Mesures radiométriques hyperspectrales autonomes dans les estuaires et lagunes côtières pour la calibration/validation des produits satellitaires

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Groupe de travail hyperspectral en milieu aquatique
16 décembre 2022

Motivation

GODDARD SPACE FLIGHT CENTER | + Visit NASA.gov

AERONET
AEROSOL ROBOTIC NETWORK

AERONET
OCEAN COLOR

+ AEROSOL OPTICAL DEPTH | + AEROSOL INVERSIONS | + SOLAR FLUX | + OCEAN COLOR | + MARITIME AEROSOL

Web Site Feature | AERONET Data Synergy Tool - Access Earth Science data sets for AERONET sites

➔ The reference autonomous network for coastal waters but old (multi-spectral: visible) and expensive…

Version 3 Level 1.0 Normalized Water-leaving Radiance

Funded by the Horizon 2020
Framework Programme of the
European Union

H2020 project HYPERNETS (2018-2023)

A new hyperspectral radiometer integrated in automated networks of water and land bidirectional reflectance measurements for satellite validation

http://www.hypernets.eu

Consortium:

museum
Operational Directorate Natural Environment
OD Nature | OD Natuur | DO Nature

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HYPERNETS

HYPSTAR

A NOVEL HYPERSPECTRAL RADIOMETER SYSTEM

presented by Kim Duong (University of Tartu) @ Ocean Optics 2022

H2020/HYPERNETS
Kevin Ruddick, Joel Kuusk, Matthew Beck, Agnieszka Bialek, Vittorio Brando, Javier Concha, Alexandre Corizzi, Pieter de Vis, Ana Dogliotti, David Doxaran, Boubaker Elkilani, Ken Flight, Anabel Gammaru, Claudia Giardino, Luis Gonzales Vilas, Clémence Goyens, Francisco Grings, Sam Hunt, Kaspars Laizans, Edouard Leymarie, Niall Origo, Pablo Perna, Estefania Piegari, Lucas Rubinstein, Mehdi Saberioon, Morven Sinclair, Daniel Spengler, Quinten Vanhellemont

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HYPERNETS

HYPSTAR radiometer: Some technical specs

Radiometer model	Model SR (water sites)	Model XR (land sites)
Measured quantity	Radiance & irradiance (multiplexed)	Radiance & irradiance (multiplexed)
Field of view	2° (radiance), 180°(irradiance)	5° (radiance), 180°(irradiance)
Detector array	2048 px Si	2048 px Si, 256 px InGaAs
Spectral range	380 … 1020 nm	380 … 1700 nm
Spectral sampling interval	0.5 nm	0.5 nm (VNIR), 3 nm (SWIR)
Spectral resolution	3 nm	3 nm (VNIR), 10 nm (SWIR)
ADC resolution	16 bit	16 bit
Integration time	1...65535 ms	1...65535 ms
Shutter	Internal	Internal
Target camera	5 Mpx, RGB	5 Mpx, RGB
Communication interface	RS485, half duplex, 115.2 … 8000 kbps	RS485, half duplex, 115.2 … 8000 kbps
Housing material	Anodised marine grade aluminium	Anodised marine grade aluminium
Dimensions (DxL)	ø 110.3 x 267 mm	ø110.3 x 434 mm
Weight	1.5 kg	3 kg
Power supply	8 … 18 V DC, 0.5 A	8 … 18 V DC, 2 A
Environmental protection	IP67	IP67
Operating temperature	-25 … +45 °C	-25 … +45 °C
Storage temperature	-35 … +70 °C	-35 … +70 °C

HYPSTAR radiometer system

4G Antenna

Webcam

Environment sensors

Control Unit

Battery
PV Control Unit
Solar panel

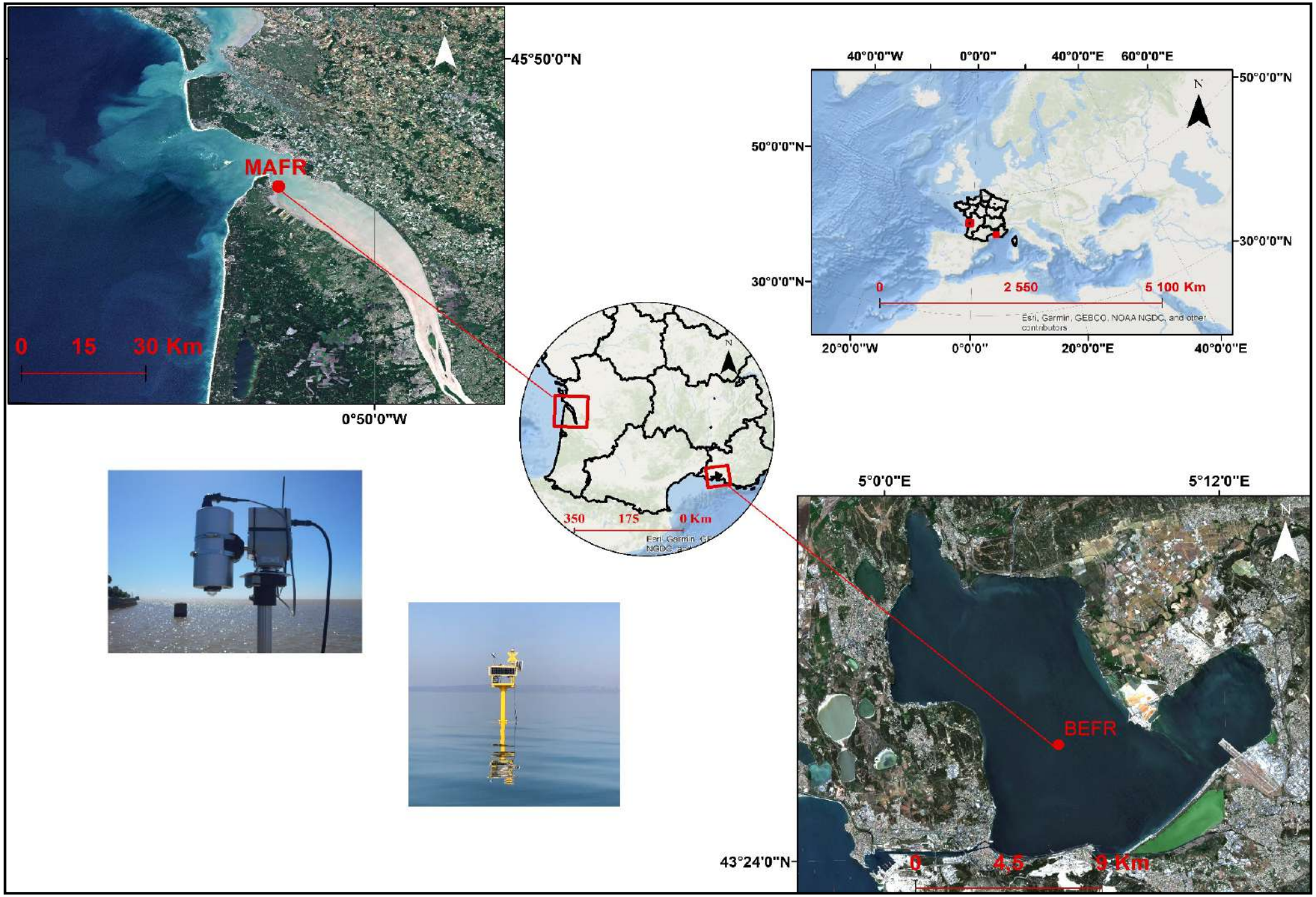
HYPSTAR
radiometer on
automated pan-tilt

https://hypstar.eu

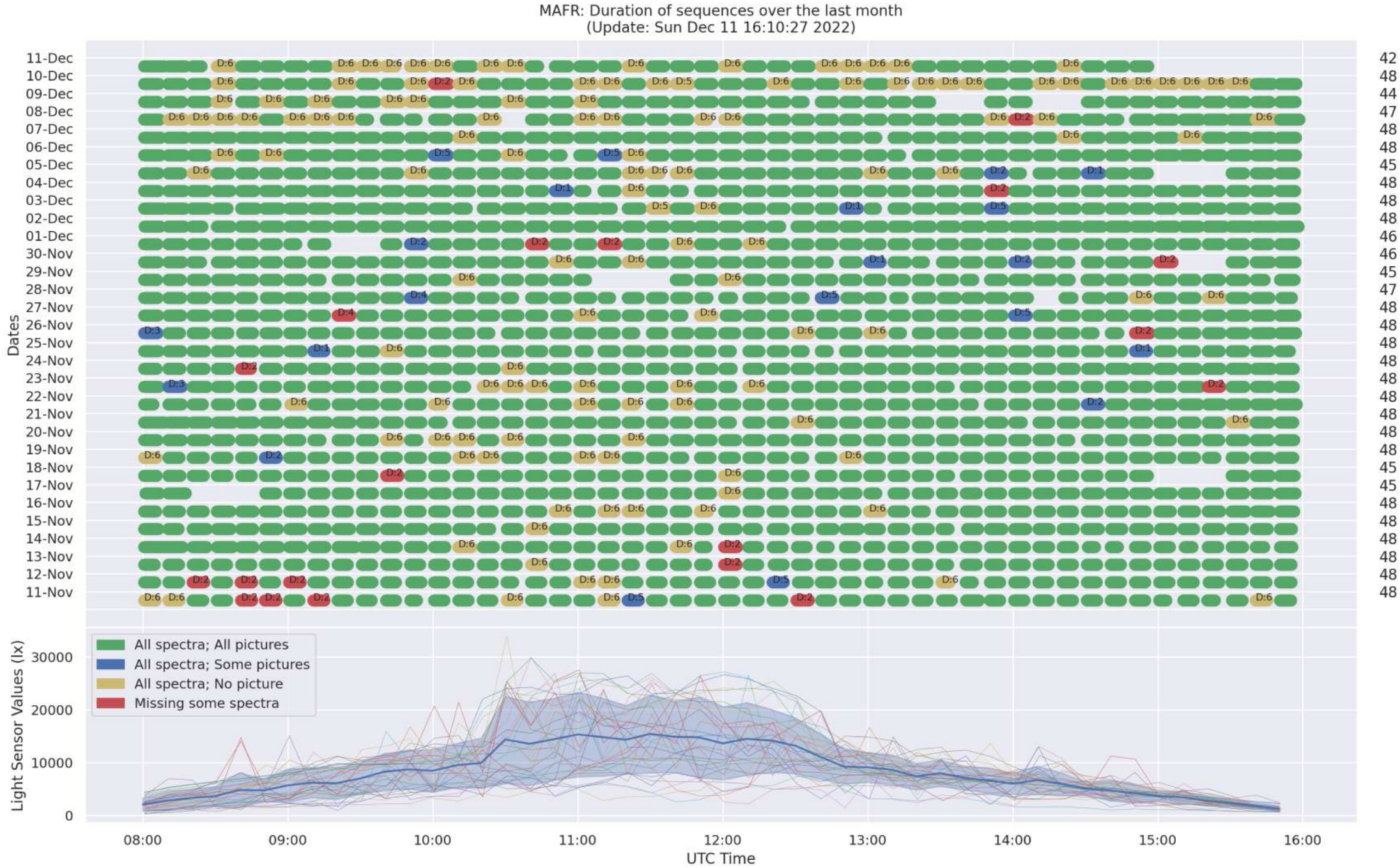
Deployment examples

1) Blankaart reservoir: **mobile water site** (Belgium, RBINS)
2) Berre coastal lagoon: **productive & sometimes turbid coastal water** (France, SU)
3) AAOT: **moderately turbid to clear waters** (Italy, CNR)
4) Lake Garda (Italy, CNR)
5) Gironde Estuary: **turbid to highly turbid macro-tidal estuarine waters** (France, SU)
6) Río de la Plata estuary (Argentina, CONICET)
7) Gobabeb Desert (Namibia, NPL)
8) Antarctica (RBINS) *(Left to right)*

V2 :
1 séquence de mesures toutes les 15mn depuis 11/2021



V1 :
1 séquence de mesures toutes les 30mn depuis 02/2021


MAFR: Duration of sequences over the last month
(Update: Sun Dec 11 16:10:27 2022)
Dates
11-Dec
10-Dec
09-Dec
08-Dec
07-Dec
06-Dec
05-Dec
04-Dec
03-Dec
02-Dec
01-Dec
30-Nov
29-Nov
28-Nov
27-Nov
26-Nov
25-Nov
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18-Nov
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16-Nov
15-Nov
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13-Nov
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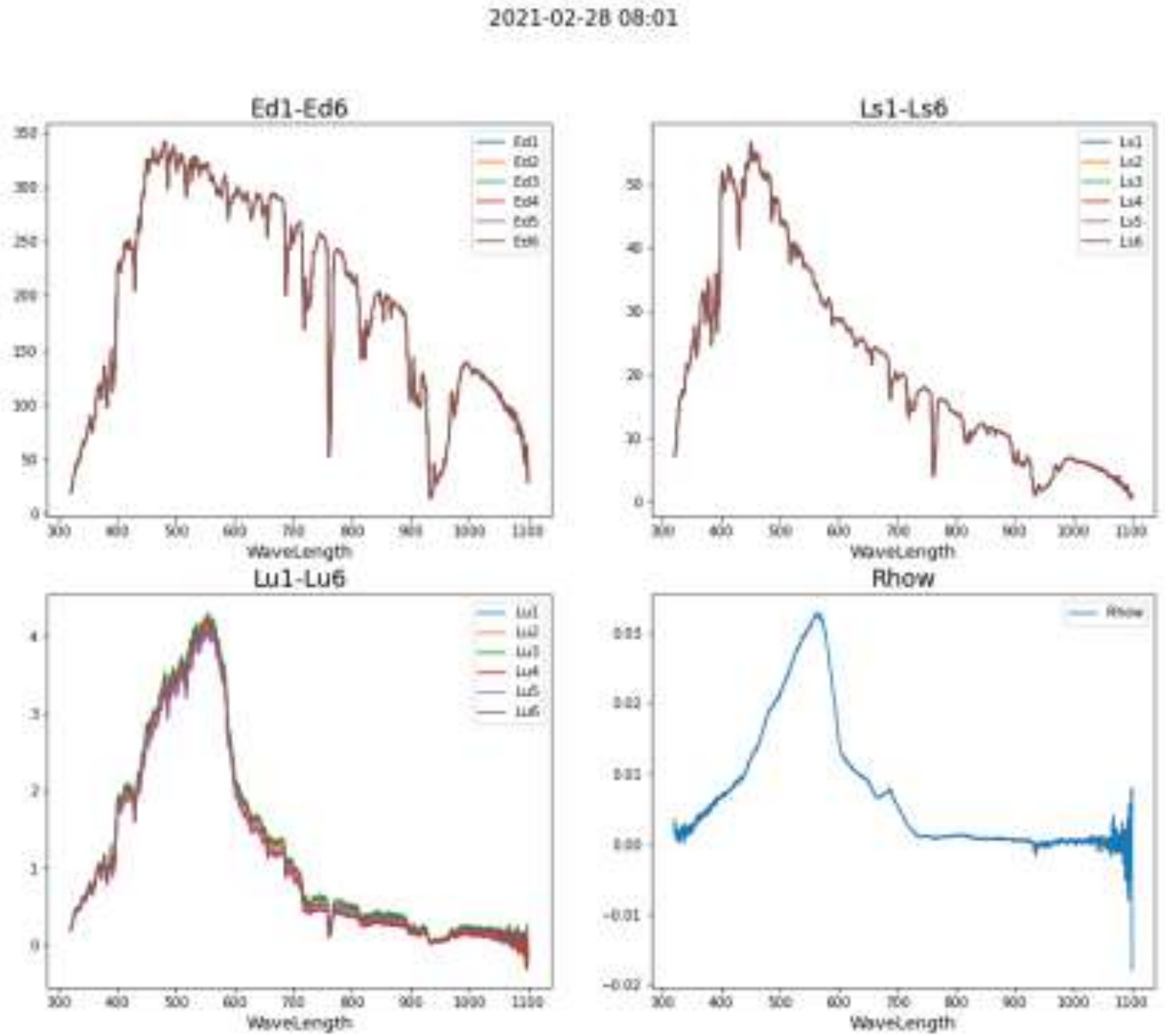
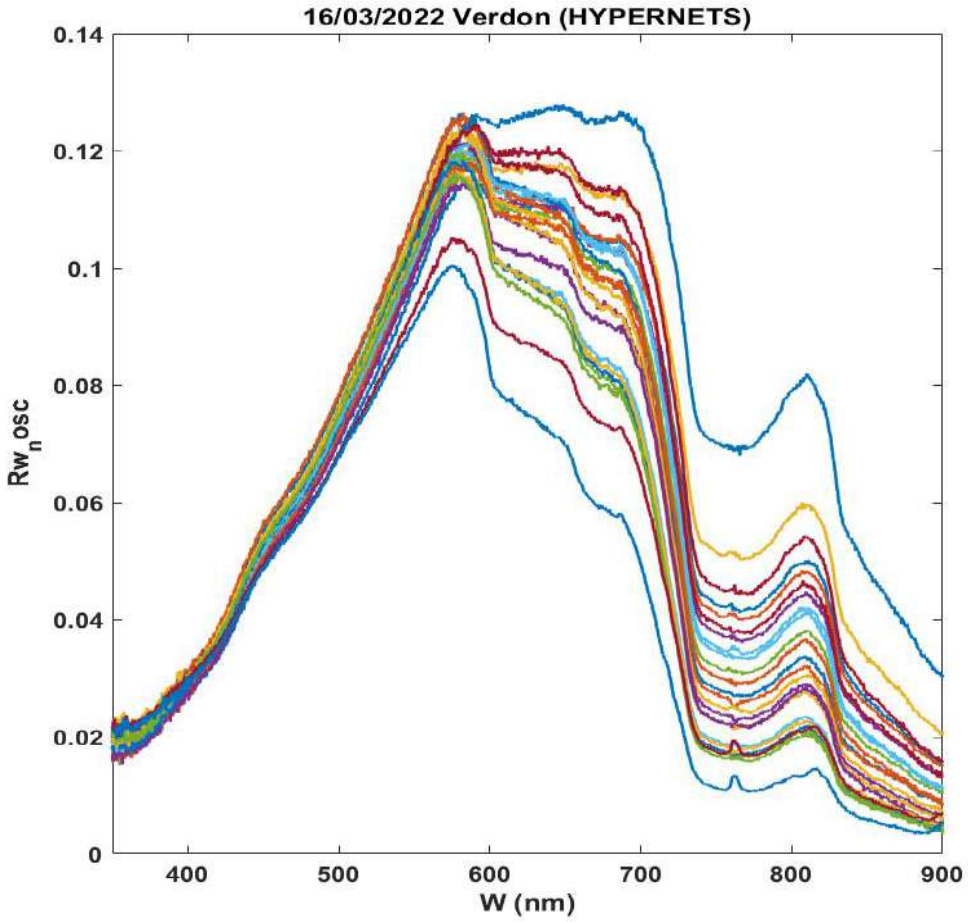
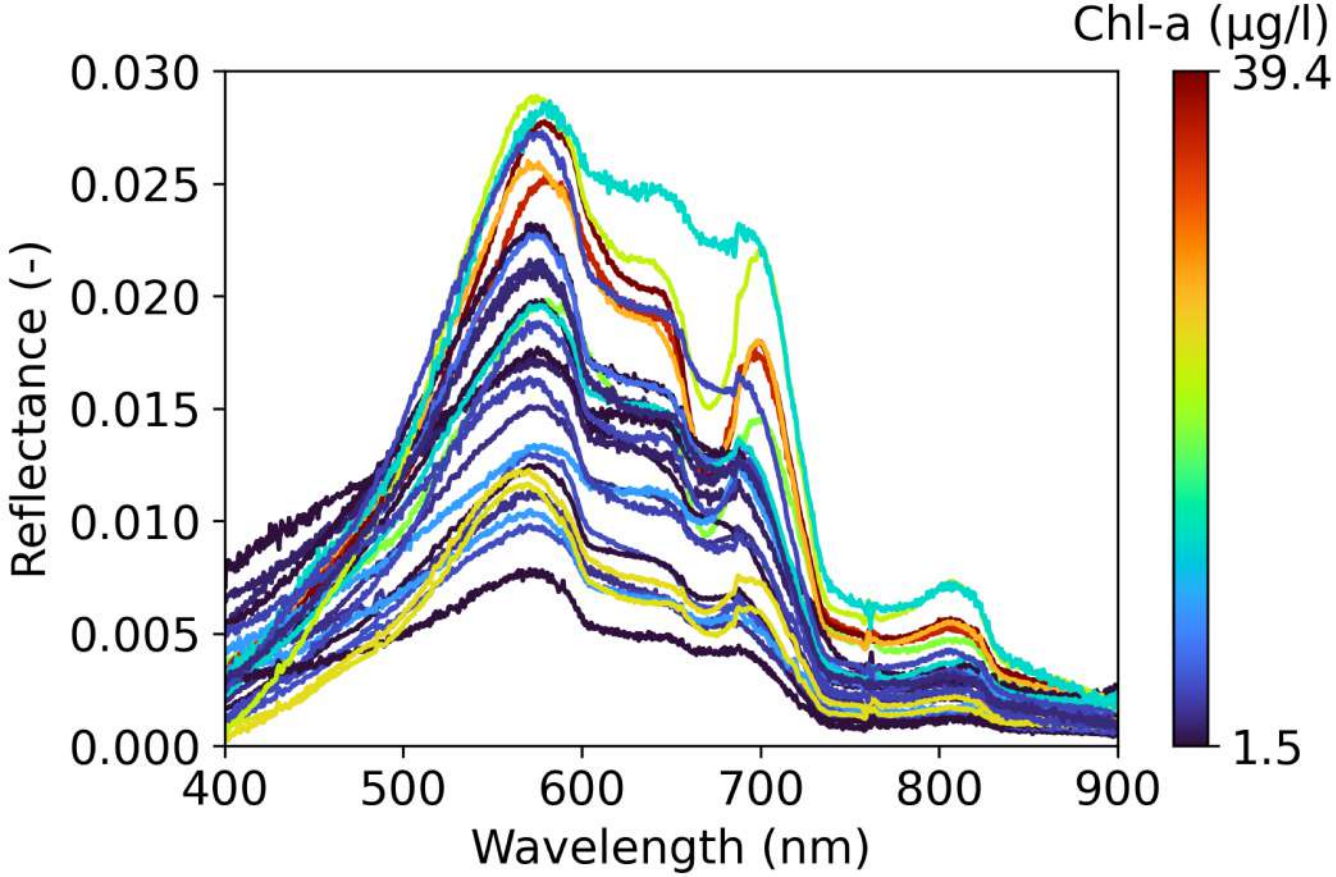
48
48
Light Sensor Values (lx)
30000
20000
10000
0
All spectra; All pictures
All spectra; Some pictures
All spectra; No picture
Missing some spectra
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
UTC Time

1 séquence de mesures standard = 6 E_d, L_t, L_s => 1 R_w =/-stdev



1 séquence de mesures standard = 6 E_d, L_t, L_s => 1 R_w =/-stdev



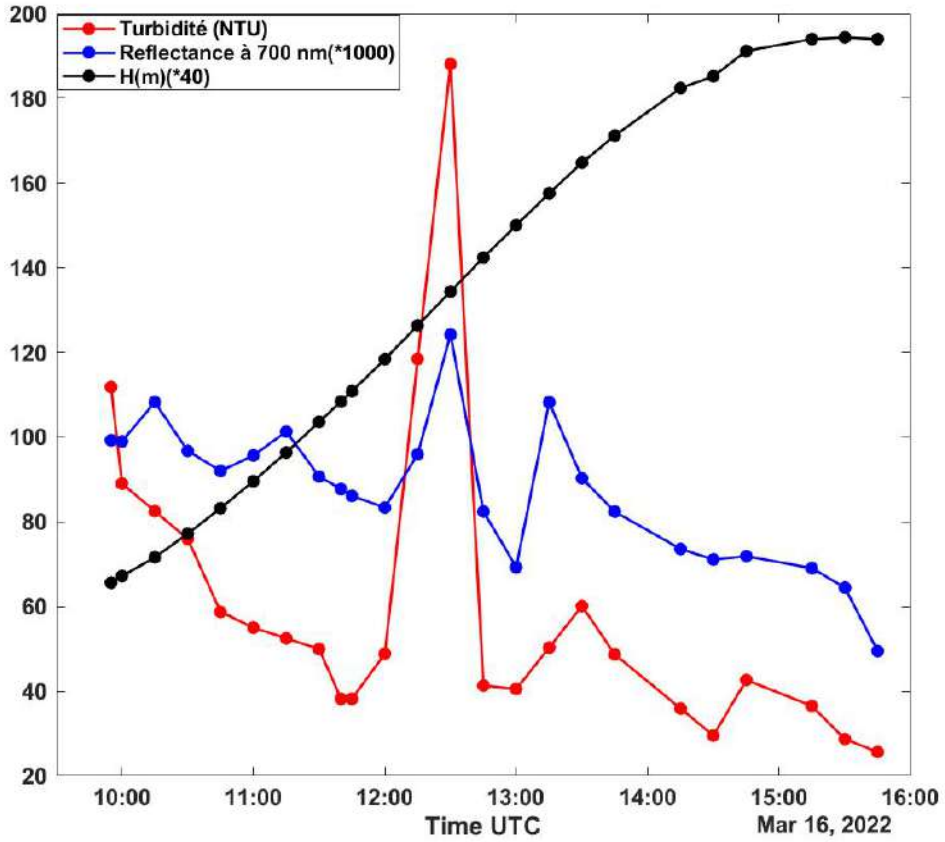


Gironde: Up to 35 water reflectance spectra a day, varying along the daily tidal cycle with turbidity and providing matchups to test the validity of AC corrections applied to any satellite data

Etangs productifs (Berre, Thau, Blankaart, Chascomus): Goyens et al. (2022)

Matchups entre produits satellitaires et mesures in situ

Adaptation des protocoles de matchups aux spécificités des estuaires et lagunes côtières (contrôles qualité, nb de pixels, Δt) (Concha et al. 2021)

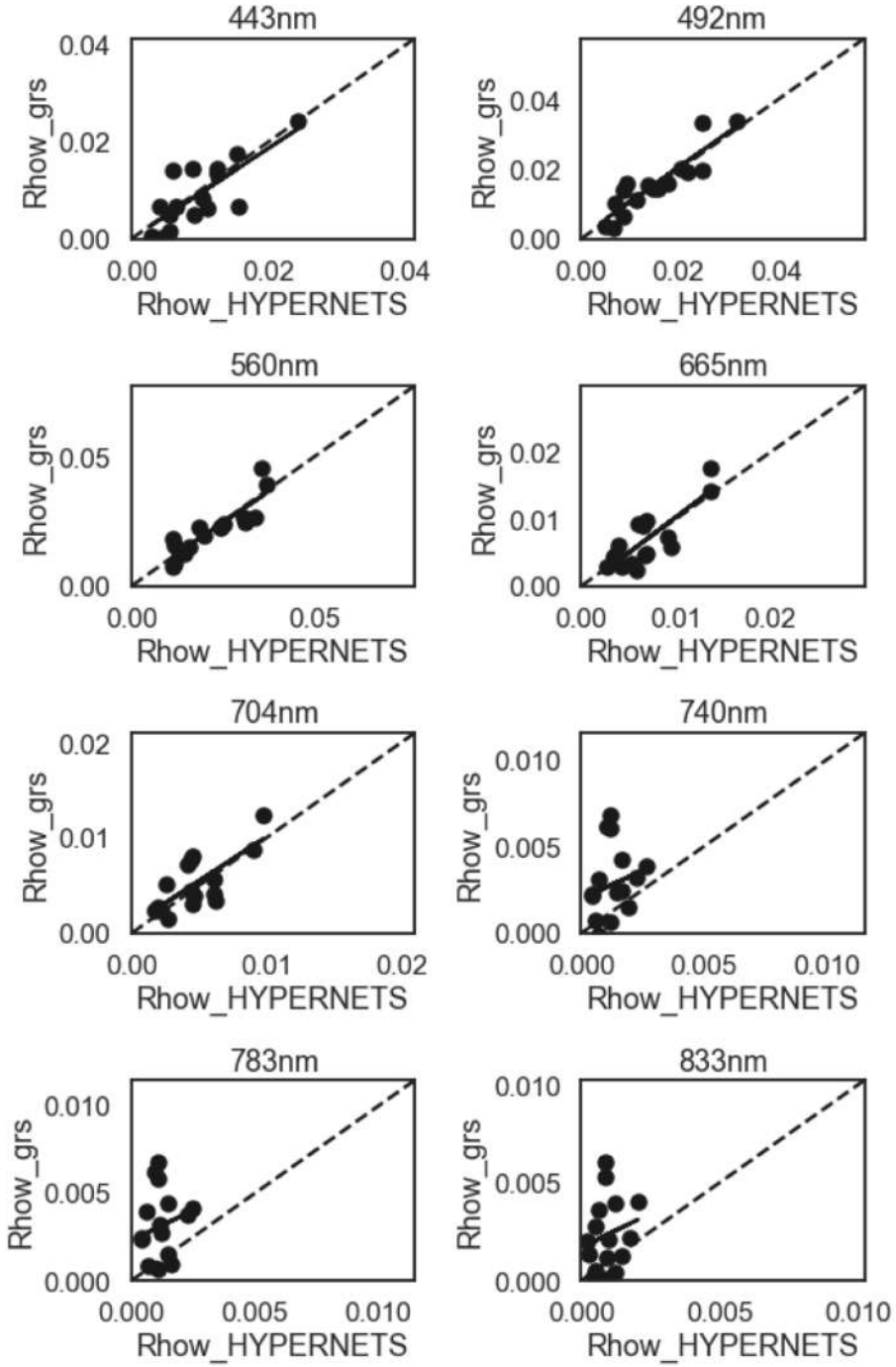


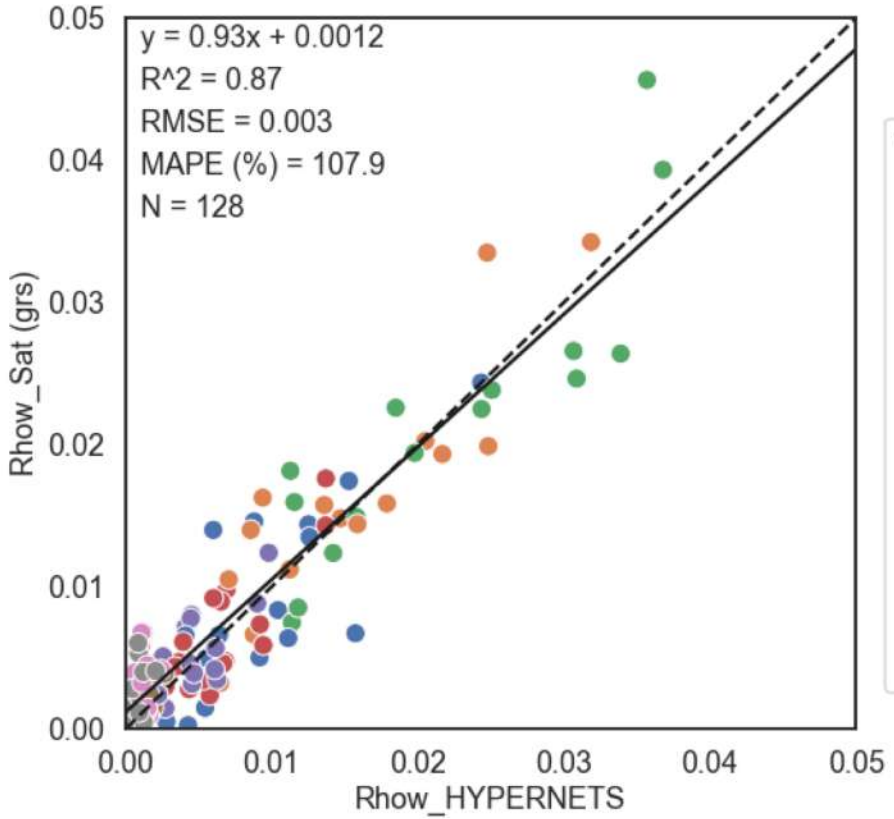
Satellite data	L8/9-OLI	S2-MSI
AC algorithms	C2RCC C2X Acolite iCOR	Sen2Cor C2RCC GRS Polymer Acolite, CMEMS-HR iCOR
Satellite data	**S3-OLCI**	**MODIS**
AC algorithms	BAC C2RCC Polymer Acolite CMEMS	MUMM NIR-SWIR

4. Matchups with satellite data / Results

Berre
S2-MSI
GRS

Glint!!



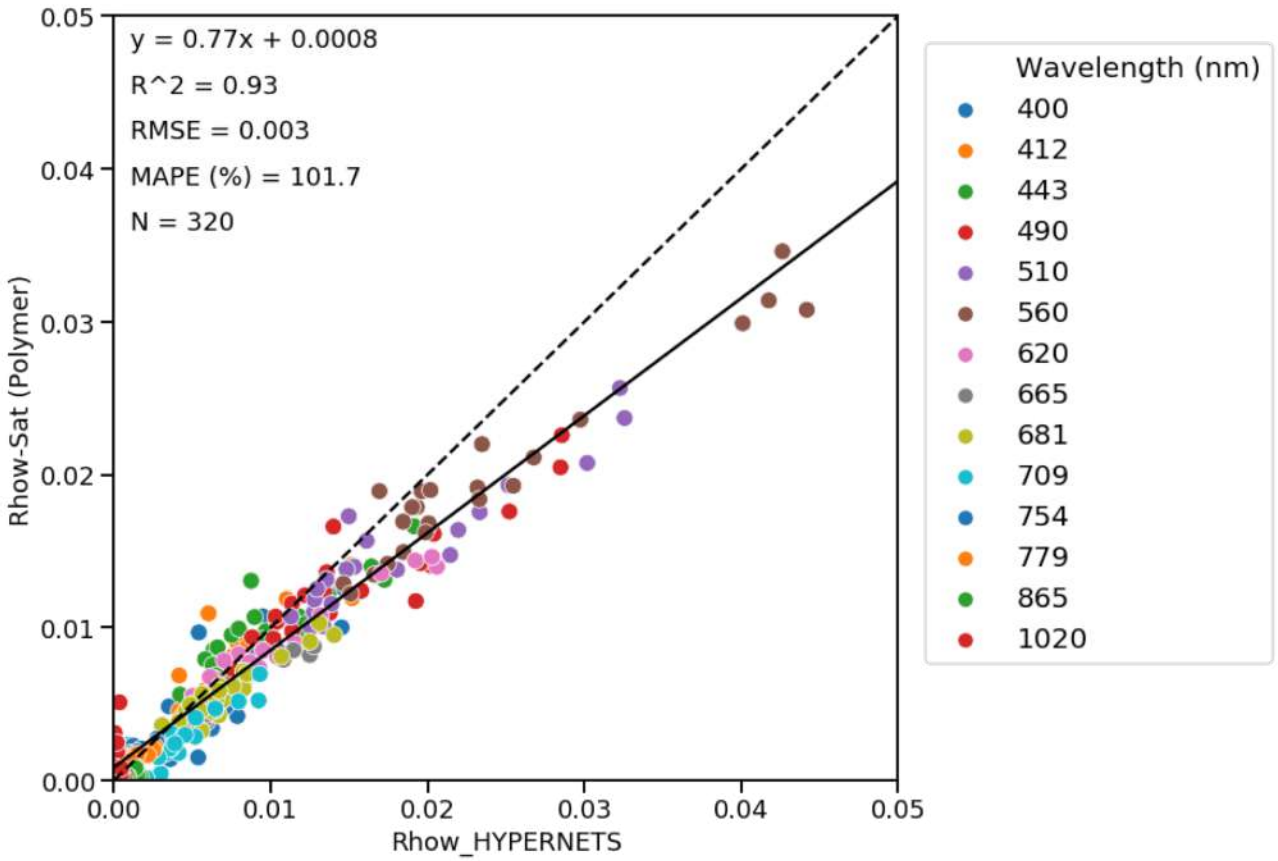


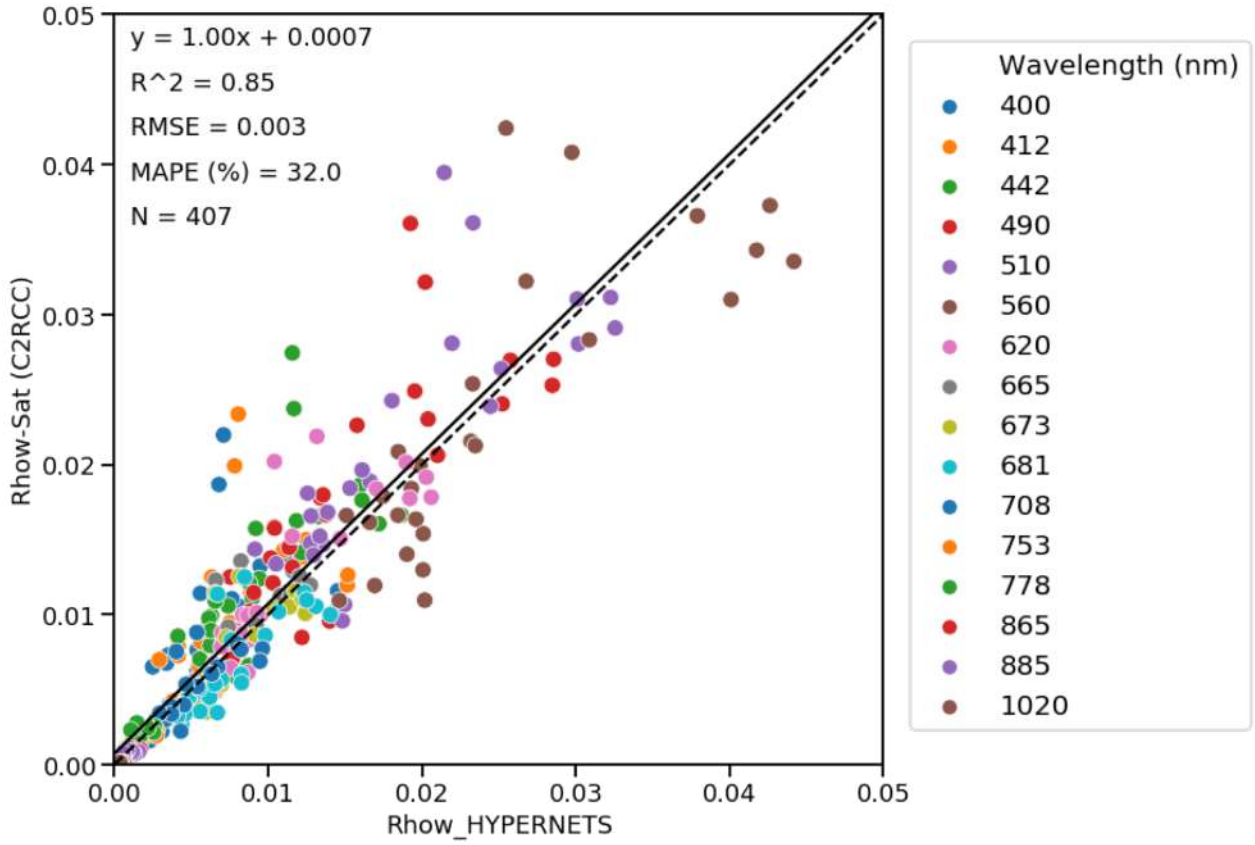
W (nm)	N	slope	intercept	R2	MAPE (%)	RMSE
443	16	0.93	0.000	0.60	45	0.0041
492	16	1.00	0.001	0.81	24	0.0037
560	16	0.96	0.001	0.78	19	0.0046
665	16	1.07	-0.0001	0.68	33	0.0023
704	16	0.93	0.001	0.55	38	0.0019
740	16	0.65	0.002	0.04	>100	0.0025
783	16	0.69	0.002	0.04	>100	0.0027
833	16	0.70	0.002	0.04	>100	0.0022

Matchups with satellite data / Results

Berre S3-OLCI POLYMER / C2RCC

Glint!!

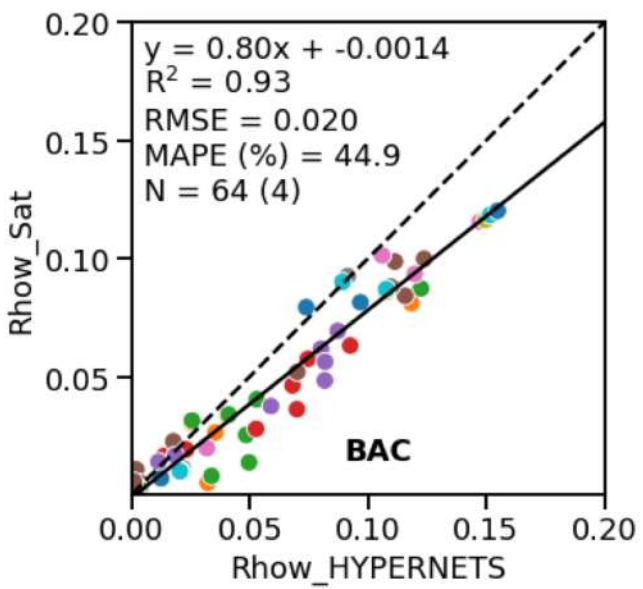


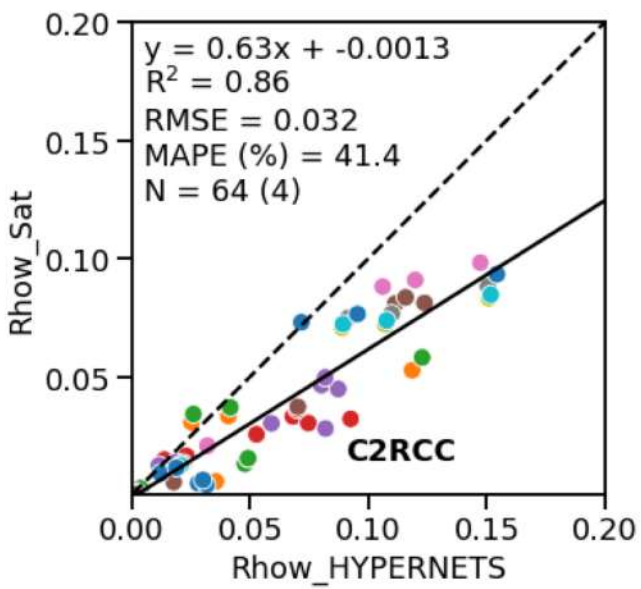


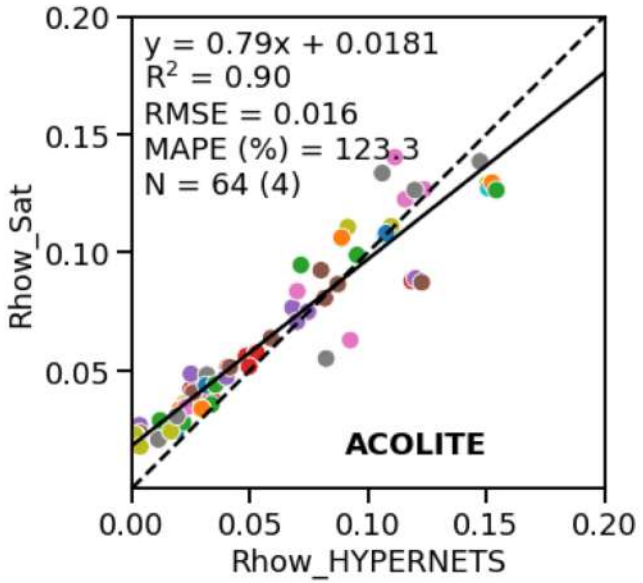
➔ Less scatter but underestimation for POLYMER compared to C2RCC (slope of 1)

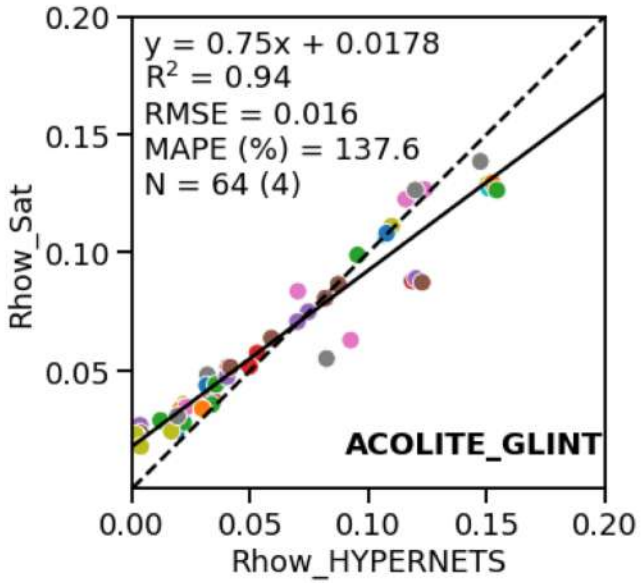
(1) depuis novembre 2021
(station MAGEST-Verdon)

(2) depuis septembre 2022
(extrémité ponton)



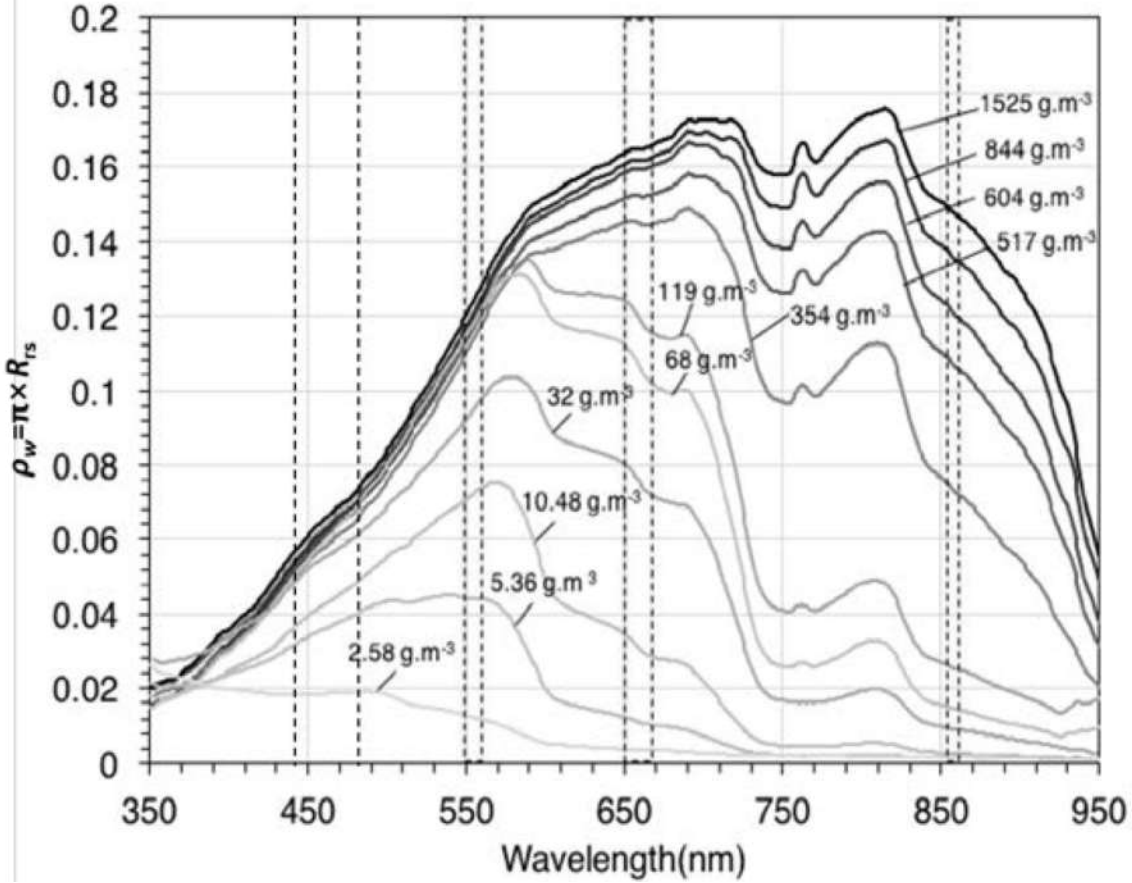






Here we used data recorded by the MAFR HYPERNETS station operated since November 2021 at the mouth of the macro-tidal estuary (measurements every 15mn, 9h - 17h)

1 sequence (2 mn):
3 consecutive Ed
3 consecutive Ls
6 consecutive Lt
3 consecutive Ls
3 consecutive Ed



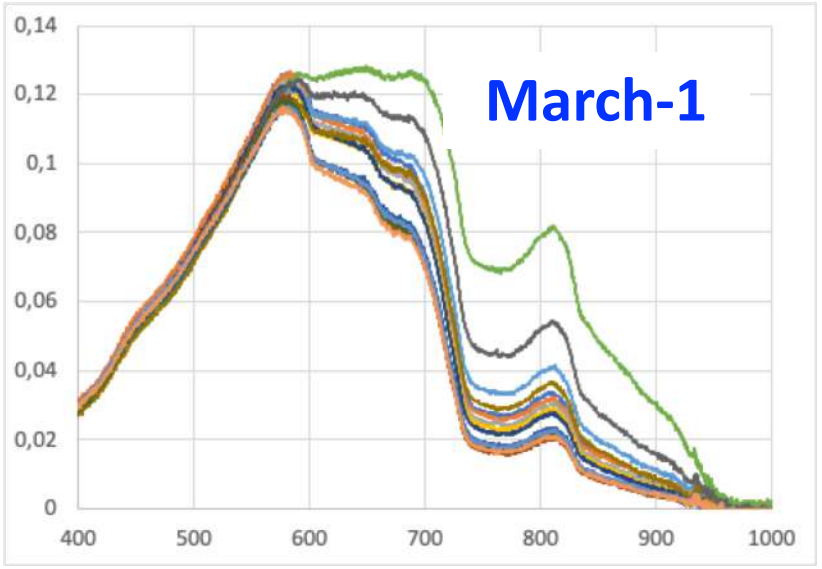
Mesures radiométriques depuis un navire le long d'un gradient de turbidité : saturation de la réflectance de l'eau au courtes longueurs d'onde (Novoa et al. 2017)

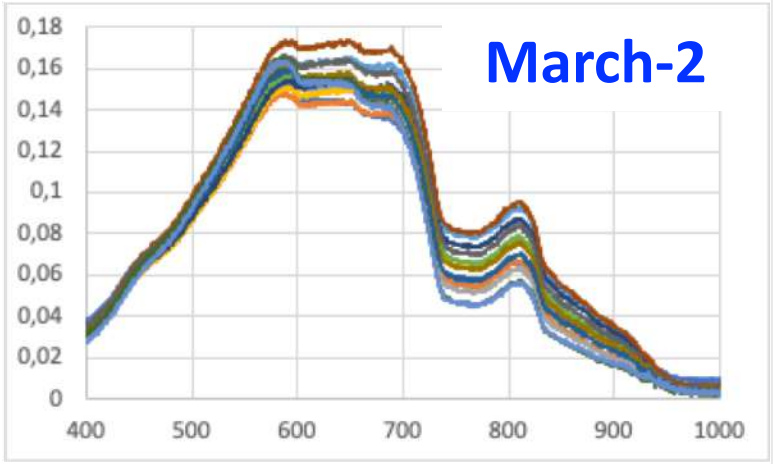
Vol. 26, No. 8 | 16 Apr 2018 | OPTICS EXPRESS 10435

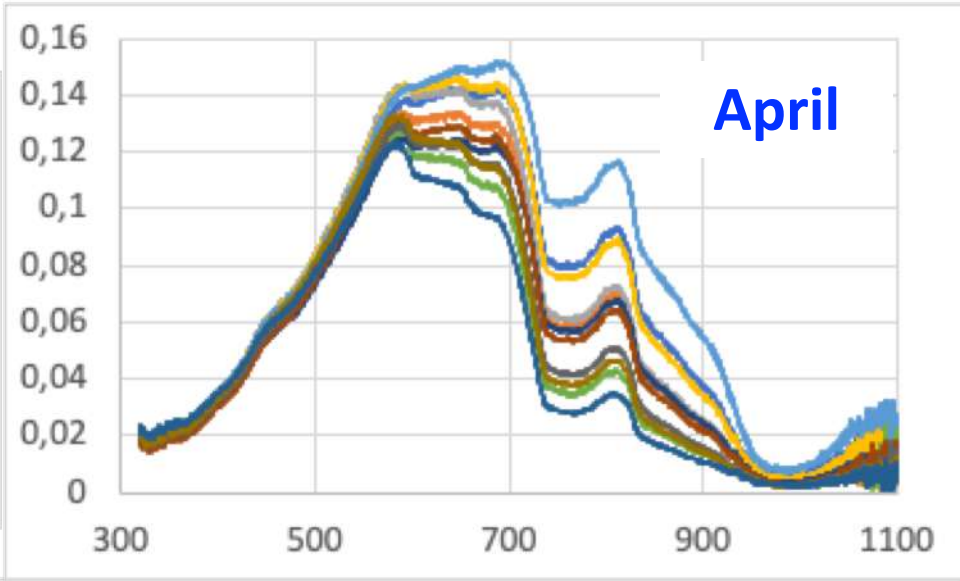
Saturation of water reflectance in extremely turbid media based on field measurements, satellite data and bio-optical modelling

YAFEI LUO,[1,2,3] DAVID DOXARAN,[3,7] KEVIN RUDDICK,[4] FANG SHEN,[5] BERNARD GENTILI,[6] LIWEN YAN,[1] AND HAIJUN HUANG[1,2,8]

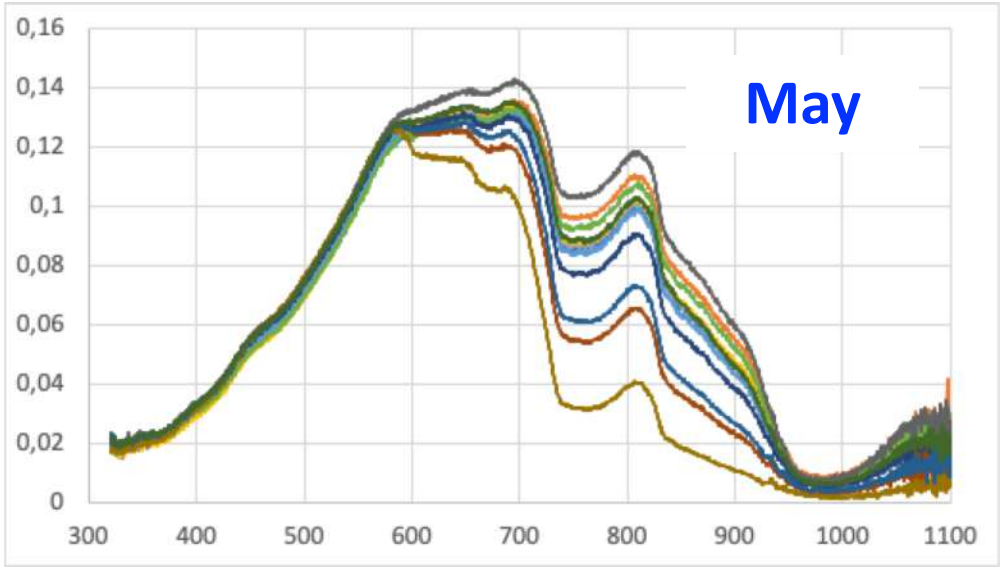
Saturation de la réflectance de l'eau (320-550 nm): plusieurs jours chaque mois

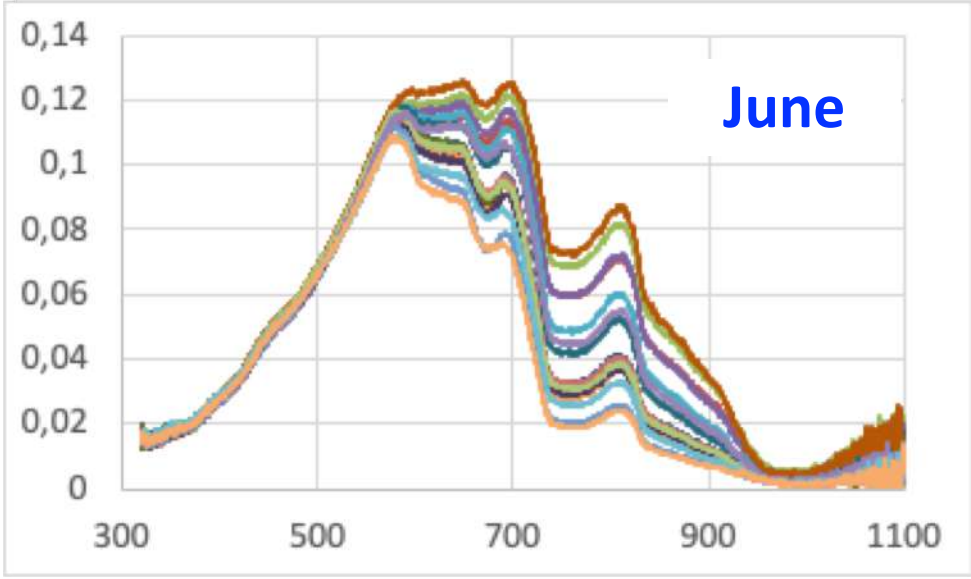






Luo et al. (2018) OE: Saturation of water reflectance in extremely turbid media based on field measurements, satellite data and bio-optical modelling



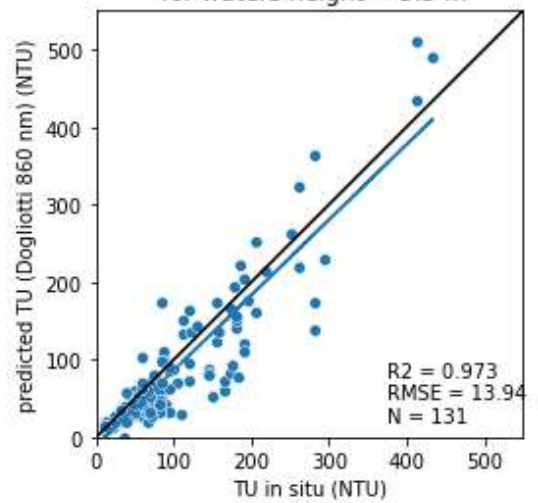


New platform:

- Above-water: meteo station, HYPSTAR-VIS, rain and light sensors, 2 webcams (N & S), solar panels
- In-water: b_b, fluo_chla, T, S, O_2 ,
- Monthly maintenance and water sampling

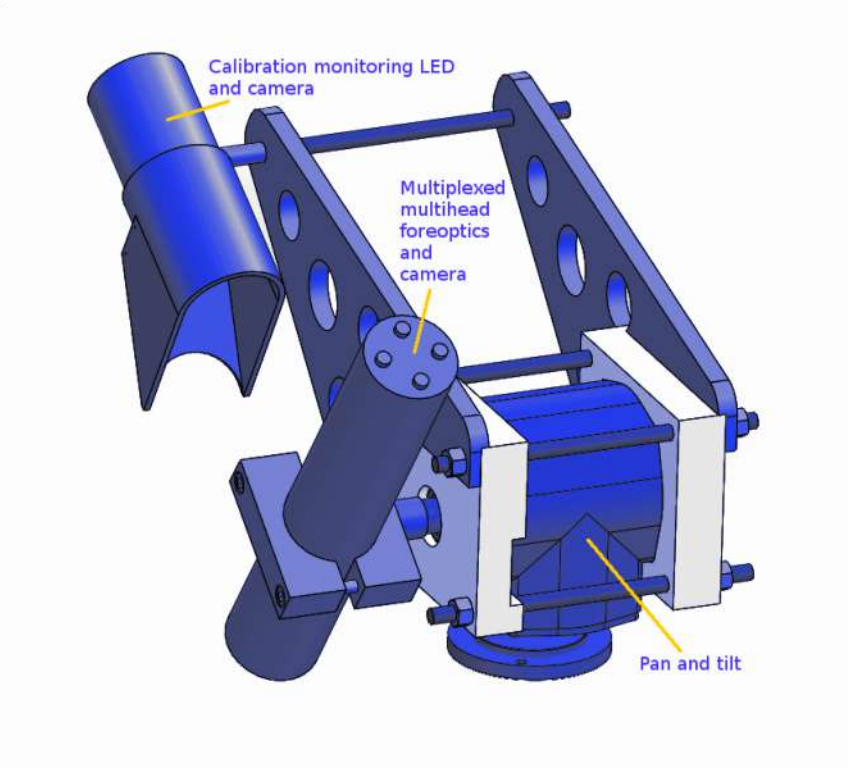
Projet CNES-TOSCA HYPERVAL

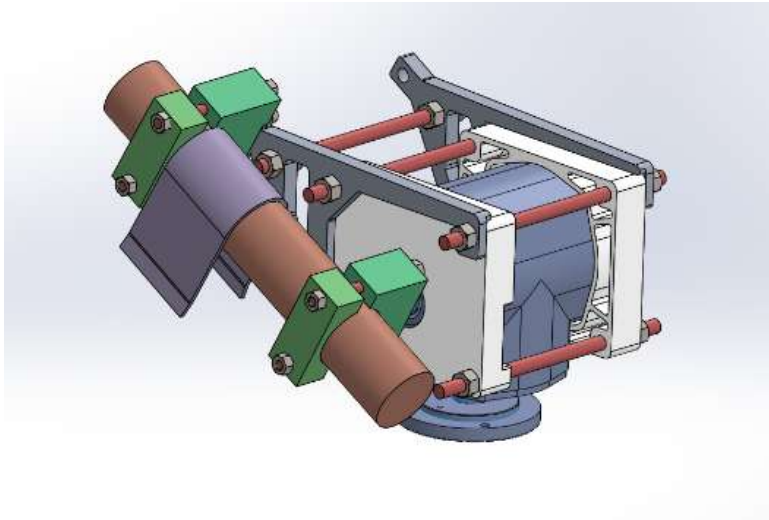
method: TU framed mean
filters: shadow, TU stdv <0,1*mean, manual cleaning
for waters height < 3.3 m



Conclusions & Perspectives

- **HYPERNETS**: un nouveau radiomètre hyperspectral, le HYPSTAR (commercialisation mi-2023)
- Un système de mesures autonomes opérationnel
- Plusieurs sites en activité (V1 & V2)
- Système cal/val (turbi/fluorimètres): **HYPERVAL**
- Système avec module de calibration (début 2023)
- Une projet de maturation (2023-2027, ESA) : **HYPERNETS-POP** (Pre-Operation Phase)





HYPERNETS

By April 2023…

31 systems built in total

12 stations for the **WATERHYPERNET** network (**WATER**)

12 stations for the **RADVALNET** network (**LAND**)

WATER and **LAND** data networks

WATERHYPERNET

https://waterhypernet.org