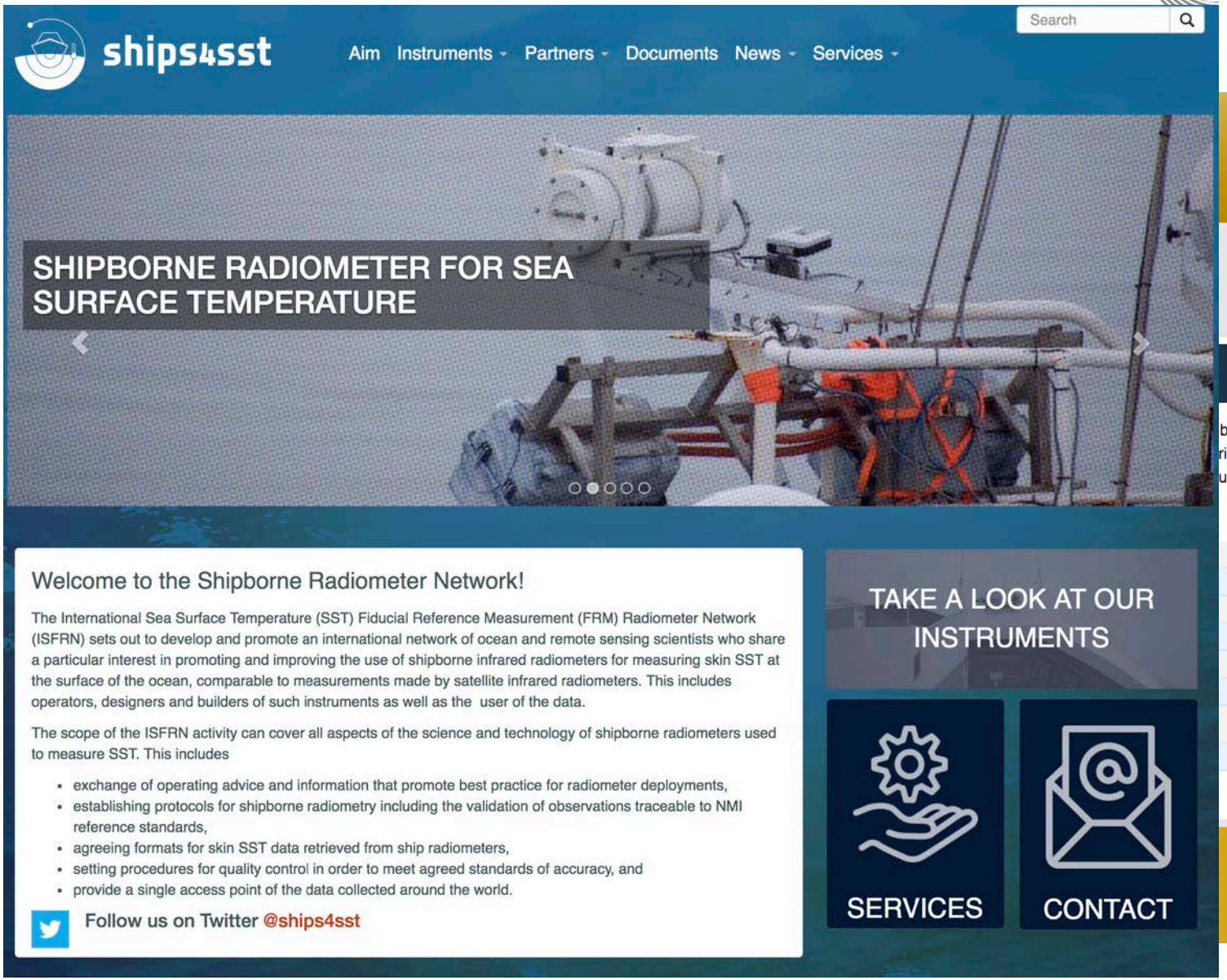
Fiducial Reference Measurements

- **Fiducial Reference**
- *the suite of* ***indepen*** *…e the* ***maximum Scientific Utility and Return*** *…by delivering, to users, the required* ***confidence*** *…ndent* ***validation results and satellite measuren*** *…**duration of the mission.***

- **The defining mand…**
  a. Have **documen…** …-comparison of instruments under operation…
  b. Are **independe…**
  c. **Include a vali…** …struments and derived measurements …re appropriate to SI ideally directly through…
  d. Are **collected u…** …munity-wide management practices (meas… …etc.) are defined and adhered to.
- **FRM are as close t…** …**as we can get with uncertainties that …an application (e.g. to validate SST to 0.2… …<0.1K)**
- **FRM are required t… …characteristics of satellite measurements via…**



FRM@ ESA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SHIPBORNE RADIOMETER FOR SEA SURFACE TEMPERATURE
Welcome to the Shipborne Radiometer Network!
The International Sea Surface Temperature (SST) Fiducial Reference Measurement (FRM) Radiometer Network (ISFRN) sets out to develop and promote an international network of ocean and remote sensing scientists who share a particular interest in promoting and improving the use of shipborne infrared radiometers for measuring skin SST at the surface of the ocean, comparable to measurements made by satellite infrared radiometers. This includes operators, designers and builders of such instruments as well as the user of the data.
The scope of the ISFRN activity can cover all aspects of the science and technology of shipborne radiometers used to measure SST. This includes
exchange of operating advice and information that promote best practice for radiometer deployments,
establishing protocols for shipborne radiometry including the validation of observations traceable to NMI reference standards,
agreeing formats for skin SST data retrieved from ship radiometers,
setting procedures for quality control in order to meet agreed standards of accuracy, and
provide a single access point of the data collected around the world.
Follow us on Twitter @ships4sst
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SERVICES
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International context

- The **FRM4SOC** project, with funding from **ESA**, has been structured to provide support for evaluating and improving the state of the art in OC validation through a series of comparisons under the auspices of **CEOS** WGCV and in support of the CEOS OCR virtual constellation.
- FRM4SOC also strives to help fulfil the **IOCCG** **in situ OCR white paper objectives** and contribute to the relevant IOCCG WGs and Task Forces (e.g. WG on uncertainty, ocean colour satellite sensor calibration task force); the European perspective and the importance of Copernicus and the Sentinel series of satellite sensors in general and in particular for ocean colour.

fiducial reference measurements for satellite ocean colour

esa

Aim ***To establish and maintain SI traceability of Fiducial Reference Measurements (FRM) for satellite ocean colour radiometry (OCR).***

- Laboratory and field radiometer characterization experiments
- Establish protocols
- Include the radiometer industry
- Laboratory comparison of radiance and irradiance sources
- Laboratory round-robin performance assessment of field OCR used for satellite validation
- Workshop to establish requirements for European OCR vicarious adjustment infrastructure

https://frm4soc.org/

PML | Plymouth Marine Laboratory

TARTU OBSERVATORY space research centre

museum

NPL National Physical Laboratory

fiducial reference measurements for satellite ocean colour

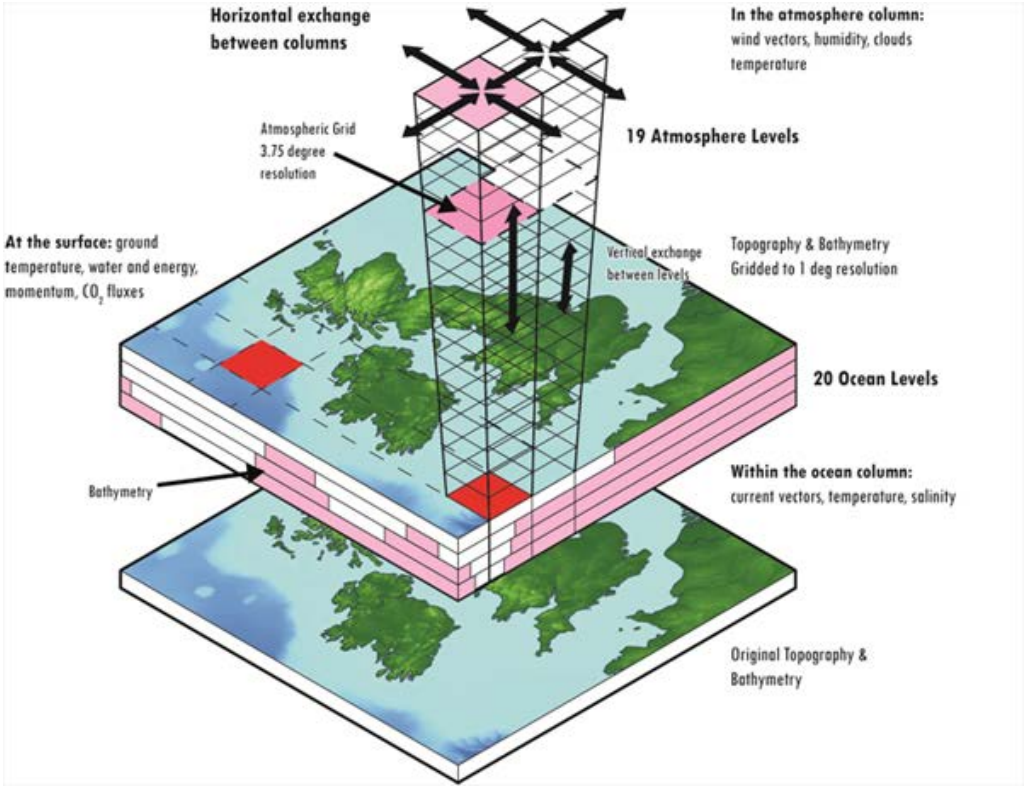
ACRI ST

The Metrological Foundation for System Vicarious Adjustment of Satellite Ocean Colour Data (part 1)

Nigel Fox
Head of Earth Observation, Climate and Optical, NPL
Chair CEOS WGCV IVOS

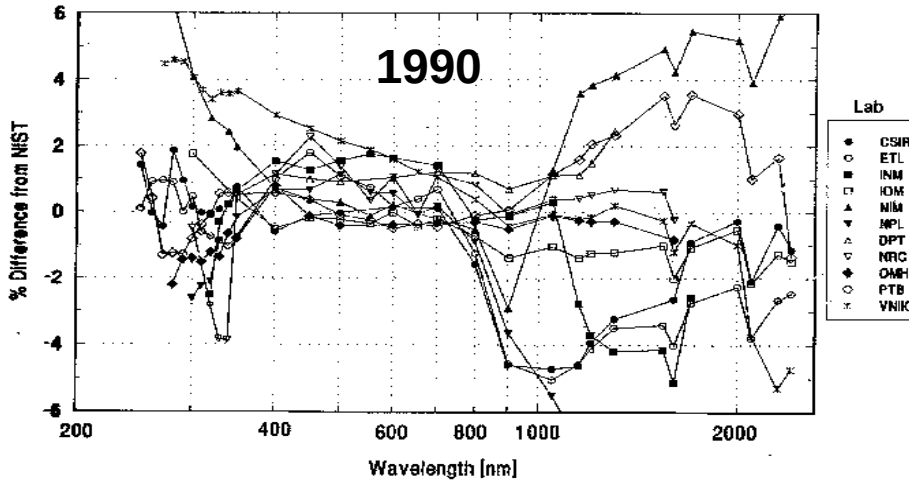
fiducial reference measurements for satellite ocean colour

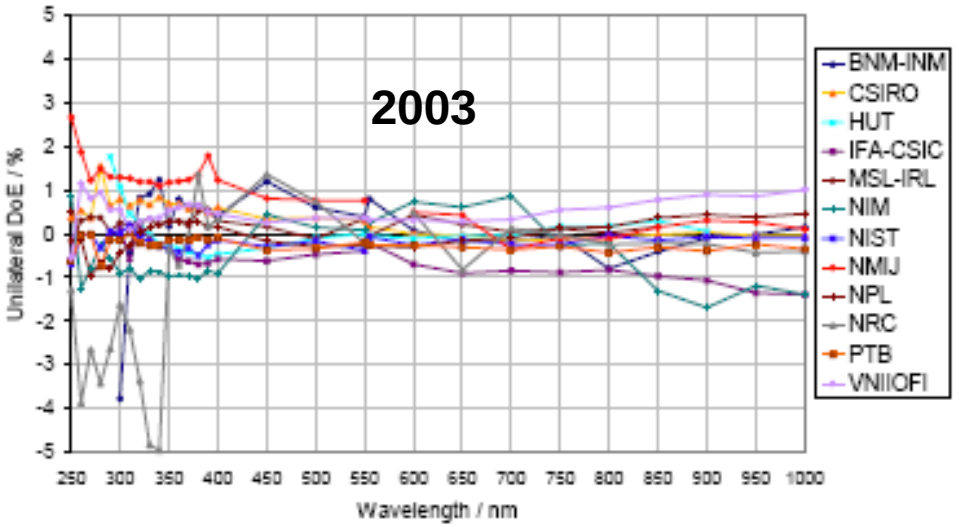
Uncertainty measurement



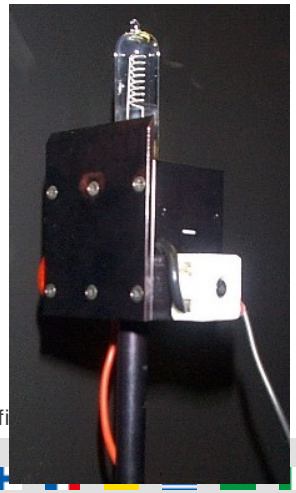
http://www.bipm.org/en/publications/guides/gum.html

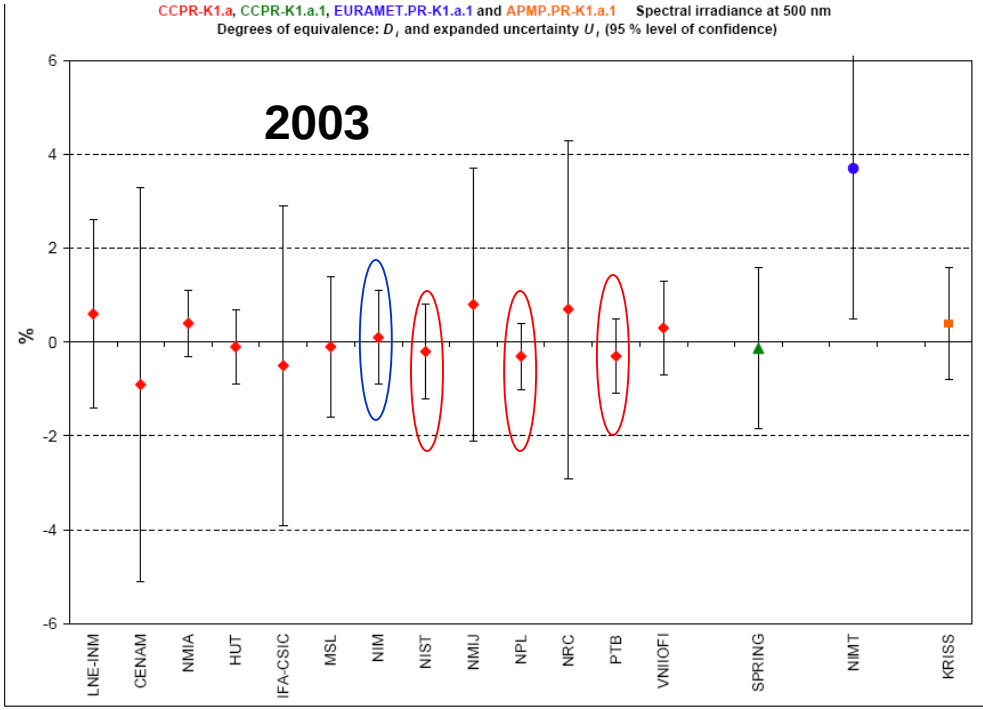
International equivalence



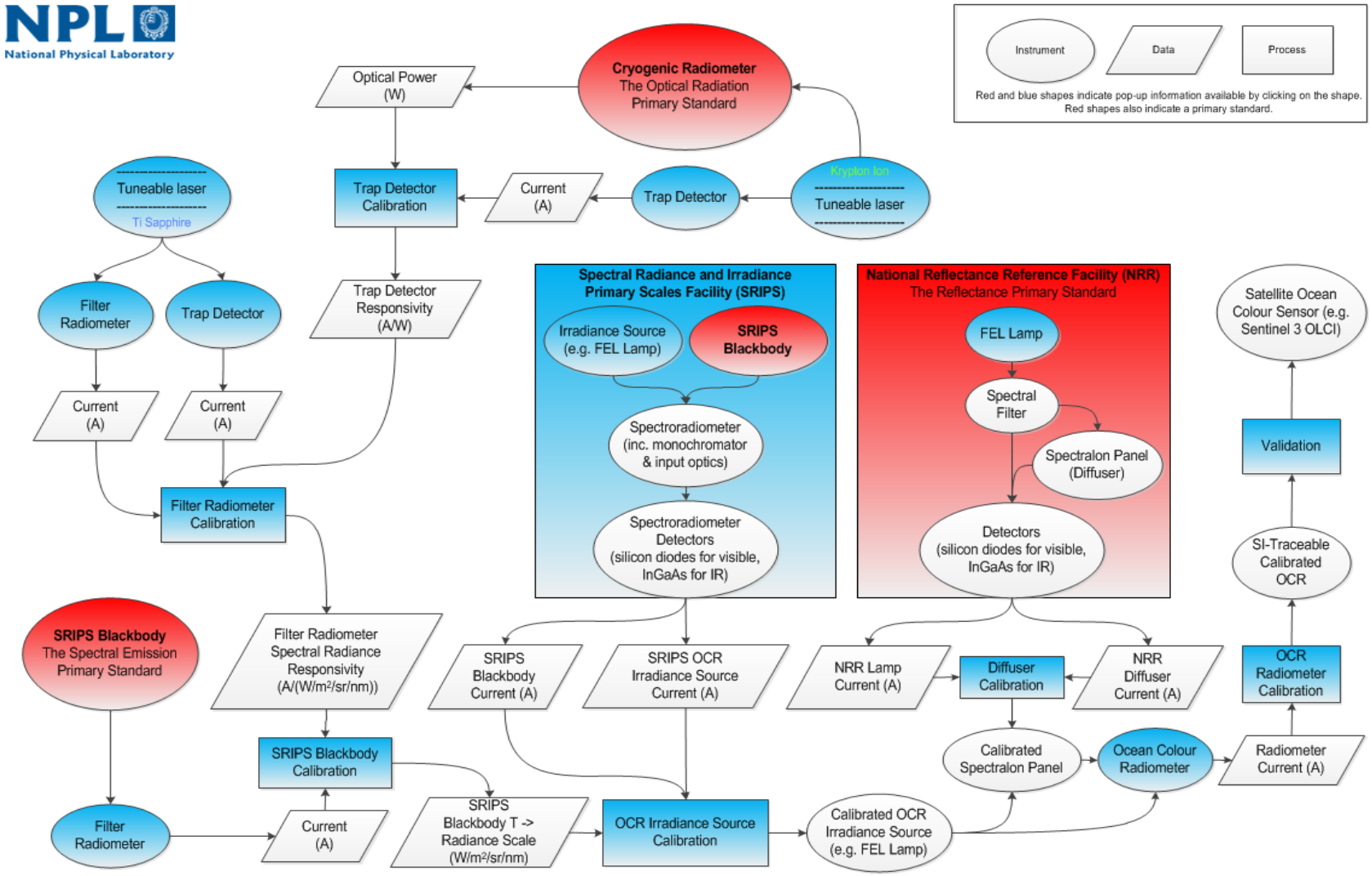


Spectral Irradiance Comparisons between NMIs



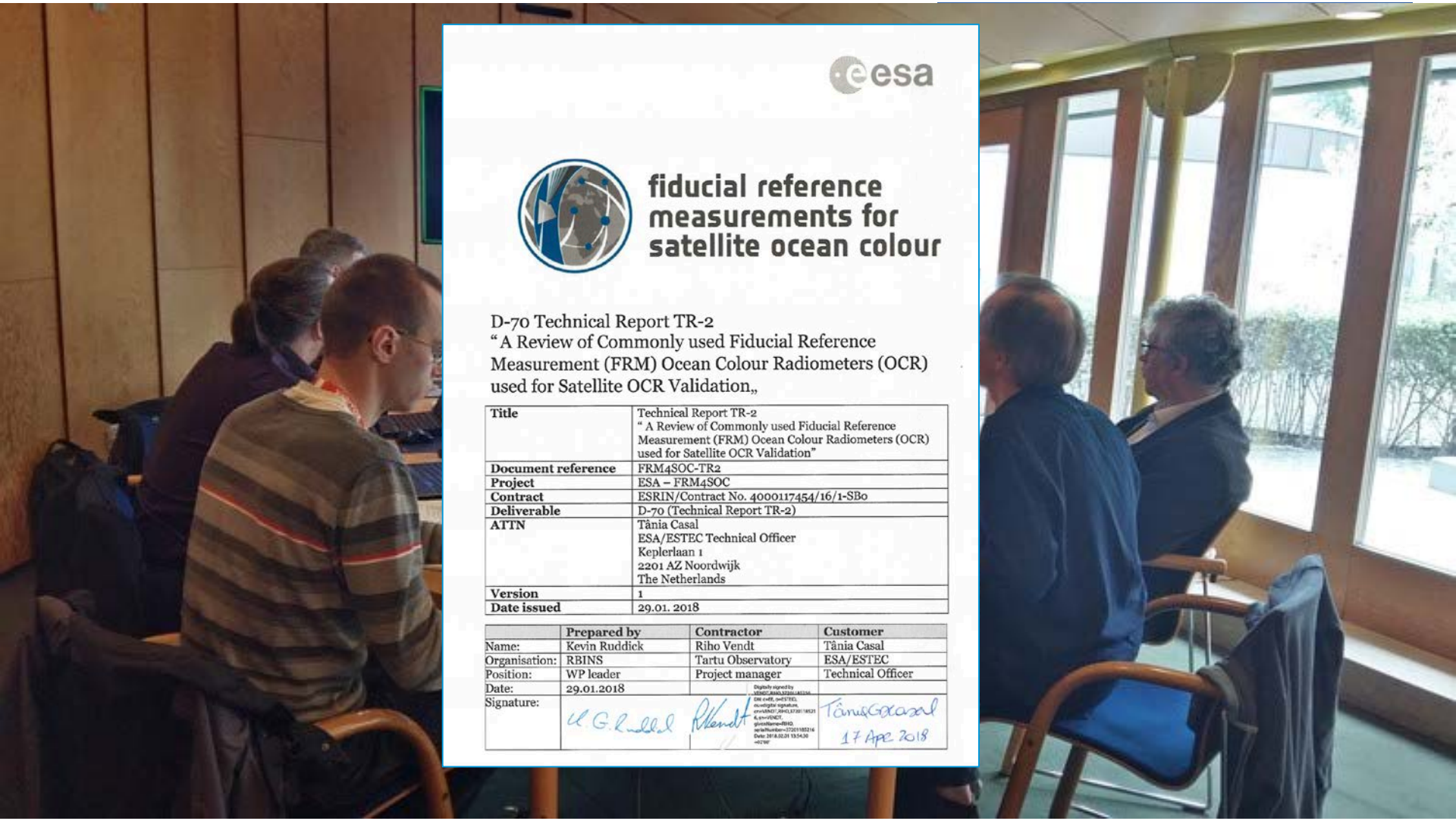


FRM4SOC: Traceability to SI – flow diagram



First ESA Contract with Estonia

Measurement Protocols and a Radiometer Manufacturers Workshop



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fiducial reference measurements for satellite ocean colour

D-70 Technical Report TR-2
"A Review of Commonly used Fiducial Reference Measurement (FRM) Ocean Colour Radiometers (OCR) used for Satellite OCR Validation„

Title	Technical Report TR-2 " A Review of Commonly used Fiducial Reference Measurement (FRM) Ocean Colour Radiometers (OCR) used for Satellite OCR Validation"
Document reference	FRM4SOC-TR2
Project	ESA – FRM4SOC
Contract	ESRIN/Contract No. 4000117454/16/1-SBo
Deliverable	D-70 (Technical Report TR-2)
ATTN	Tânia Casal ESA/ESTEC Technical Officer Keplerlaan 1 2201 AZ Noordwijk The Netherlands
Version	1
Date issued	29.01. 2018

	Prepared by	Contractor	Customer
Name:	Kevin Ruddick	Riho Vendt	Tânia Casal
Organisation:	RBINS	Tartu Observatory	ESA/ESTEC
Position:	WP leader	Project manager	Technical Officer
Date:	29.01.2018		
Signature:			17 Apr. 2018

Workshop on System Vicarious Calibration

esa

fiducial reference measurements for satellite ocean colour

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

Title	D-240 Proceedings of WKP-1(PROC-1) Report of the international workshop
Document reference	FRM4SOC-PROC1
Project	ESA – FRM4SOC
Contract	ESRIN/Contract No. 4000117454/16/1-SBo
Deliverable	D-240 Proceedings of WKP-1 (PROC-1)
ATTN	Craig Donlon ESA/ESTEC Technical Officer Keplerlaan 1 2201 AZ Noordwijk The Netherlands
Version	1.1
Date issued	10.10.2017

Approved by	**Sub-contractor**	**Contractor**	**Customer**
Name:	Christophe Lerebourg	Riho Vendt	Craig Donlon
Organisation:	ACRI-ST	Tartu Observatory	ESA/ESTEC
Position:	Senior research engineer	Project manager	Technical Officer
Date:	10.10.2017		
Signature:			

Copernicus fiducial reference measurements for satellite ocean colour

CEOS https://frm4soc.org esa

FRM radiometer inter-comparison (8 – 13 May 2017 at TO, 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)

Indoor / Outdoor

41 Radiometers calibrated!

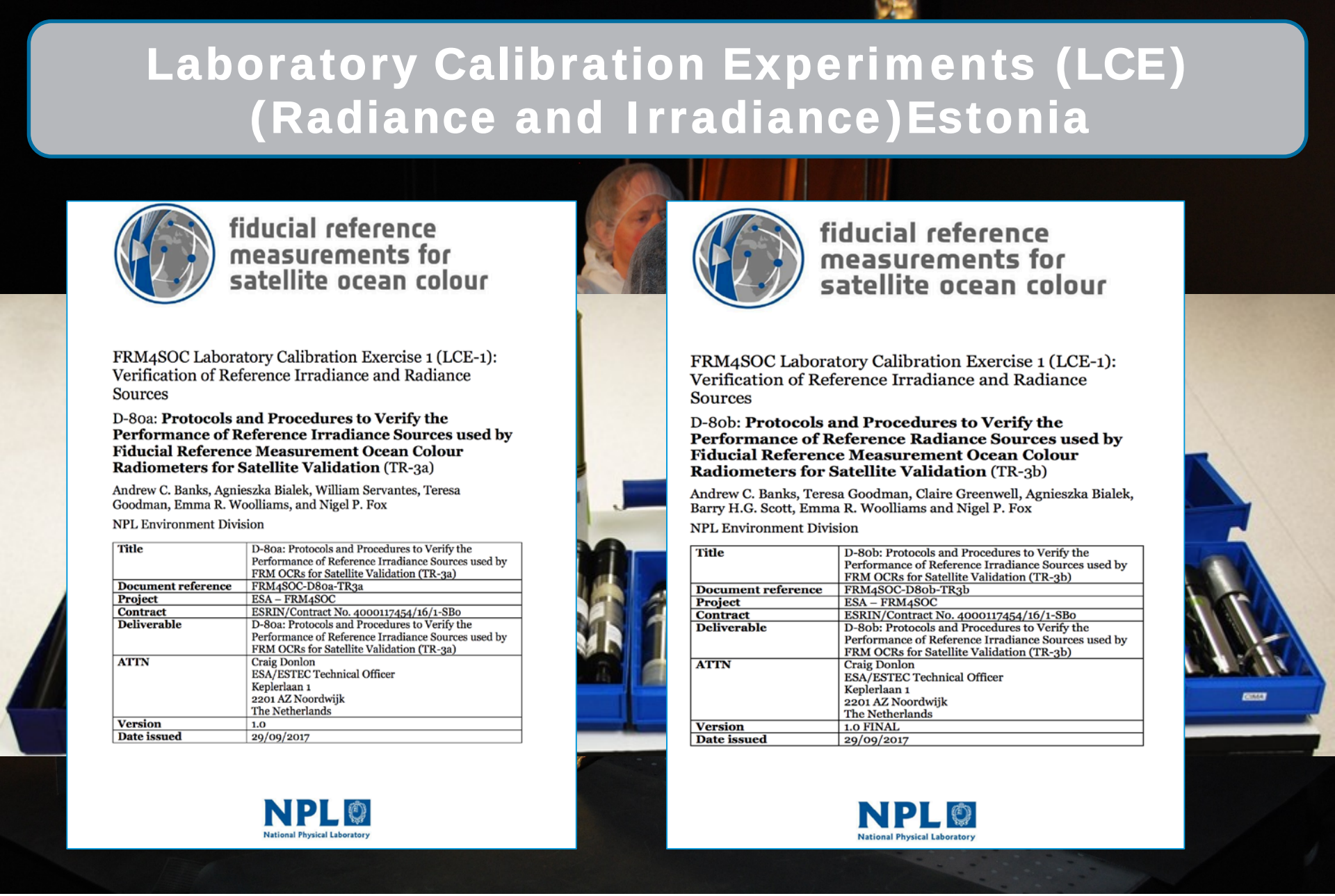
TARTU OBSERVATORY space research centre

ACRI ST PML Plymouth Marine Laboratory

NPL National Physical Laboratory

museum

Laboratory Calibration Experiments (LCE) (Radiance and Irradiance)Estonia



fiducial reference measurements for satellite ocean colour

FRM4SOC Laboratory Calibration Exercise 1 (LCE-1): Verification of Reference Irradiance and Radiance Sources

D-80a: **Protocols and Procedures to Verify the Performance of Reference Irradiance Sources used by Fiducial Reference Measurement Ocean Colour Radiometers for Satellite Validation** (TR-3a)

Andrew C. Banks, Agnieszka Bialek, William Servantes, Teresa Goodman, Emma R. Woolliams, and Nigel P. Fox

NPL Environment Division

Title	D-80a: Protocols and Procedures to Verify the Performance of Reference Irradiance Sources used by FRM OCRs for Satellite Validation (TR-3a)
Document reference	FRM4SOC-D80a-TR3a
Project	ESA – FRM4SOC
Contract	ESRIN/Contract No. 4000117454/16/1-SBo
Deliverable	D-80a: Protocols and Procedures to Verify the Performance of Reference Irradiance Sources used by FRM OCRs for Satellite Validation (TR-3a)
ATTN	Craig Donlon ESA/ESTEC Technical Officer Keplerlaan 1 2201 AZ Noordwijk The Netherlands
Version	1.0
Date issued	29/09/2017

NPL National Physical Laboratory

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FRM4SOC Laboratory Calibration Exercise 1 (LCE-1): Verification of Reference Irradiance and Radiance Sources

D-80b: **Protocols and Procedures to Verify the Performance of Reference Radiance Sources used by Fiducial Reference Measurement Ocean Colour Radiometers for Satellite Validation** (TR-3b)

Andrew C. Banks, Teresa Goodman, Claire Greenwell, Agnieszka Bialek, Barry H.G. Scott, Emma R. Woolliams and Nigel P. Fox

NPL Environment Division

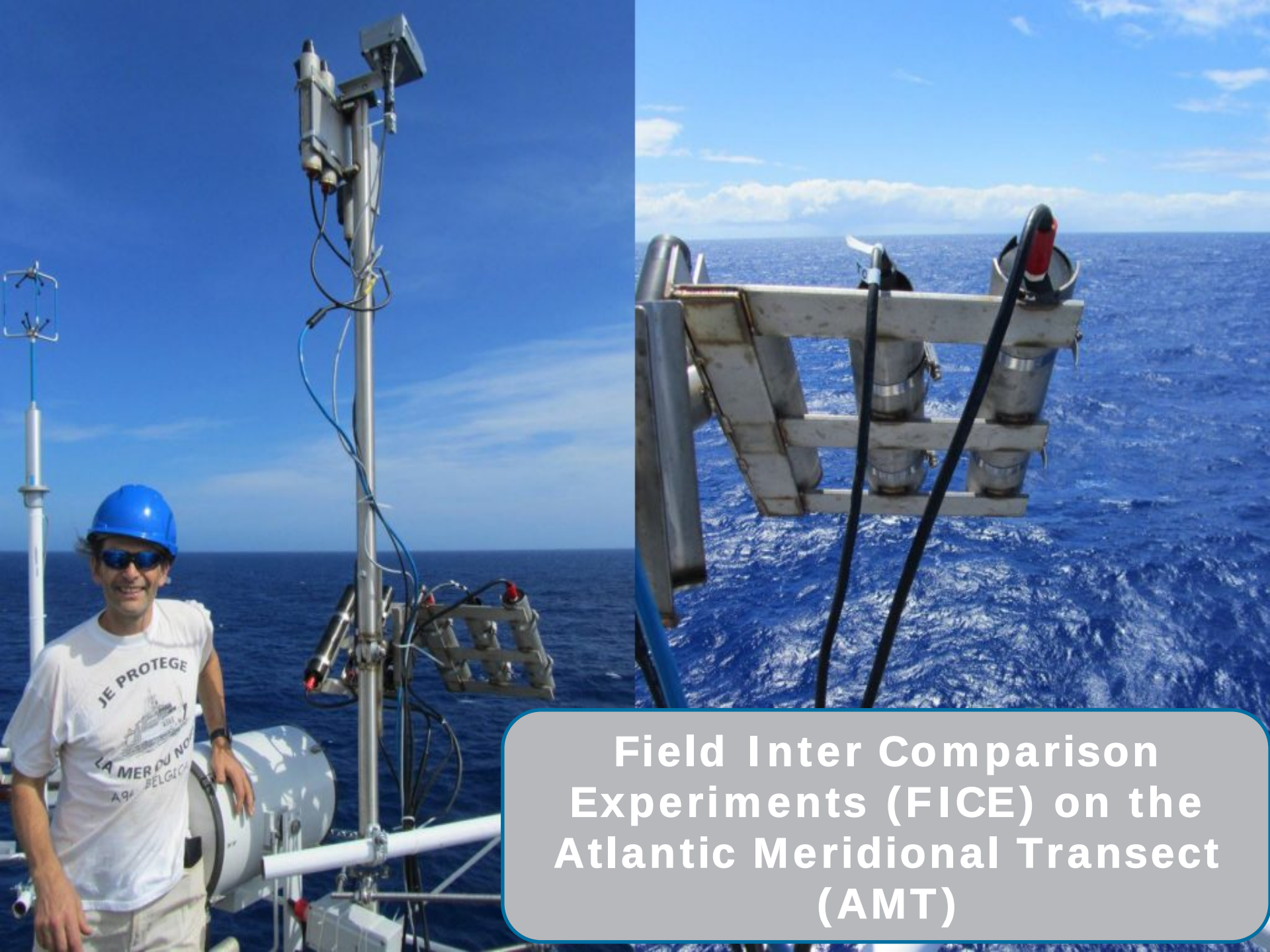
Title	D-80b: Protocols and Procedures to Verify the Performance of Reference Irradiance Sources used by FRM OCRs for Satellite Validation (TR-3b)
Document reference	FRM4SOC-D80b-TR3b
Project	ESA – FRM4SOC
Contract	ESRIN/Contract No. 4000117454/16/1-SBo
Deliverable	D-80b: Protocols and Procedures to Verify the Performance of Reference Irradiance Sources used by FRM OCRs for Satellite Validation (TR-3b)
ATTN	Craig Donlon ESA/ESTEC Technical Officer Keplerlaan 1 2201 AZ Noordwijk The Netherlands
Version	1.0 FINAL
Date issued	29/09/2017

NPL National Physical Laboratory

Laboratory work at Tartu Observatory, Estonia

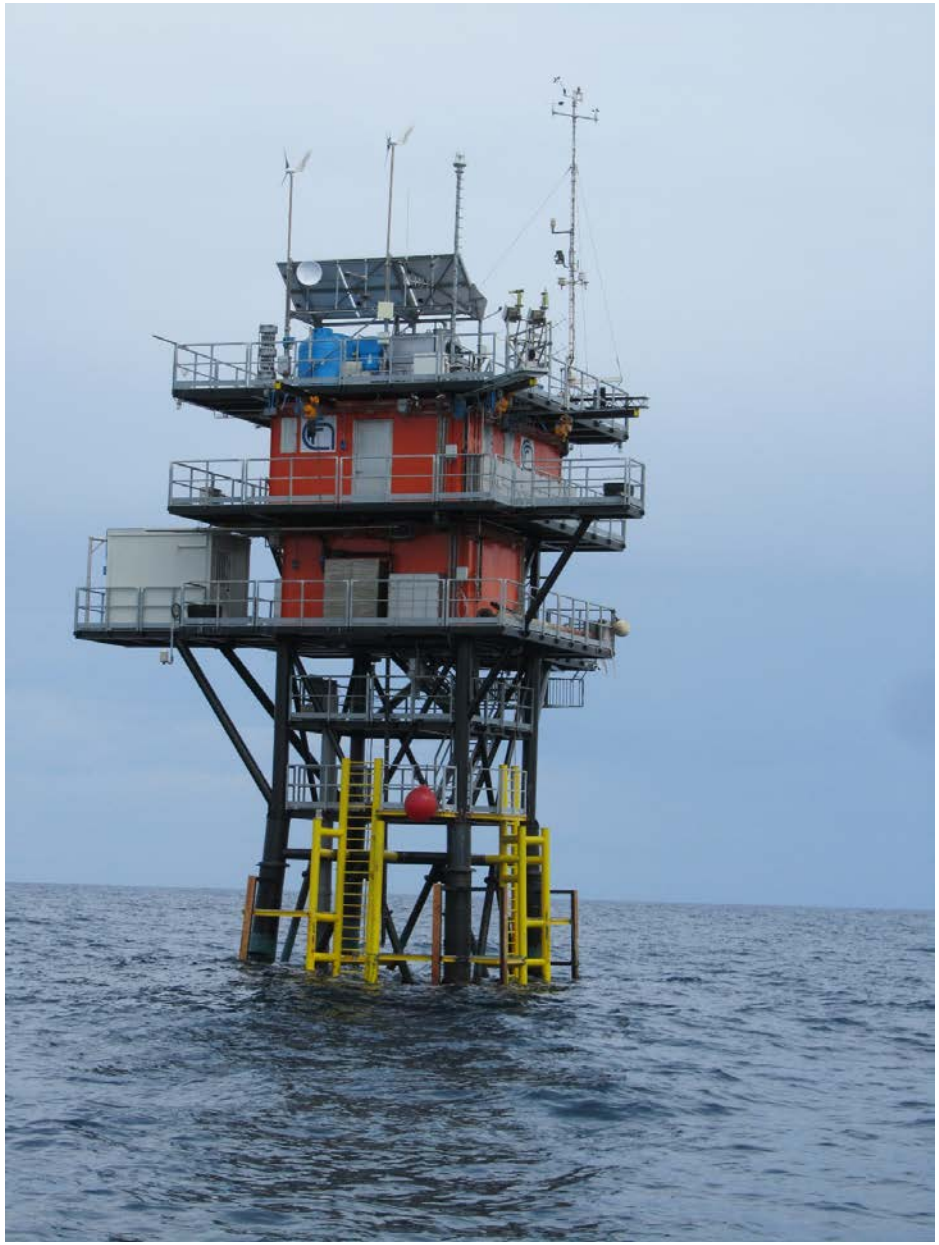
Field Intercomparisons, Estonia

Field Inter Comparison Experiments (FICE) on the Atlantic Meridional Transect (AMT)



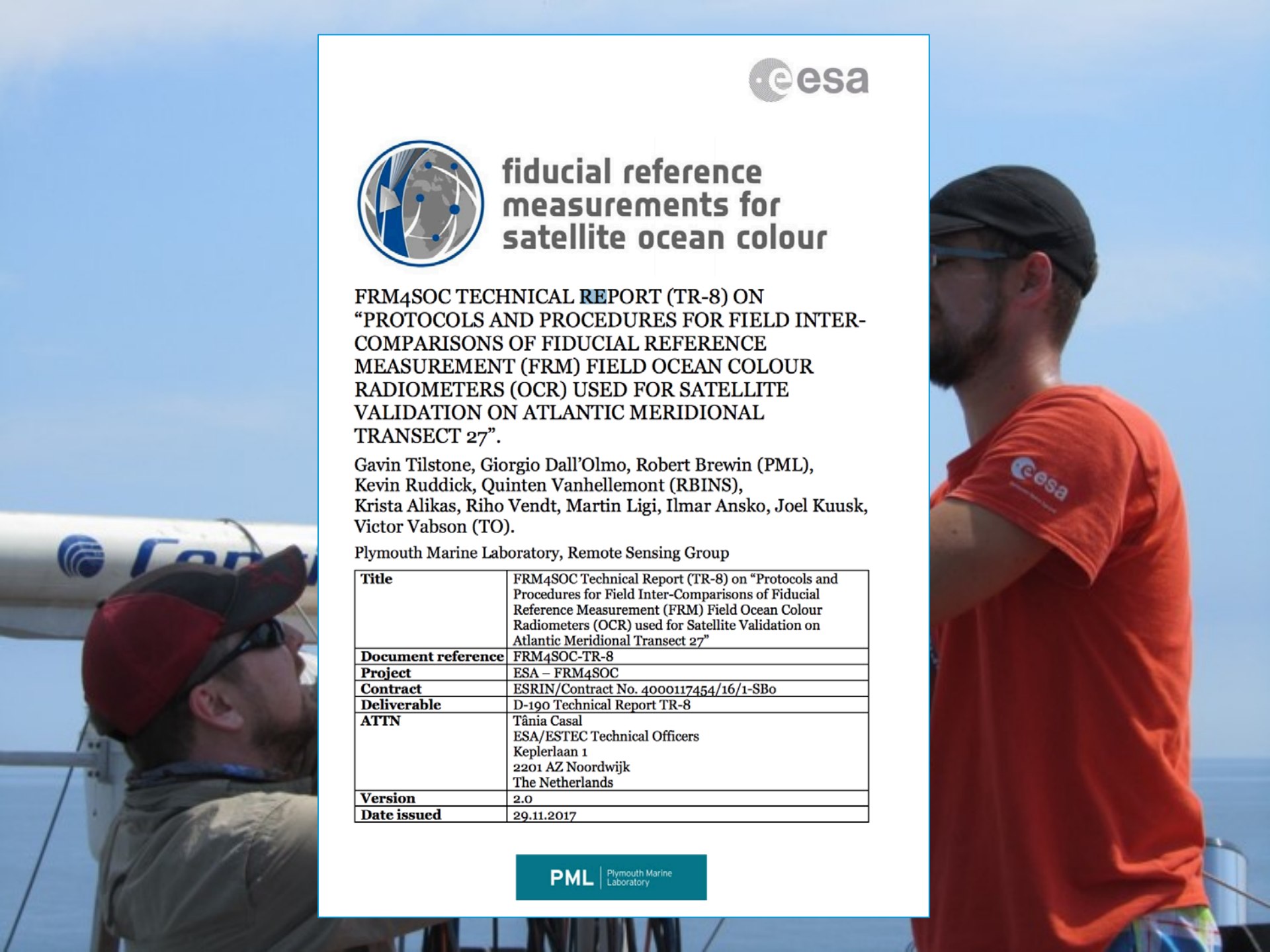
Field Inter Comparison Experiments (FICE) on the Atlantic Meridional Transect (AMT)


KONA



Field Inter Comparison Experiments (FICE) on the new Aqua-alta Tower, Italy


MAINE



fiducial reference measurements for satellite ocean colour

FRM4SOC TECHNICAL REPORT (TR-8) ON "PROTOCOLS AND PROCEDURES FOR FIELD INTER-COMPARISONS OF FIDUCIAL REFERENCE MEASUREMENT (FRM) FIELD OCEAN COLOUR RADIOMETERS (OCR) USED FOR SATELLITE VALIDATION ON ATLANTIC MERIDIONAL TRANSECT 27".

Gavin Tilstone, Giorgio Dall'Olmo, Robert Brewin (PML),
Kevin Ruddick, Quinten Vanhellemont (RBINS),
Krista Alikas, Riho Vendt, Martin Ligi, Ilmar Ansko, Joel Kuusk,
Victor Vabson (TO).

Plymouth Marine Laboratory, Remote Sensing Group

Title	FRM4SOC Technical Report (TR-8) on "Protocols and Procedures for Field Inter-Comparisons of Fiducial Reference Measurement (FRM) Field Ocean Colour Radiometers (OCR) used for Satellite Validation on Atlantic Meridional Transect 27"
Document reference	FRM4SOC-TR-8
Project	ESA – FRM4SOC
Contract	ESRIN/Contract No. 4000117454/16/1-SBo
Deliverable	D-190 Technical Report TR-8
ATTN	Tânia Casal ESA/ESTEC Technical Officers Keplerlaan 1 2201 AZ Noordwijk The Netherlands
Version	2.0
Date issued	29.11.2017

PML | Plymouth Marine Laboratory

→ 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**

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"

Contact:
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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:
Christophe Lerebourg
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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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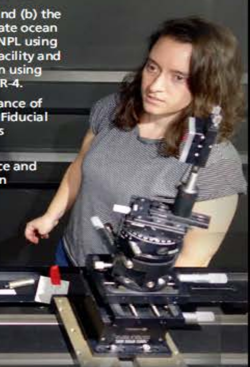

LCE-2

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"

Contact:
Joel Kuusk, joel.kuusk@ut.ee

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"

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

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

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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Conclusions

fiducial reference measurements for satellite ocean colour

- FRM are important
- FRM mean that you make excellent measurements → Great for science!
- FRM are striving to get as close to the “truth” as we can manage for a given variable
- FRM allow us to reduce uncertainties
- However..
    - FRM are extremely challenging
    - Require international consensus
    - Involve by definition, National Metrology Institutes
- FRM are certainly the future.
- ESA intends to continue FRM4SOC activities in support of its missions and Copernicus
- Lets hear from the experts all about FRM4SOC!


Thank You –
any Questions
Contact: Craig.Donlon@esa.int