Recent marine optics and S3-OLCI validation measurements at the potential Copernicus Ocean Colour System Vicarious Calibration (OC-SVC) site of Crete.

SENTINEL-3 VALIDATION TEAM MEETING 7, ESA-ESRIN, OCT 18-20, 2022

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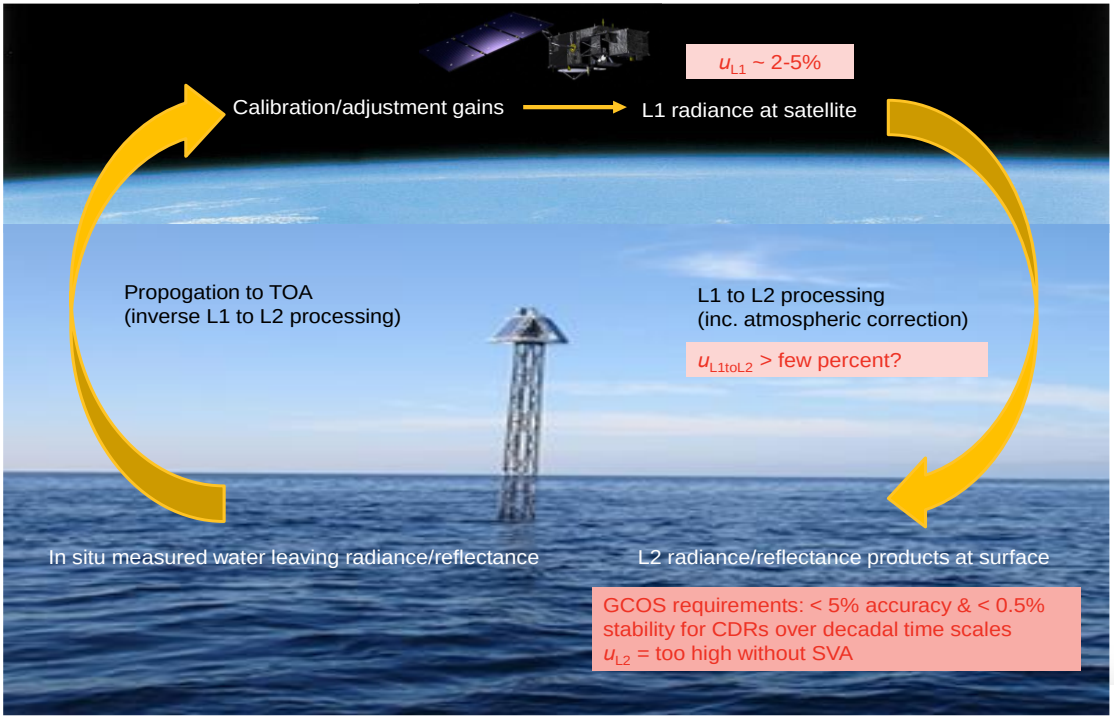
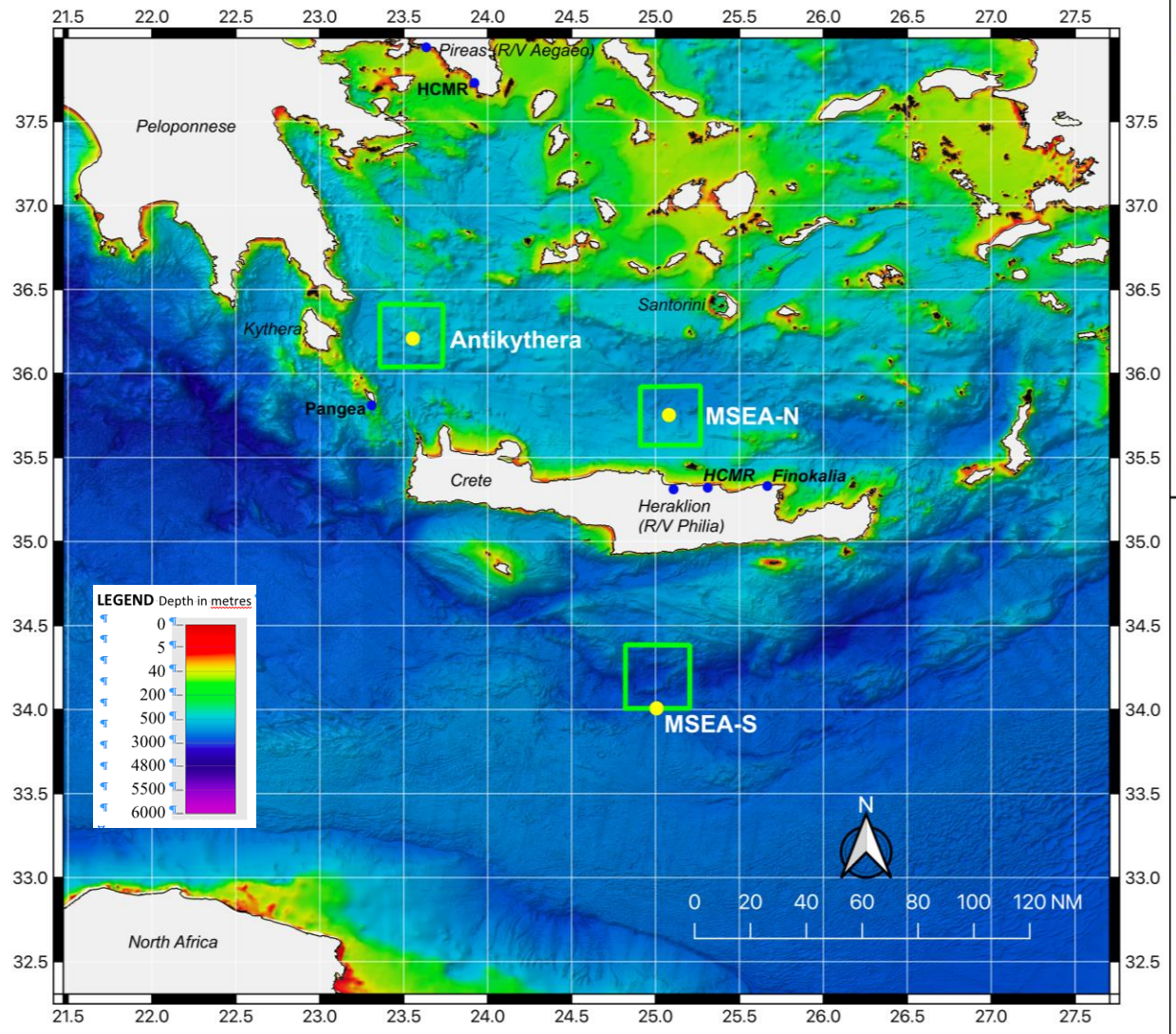
Recent Crete OC-SVC Site Marine Optics
Copernicus Ocean Colour System Vicarious Calibration

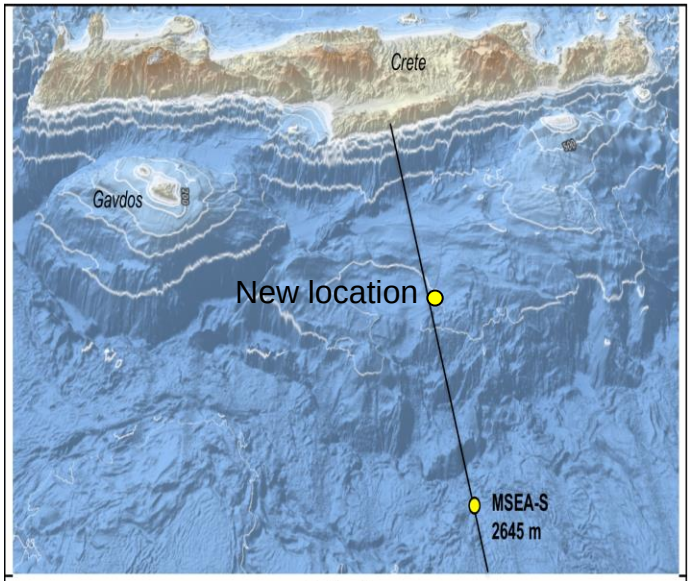


ROADMAP

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

RECENT CRETE OC-SVC MARINE OPTICS
Area of Interest





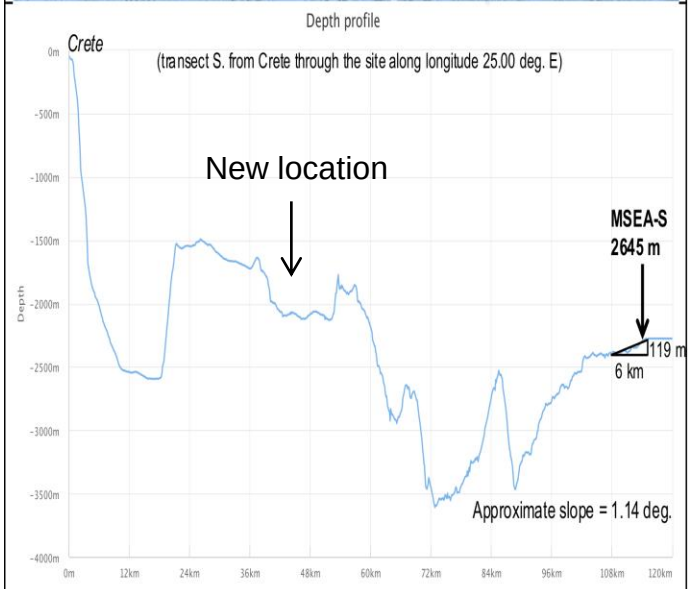


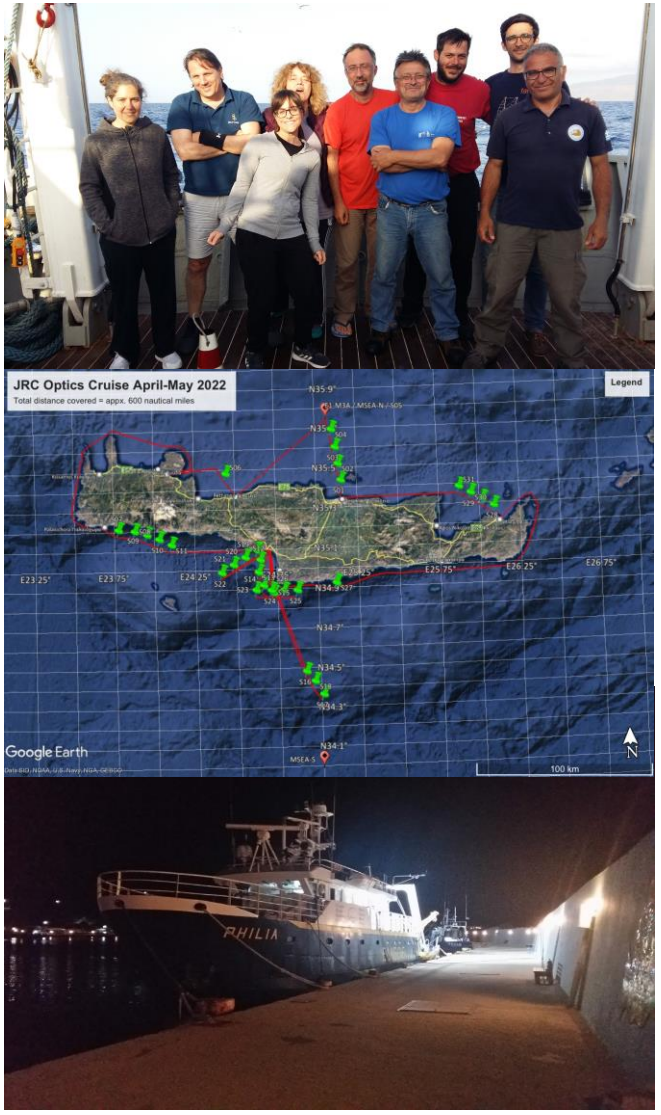
Figure G4. 3D bathymetry and depth profile (including slope at site) for MSEA-S from EMODnet data.

Recent Crete OC-SVC Marine Optics
Recent research cruise data sources

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

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

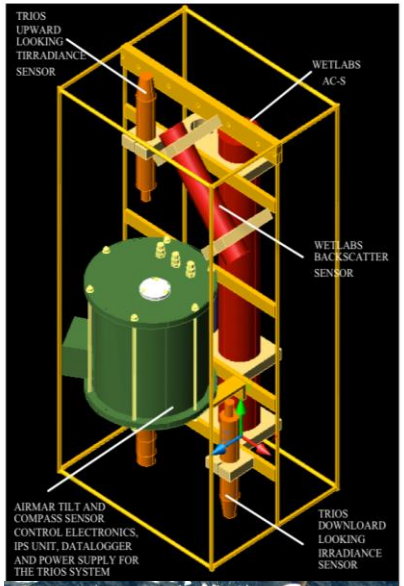
3. **JRC**-HCMR Bio-optics cruise 29 April - 09 May 2022

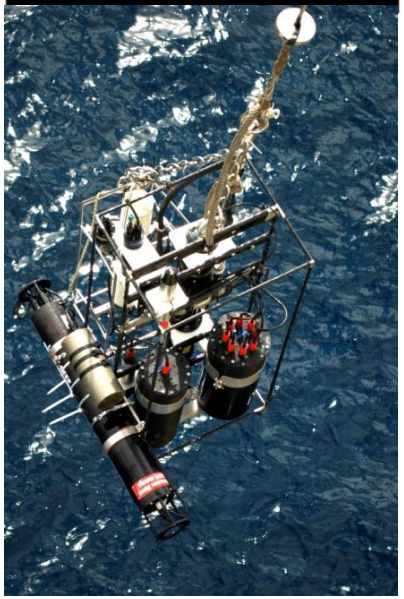


Recent Crete OC-SVC Marine Optics

Optics systems used

HCMR optics suite

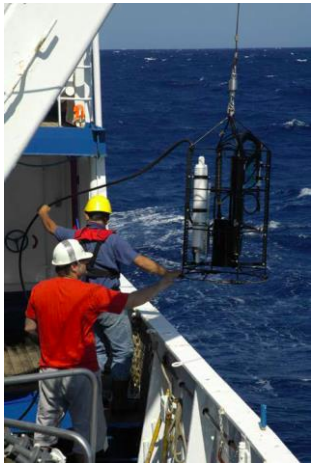




UNIWA handheld spectroradiometer (JAZ Ocean Optics)

NASA / Seabird HyperNAV radiometer system (surface mode)

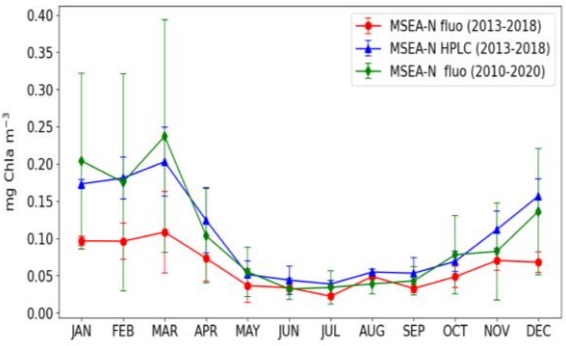
JRC profiling radiometer systems (x2)

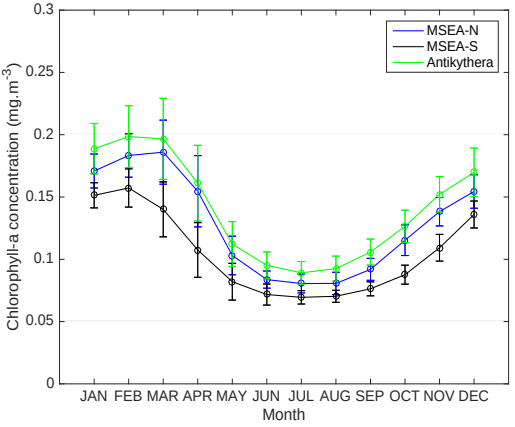


JRC profiling IOP package

Recent Crete OC-SVC Marine Optics Results – in situ chlorophyll-a

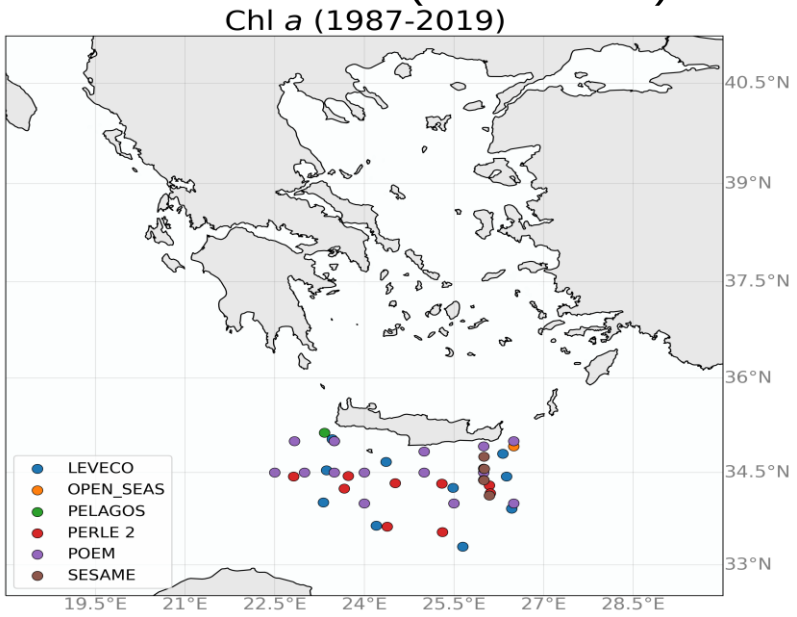
In situ Cretan Sea (10 yrs)

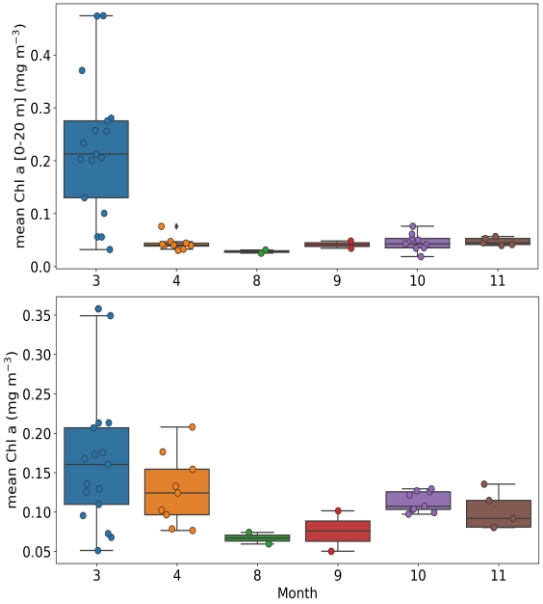


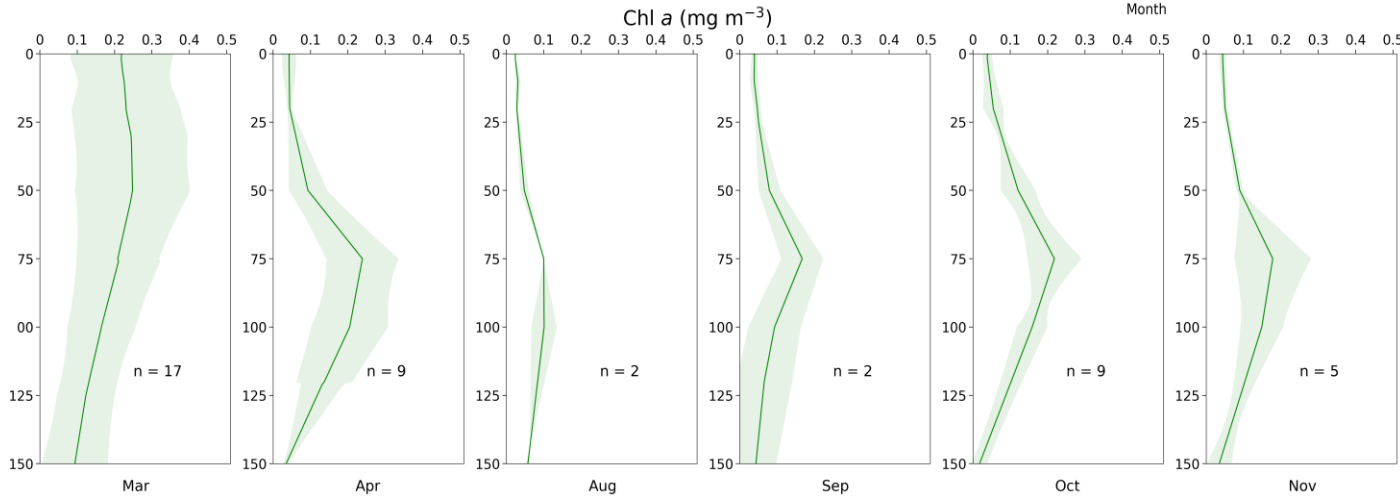


ESA OC-CCI (22 yrs)

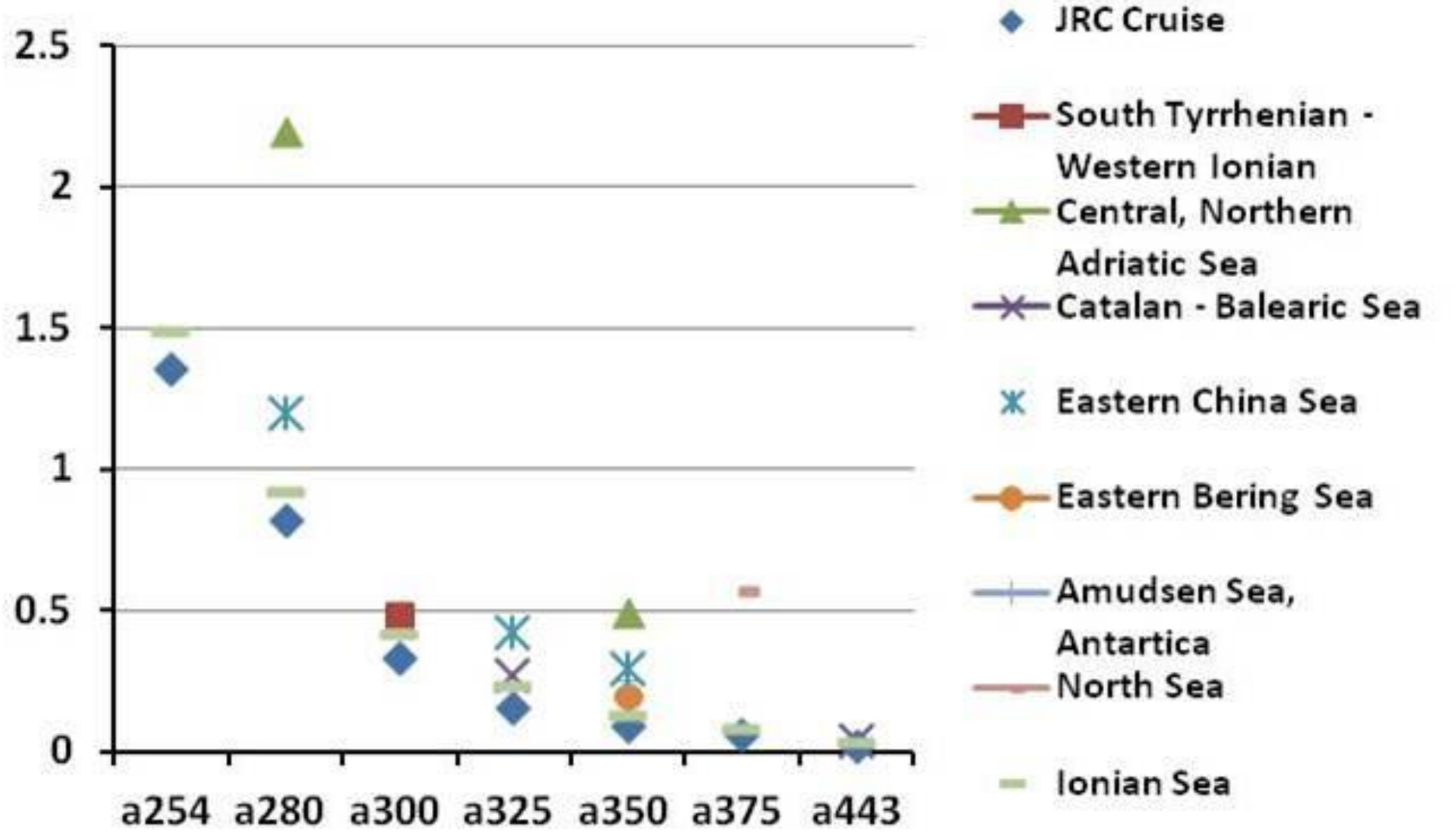
Focused HPLC subset of all Levantine data (44 stations)



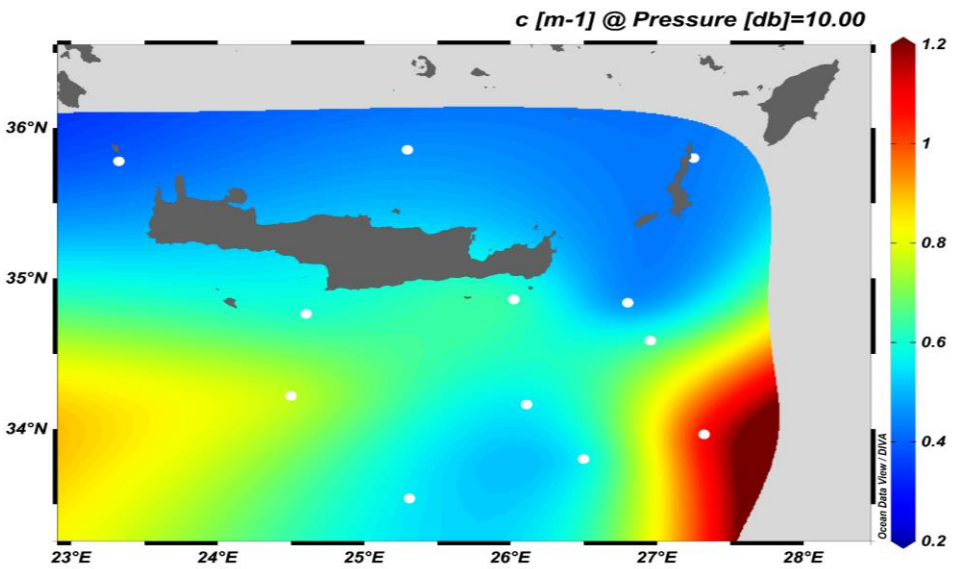


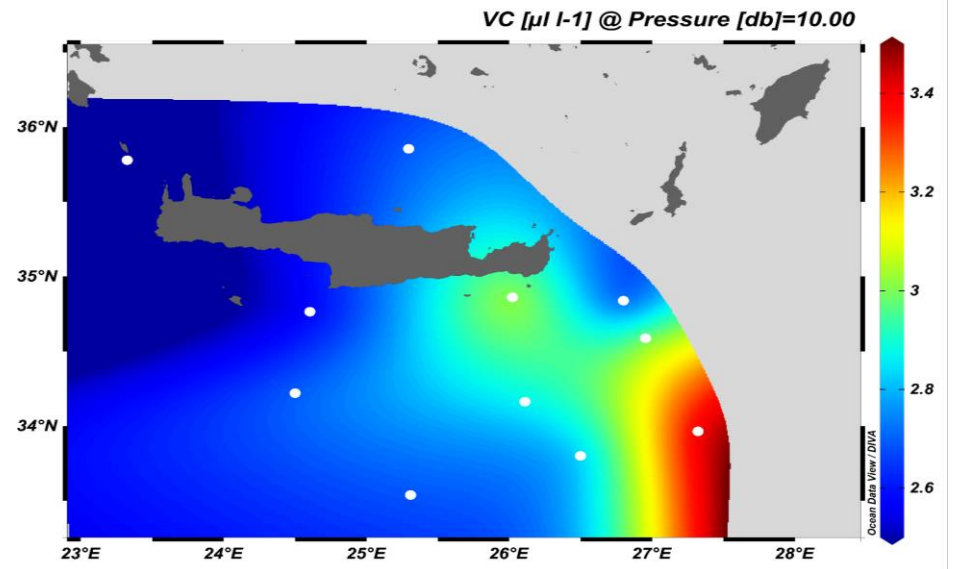


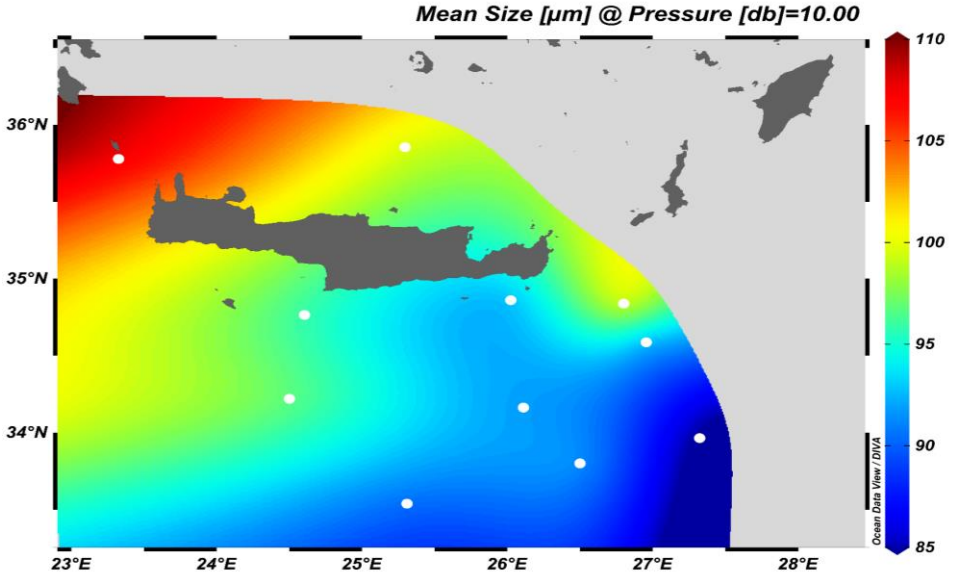
Recent Crete OC-SVC Marine Optics Results – in situ CDOM absorption

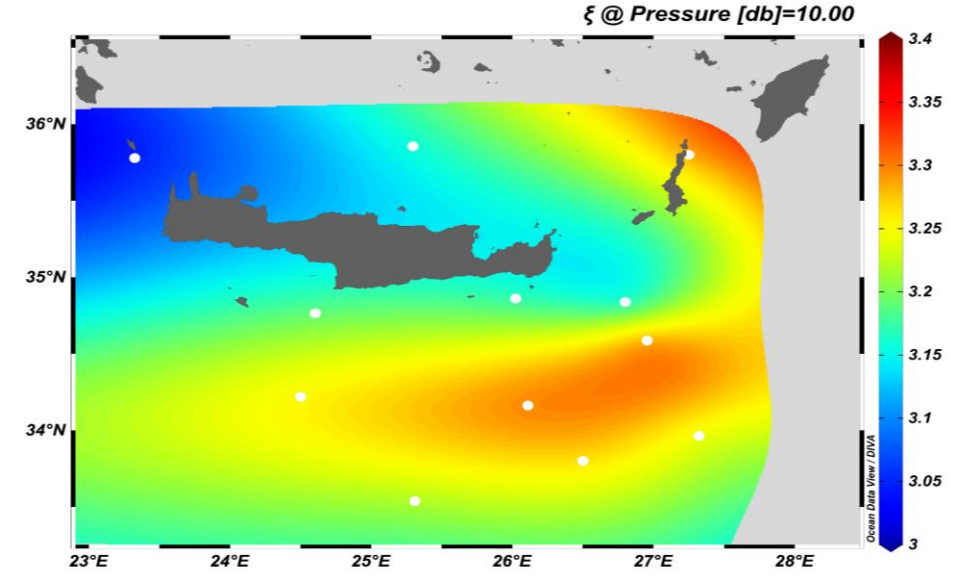


Recent Crete OC-SVC Marine Optics
Results IOPs – c, particle VC, mean size, PSD slope



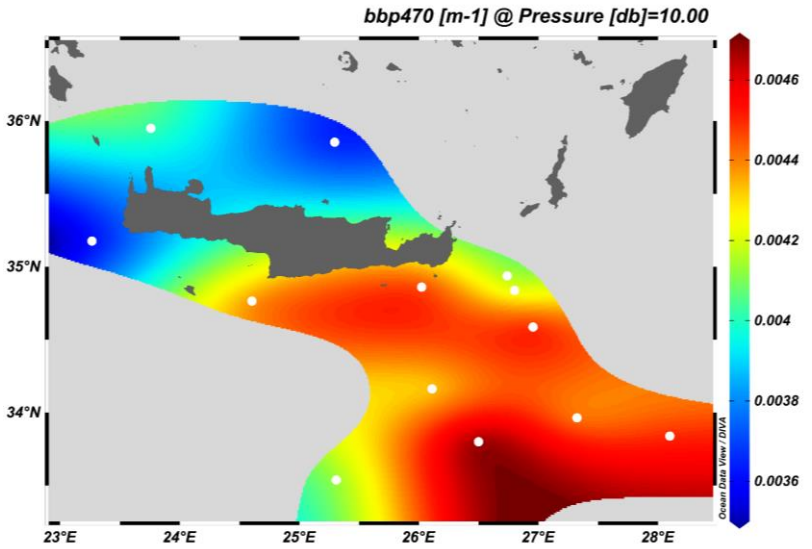


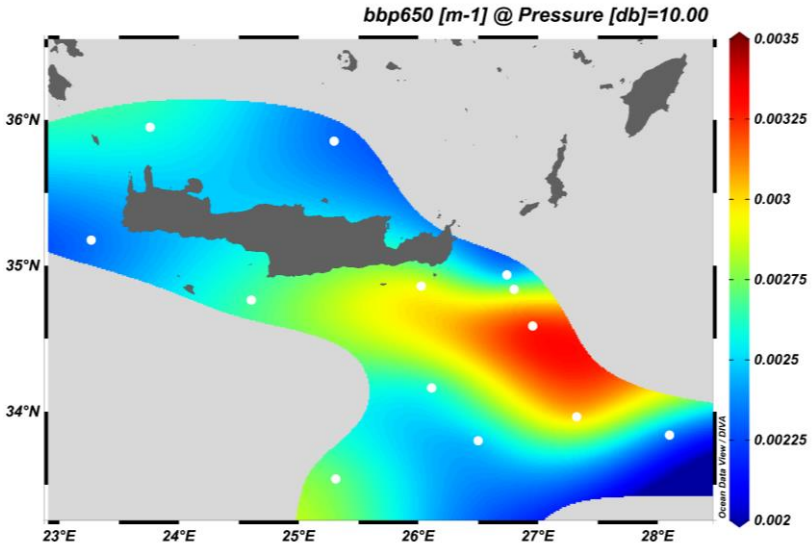


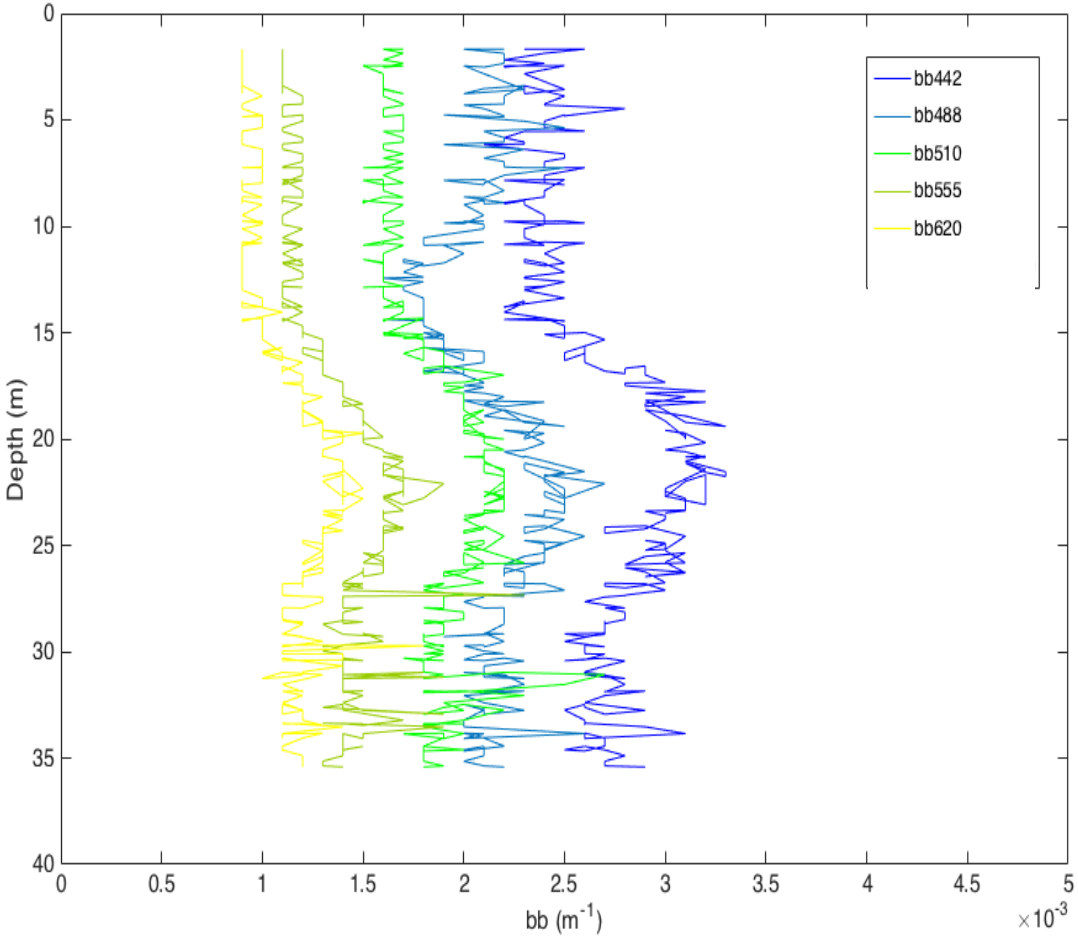


Recent Crete OC-SVC Marine Optics
Results IOPs – in situ bbp

PERLE 2 – particulate backscatter (b_{bp})



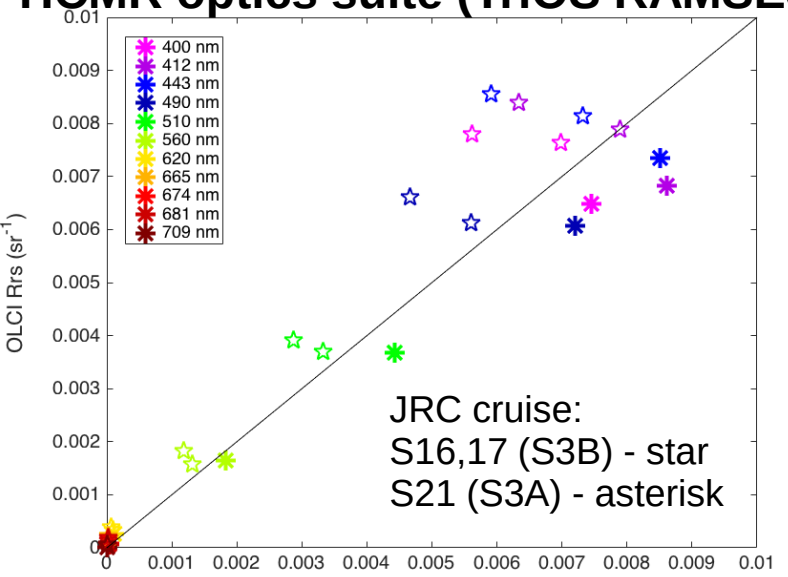


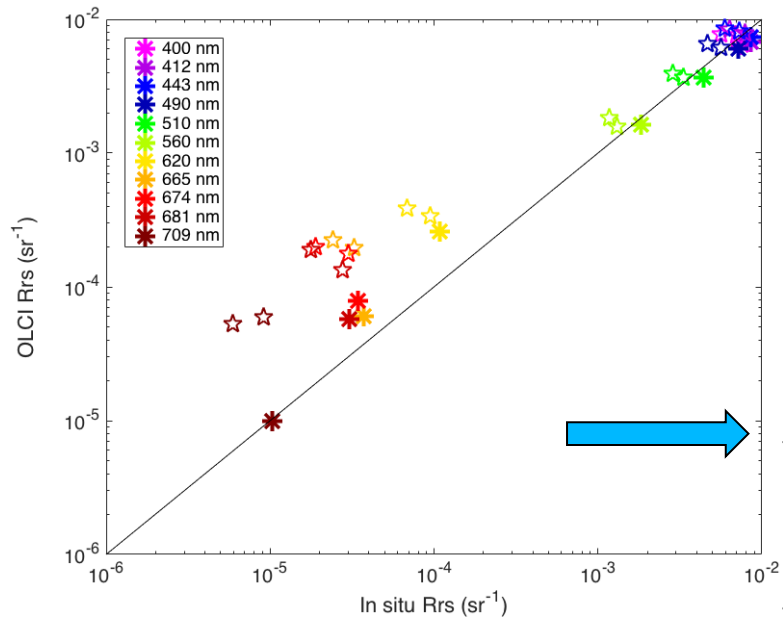


JRC optics S17–Hydroscat 6 total backscatter (b_b)

Recent Crete OC-SVC Marine Optics Results – Sentinel 3 OLCI Rrs validation

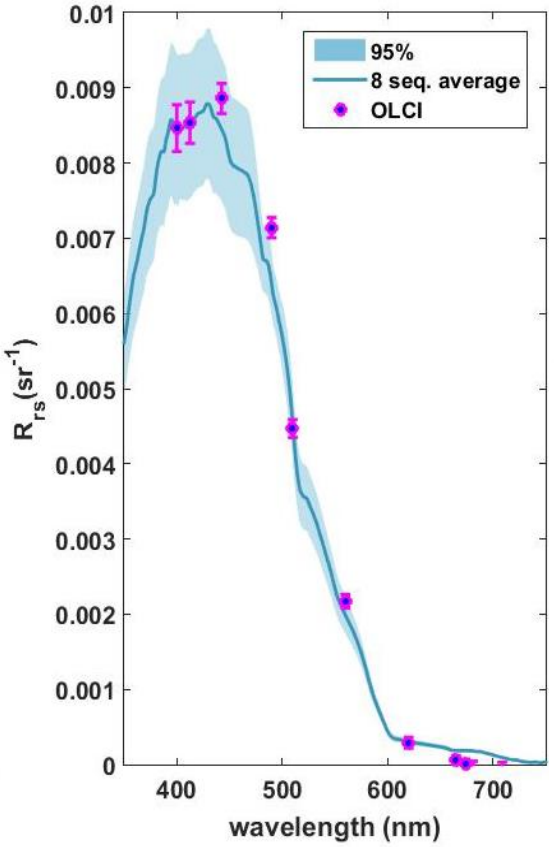
HCMR optics suite (TriOS RAMSES)



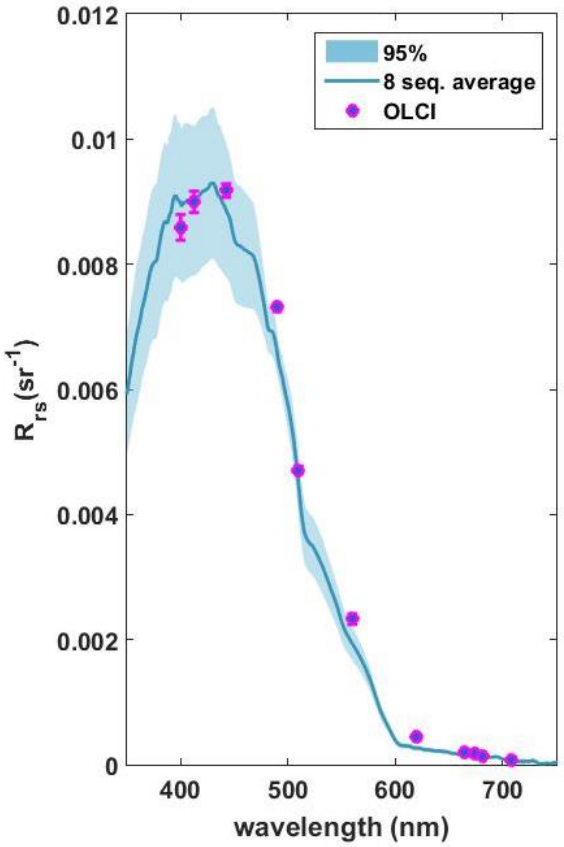


UNIWA JAZ above-water

JRC cruise: S08 (S3A)



JRC cruise: S09 (S3A)



Regression statistics

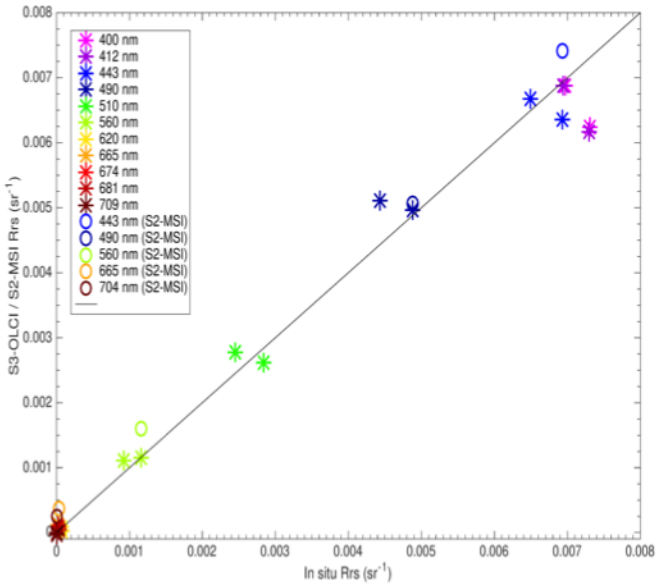
N obs.	R	R^2	RMSE	Slope	Intercept
33	0.960	0.921	0.00096	0.993	0.0003

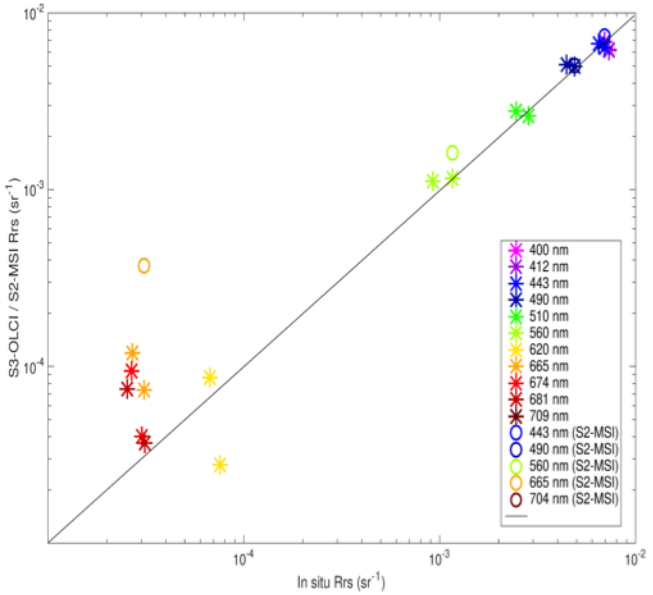
Uncertainty of in situ measurements: ~4-6% (400-700 nm)

Recent Crete OC-SVC Marine Optics Results – Sentinel 3 OLCI Rrs validation

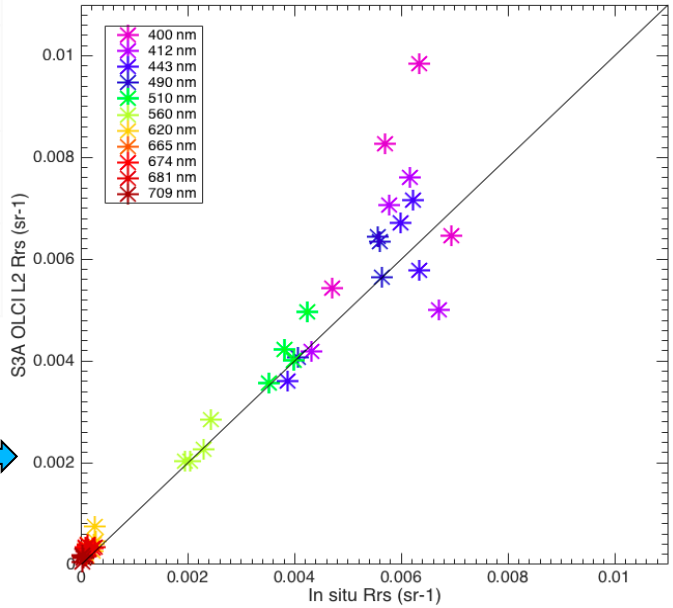
MARRE (S3A)

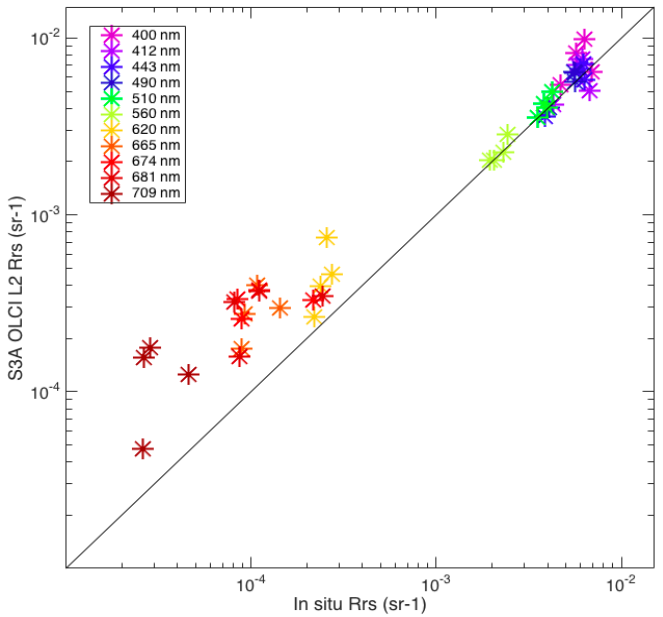
Regress stat.	PERLE2	MARRE
N obs.	44	27
R	0.966	0.992
R^2	0.933	0.984
Abs. RMSE (Ψ)	0.00084	0.00039
Unbias. RMSE (Δ)	0.00076	0.00038
Slope	1.106	0.949
Intercept	0.0001	0.0001





PERLE-2 (S3A)





Recent Crete OC-SVC Marine Optics Results – Sentinel 3 OLCI Rrs validation

JRC profiling radiometry (Satlantic OCR)

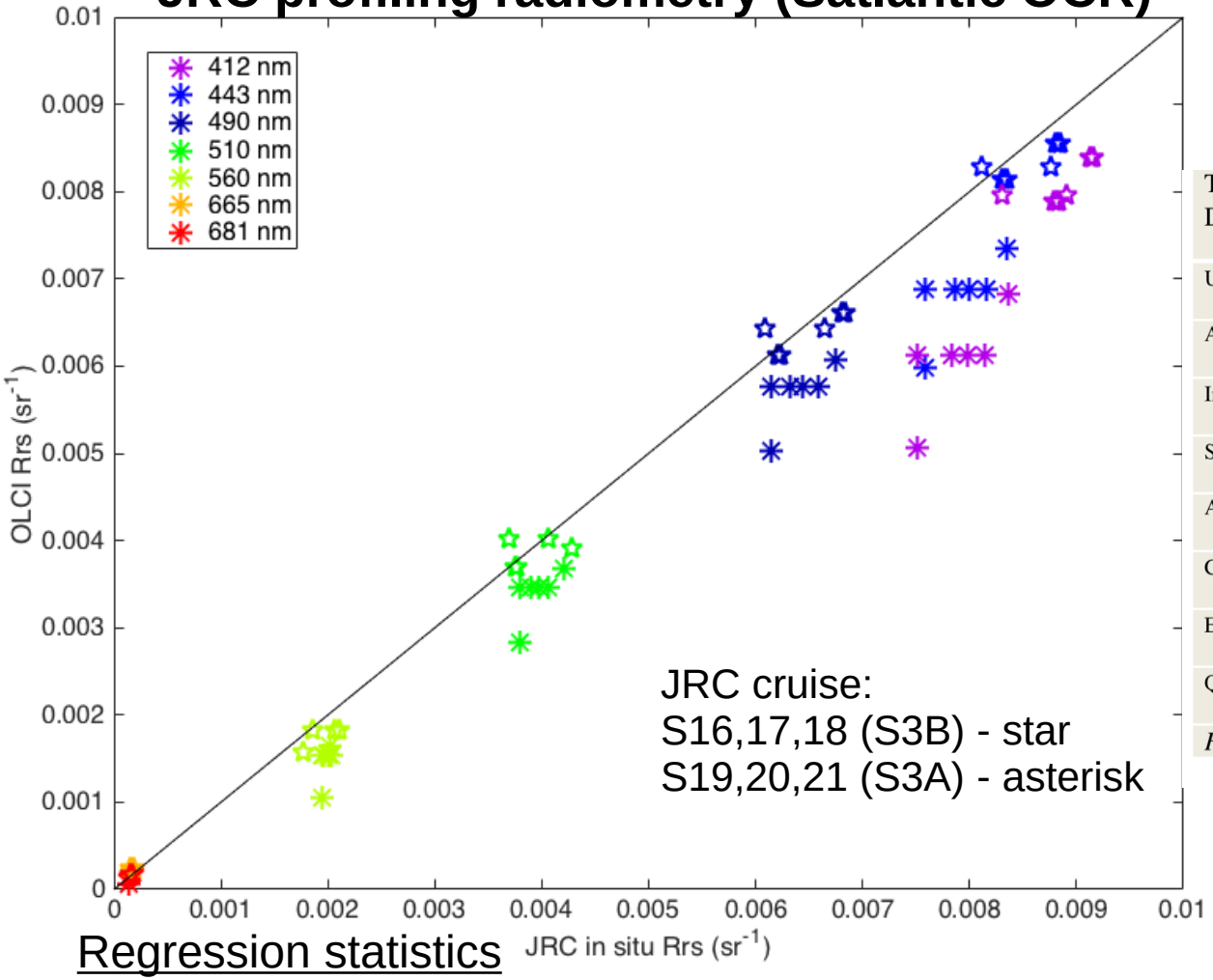


TABLE 1 Uncertainty Budget (in Percent) for L_{WN} Determined from In-Water Profile Data

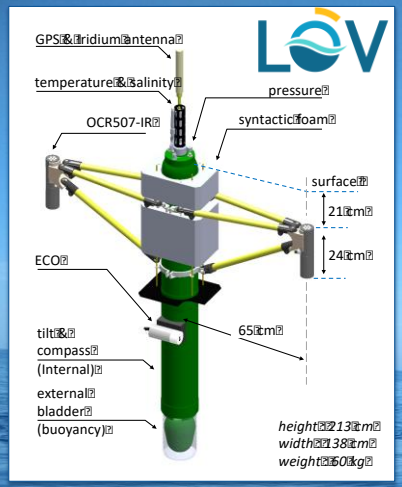
Uncertainty Source	443	555	665
Absolute calibration of L_u	2.7	2.7	2.7
Immersion factor	0.4	0.4	0.4
Self-shading correction	0.5	0.3	1.3
Absolute calibration of above-water E_d	2.3	2.3	2.3
Cosine response correction	1.0	1.0	1.0
Environmental effects	2.1	2.2	3.2
Quadrature sum	4.3	4.3	5.1

From Zibordi and Voss, 2014

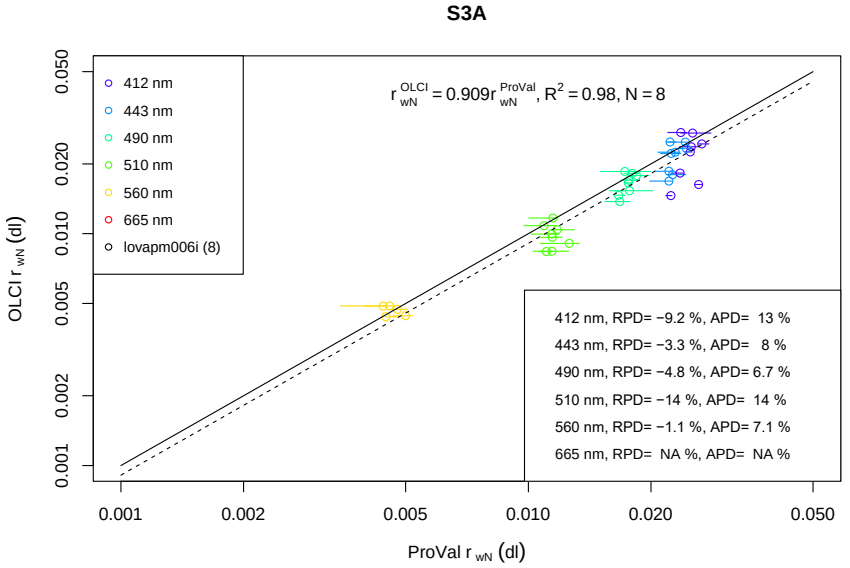
Regression statistics

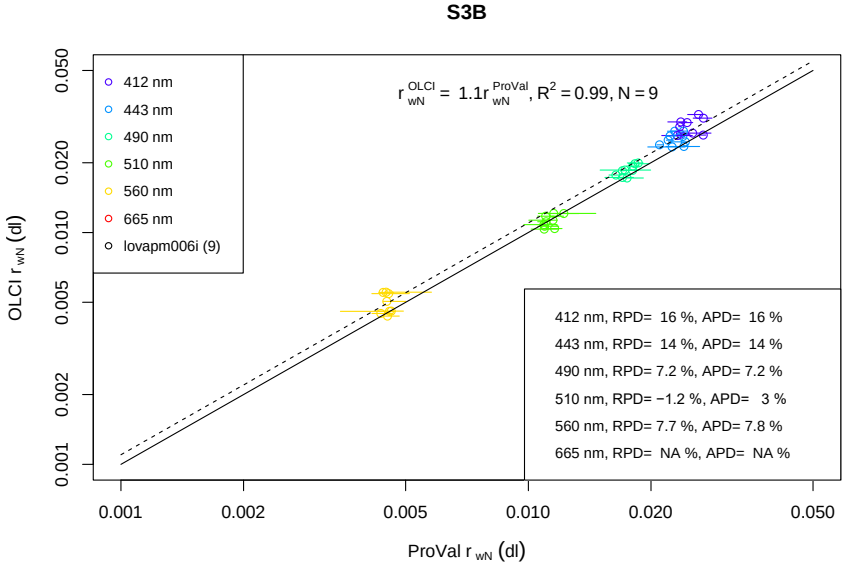
Sensor	No. obs.	R	R^2	RMSE	Slope	Intercept
S3A OLCI	56	0.989	0.979	0.00041	0.857	-0.0003
S3B OLCI	63	0.997	0.994	0.00025	0.950	0.00004

RECENT CRETE OC-SVC MARINE OPTICS
OC-SVC support – ProVal measurement campaign

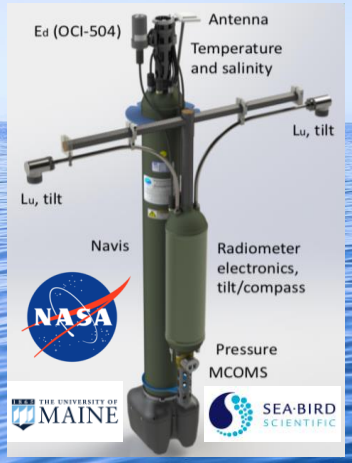


Deployed 35° 43.755' N, 25° 08.138' E
26/09/2019 1300 m depth for 19 days





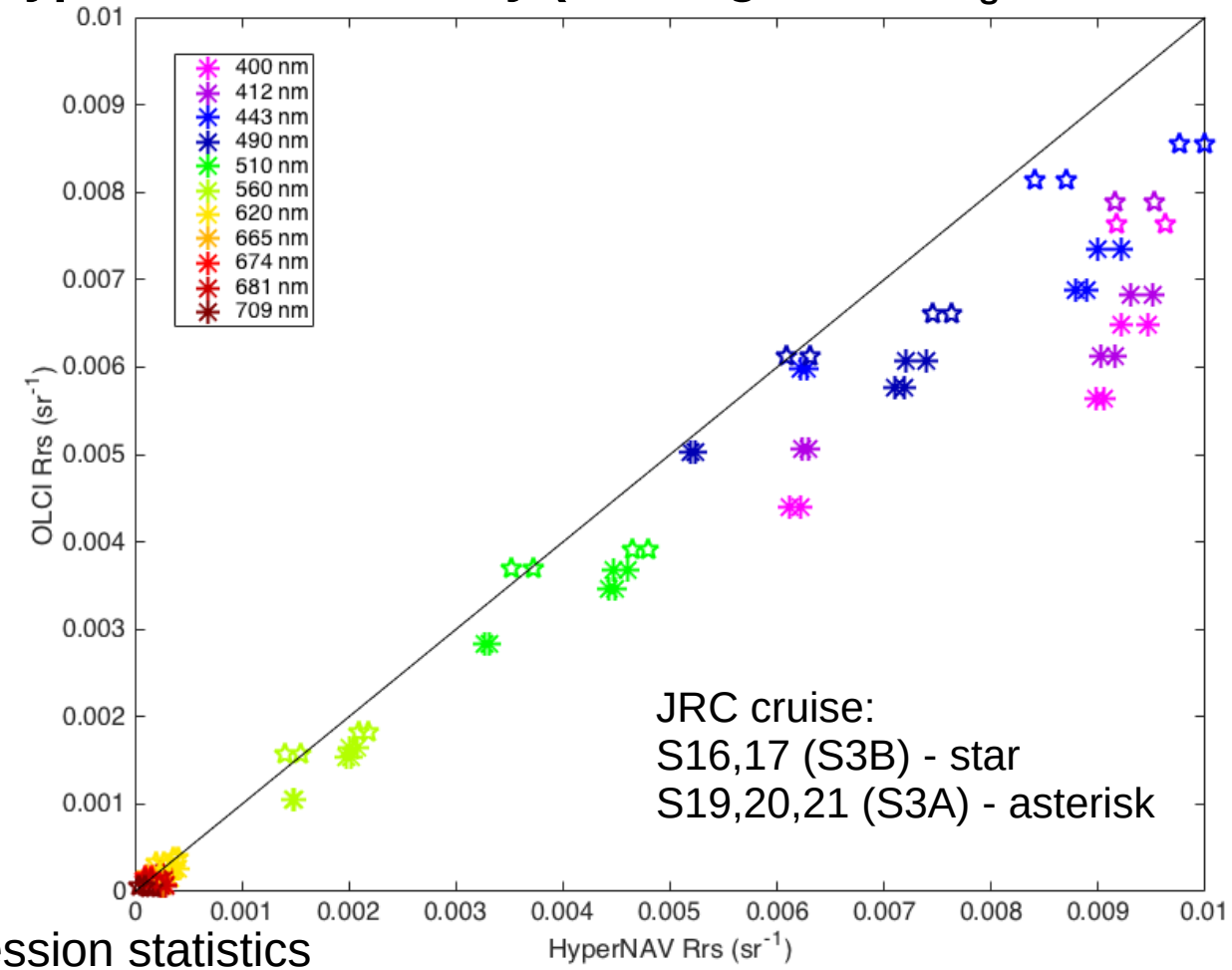
RECENT CRETE OC-SVC MARINE OPTICS
OC-SVC support – HyperNAV measurement campaign



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 SimulO 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	

RECENT CRETE OC-SVC MARINE OPTICS
OC-SVC support – HyperNAV measurement campaign

HyperNAV radiometry (floating mode, E_s from HCMR)



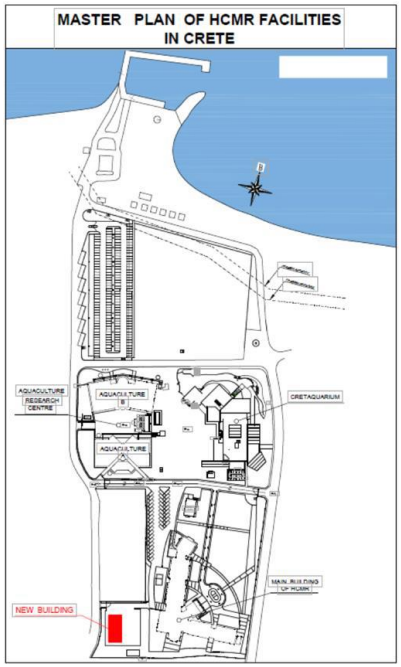
Regression statistics

Sensor	No. obs.	R	R^2	RMSE	Slope	Intercept
S3A OLCI	66	0.985	0.971	0.00049	0.784	-0.0002
S3B OLCI	44	0.992	0.984	0.00045	0.822	0.00015

Recent Crete OC-SVC Marine Optics
Conclusions and ongoing optics development in Crete

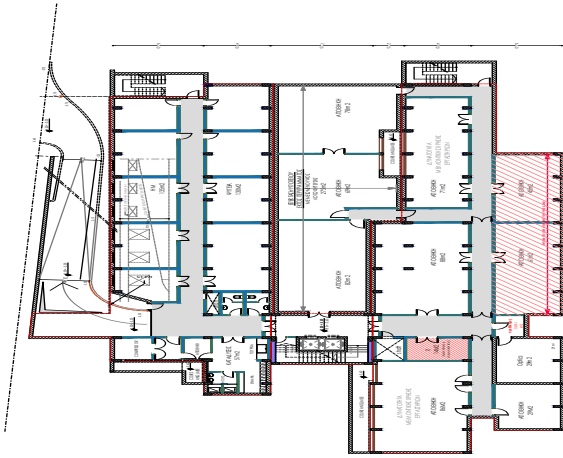
Marine Optics

- Low values of in situ measured inherent optical properties.
- Associated low values of optically important water column constituents (Chl-a, CDOM, suspended particles).
- Stable oligotrophic environment eminently suitable for radiometric measurements for satellite validation and as an OC-SVC site.



Ongoing developments in Crete

- Working towards full FRM status for radiometry.
- Further marine optics research inc. regional Chl-a algorithm development (NABUCCO, Hydrolight modelling)
- S3VT Sentinel-3 Collection 3 and 4 Rrs, Chl-a & IOP validation
- HYPERNAV continuing.
- New large marine engineering building at HCMR-Crete with area for handling OC-SVC buoy components – 1.2 M Euro.
- 5 M Euro new HCMR-Crete research labs extension to existing 3000m^2 with custom optics calibration lab + field station South of Crete in support of Copernicus OC-SVC.



Contact: andyb@hcmr.gr