# MEASURING AND MODELLING THE OPTICAL PROPERTIES IN THE CRETAN SEA

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MARRE

Marine and Inland Waters Research Symposium
2022

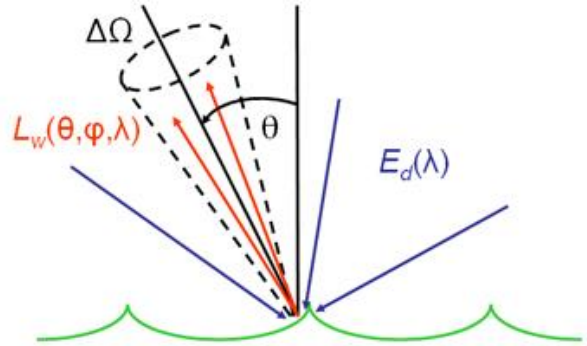
# Introduction

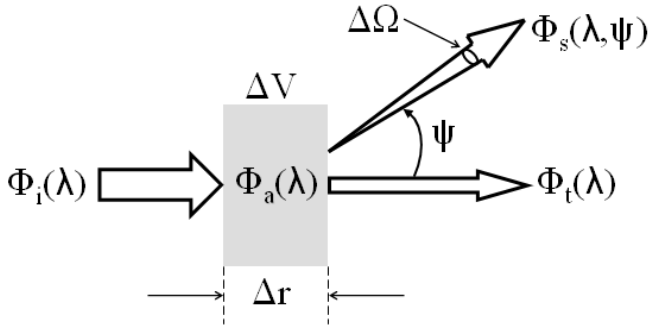
Report on configuration and development of algorithms in selected areas. Combination optical properties of water masses and in-situ measurements for its supply Hydrolight model. Estimation of remote sensing Reflectance: $R_{rs}(\lambda) = L_w(\lambda)/\mathrm{E}_d(\lambda)$, where Lw: Water Leaving Radiance and Ed: final incoming above water solar irradiance.

In Situ data

Satellite data

Hydrolight Model

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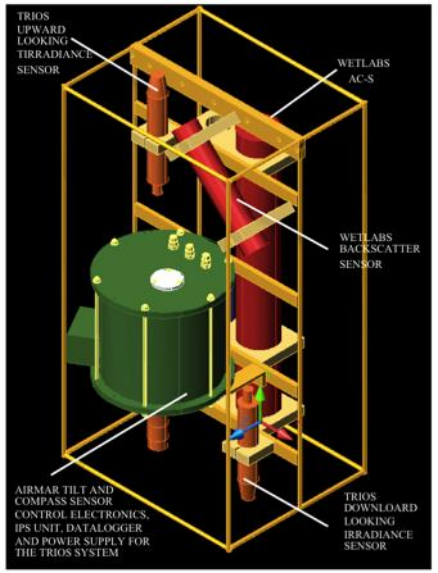
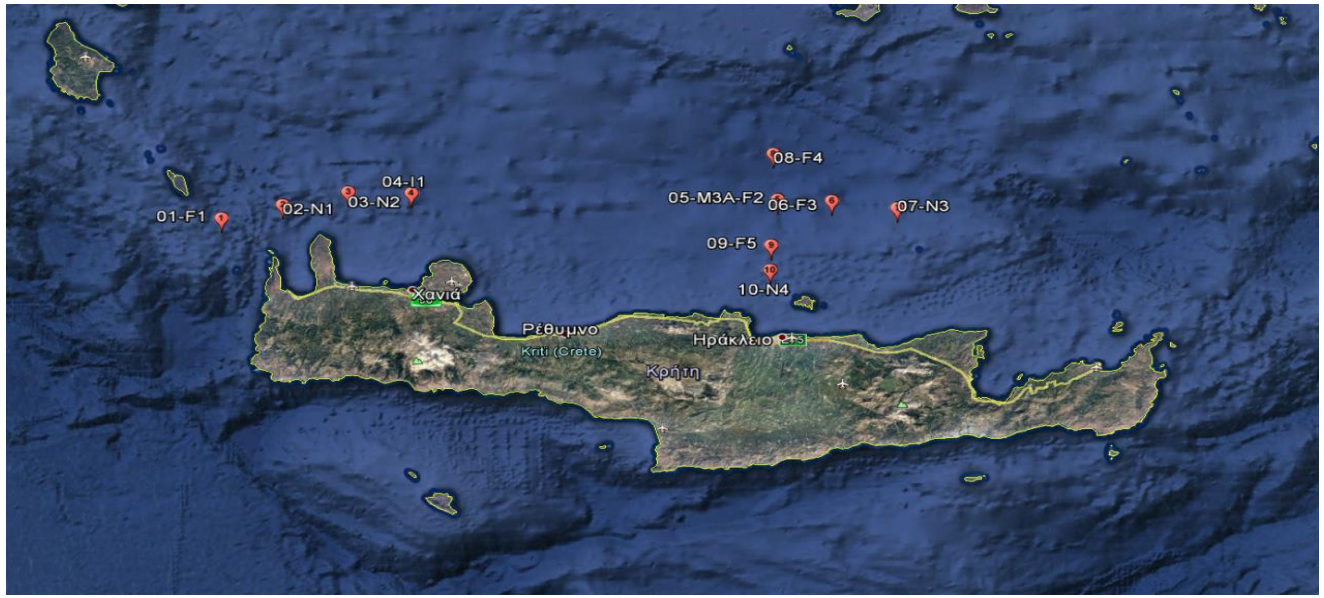
# MARRE cruises optics stations

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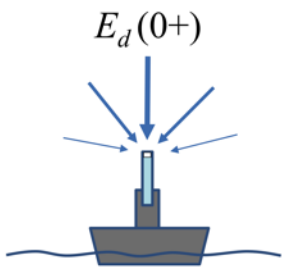
# Measurement protocols / Apparent Optical Properties

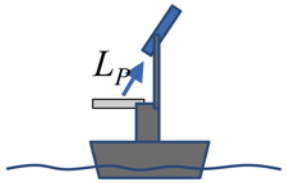
Fiducial Reference Measurements of downwelling irradiance

**Irradiance sensor**



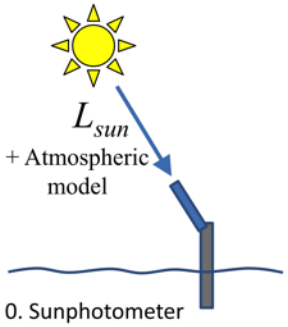

0. Radiometer
1. Tilt
2. Shading
3. Fouling
4. Unstable illumination

**Reflectance plaque**




0. Radiometer
1. Plaque calibration and BRDF
2. Plaque homogeneity
3. Tilt
4. Shading
5. Fouling
6. Unstable illumination

**Sunphotometry**

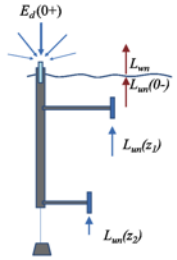



0. Sunphotometer
1. Atmospheric model+inputs
2. Sky conditions
3. Pointing
4. Shading
5. Fouling
6. Unstable illumination

Measurement uncertainty

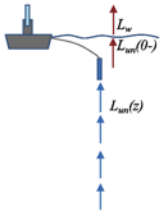
Fiducial Reference Measurements of water-leaving radiance

**Under water fixed depths**



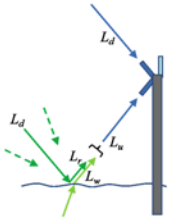

0. Radiometer
1. Vertical extrapolation
2. Tilt
3. Shading
4. Fouling
5. Depth
6. Transmittance
7. Unstable illumination

**Under water profiling**



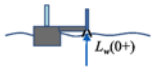

0. Radiometer
1. Vertical extrapolation
2. Tilt
3. Shading
4. Fouling
5. Depth
6. Transmittance
7. Unstable illumination

**Above water**




0. Radiometer
1. Reflected skylight
2. Tilt
3. Shading
4. Fouling
5. Unstable illumination
6. BRDF
7. Atmospheric path

**Skylight blocked**




0. Radiometer
1. Shading
2. Tilt
3. Fouling
4. Unstable illumination

Measurement uncertainty

*From Ruddick et al., 2019a & 2019b, Remote Sensing*

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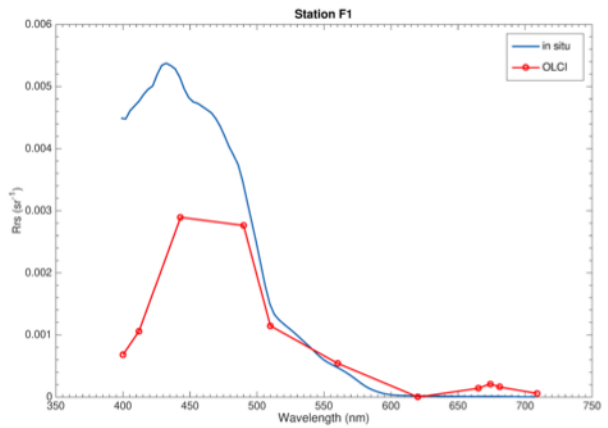
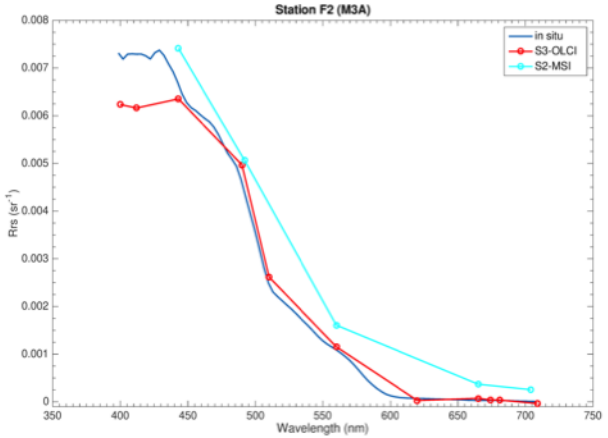
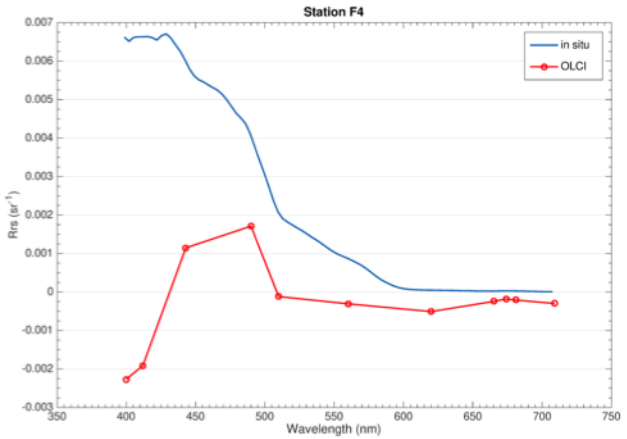
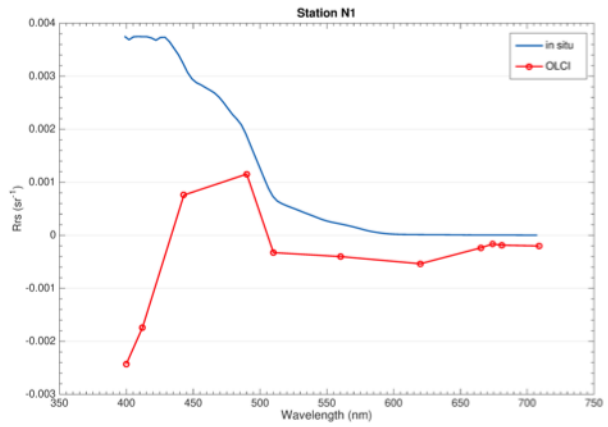
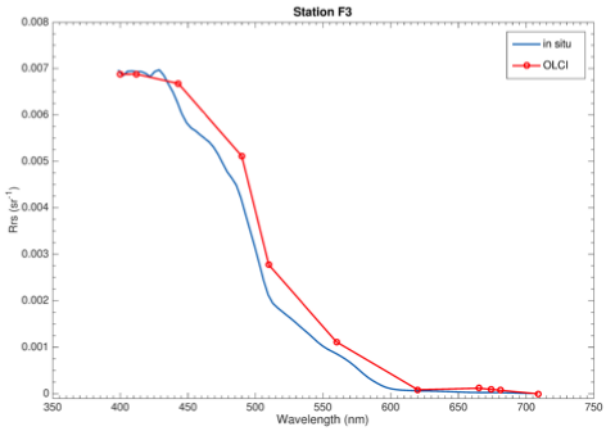
# Initial MARRE comparisons

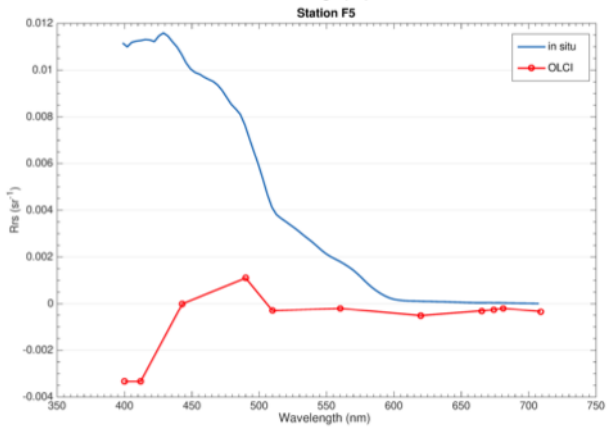


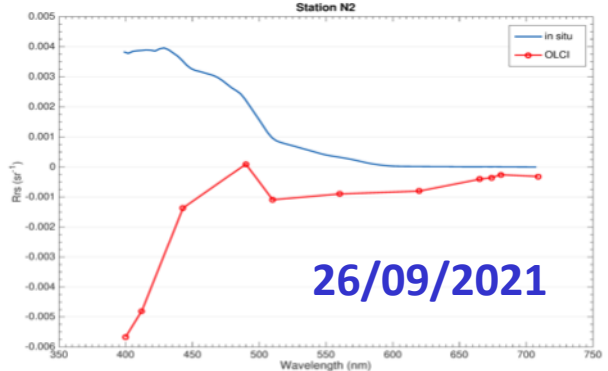




**27/09/2021**

**28/09/2021**

**26/09/2021**

- Inspection of the S3-OLCI L2 flags revealed suspect or erroneous data due to a **high aerosol load** in the atmosphere (dust from S winds), particularly affecting blue-green wavelengths and on 26/09 & 28/09.
- The 2 stations from 27/09 provided the best data.

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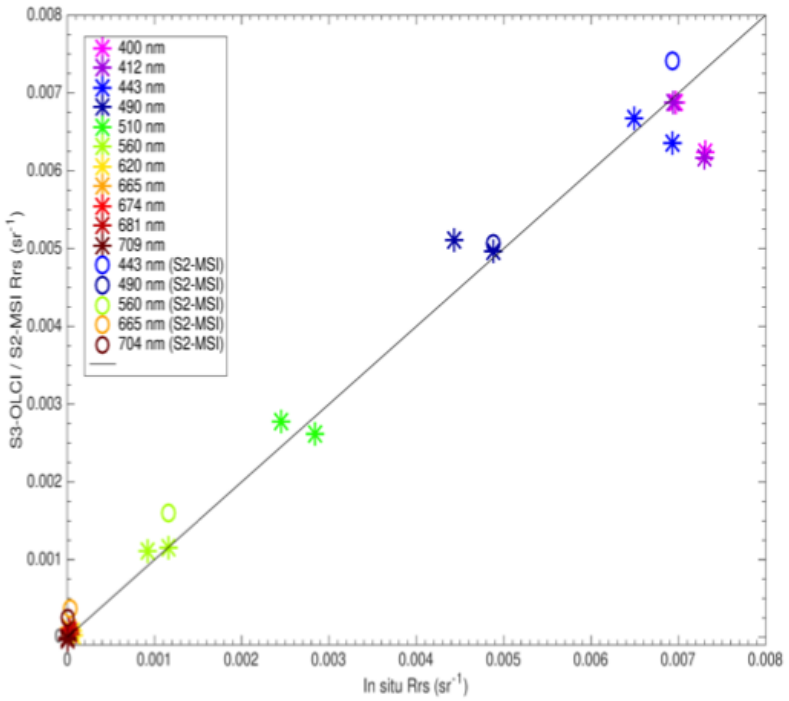
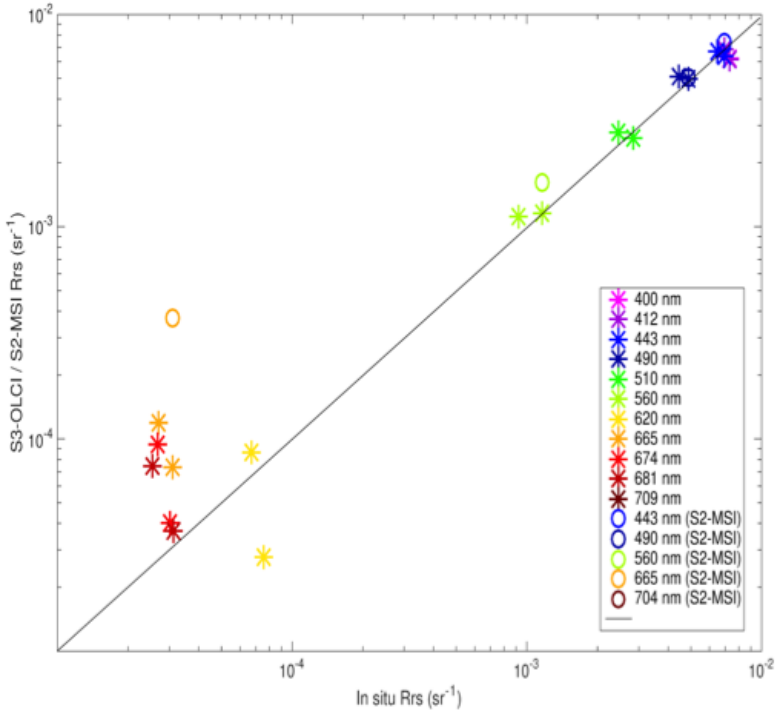
# Validation results

| Regressst at. | MARRE cruise |
|---|---|
| N obs. | 27 |
| R | 0.992 |
| $R^2$ | 0.984 |
| Abs. RMSE (Ψ) | 0.00039 |
| Unbias. RMSE (Δ) | 0.00038 |
| Slope | 0.949 |
| Intercept | 0.0001 |

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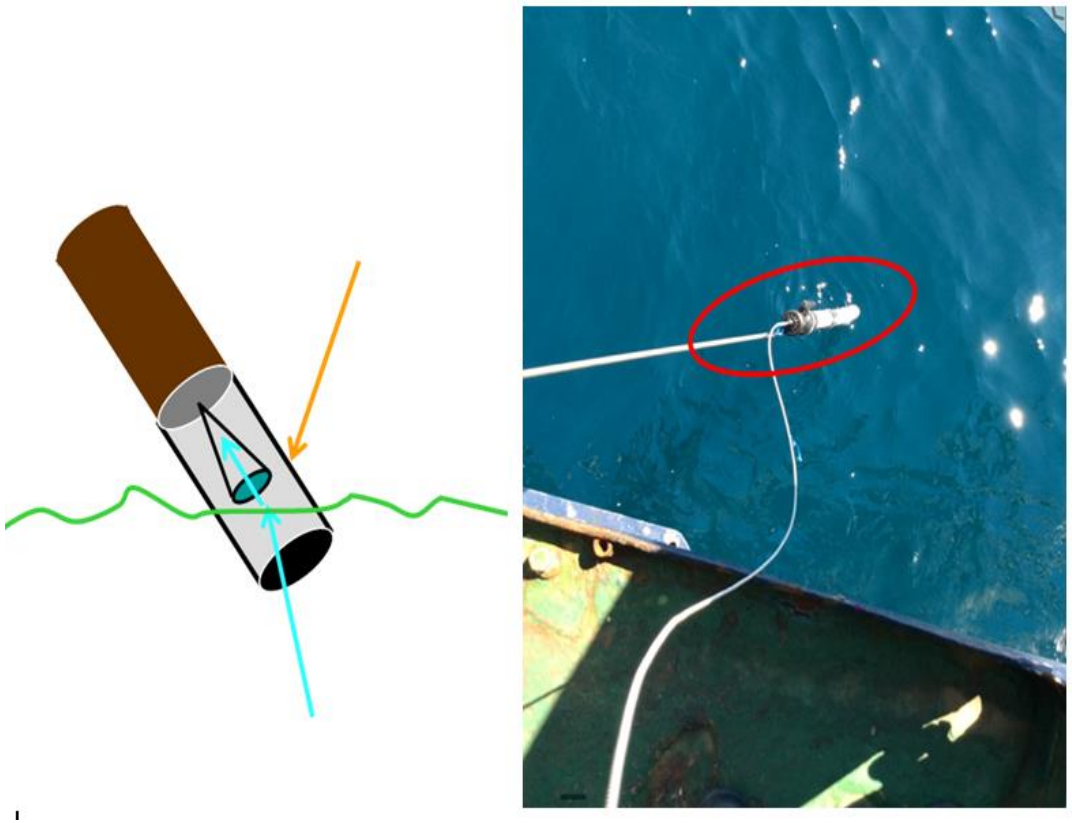
# Above water radiometry comparison



Configuration of a handheld portable spectroradiometer system (JAZ Ocean Optics) on the R/V Aegaeo during MARRE. The tube is attached to the spectrometer via an optical fiber.

**Method**

- The instrument was attached to a 3º FOV Gershun tube via a flexible optical fiber.
- Radiance reference was provided by a calibrated 10% reflectance Spectralon© plate.
- For the water leaving radiance $L_w$, a scheme avoiding sky reflection was followed, known as Skylight Blocked Approach (SBA, Lee et al.,Applied Optics, 2013).
- An average of ten spectra was collected with the complete measuring sequence (lasting less than a minute) repeated at least four times.

The remote sensing reflectance was estimated according to the following equation:

$$R_{rs} = \frac{L_u(0+)}{E_d(0+)} = \frac{0.1L_u(0+)}{\pi L_d(0+)}$$

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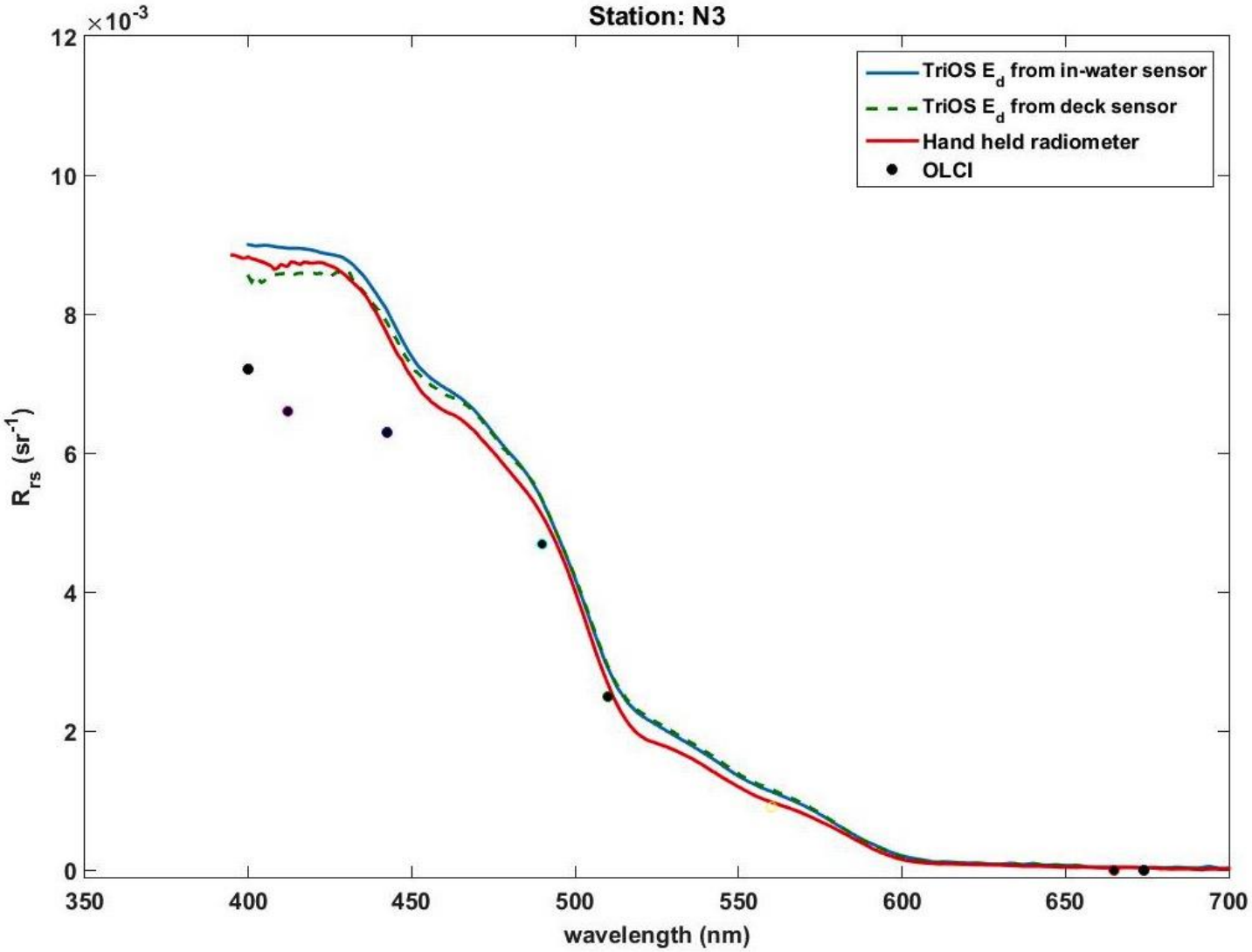
# Above water radiometry comparison

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# IOPs methodology

WetLabs C- Star Transmissometer:

$$c = -\frac{1}{L}\ln(LT)$$

ECOBB3B

- 3 wavelengths
  - 470 nm
  - 532 nm
  - 650 nm

- Estimated particles backscattering coefficient (bbp) following the calculations described by Sullivan et al. , 2013;
- Absorption correction was calculated as a function of Chl –a

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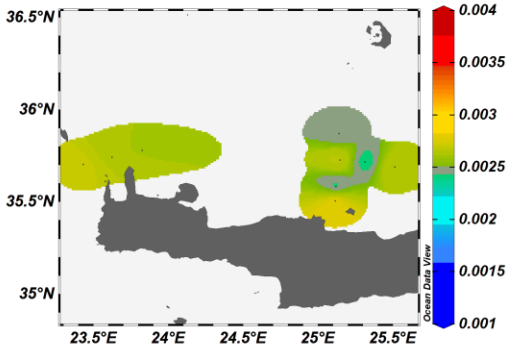
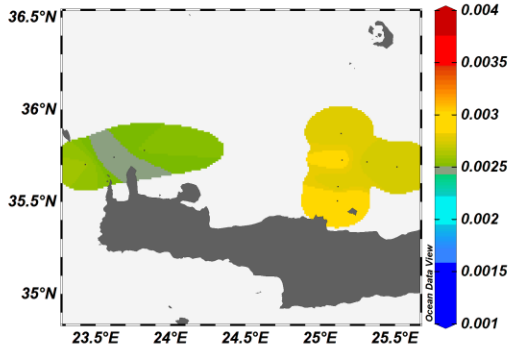
# IOPs Results

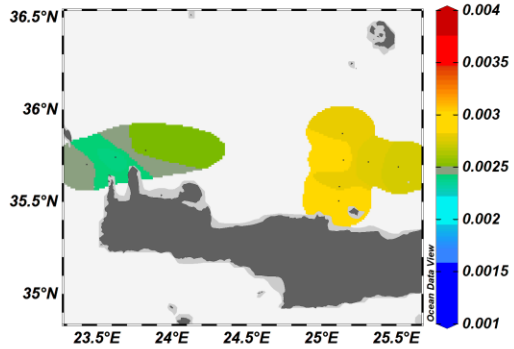
bbp470 [m-1] @ Pressure [db]=2.00



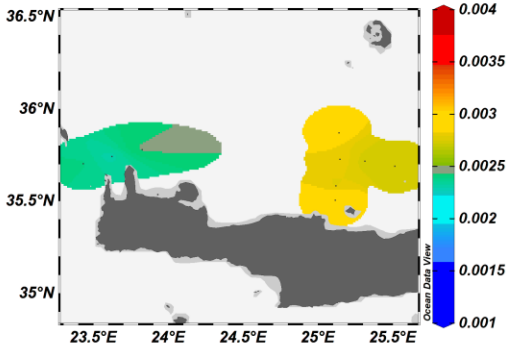

bbp470 [m-1] @ Pressure [db]=20.00



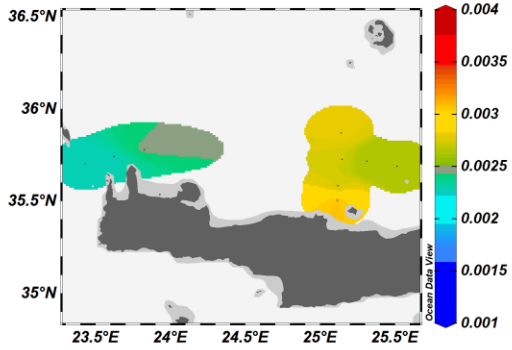

bbp470 [m-1] @ Pressure [db]=50.00



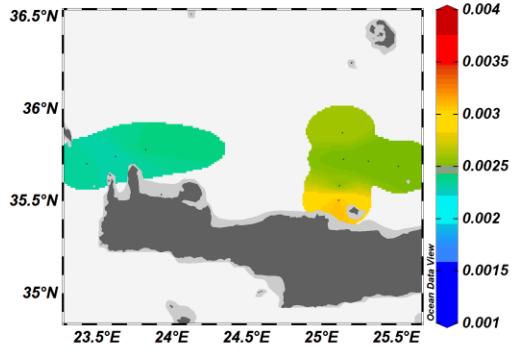

bbp470 [m-1] @ Pressure [db]=75.00

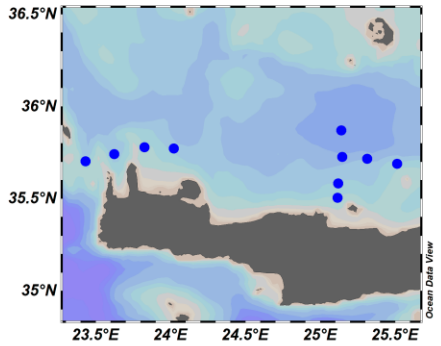



bbp470 [m-1] @ Pressure [db]=100.00

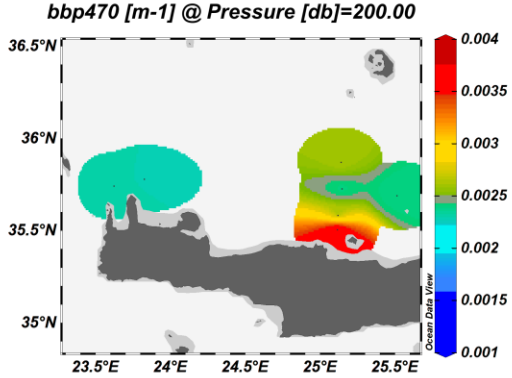



bbp470 [m-1] @ Pressure [db]=150.00

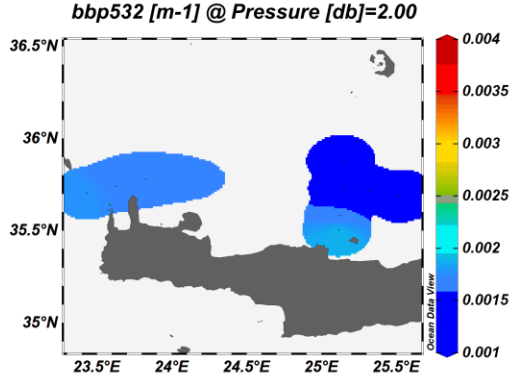



bbp470 [m-1] @ Pressure [db]=200.00




bbp532 [m-1] @ Pressure [db]=2.00

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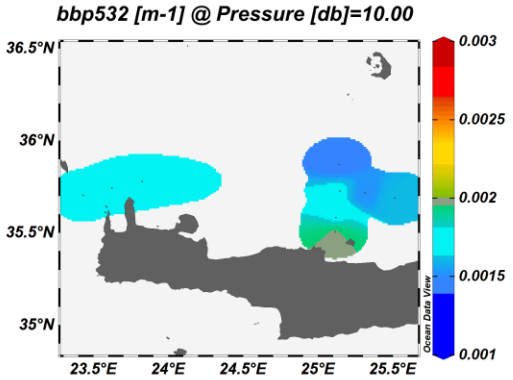
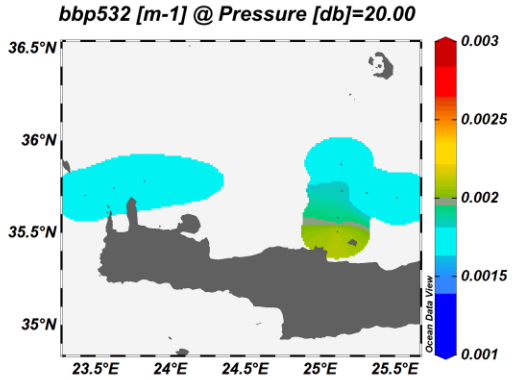
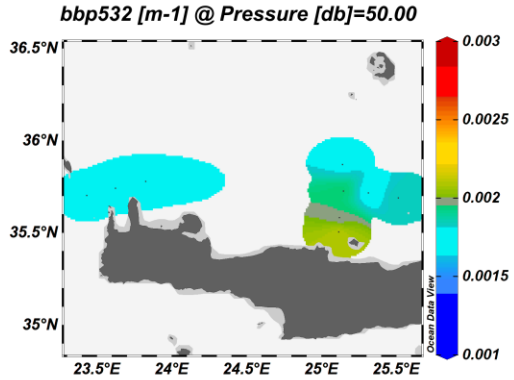
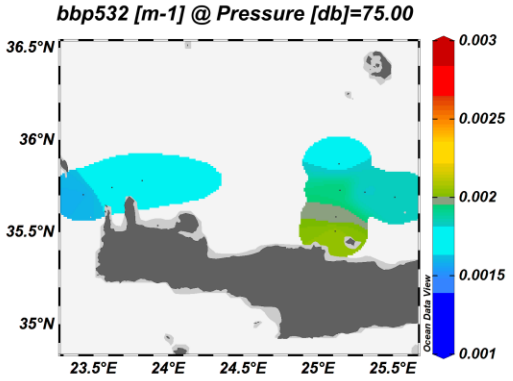
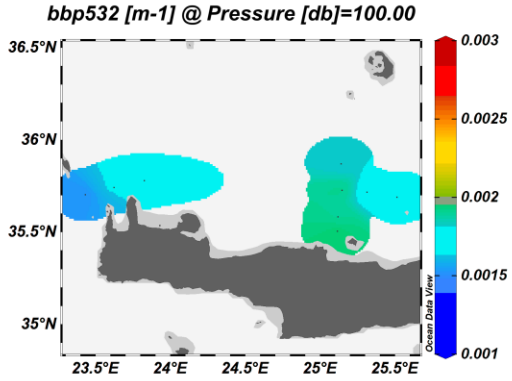
# IOPs Results

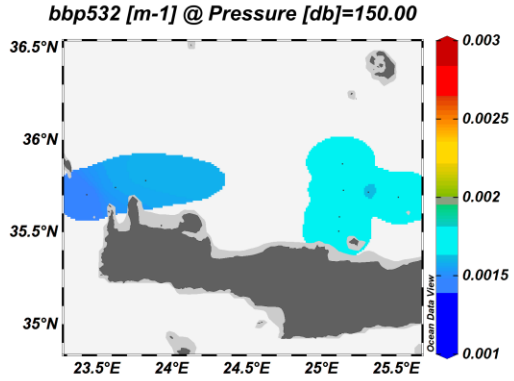


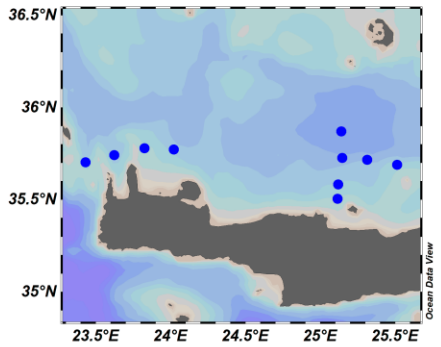



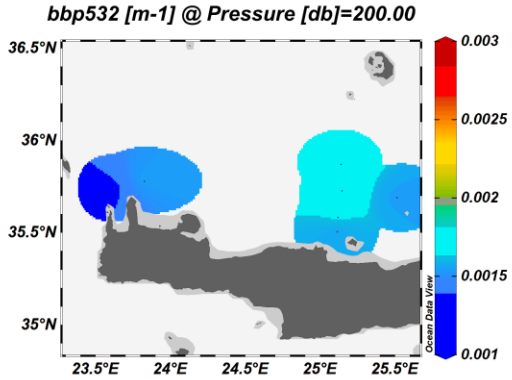



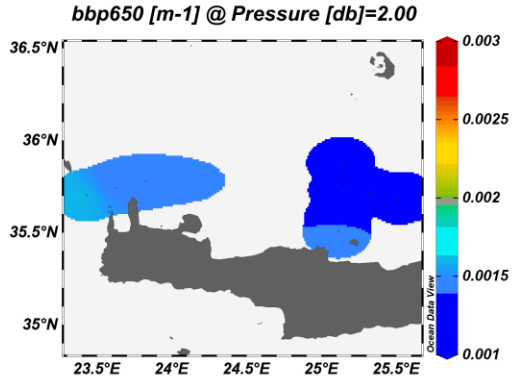

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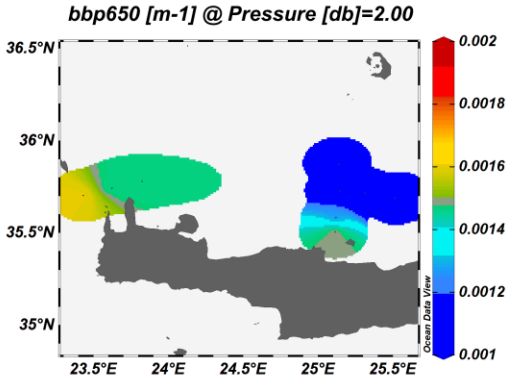


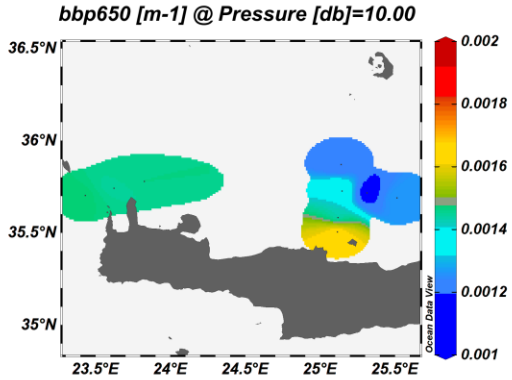


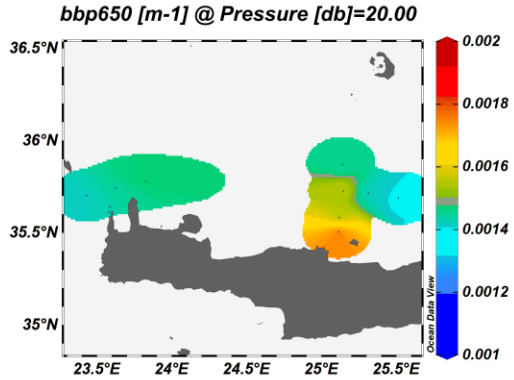


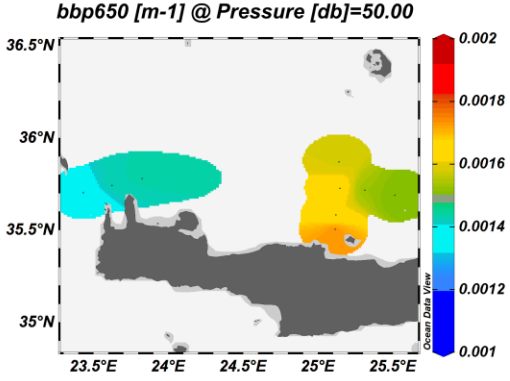


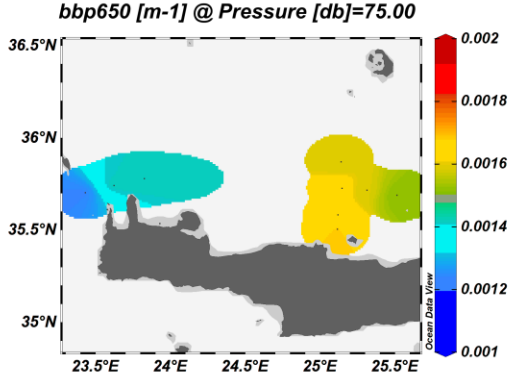


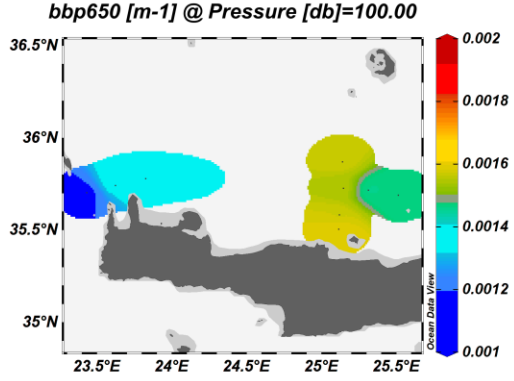


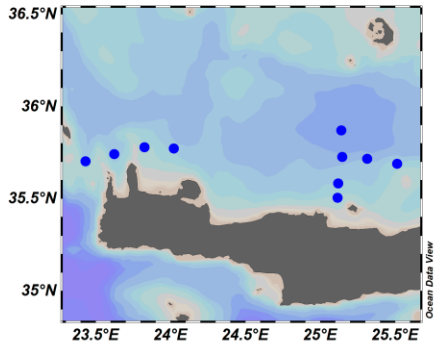


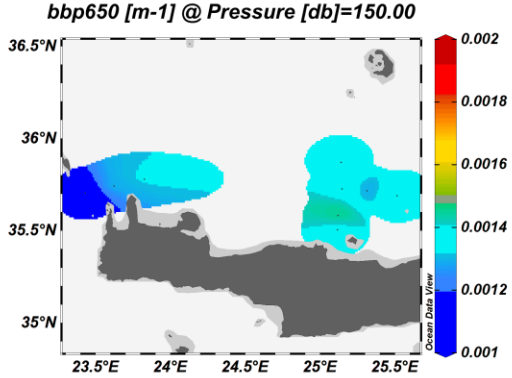


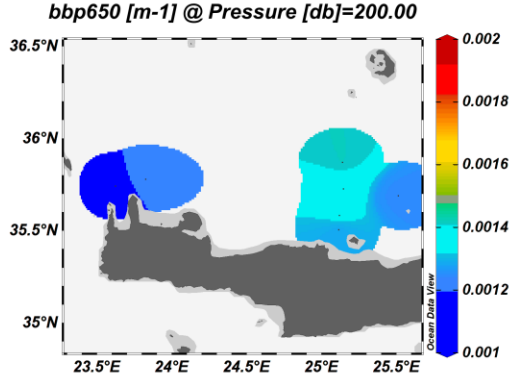


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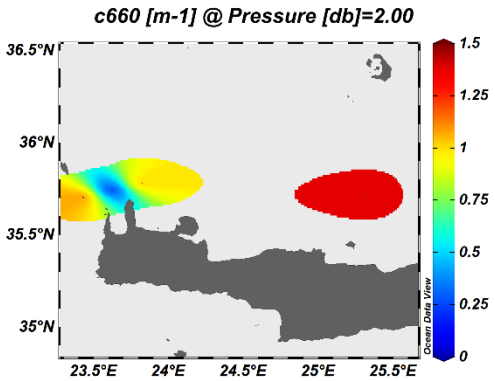


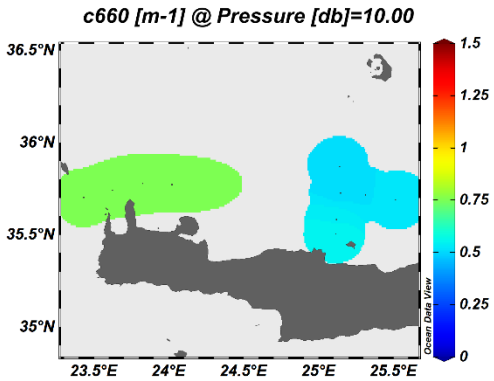


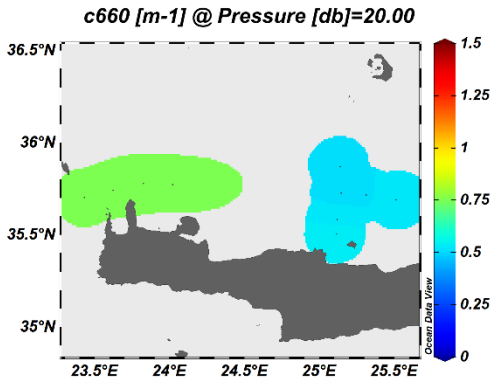


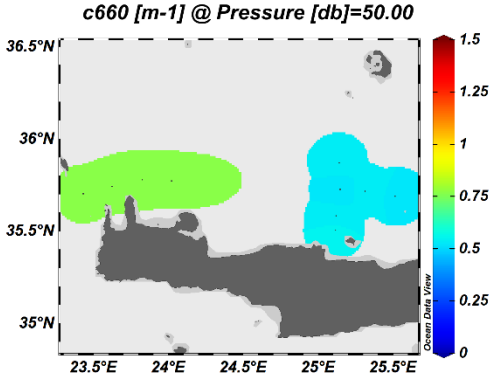


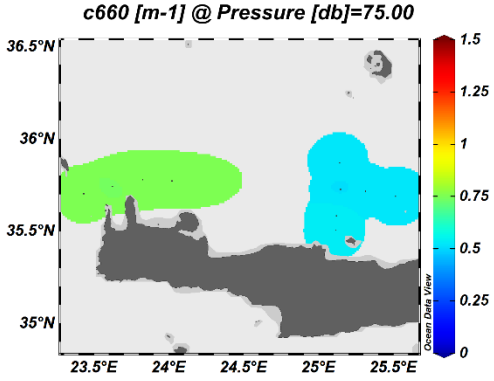


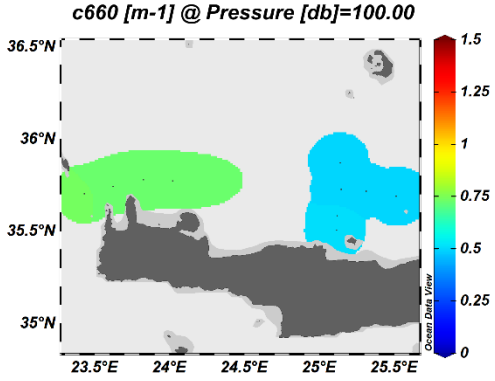


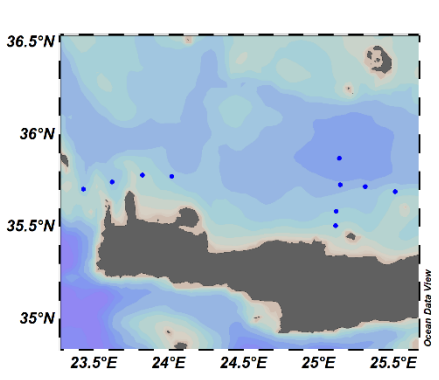


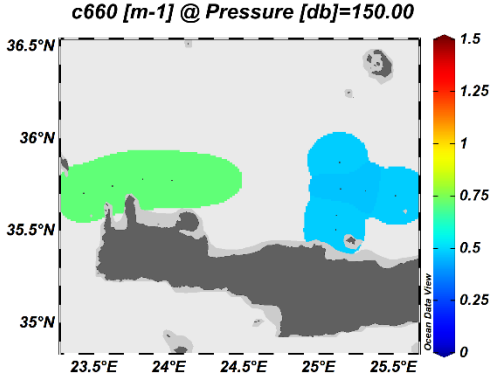


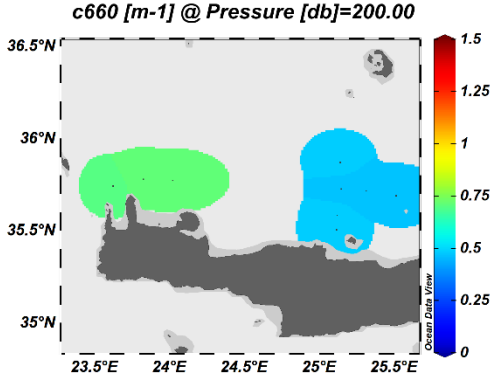


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# S3-OLCI & S2-MSI Validation in the E. Mediterranean
# Hydrolight simulation comparison - method

## INPUT

- Chlorophyll input by bottles in discrete depths
- Temperature and Salinity in situ data
- Wind speed and cloud / Sky conditions
- Julian day / Longitude and Latitude
- Selection output wavelength bands (corresponding to Sentinel-2, Sentinel-3)

## OUTPUT

- Remote sensing reflectance
- Upwelling underwater radiance
- Downwelling underwater irradiance
- Water leaving radiance
- Diffuse attenuation coefficient


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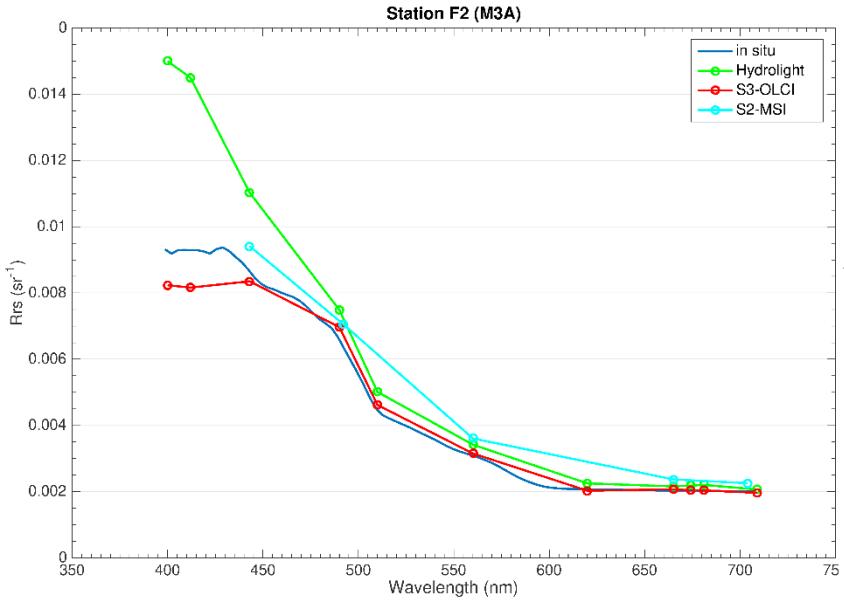
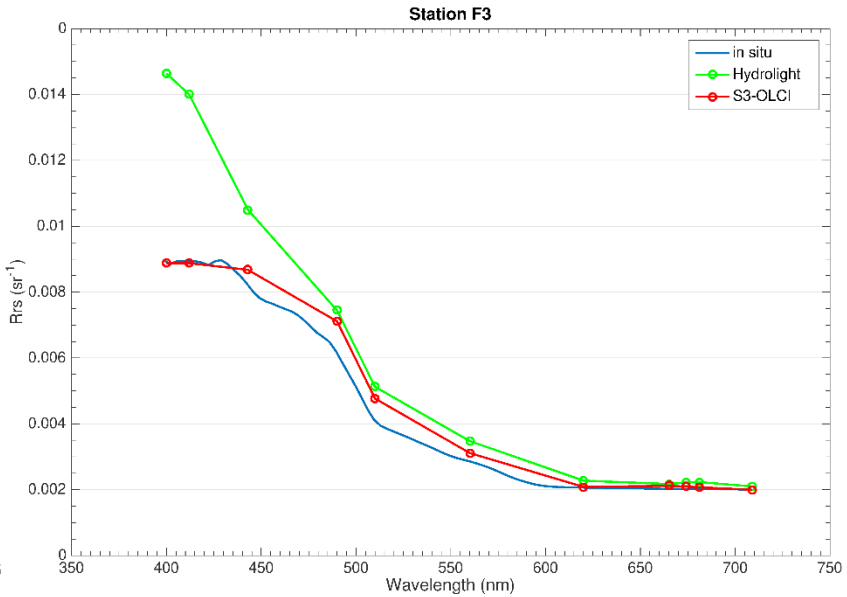
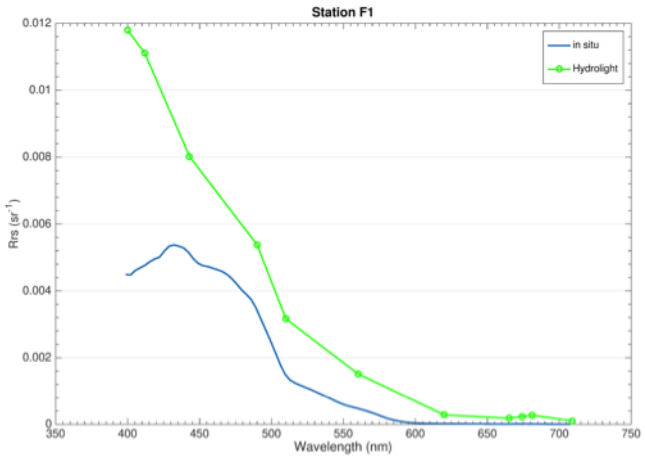
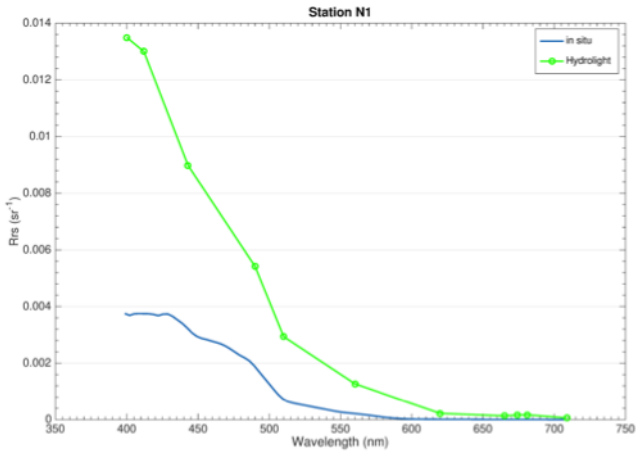
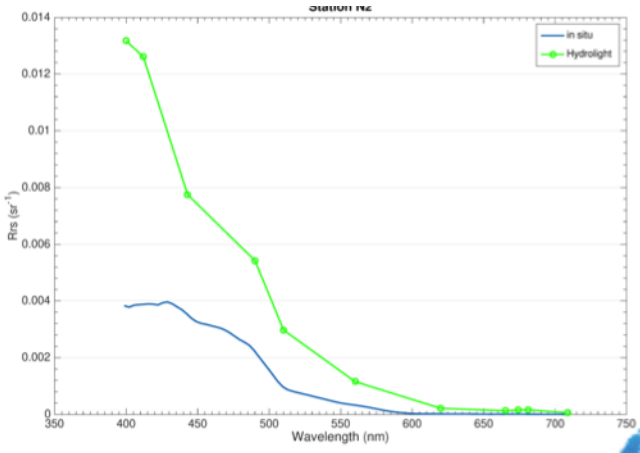
# Hydrolight simulation comparison - results

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# Conclusions

- **MARRE has helped** build up our validation database and **continue work towards OC FRM for the E.Med**.
- **MARRE has contributed to our understanding of the marine optics of the Eastern Mediterranean** through radiometry and IOP measurements and radiative transfer modelling (Hydrolight).
- This part of the **MARRE work is contributing to ensure accurate monitoring of the marine environment using satellite ocean colour** data which in turn supports the aims of the Marine Strategy Framework Directive and national monitoring programs to assess the environmental status of coastal waters and the wider marine environment.

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# Ongoing work

- Working towards full FRM - continuing measurement uncertainty evaluation.
- Regional Chl-a algorithm development (NABUCCO, Hydrolight modelling)
- S3VT Sentinel-3 Collection 3 and 4 Rrs, Chl-a & IOP validation
- Long-term (1997->present day) satellite chlorophyll-a validation and algorithm evaluation for the oligotrophic Eastern Mediterranean (*Banks, Psarra, Drakopoulos, et al. Remote Sensing of Environment, in preparation - still possibility of contribution and collaboration, contact andyb@hcmr.gr)*

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Thank you!