



Towards Fiducial Reference Measurements in the Eastern Mediterranean for the Validation and Calibration of Satellite Ocean Colour

FRM4SOC Phase 2 FICE, CNR-ISMAR, Venice, 15/05/2024

Dr. Andrew Banks, Dr. A. Karageorgis, Dr. S. Psarra, Dr. S. Chaikalis, Dr. A. Pelteki, Dr. E. Livanou,
Dr. E. Pitta, Dr. C. Zeri, Mr. N. Spyridakis, Prof. P. Drakopoulos (UNIWA)

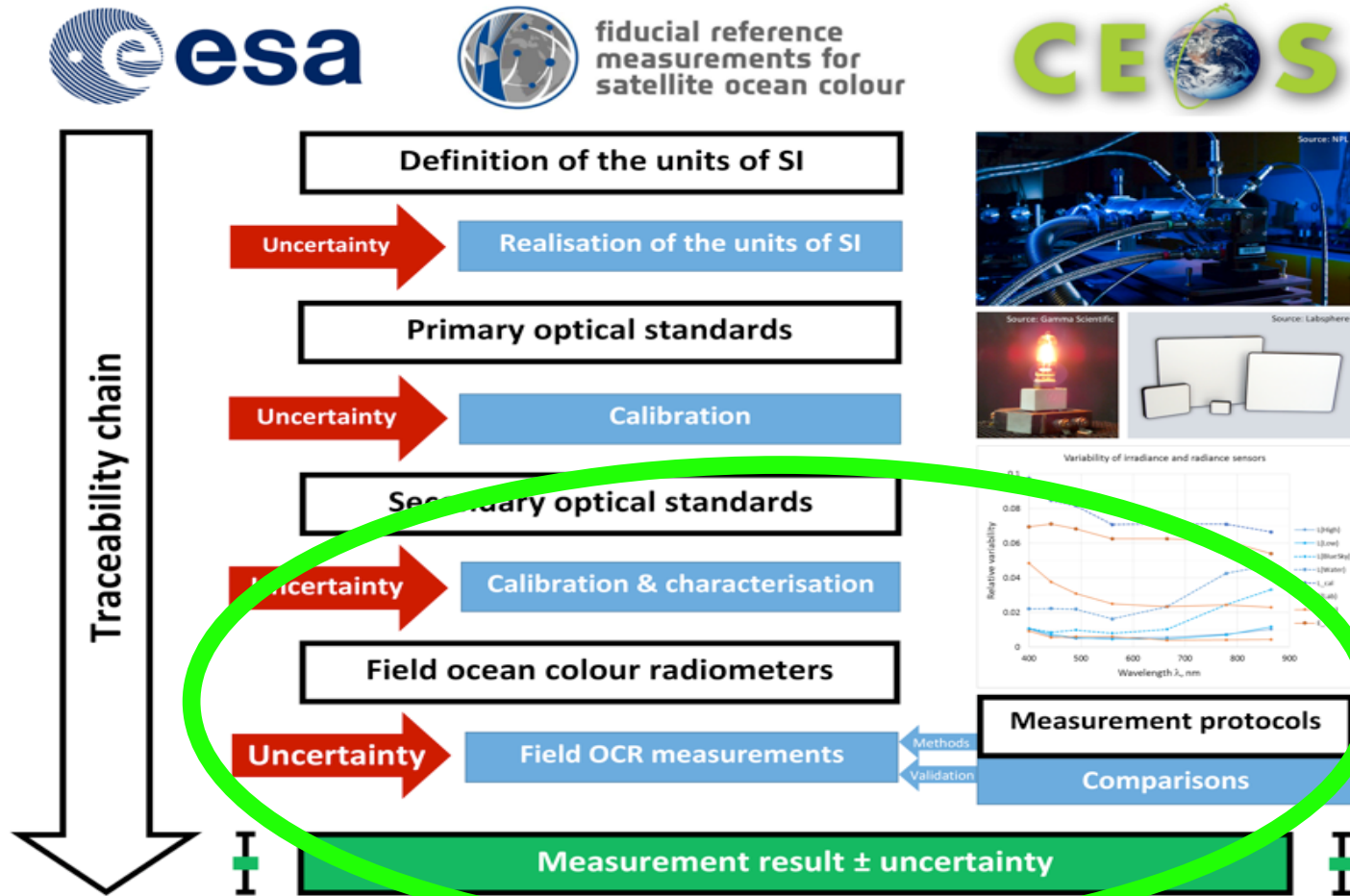
Institute of Oceanography, Hellenic Centre for Marine Research (HCMR), Crete, Greece

with great help from G. Zibordi (JRC / NASA), NPL & Tartu Observatory



TOWARDS FRM IN THE EASTERN MEDITERRANEAN

Key objectives & milestones



For HCMR OCR:

- SI traceable radiometric calibration and characterisation
- Follow FRM measurement & processing protocols
- Uncertainty budget from calibration to processed field measurement
- International radiometry comparisons
- OC-SVC and validation

TOWARDS FRM IN THE EASTERN MEDITERRANEAN

History of OCR at HCMR

2005

2007-2010:

- Dr. Banks purchases HCMR's first radiometers (TriOS RAMSES), first deployments above water.



2010

2011-12:

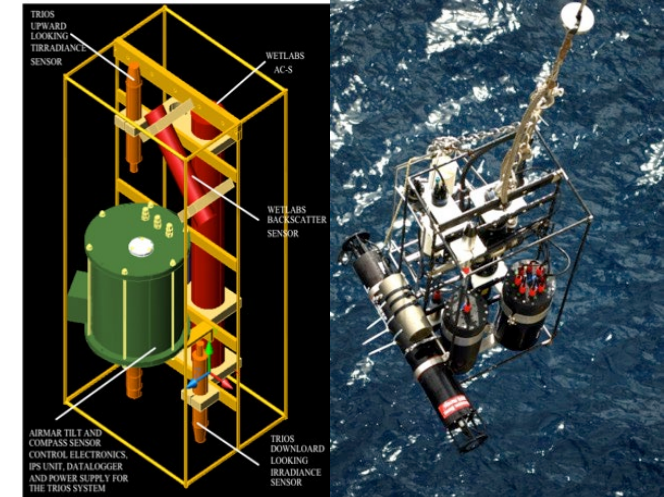
- Design and construction of HCMR profiling optics suite – in water radiometry.
- Dr. Banks moves to JRC & NPL.

2013-2017:

- HCMR optics suite deployments in E. Med & Black Sea.

2018-2021:

- Dr. Banks moves back to HCMR.
- Start to follow FRM principles at HCMR.
- Proposed Crete Copernicus OC-SVC site.
- ProVal in Crete.
- Continued deployments of HCMR optics suite.

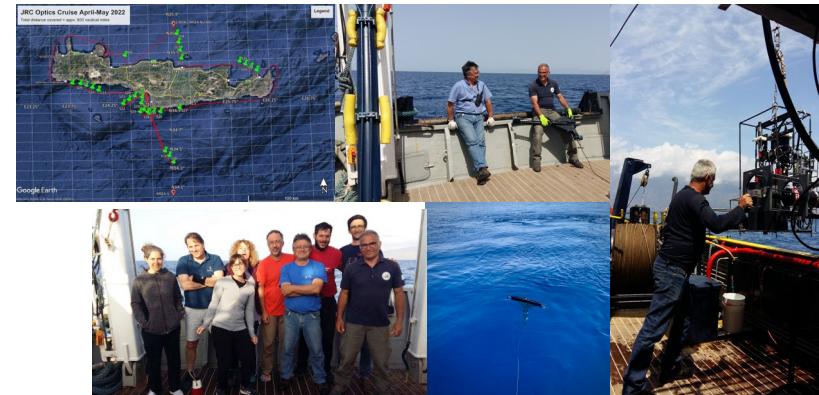


2015

2020

2022-2024:

- JRC-HCMR optics cruises around Crete.
- HyperNAV in Crete.
- Crete Copernicus OC-SVC site -> Design phase.
- Separation of OCR from IOPs – back above water
- NABUCCO & development of OCR calibration lab.



TODAY

Team members: Dr. Andrew Banks, Dr. Aris Karageorgis, Dr. Stella Psarra, Dr. Spyros Chaikalis, Dr. Alexandra Pelteki, Dr. Eleni Livanou, Dr. Elli Pitta, Dr. Christina Zeri, Mr. Nektarios Spyridakis, Prof. Panos Drakopoulos^(UNIWA)

**Institute of Oceanography,
Hellenic Centre for Marine Research (HCMR)**

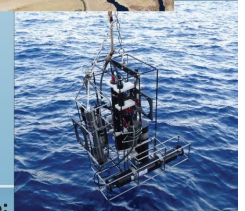
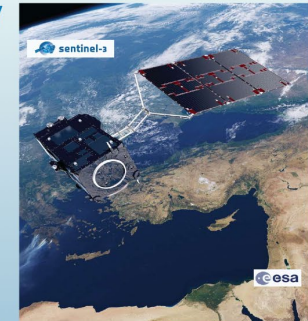
Contact: andyb@hcmr.gr

- 9 post doctoral researchers
- 1 dedicated engineer
- 15 years marine optics experience in the Eastern Mediterranean

Marine Optics & Satellite Oceanography

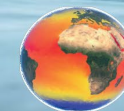
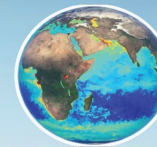
Satellite remote sensing products such as **ocean colour** and **sea surface temperature (SST)** are essential climate variables as defined by the World Meteorological Organization (WMO) and the Global Climate Observing System (GCOS).

They are important in helping us to monitor climate change, assess the health and productivity of marine ecosystems, and understand the role of the oceans in the global carbon cycle. For maintaining and improving the quality of these types of satellite data, in this cross cutting activity, the Institute of Oceanography (I.O.) of HCMR focuses on SST and ocean colour validation and vicarious calibration and retrieval algorithm improvement for satellite products. The I.O. is also attempting to understand the underlying optical processes in the Eastern Mediterranean and so is additionally focused on measurement and analysis of marine optical properties and their relationship with the biogeochemical constituents of the water column.



The main activities of the group therefore include:

- Fiducial Reference Measurements (FRM) for the validation of satellite ocean colour and sea surface temperature
- Ocean colour system vicarious calibration (OC-SVC)
- Apparent and inherent optical properties field measurement and sensor calibration
- Measurement of marine particles and phytoplankton
- Absolute radiometric calibration facilities in support of FRM and OC-SVC
- Radiative transfer modelling of the atmosphere and ocean
- SI-traceability and uncertainty evaluation for in situ and satellite measurements
- Satellite derived fundamental climate data records of ocean colour and SST
- Copernicus / ESA Sentinel next generation optical satellite mission development



IO Team members:

Dr. Andrew C. Banks, Dr. Aristomenis Karageorgis,
Dr. Stella Psarra, Dr. Christina Zeri, Dr. Elli Pitta,
Dr. Spyros Chaikalis, Mr. Nektarios Spyridakis.

Contact: andyb@hcmr.gr

<https://io.hcmr.gr/>

Photos: Giannis Issaris, Thanos Dailanis, Julius Galimpeidakis
Poster design: mk@hcmr.gr, fotini@hcmr.gr

TOWARDS FRM IN THE EASTERN MEDITERRANEAN

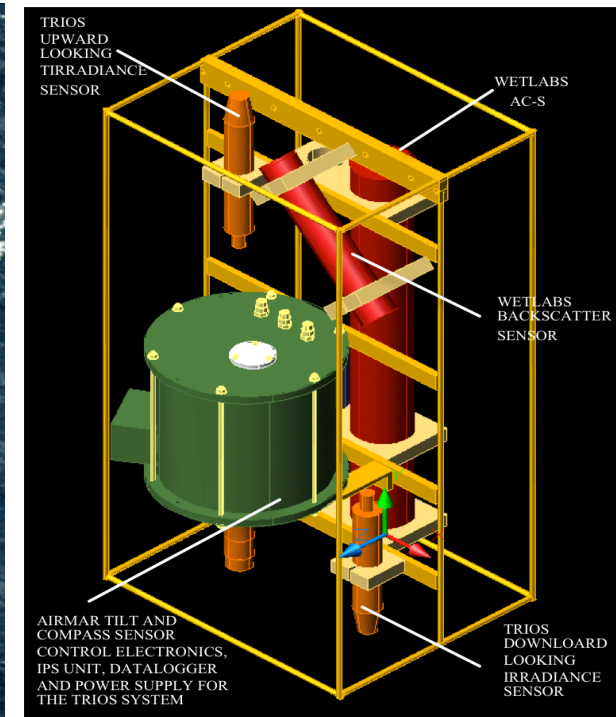
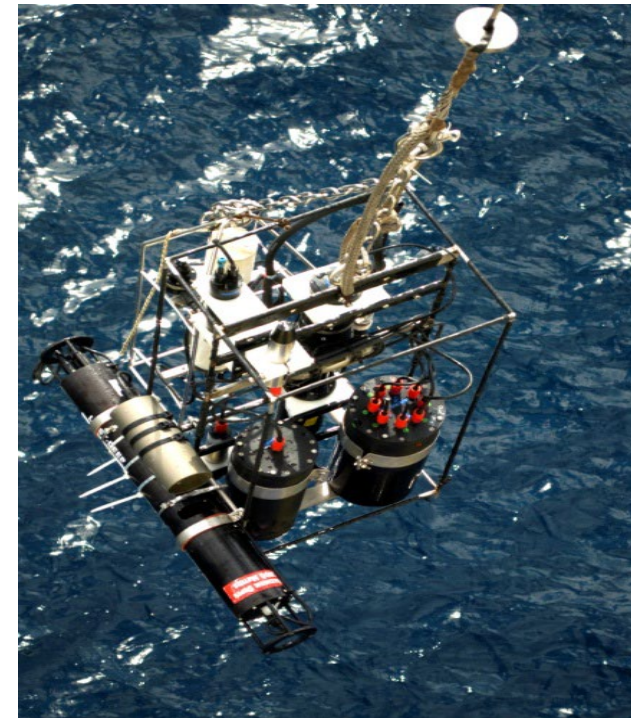
Supporting infrastructure for OCR & FRM



HCMR-Crete is a modern 6000 m² marine research complex on the north coast of Crete with high speed internet, calibration, radiometric, and HPLC labs + many other marine labs and facilities already in place. Houses optics calibration lab & local QC data lab. Also home of R/V Philia, the HCMR optics suite, a 10m offshore RIB, in-house professional diving team, and the largest aquarium in Greece & the Eastern Mediterranean.

HCMR marine optics sensors

- 4 TriOS radiometers
- AC-S & ECOBB3
- Chelsea transmissometer
- LISST-Deep
- LISST-Holo 2



TOWARDS FRM IN THE EASTERN MEDITERRANEAN

Supporting infrastructure for OCR & FRM

HCMR research vessels



AEGAEO

Home port: Piraeus (Athens)
Built in 1985, Rebuilt in 1997
Length : 61.51 m
Max. Speed : 12.5 Knots
Maximum cruising range : 20 days

On-board Staff

Crew: 21 persons
Scientific personnel: 21 persons



PHILIA

Home port: Heraklion
Built in 1986
REBUILT in 2021-2022
Length: 31 m

On-board Staff

Crew: 7 persons
Scientific personnel: 10 persons



New Research Vessel

European Investment Bank
55 M €

STATE-OF-THE-ART 70 m R/V

TO BE BUILT 2024-2026



ALKYON

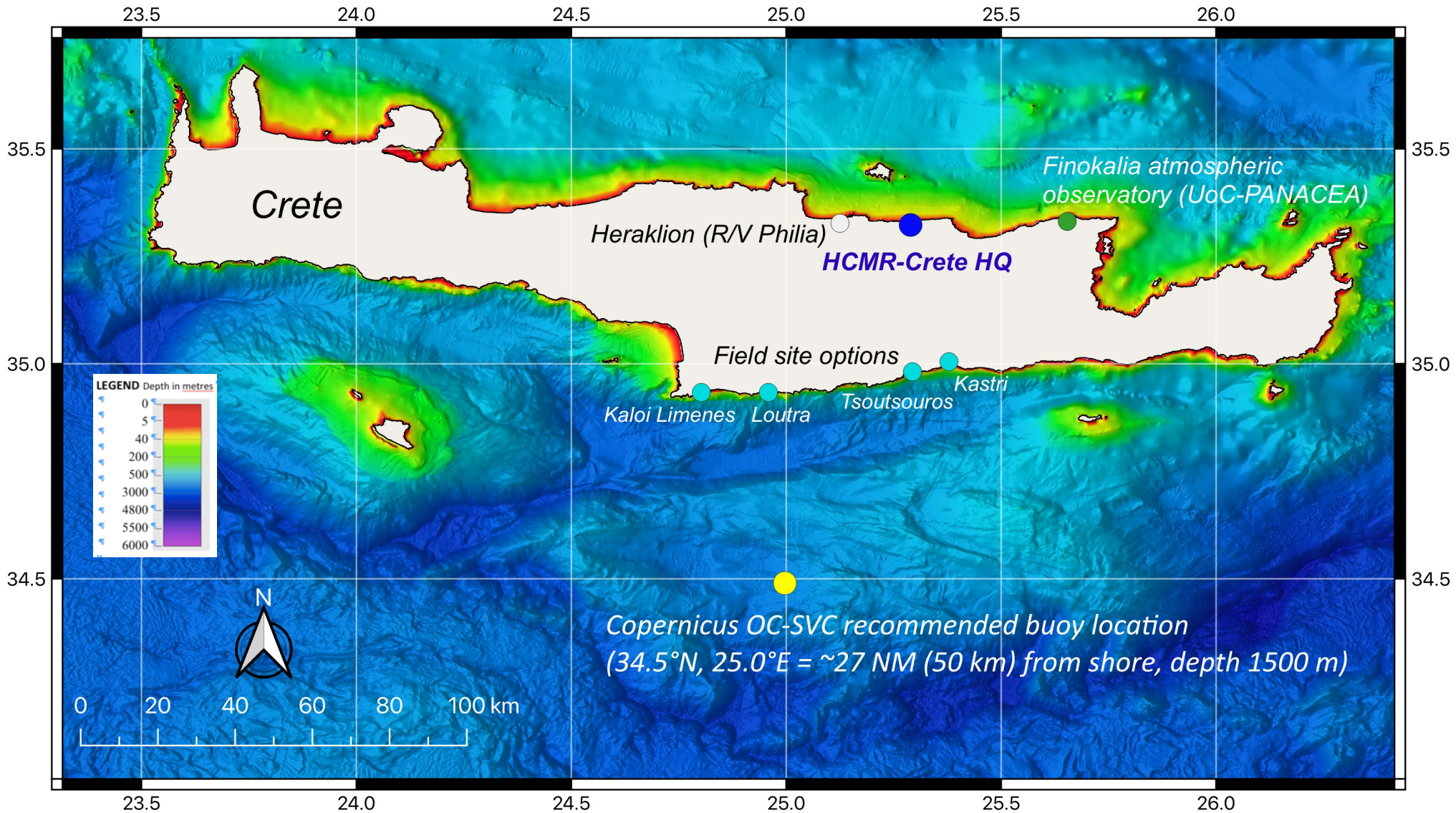
Built in 2009; Length : 13.4 m

On-board Staff

Crew : 2 persons
Scientific personnel : 8 persons

TOWARDS FRM IN THE EASTERN MEDITERRANEAN

Area of Interest



TOWARDS FRM IN THE EASTERN MEDITERRANEAN

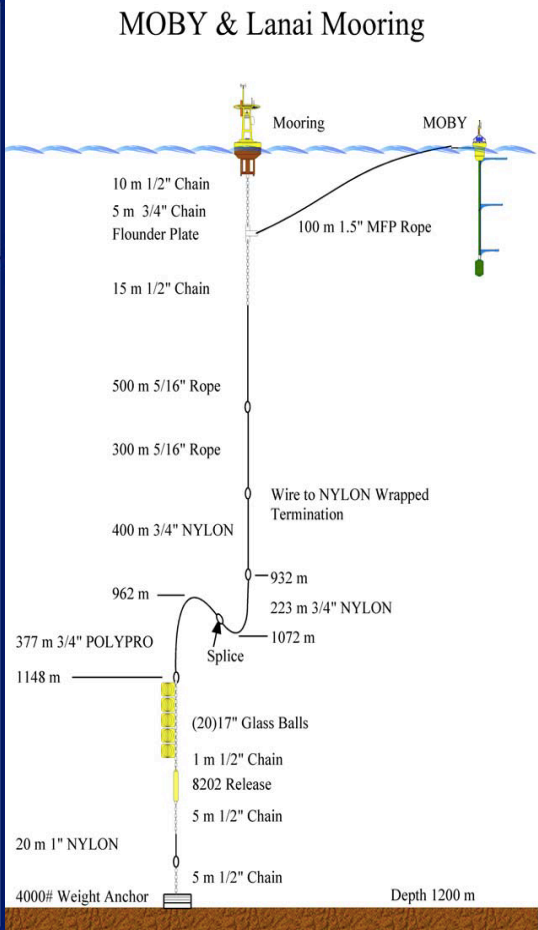
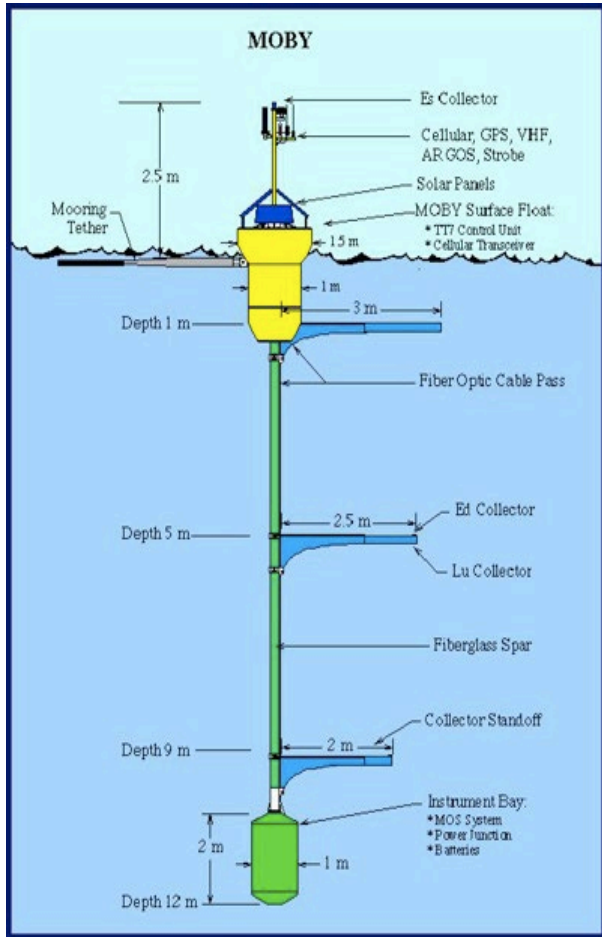
Copernicus Ocean Colour System Vicarious Calibration (OC-SVC) Development

ROADMAP

Phase	Status
<u>Requirements</u>	Completed
<u>Preliminary Design, Project Plan and Costing</u>	Completed
<u>Infrastructure Location</u>	Completed
Engineering Design, Technical Definition, Specifications	Proposed
Development, Testing and Demonstration in the Field	Proposed
Operations	Proposed

TOWARDS FRM IN THE EASTERN MEDITERRANEAN

OC-SVC in situ radiometric measurements – a special kind of FRM



MOBY / MARONET radiometry

- Follows MOBY design from US Identical instrumentation with MOBY
- Base spectrometer from Resonon (camera from Apogee)
- Custom assembly
- Separate blue and red wavelength spectrometers
- Consistent calibration system with MOBY and now EIO site

The Crete Candidate Site for the European Copernicus Satellite Ocean Colour Calibration Facility

Key points

- Copernicus is Europe's satellite earth observation system, our eyes on Earth. A central component of this system is the Sentinel satellites that operationally monitor the planet's environment including how our climate is changing.
- Ocean colour from satellite sensors is an essential climate variable and the main data source for systematically monitoring the status of marine ecosystems globally and regionally.
- For reliable and accurate data from the Sentinel ocean colour satellites it is critical to have accurate calibration of the satellite sensors based on surface measurements. This requires an ocean colour calibration buoy with a fixed mooring and the most advanced radiometry available.
- This facility is the European contribution to an international effort to have at least 3 calibration sites in the world's oceans. A global survey (Zibordi et al., 2017, RSE) highlighted top locations as Hawaii (only existing operational buoy, MOBY, USA), the East Indian Ocean (Australia) and Crete (Greece).
- European Commission budget is 25 Million Euros over 20 years. Crete is one of two European candidate sites recommended from the first three development phases to pass on to phase 4, "Engineering Design, Technical Definition and Specifications".
- Greece must commit long-term national support now to complement Copernicus funding and succeed in winning the bid to implement and run the site in Crete (phases 5 & 6).

TOWARDS FRM IN THE EASTERN MEDITERRANEAN

Preparation activities for OC-SVC

HCMR-Crete – ABSOLUTE RADIOMETRIC CALIBRATION LABORATORY



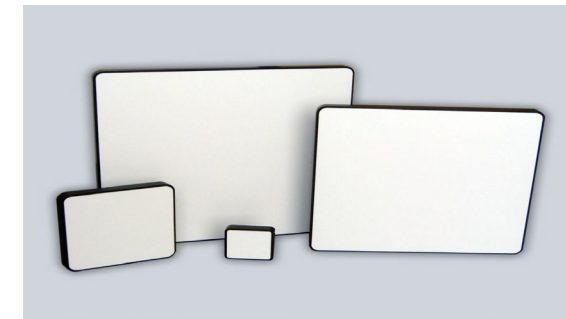
Black out wooden baffling, curtains, flooring and paint + optics table and stages, power, climate control and air filtering systems (not shown)



THORLABS 2.5 x 1.5 m optical table with stabilizing legs & instrument fittings



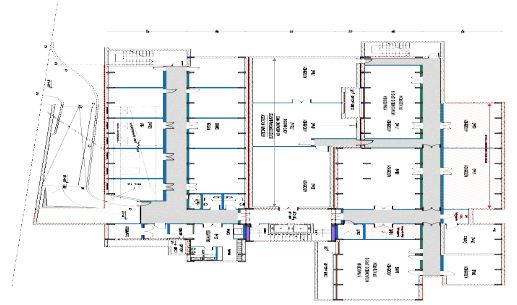
Gigahertz-Optik BN-9101 FEL 1000 W calibration lamps



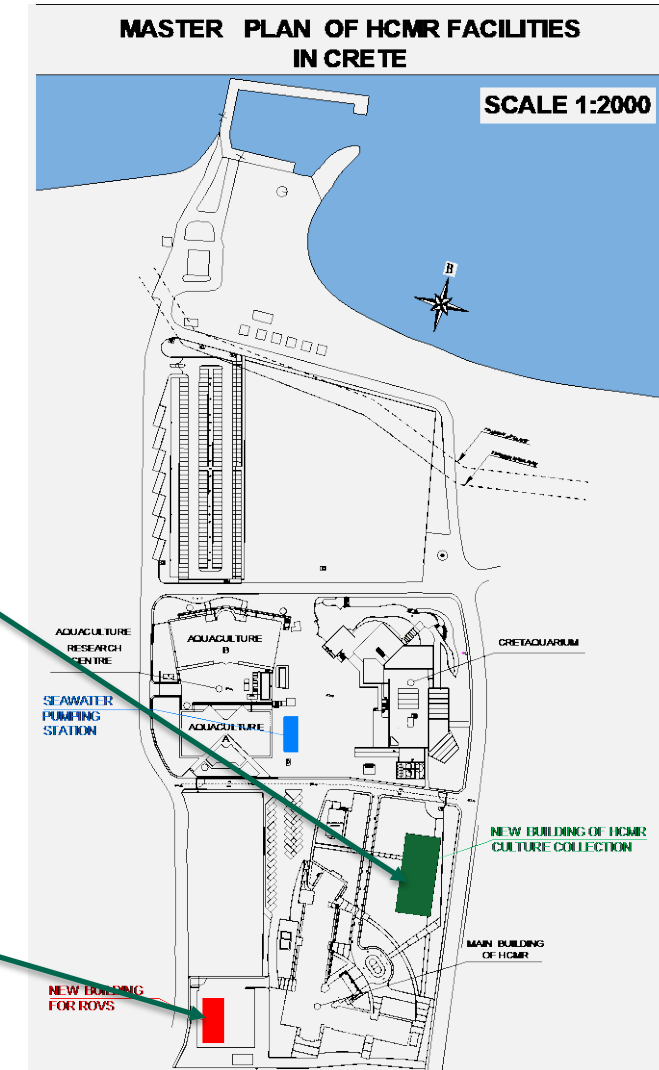
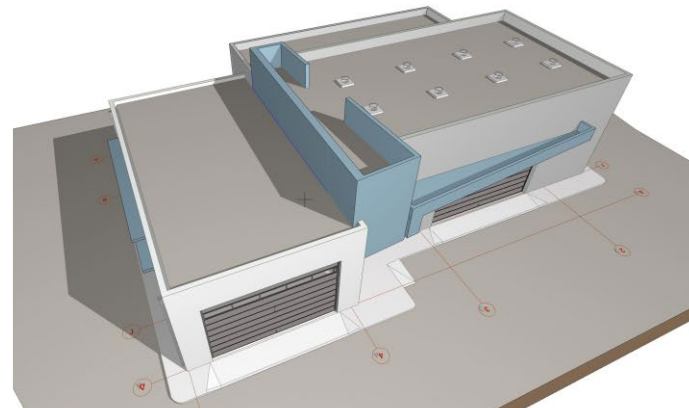
Spectralon 99% reflectance panel from LabSphere

HCMR-CRETE NEW BUILDINGS - FACILITIES

- 5 M Euro new HCMR-Crete research labs extension to existing 6000m² with custom optics calibration lab

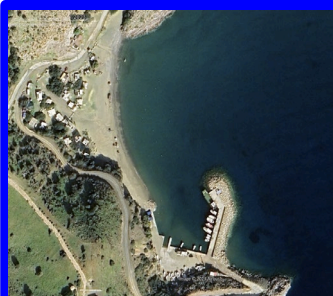
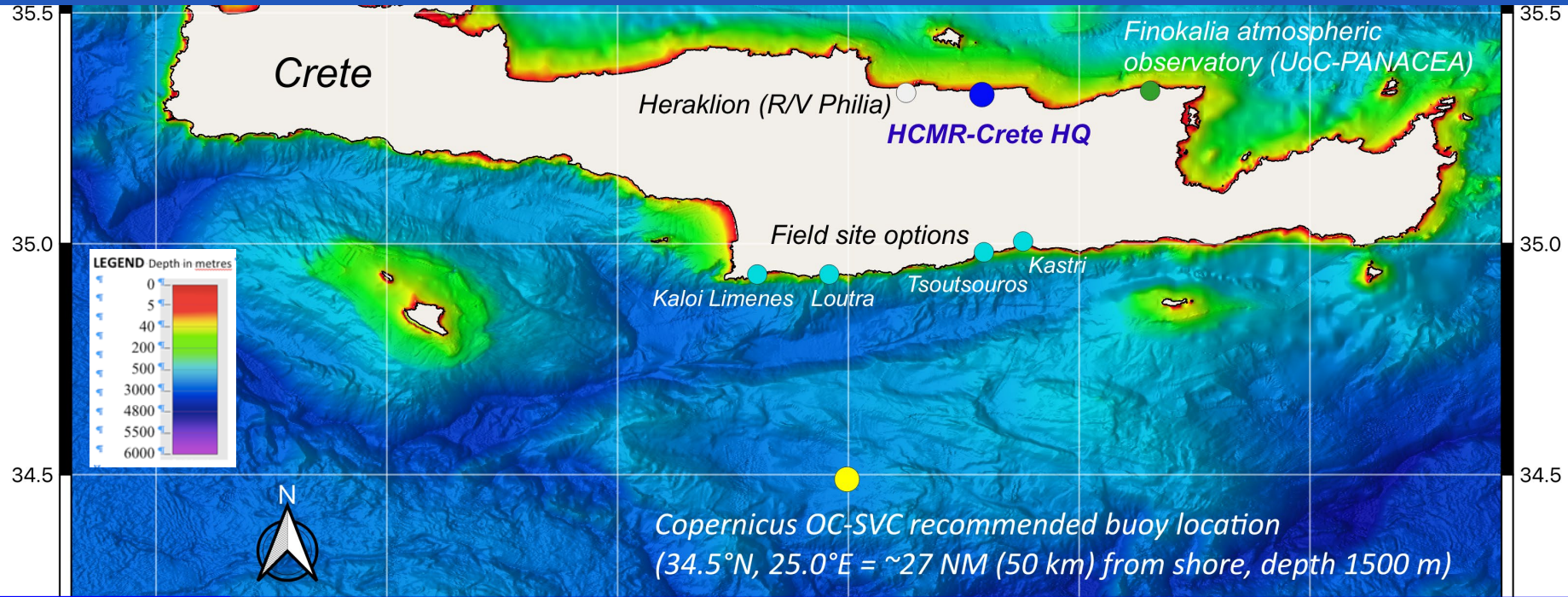


- New large marine engineering building at HCMR-Crete with area for handling OC-SVC buoy components – 1.2 M Euro.



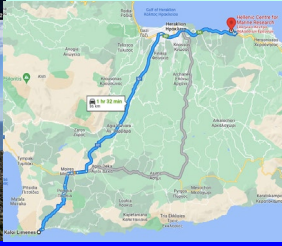
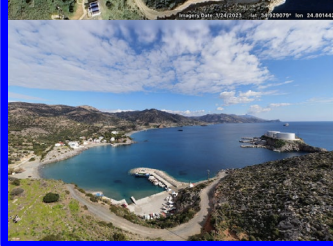
TOWARDS FRM IN THE EASTERN MEDITERRANEAN

Preparation activities for OC-SVC – field site



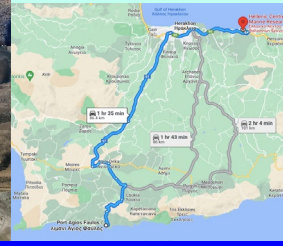
PORT OF KALOI LIMENES

- 27.5 nautical miles from OC-SVC buoy
- 86 km (1 hr 32 min) drive to HCMR-Crete
- Developed village
- Small port & cargo ship fuel station



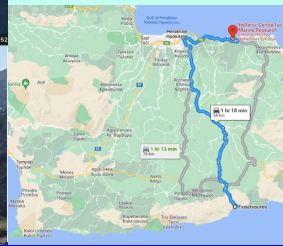
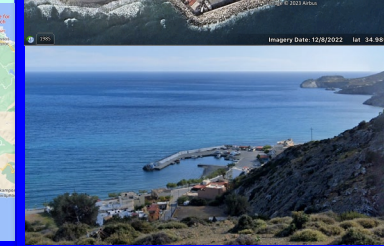
PORT OF AGIOS FAULOS, LOUTRA

- 26 nautical miles from OC-SVC buoy
- 86 km (1 hr 35 min) drive to HCMR-Crete
- Remote, no village
- Large refuge port



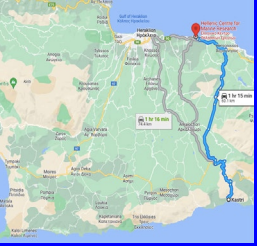
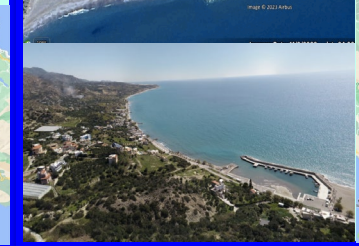
PORT OF TSOUSOUROS

- 32 nautical miles from OC-SVC buoy
- 68 km (1 hr 10 min) drive to HCMR-Crete
- Developed village
- Small port



PORT OF KASTRI

- 35 nautical miles from OC-SVC buoy
- 60 km (1 hr 15 min) drive to HCMR-Crete
- Developed village
- Large port



TOWARDS FRM IN THE EASTERN MEDITERRANEAN

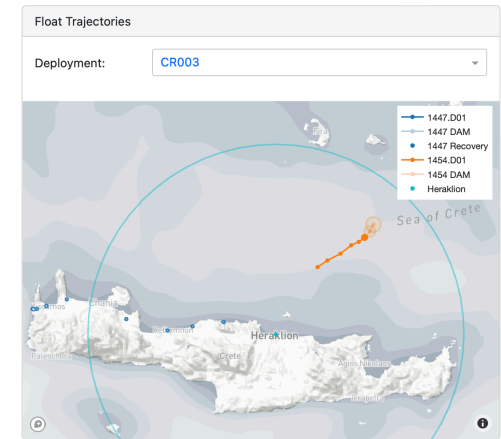
NASA HyperNAV in Crete in support of PACE OC-SVC



Source	380nm	412nm	443nm	490nm	510nm	550nm	665nm	Method
Calibration	1.88	1.87	1.80	1.74	1.68	1.68	1.71	
Irradiance Standard	0.55	0.51	0.48	0.44	0.42	0.4	0.34	Manufacturer certificate
Reflectance Target	1.1	1.1	1	0.9	0.8	0.8	0.9	Manufacturer certificate
Geometric Effects	1.4	1.4	1.4	1.4	1.4	1.4	1.4	Modeling based on Hooker et al (2002)
Reproducibility	0.23	0.23	0.23	0.23	0.23	0.23	0.23	Previous studies (see Orrico et al 2018)
Instrument	1.43	0.71	0.64	0.45	0.66	0.46	1.17	
Polarization	0.9	0.5	0.4	0.1	0.06	0.07	0.5	Laboratory measurements
Thermal	0.08	0.08	0.08	0.08	0.08	0.08	0.08	Laboratory measurements
Immersion	0.43	0.45	0.45	0.36	0.4	0.39	0.3	Laboratory measurements & Feinholz et al. (2017)
Integration Time Linearity	0.05	0.05	0.05	0.05	0.05	0.05	0.05	Laboratory measurements
Counts Linearity	0	0	0	0	0.01	0.03	1	Characterized by NIST
Stray Light	0.12	0.1	0.09	0.08	0.05	0.04	0.09	Characterized by NIST
Wavelength @ Cal	0.19	0.15	0.13	0.09	0.08	0.06	0.03	Laboratory measurements
Wavelength @ Field	1	0.1	0.1	0.2	0.5	0.2	0.1	Field data
Field	2.58	2.55	2.54	2.54	2.62	2.78	5.42	
Self-shading	0.3	0.26	0.22	0.24	0.32	0.56	2.7	Modeling using SimuIO software
Tilt Effects	2.2	2.2	2.2	2.2	2.2	2.2	2.2	Field data and Kwiatkowska et al. (2017)
Biofouling	1	1	1	1	1	1	1	Brown et al. (2007)
Wave Focusing	0.5	0.5	0.5	0.5	0.5	0.5	0.5	Estimated from literature
Depth Uncertainty	0.7	0.56	0.54	0.54	0.82	1.14	4	Extrapolated from Voss et al. 2017 and field data
Surface Transmittance	0.1	0.1	0.1	0.1	0.1	0.1	0.1	Modeling based on Quan & Fry (1995)
Total, k=1	3.5	3.2	3.2	3.1	3.2	3.3	5.8	

HyperNav Portal

ID	Deployment	Duration	Latitude	Longitude	Start Time	End Time	Details
PR001	1543.D3	27	17.8848 °N	66.8244 °W	2024-05-14 16:55:30	3 h 22 m	Details
HI005	1312.D3	19	19.4361 °N	157.0528 °W	2024-05-13 22:55:00	21 h 23 m	Details
CR003	1454.D1	14	35.8570 °N	25.7196 °E	2024-05-14 10:16:00	10 h 2 m	Details



Satellite Overpass Times

Site: Crete

Time Zone: UTC Europe/Athens

Sensor	Today	Tomorrow	Thursday	Friday	Saturday
MODIS-Aqua	11:56:31 ⁴	12:37:11 ³	11:40:15 ⁴	12:20:46	11:23:56 ³
MODIS-Terra	09:07:03 ^{3 4}	08:09:43	08:49:50 ⁴	07:52:19 ³	08:32:31 ⁴
MSI-2A	09:22:27 ^{4 6}	-	-	-	-
MSI-2B	09:20:25 ⁴	-	-	-	-
OCM-2	-	-	-	-	-
OLCI-S3A	09:20:48 ⁴	08:55:02 ⁴	08:29:12	-	09:17:08 ⁴
OLCI-S3B	08:42:30 ⁴	-	09:30:20 ³	09:04:36 ⁴	08:38:47
PACE-HARP2	11:23:54	10:21:12 ³	10:55:31 ⁴	11:29:57 ³	10:27:12
PACE-OCI	11:24:26	10:21:56 ³	10:56:05 ⁴	11:30:41 ³	10:27:44

26/05/2022 10:06

New chlorophyll-a concentration retrieving Algorithm Based on fidUcial referenCe measurements of ocean COlour (NABUCCO).

- Aims at measuring and studying the optical properties of seawater in the oligotrophic Cretan and NW Levantine Seas, improving their SI-traceability and uncertainty evaluation and thereby deriving an appropriately accurate regional Chl-a retrieval algorithm.
- WP1: Fiducial reference measurements, technological development and new field data.
 - New optics calibration lab.
 - New FRM field data collection.
- WP2: Data analysis and modelling
 - FRM database of existing and new optical data.
 - Radiative transfer modelling in optical closure experiments and remote sensing reflectance estimation from IOPs.
 - Processing AOPs with FRM4SOC & IOCCG protocols.
- WP3: Algorithm development and testing
 - Using the basis of FRM data - evaluate existing and develop new algorithms to estimate Chl-a concentration more accurately from satellite products of the oligotrophic E. Mediterranean.



NABUCCO
New chlorophyll-a concentration retrieving Algorithm Based on fidUcial referenCe measurements of ocean COlour

Andrew Banks, Stella Psarra, Panos Drakopoulos (UNIWA), Aris Karageorgis, Spyros Chaikalis, Nektarios Spyridakis, Eleni Livanou, Alexandra Pelteki, Elli Pitta, Christina Zeri.

BASED ON FRM

Project Objectives & Challenges
Ocean colour is an essential climate variable (ECV) that has revolutionised biological oceanography. It is used as a central element in assessing the health and productivity of marine ecosystems and the role of oceans in the global carbon cycle. However, there are still substantial systematic and unresolved errors in the estimation of its key parameters, i.e. water leaving radiance and chlorophyll-a (Chl-a), making such an application of ocean colour particularly challenging in the ultra-oligotrophic waters of the E. Mediterranean, that also comprise most of the Hellenic pelagic territorial waters, and services for the region. Thus, NABUCCO aims at working towards resolving this problem by studying the optical properties of seawater in the oligotrophic Cretan and NW Levantine Seas, improving their SI-traceability and uncertainty evaluation and thereby deriving an appropriately accurate regional Chl-a retrieval algorithm. This will improve the quality and spatio-temporal resolution of ocean data products for the E. Mediterranean and significantly reduce the cost of data collection. Such an achievement will support national monitoring projects and in particular substantially improve marine ecosystem monitoring programs, management applications, and services for the region.

MARINE OPTICS

SATELLITE CHL-A

Research Methodology
The project is being implemented through three work packages. WP1 (Fiducial reference measurements, technological development and new field data) constitutes the foundation of NABUCCO, and involves apparent and inherent optical property measurements (AOPs & IOPs) of the water column using well calibrated instruments with a full uncertainty budget. For AOPs, state-of-the-art SI-traceable absolute radiometric calibrations with this full uncertainty evaluation are necessary and so HCMR is developing its own optical calibration facilities. For the IOP measurements, HCMR facilities are being upgraded to calibrate absorption and backscattering sensors beyond the standard calibration and include an uncertainty budget. Existing hardware and software are being upgraded for optimum optical field data acquisition with new data being collected from state-of-the-art optics cruises in the Cretan and Levantine Seas. WP2 (Data analysis and modelling) involves creating an FRM database of existing and new optical data, applying radiative transfer modelling in optical closure experiments and remote sensing reflectance estimation from IOPs, and processing AOPs using FRM4SOC & IOCCG protocols. Finally, WP3 (Algorithm development and testing) is using the data and understanding from WP1 & 2 to evaluate existing and develop new algorithms to estimate Chl-a concentration more accurately from satellite products of the oligotrophic E. Mediterranean.

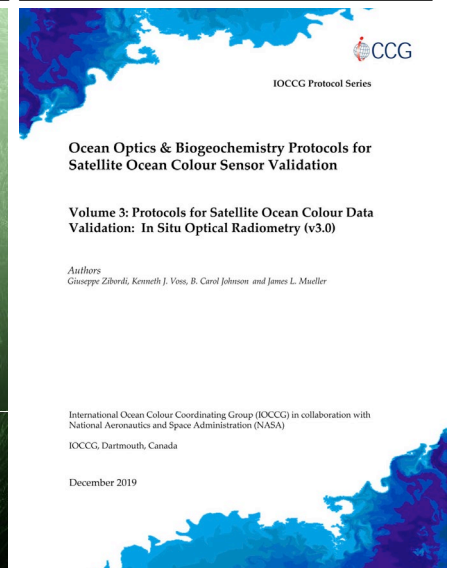
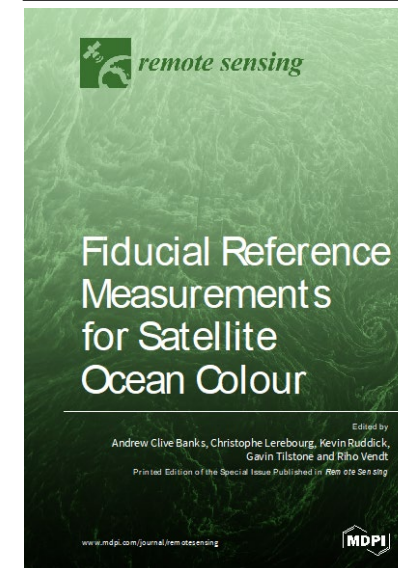
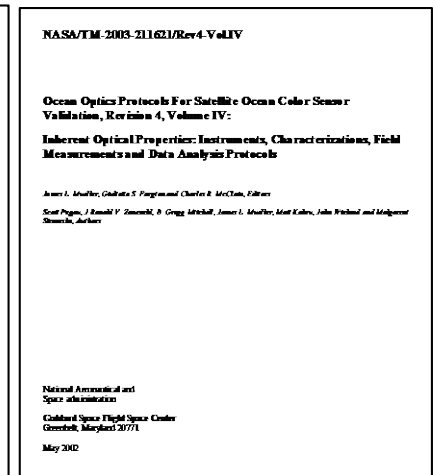
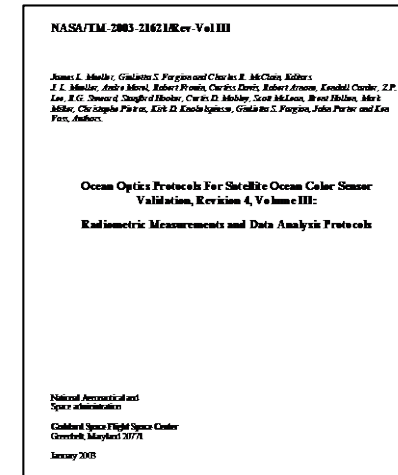
With support from:
H.F.R.I. Hellenic Foundation for Research & Innovation
hcmr INSTITUTE OF OCEANOGRAPHY
UNIVERSITY OF TARTU Tartu Observatory
DG-JRC

TOWARDS FRM IN THE EASTERN MEDITERRANEAN

Field measurement protocols

OCR in situ by HCMR above water 2007-2012, in water profiling 2012-2022

- We have been following NASA protocols (Mueller et al., 2003) since 2007
- Trying to follow FRM principles (Banks et al., 2020) and FRM4SOC protocols update (Ruddick et al., 2019a&b) since 2018-2019
- Following IOCCG protocols (Zibordi et al., 2019) since 2020.



TOWARDS FRM IN THE EASTERN MEDITERRANEAN

SI traceable radiometric calibration

- ✓ **First recalibrations since 2009 purchase – JRC Nov.2018**
- ✓ Adjustment factors to manufacturers original calibration calculated from these measurements.



TOWARDS FRM IN THE EASTERN MEDITERRANEAN

SI traceable radiometric calibration

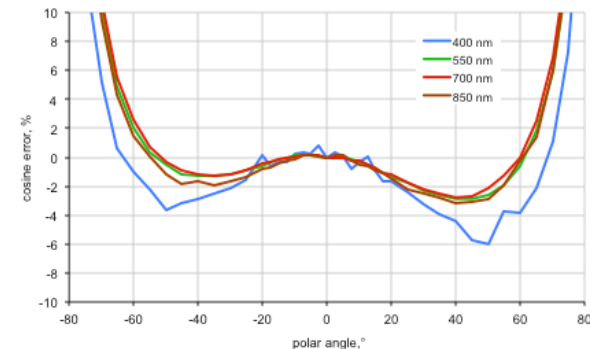
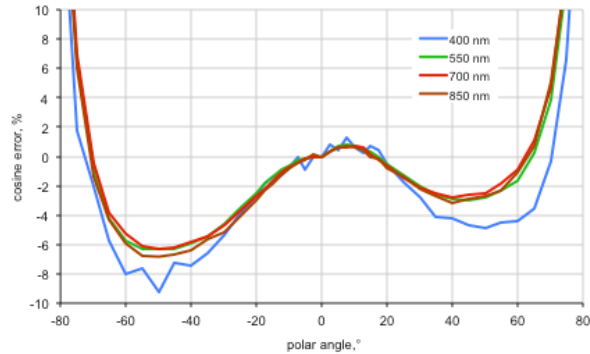
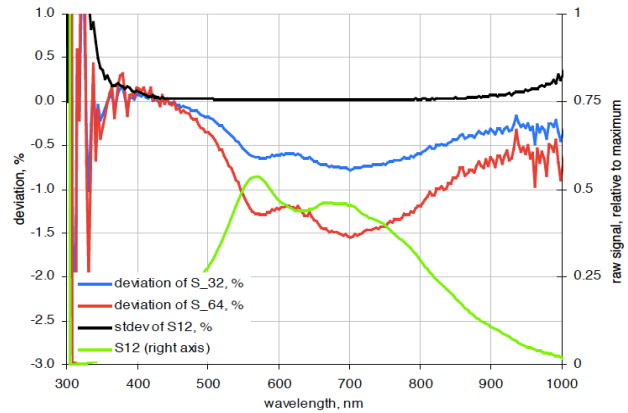
✓ **Second and third calibrations - full absolute radiometric calibrations with per wavelength uncertainties. November 2020 & March 2023 – at Tartu Observatory**



	Irradiance (E) uncertainty (%) at OLCI wavelengths (nm)											
Source	400	412	443	490	510	560	620	665	674	681	709	Method
E radiometer lab calibration	2.1	2.0	1.8	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.7	TO FEL lamp ($k=2$)

	Radiance (L) uncertainty (%) at OLCI wavelengths (nm)											
Source	400	412	443	490	510	560	620	665	674	681	709	Method
L radiometer lab calibration	2.3	2.0	1.9	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.8	TO FEL lamp-reflectance panel ($0^\circ/45^\circ, k=2$)

Linearity & cosine response characterisations – November 2020 and March 2023 at Tartu Observatory

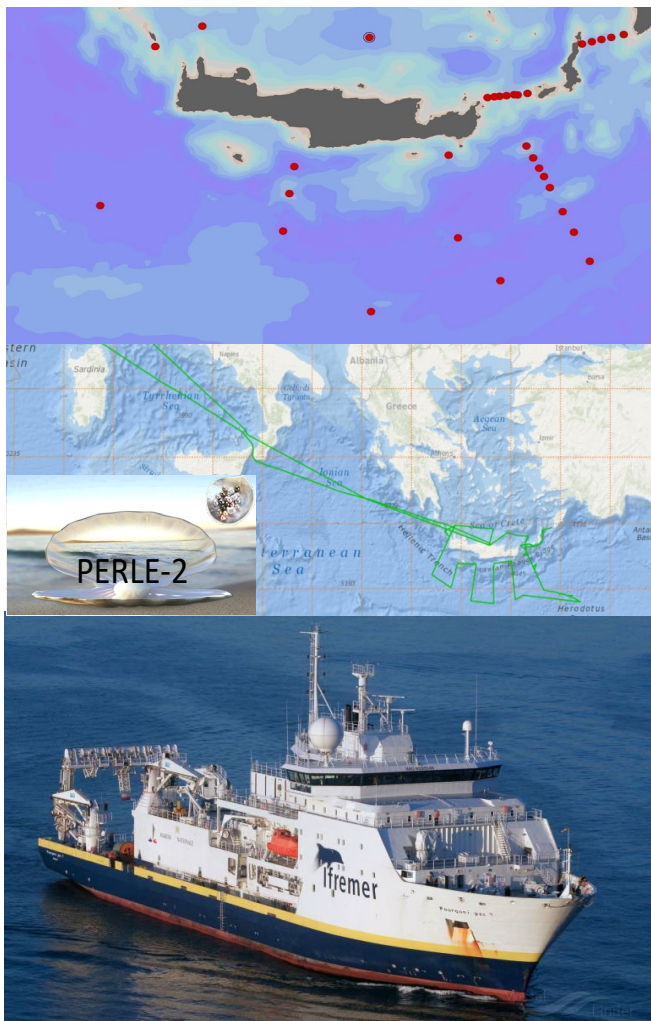


L _{wn} uncertainty budget (%) at OLCI wavelengths (nm)												
Source	400	412	443	490	510	560	620	665	674	681	709	Method
L _u radiometer lab calibration	2.3	2.0	1.9	1.9	1.8	1.8	1.8	1.8	1.8	1.8	1.8	TO lab FEL lamp-reflectance panel (0°/45°, k=2)
L _u instrument characterisation												
Immersion factor	0.2	0.2	-0.6 0.2	0.2	0.2	-0.9 0.2	0.2	-1.2 0.2	0.2	0.2	0.2	Zibordi et al., 2018 Zibordi et al., 2018
Temp. response	0.02 0.4	0.2	0.2 0.01 0.2	0.01 0.2	0.2	-0.3 0.03 0.2	0.2	-0.7 0.09 0.2	0.2	0.2	0.2	Zibordi et al., 2017, 2018 Vabson et al., 2019a (lab) Vabson et al., 2019b (field)
Polarization sens.	0.2	0.2	0.1 0.2	0.2	0.2	0.2	0.2	0.5 0.2	0.2	0.2	0.2	Talone & Zibordi, 2016, Zibordi et al., 2018 Vabson et al., 2019b (field)
Straylight effects	0.2 0.9	0.2	-1.0 0.2 0.7	0.2 0.3	0.2	0.5 0.2 0.3	0.2	0.4 0.2 0.7	0.2	0.2	0.2	Talone et al., 2016 Zibordi et al., 2018 Vabson et al., 2019a (lab) Vabson et al., 2019b (field)
Nonlinearity	0.11	0.07	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	TO laboratory characterization (k=1).
E _s radiometer lab calibration												
E _s radiometer lab calibration	2.1	2.0	1.8	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.7	TO lab FEL lamp (k=2)
E _s instrument characterisation												
Temp. response	0.02 0.4	0.2	0.2 0.01 0.4	0.01 0.2	0.2	-0.3 0.03 0.2	0.2	-0.7 0.09 0.2	0.2	0.2	0.2	Zibordi et al., 2017,2018 Vabson et al., 2019a (lab) Vabson et al., 2019b (field)
Straylight effects	0.2 0.9	0.2	-1.0 0.2 0.7	0.2 0.3	0.2	0.5 0.2 0.3	0.2	0.4 0.2 0.7	0.2	0.2	0.2	Talone et al., 2016, Zibordi et al., 2018 Vabson et al., 2019a (lab) Vabson et al., 2019b (field)
Nonlinearity	0.09	0.06	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.01	TO laboratory characterization (k=1)
Cosine response	1.3	0.8	0.6	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.2	TO laboratory characterization (k=2)

TOWARDS FRM IN THE EASTERN MEDITERRANEAN

Recent OCR validation cruises

1. Pelagic Ecosystem Response to dense water formation in the Levant Experiment (**PERLE 2**) cruise 27 Feb-15 Mar 2019



2. MARine monitoring system of the Hellenic Seas using REmote sensing satellite data and in-situ measurements (**MARRE**) cruise 25 – 28 Sept 2020

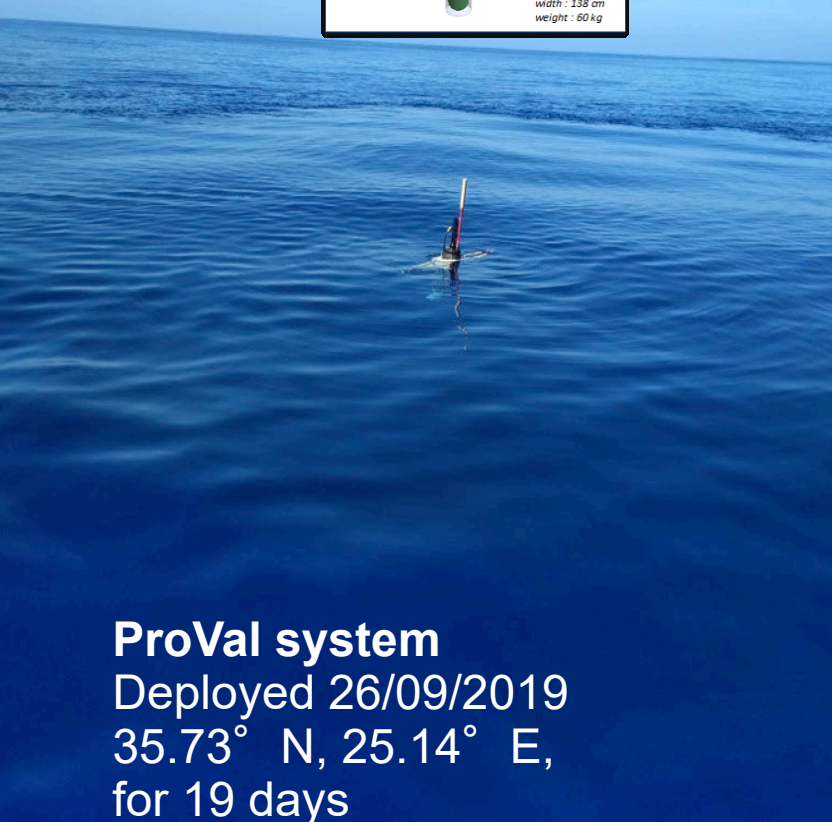
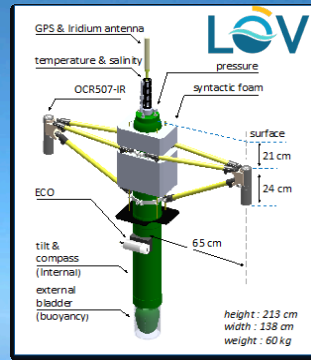


3. **JRC-HCMR Bio-optics** cruise 29 April - 09 May 2022

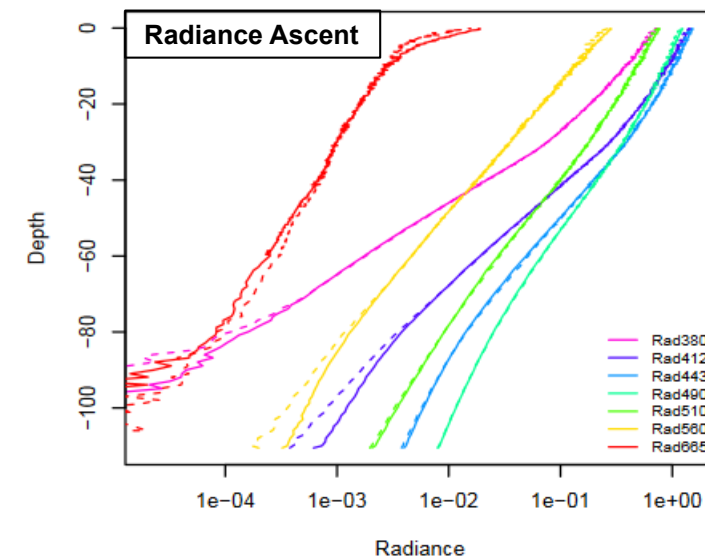
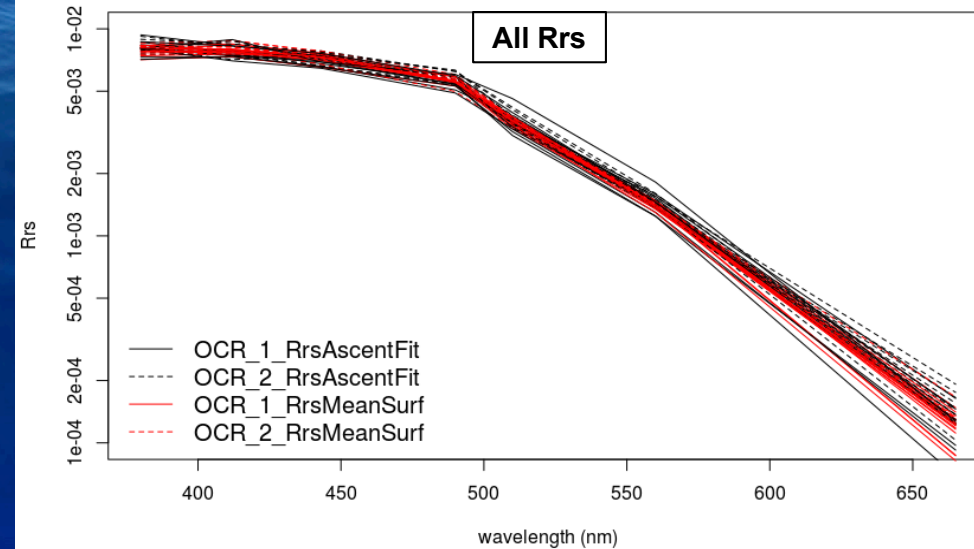


TOWARDS FRM IN THE EASTERN MEDITERRANEAN

Other advanced OCR in-water systems deployed in Crete



Initial (very promising) results: 20 cloud free S3A-OLCI matchups over 3 weeks

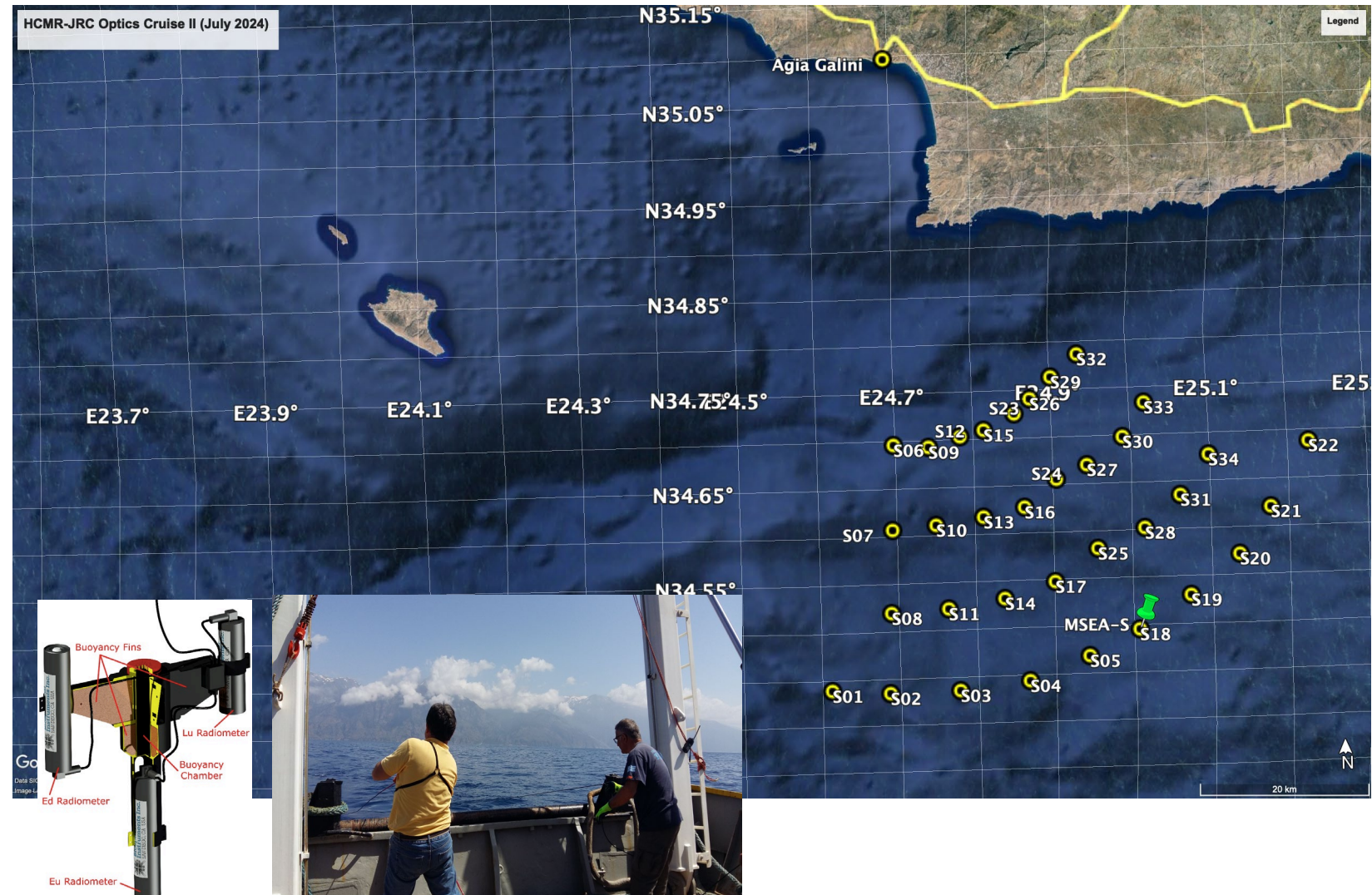


ProVal system
 Deployed 26/09/2019
 35.73° N, 25.14° E,
 for 19 days

JRC-HCMR optics cruise II in Crete, 15-30 July 2024

Planned sampling:

- 4 sets of radiometry data, JRC Satlantic, Biospherical and TriOS in-water profilers; HCMR above water TriOS system.
- IOP profiles from JRC AC-9 and Hydroscat-6 to 35m; HCMR AC-S and ECOBB3 + LISST-Deep & LISST-Holo 2 particle measurements to 150-200 m.
- Surface water sampling and Niskin bottle sampling down to 150-200 m for filtration and lab analysis – HPLC, aCDOM, aph, adt, adg.
- CTD profiles with fluorescence to 150-200m



TOWARDS FRM IN THE EASTERN MEDITERRANEAN

A few lessons learnt



Calibrations / characterisations

- Allow a substantial budget in projects and enough time before cruises for this. It is expensive and time consuming – FRM4SOC free calibration offer very welcome.
- More OCR calibration labs needed in Europe but building your own lab is a long and expensive process – guidelines / advice from FRM4SOC, NPL, TO and JRC invaluable.
- Applying characterisation corrections on your own takes considerable effort and is complex – thank goodness for class based work by JRC and FRM4SOC.

Measurement and processing

- Carefully follow FRM4SOC and IOCCG protocols – have checklist onboard.
- Keeping exact relative azimuth angle to sun on an R/V very difficult (captains attention, prevailing weather direction etc.). Always record angle away from ideal orientation relative to sun. Simple indicator for captain very useful.
- Try to evaluate your own environmental uncertainties for your cruise setup.

Uncertainty budgets

- Evaluating an uncertainty budget on your own takes considerable effort and is complex. Thank goodness for FRM4SOC and the community processor!
- Need a standardized way of evaluating the in situ and satellite uncertainties in the validation process – coming in ThoMaS?

Comparisons

- Try to get involved in field intercomparison exercises.

TOWARDS FRM IN THE EASTERN MEDITERRANEAN

Lessons learnt – quality assurance





Thank you!!



Contact: andyb@hcmr.gr