water (ocean, coastal, lakes)

A Hyperspectral network for ~~ocean~~ colour validation
WATERHYPERNET

by Kevin Ruddick[1],

Dieter Vansteenwegen[2], Quinten Vanhellemont[1], Matthew Beck[1], David Doxaran[3], Ana Dogliotti[4], Fang Shen[5], Dimitry Van der Zande[1], Thanos Gkritzalis[2], André Cattrijsse[2]

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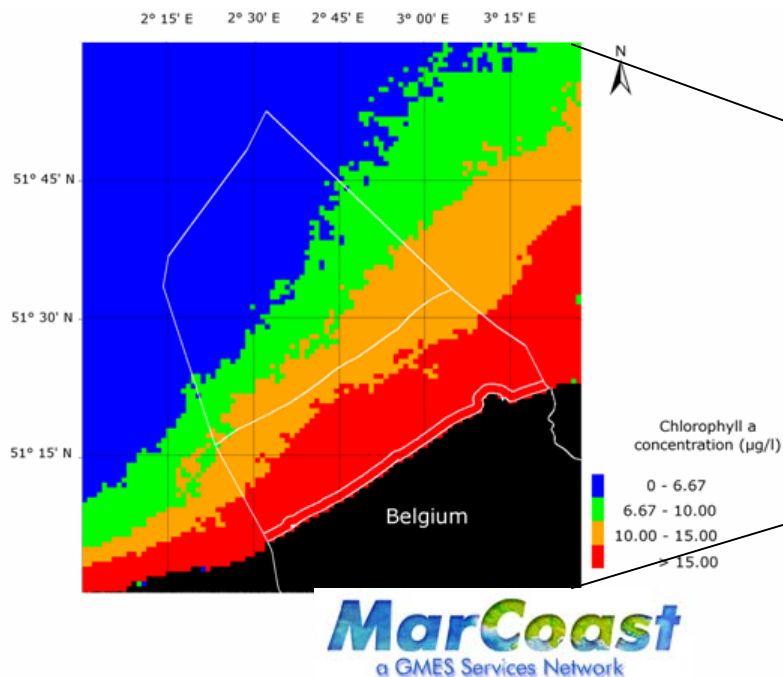
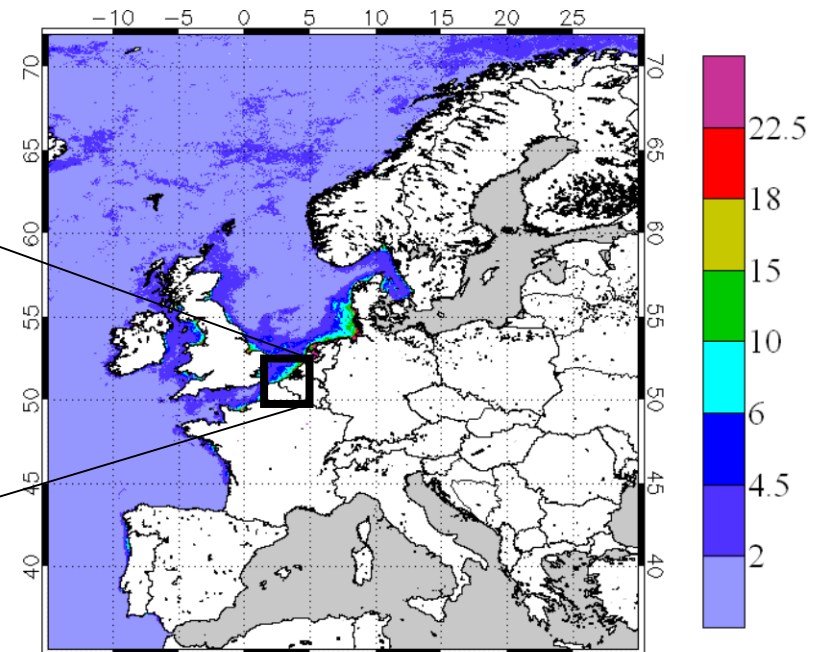# Satellite data is used to support Belgian environmental policy

- Satellite-based eutrophication assessment service (OSPAR convention, EU Water Framework Directive, MSFD)

Belgian CHLa 90% Mar-Oct 2005-2010, Water Framework Directive product
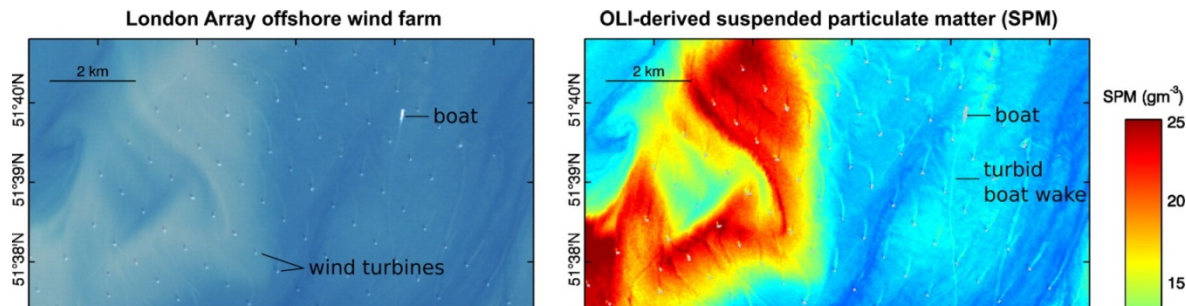
[Image: D. Vanderzande]

CHLa 90 percentile (MERIS,2005)

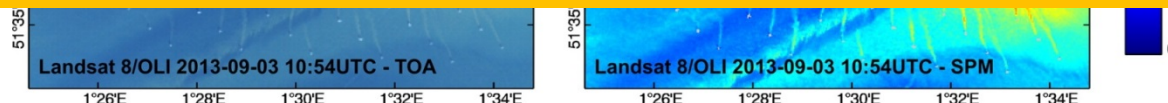Remote sensing is neutral, transparent, and spatially extensive (cross-boundary)

... and support Environmental Impact Assessments

[Vanhellemont & Ruddick, 2014]

London Array offshore wind farm — OLI-derived suspended particulate matter (SPM)

But the quality and usability of all these products depends on "level 2" water reflectance validation

MAY2018 TITLE (S3VT):

An international network for validation
of water reflectance for all VIS/NIR spectral bands of Sentinel-3AB…CD

And MODIS-TERRA/AQUA

And Landsat-8/9/10

And Sentinel-2ABCD

And Pléiades

And PACE

And CHRIS-PROBA1
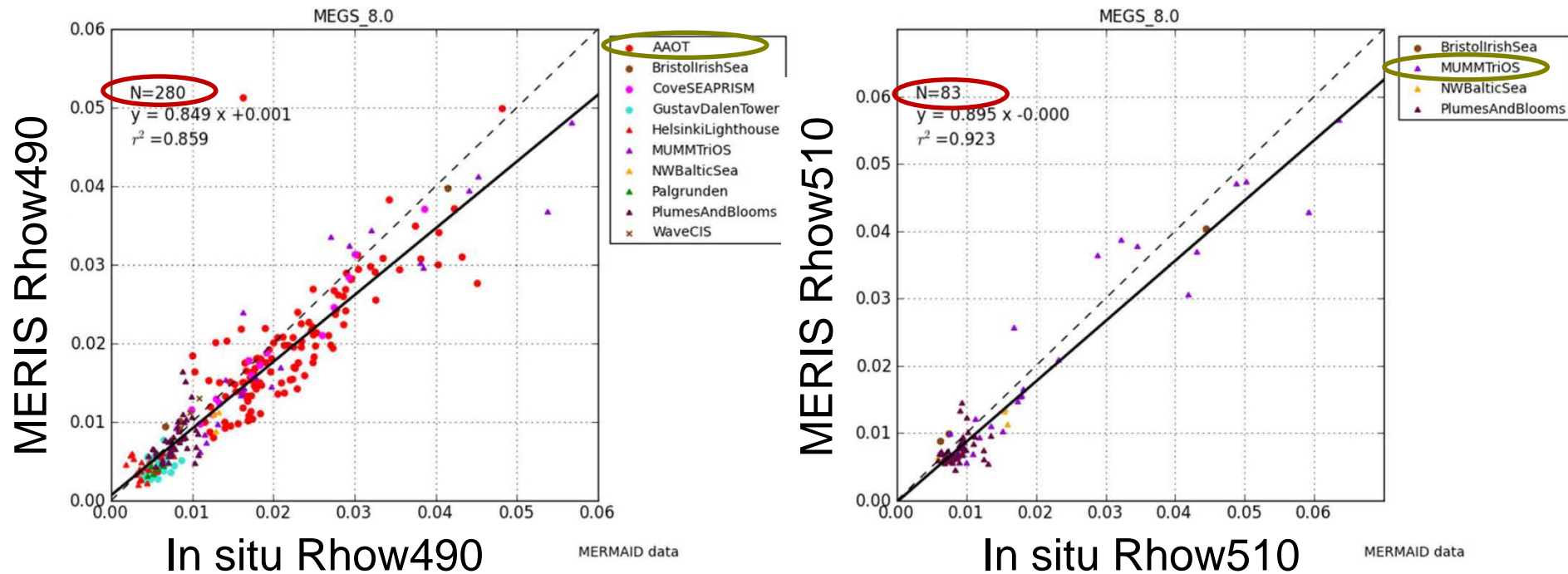
And all other ocean colour sensors

And MODIS-AQUA

And all future hyperspectral sensors
(inc "Sentinel-10", Hyspiri, CHIME, …)

And SEVIRI … and MTG

And VIIRS

And all future optical nanosatellites (Planetscope, etc.)

And PROBA-V

And GOCI-1&2

# 10 years of MERIS validation data, including a few years of AERONET-OC…

MEGS_8.0

In situ Rhow490 — MERIS Rhow490

N=280
y = 0.849 x +0.001
r^2 =0.859

Legend:
- AAOT
- BristolIrishSea
- CoveSEAPRISM
- GustavDalenTower
- HelsinkiLighthouse
- MUMMTriOS
- NWBalticSea
- Palgrunden
- PlumesAndBlooms
- WaveCIS

MERMAID data

MEGS_8.0

In situ Rhow510 — MERIS Rhow510

N=83
y = 0.895 x -0.000
r^2 =0.923

Legend:
- BristolIrishSea
- MUMMTriOS
- NWBalticSea
- PlumesAndBlooms

MERMAID data

- **AERONET-OC = main validation source for MERIS (and OLCI):**
  - 1 image, 1 matchup
- **AND have standardised calibration, processing and Quality Control**
- **BUT do not cover all wavelengths**

[MERIS 3rd reprocessing data validation report, ACRI, 2012]
Data courtesy of PIs (D. McKee, K. Ruddick, D. Siegel, S. Kratzer) and AERONET-OC PIs (G. Zibordi, G. Schuster, S. Kratzer, B. Gibson), matchup using MERMAID

Heritage: NASA/JRC AERONET-OC

- Federated network of instrumented sites for ocean color validation, spawned from larger AERONET network
- Built up from 1 site (2002) to 15 (2017)
- Full details in [Zibordi et al, 2009]

RBINS -OD Nature
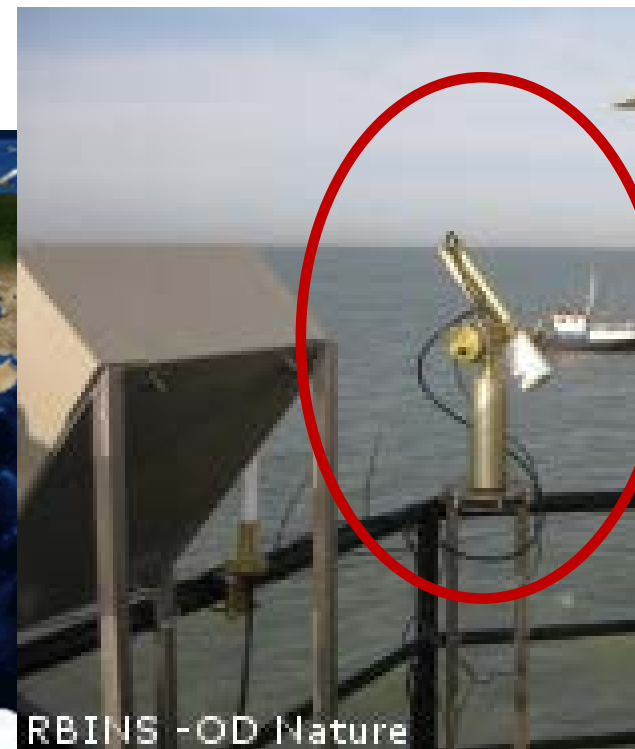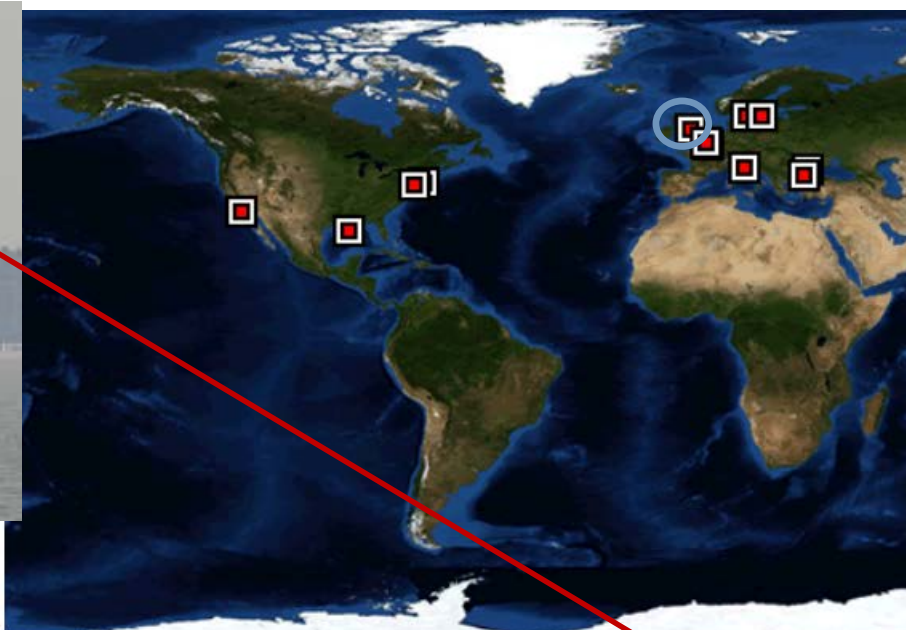
Blyth_NOAH (55N,1W)	Galata_Platform (43N,28E)	Gloria (44N,29E)
Gustav_Dalen_Tower (58N,17E)	Ieodo_Station (32N,125E)	LISCO (40N,73W)
Lucinda (18S,146E)	MVCO (41N,70W)	Palgrunden (58N,13E)
Socheongcho (37N,124E)	Thornton_C-power (51N,2E)	USC_SEAPRISM (33N,118W)
Venise (45N,12E)	WaveCIS_Site_CSI_6 (28N,90W)	Zeebrugge-MOW1 (51N,3E)

[aeronet.gsfc.nasa.gov]
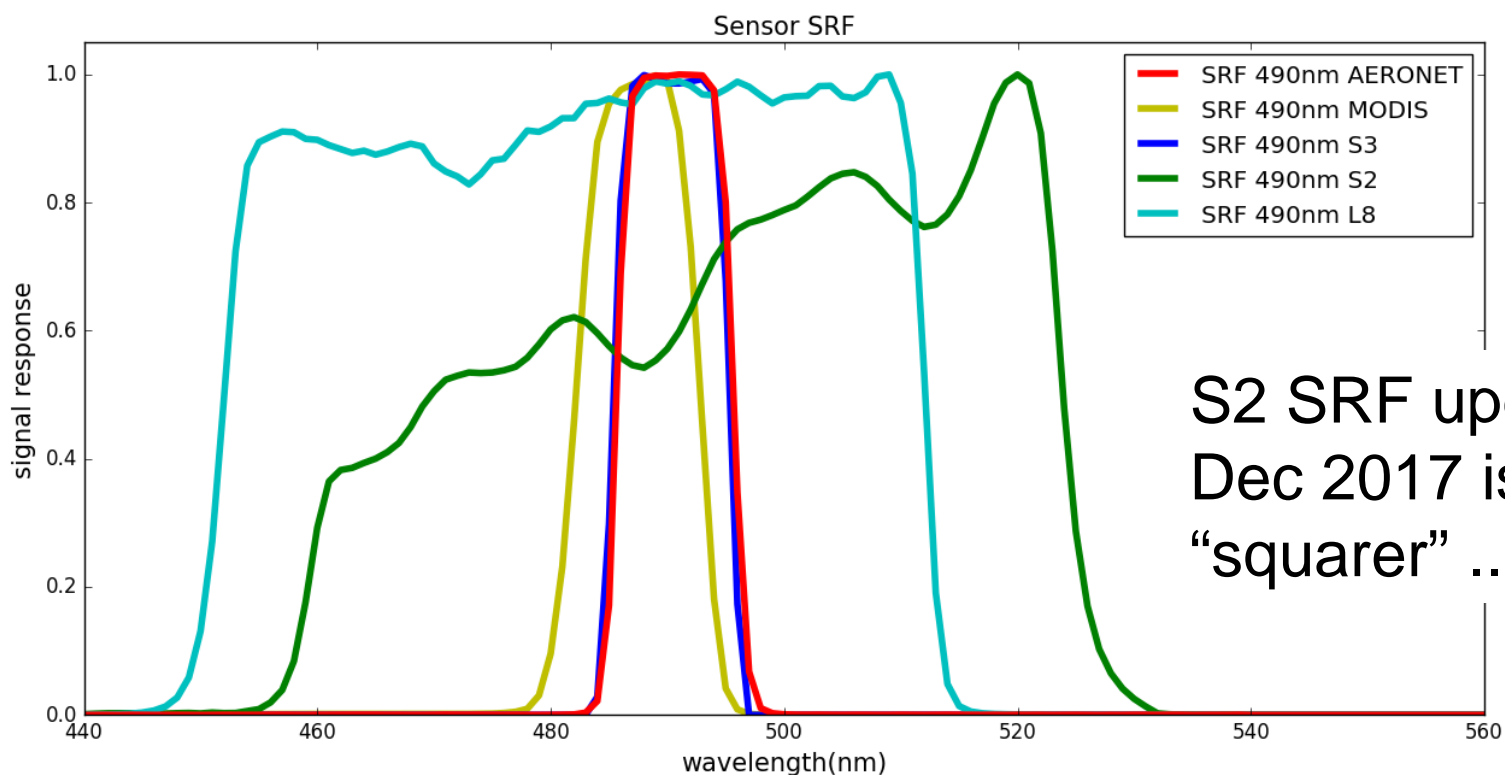
Multi-Mission Validation

[Van der Zande, Ruddick et al. Validation of Landsat-8/OLI for ocean colour applications with AERONET-OC sites in Belgian coastal waters (2016) Ocean Optics, Victoria, BC]

🟩 MAPE < 3%	→ 12 bands	
🟧 3% < MAPE < 5%	→ 8 bands	
⬛ MAPE > 5%	→ 36 bands	

Spectral Bands

Ocean

Land
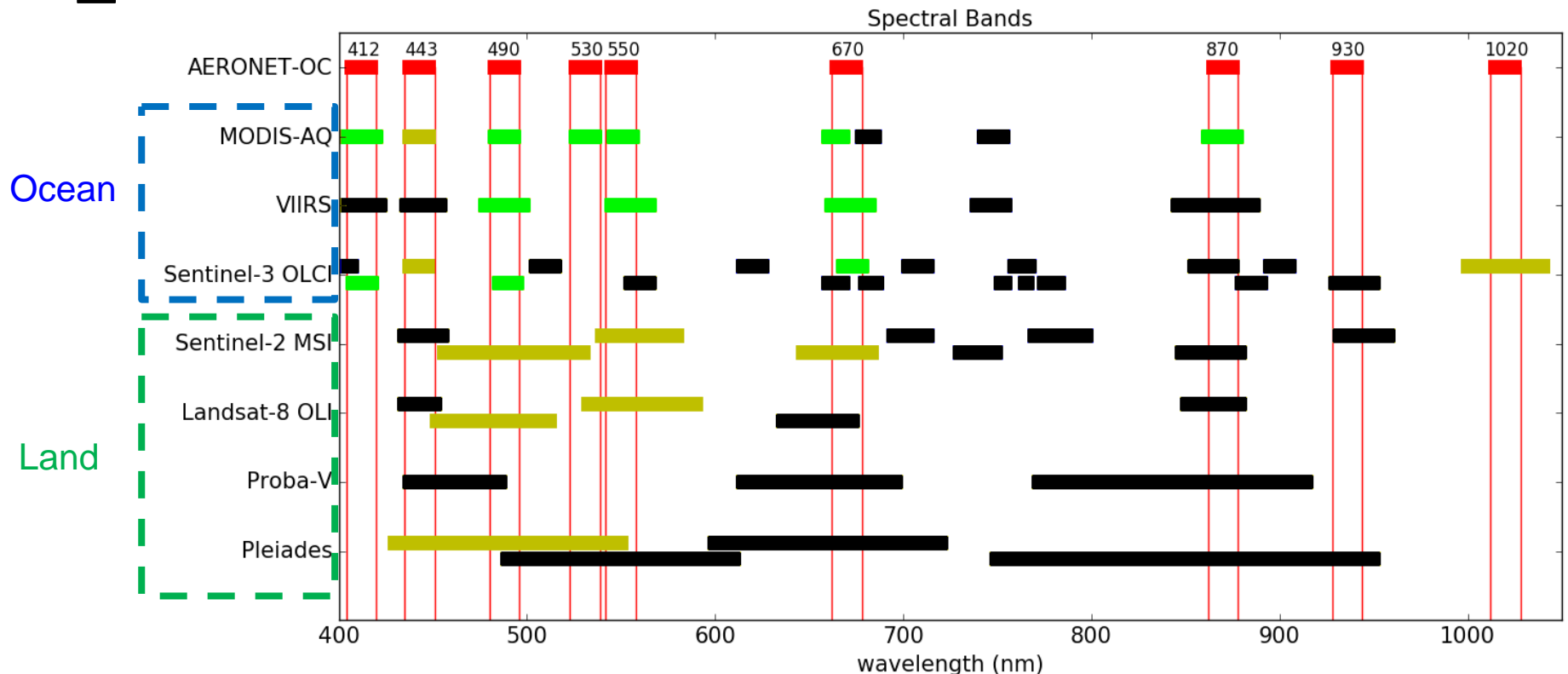
e.g. "490nm" spectral band of MODIS, S3/OLCI … L8/OLI and S2/MSI (and AERONET-OC)

Need hyperspectral to fit all these with low uncertainty

Sensor SRF

- SRF 490nm AERONET
- SRF 490nm MODIS
- SRF 490nm S3
- SRF 490nm S2
- SRF 490nm L8

S2 SRF updated Dec 2017 is a bit "squarer" ...

From AERONET-OC to WATERHYPERNET

NASA/JRC AERONET-OC
CIMEL SEAPRISM instrument
412-440-500-531-555-670-870-1020nm
(5/19 S3/OLCI bands…)
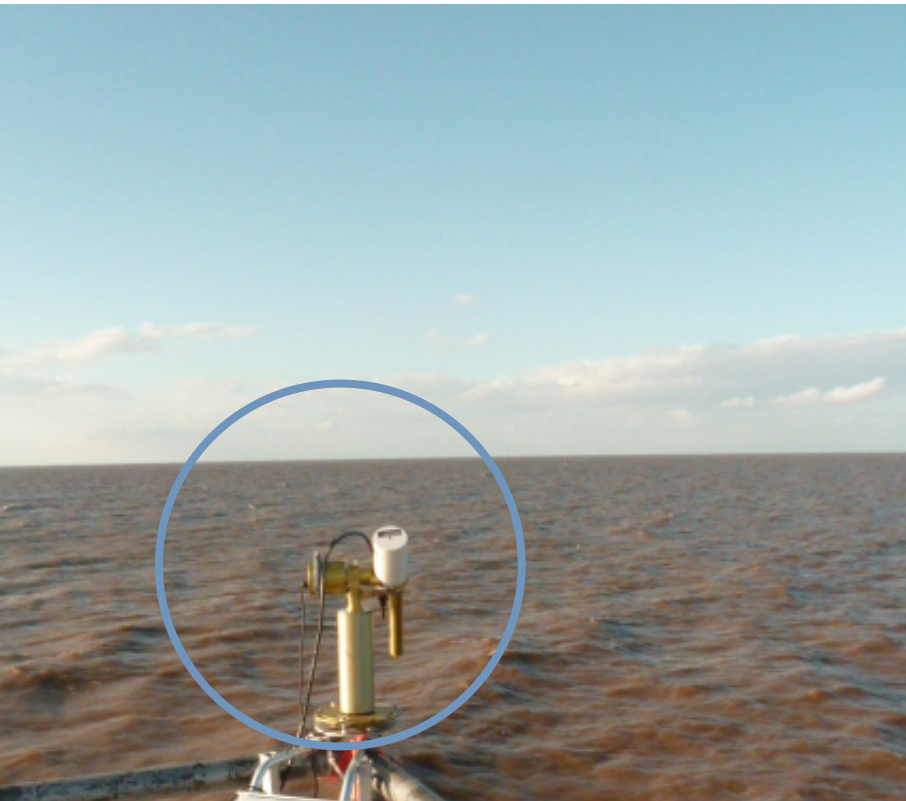
WATERHYPERNET
TRIOS/RAMSES instrument
Hyperspectral 350-900nm
⇒ All bands, all sensors
⇒ No band-shift/widening errors

Which instrument to use? (now)

- TRIOS/RAMSES instrument:
  - **Hyperspectral 350-900nm**
  - Robust and mature (~100s in use since 2000)
  - Relatively low cost for high performance
  - Manufacturer provides support and details of communication protocol for own data acquisition development
  - Well-characterised:
    - Spectral Straylight [Talone et al, 2016]
    - Thermal sensitivity [Zibordi et al, 2017]
    - Cosine response [Mekaoui and Zibordi, 2013]
    - Polarisation sensitivity [Talone and Zibordi, 2016]
    - Non-linearity tests [Tartu Observatory, FRM4SOC project + Zibordi, in prep.]
  - Portable "FieldCAL" LED light source for relative calibration monitoring
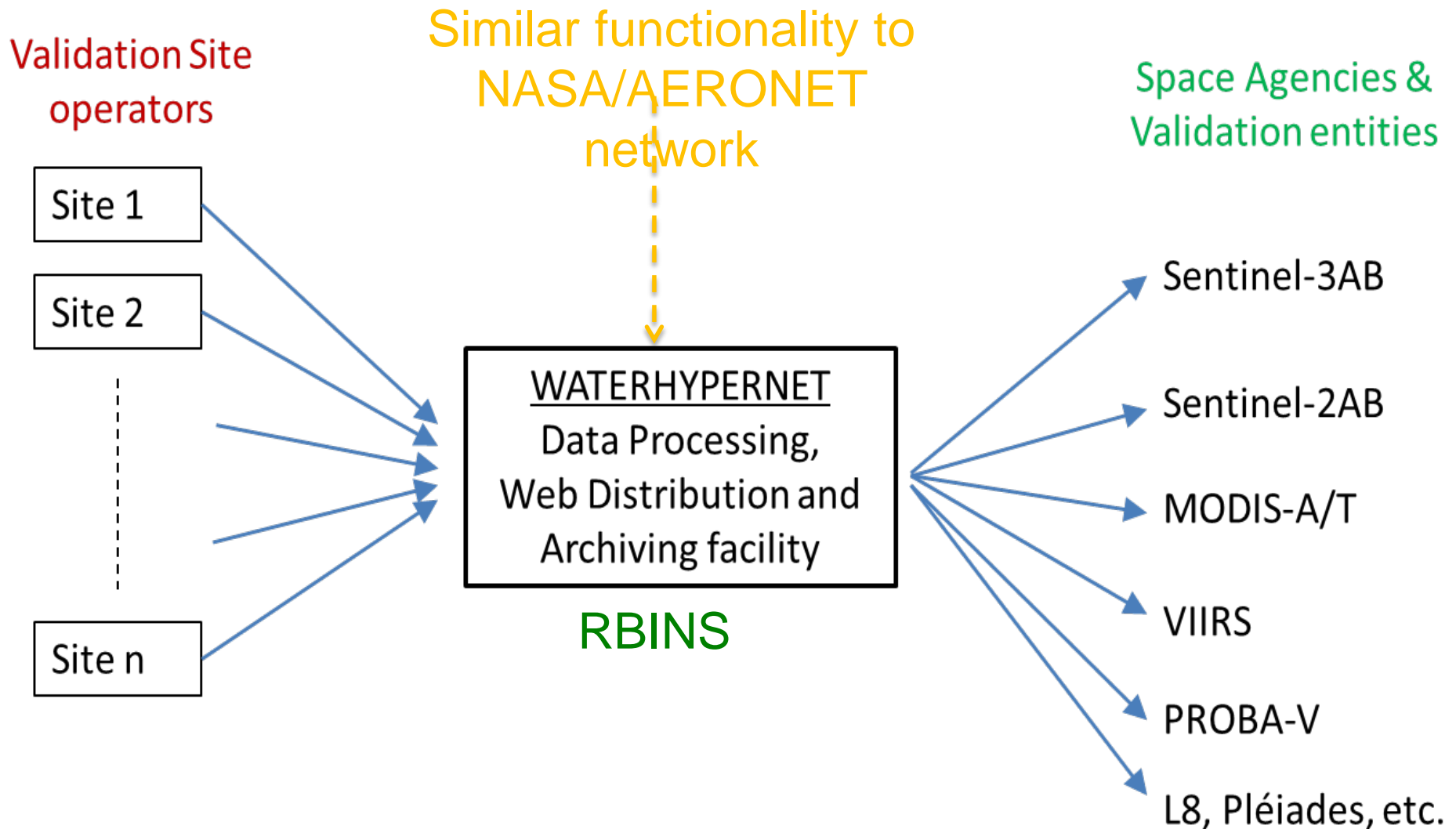
Pointing system
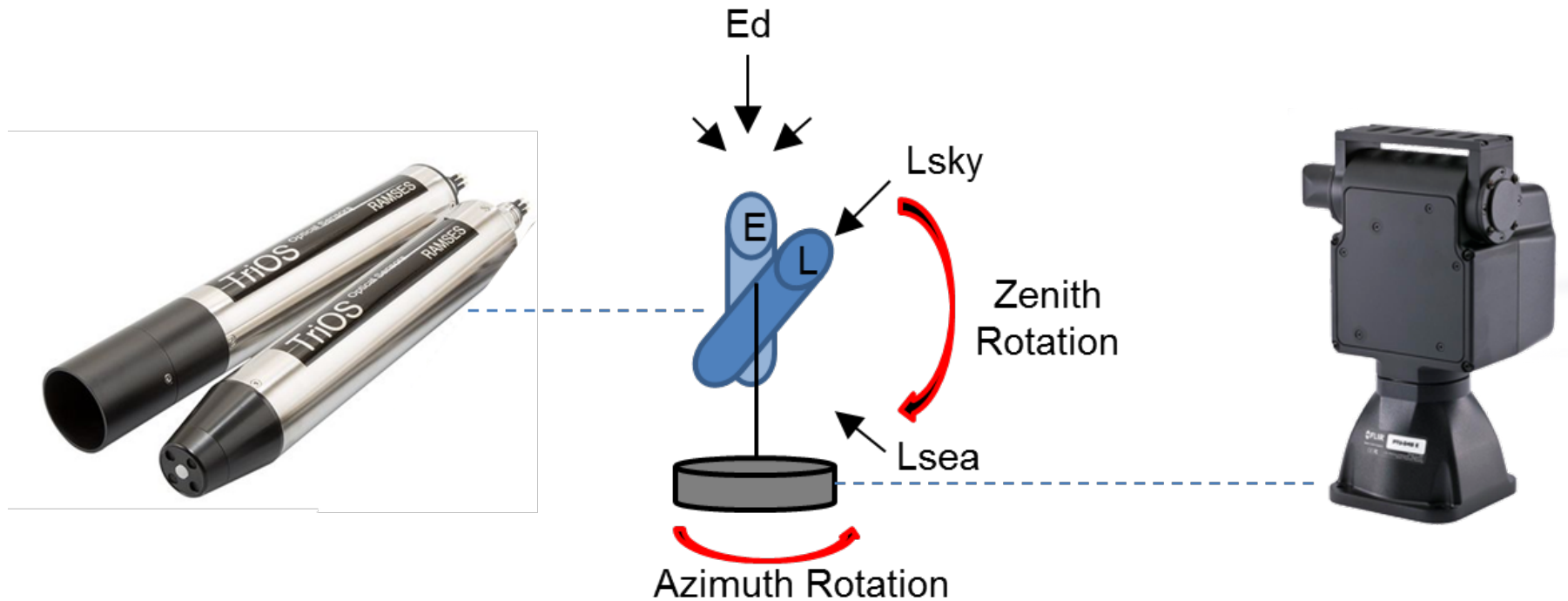
Pointing system reduces cost (2 sensors instead of 3), provides "parking" protection ... and possibility to explore multi-angle zenith/azimuth pointing scenarios

System design (low power, low cost controller; python open source data acquisition)
- Dieter's talk and demo at 12:15

Network concept

Validation Site operators

Similar functionality to NASA/AERONET network

Space Agencies & Validation entities

Site 1

Site 2

Site n

WATERHYPERNET
Data Processing,
Web Distribution and
Archiving facility

RBINS

Sentinel-3AB

Sentinel-2AB
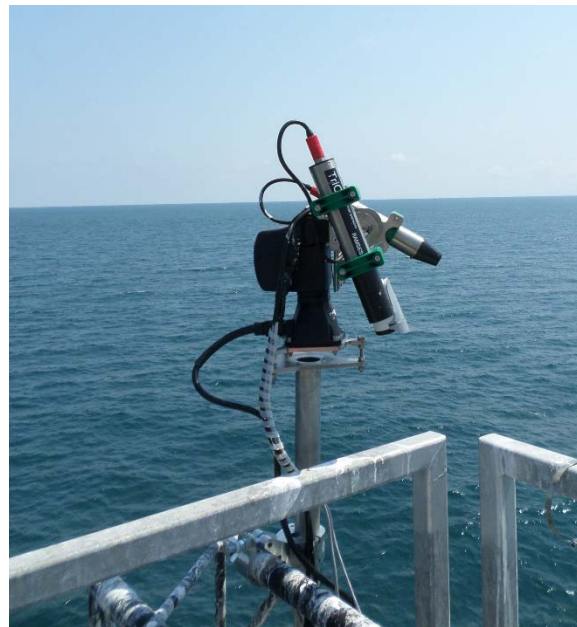
MODIS-A/T

VIIRS

PROBA-V

L8, Pléiades, etc.

Aqua Alta 2018 prototype testing (1/2)

- FRM4SOC Project field intercomparison exercise in July 2018 with 8 Validation Teams

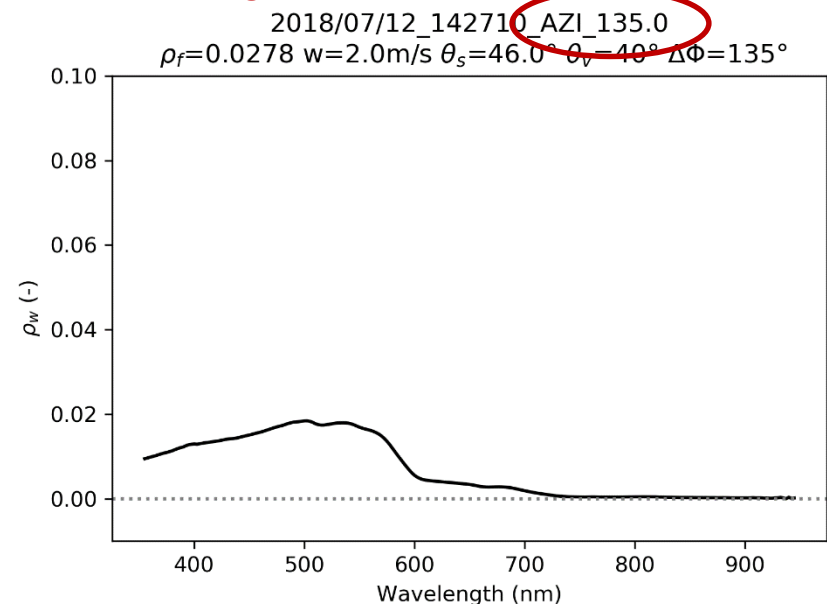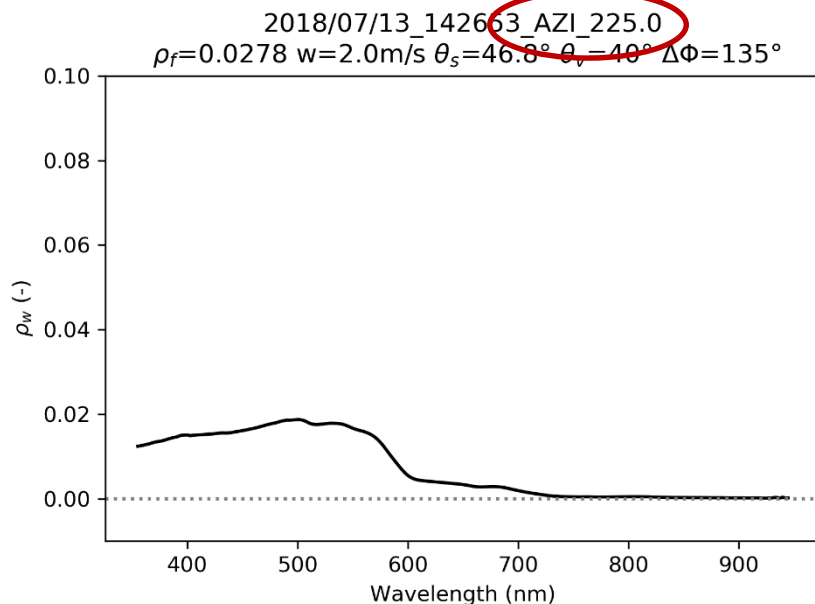(Chief scientist: PML, Gavin Tilstone)

Parked/Sleep position

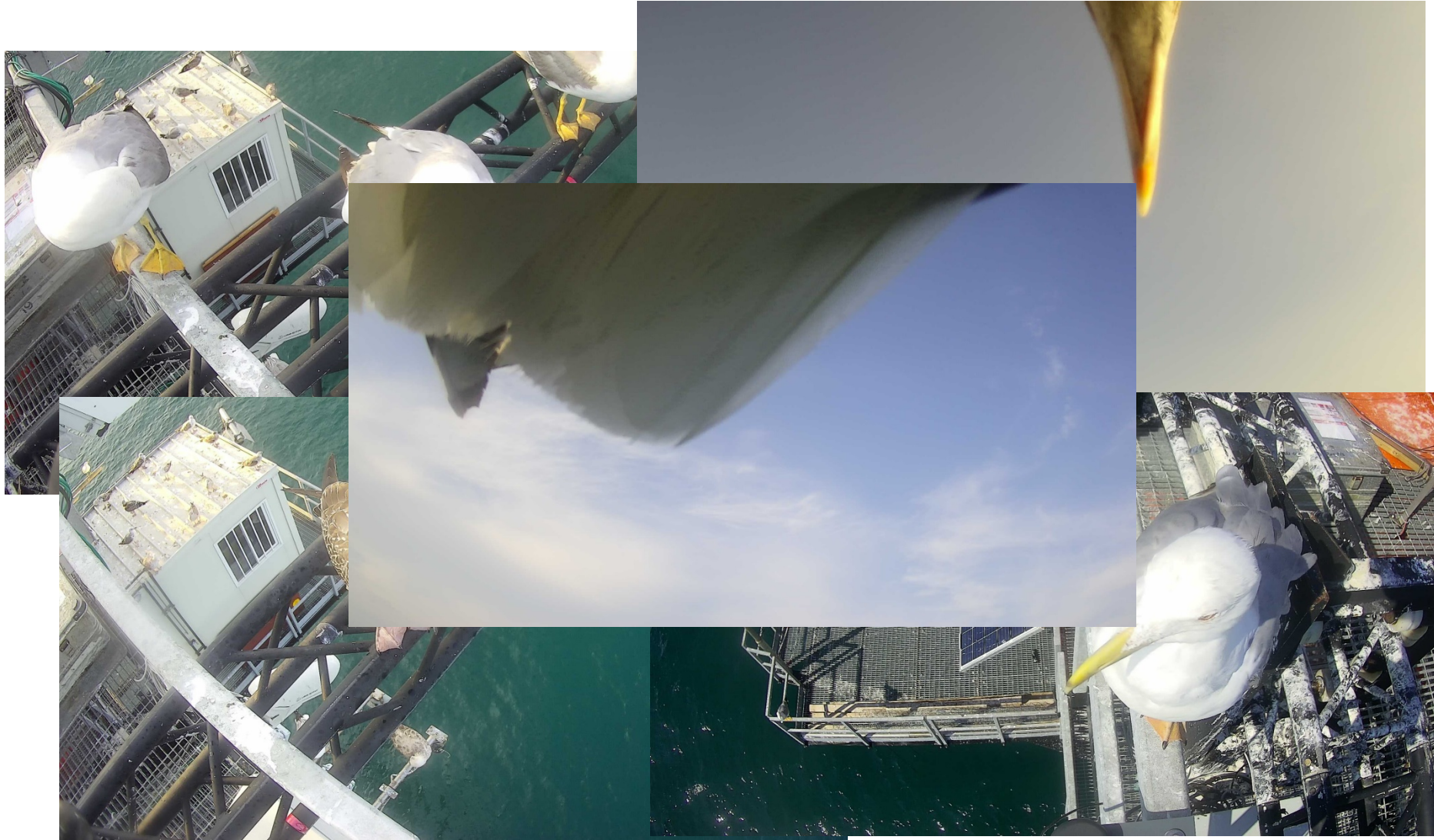Downwelling irradiance and sky radiance position

Aqua Alta 2018 prototype testing (2/2)

- Data processing and intercomparison in progress

- Some example water reflectance spectra … (looks like water)

Can measure at many zenith and azimuth angles…

2018/07/13_142653_AZI_225.0
ρ_f=0.0278 w=2.0m/s θ_s=46.8° θ_v=40° $\Delta\Phi$=135°

2018/07/12_142710_AZI_135.0
ρ_f=0.0278 w=2.0m/s θ_s=46.0° θ_v=40° $\Delta\Phi$=135°

Aqua Alta prototype testing - lessons learned

Conclusions

- Radiometric validation (L2 water reflectance) is essential for all aquatic products (CHL a, Suspended Particulate Matter, etc.)

- AERONET-OC (multispectral) is main source of satellite validation data, but does not cover all spectral bands

- WATERHYPERNET is being developed as federated network of coastal and inland water validation sites using:
  - Automated pointing system
  - Hyperspectral (TRIOS/RAMSES) radiometer

- Prototype tested July 2018, Aqua Alta Oceanographic Tower:
  - System functioned autonomously for full 7 day period
  - Data processing and intercomparison in progress looks good
  - Many lessons learned (including seagulls!)

- Belgium "and friends" (2019) and full International (2020) expansion planned

THE END