

Emerging New Technologies

Radiometric Validation

(abovewater)

by Kevin Ruddick (RBINS)

Including ideas from:

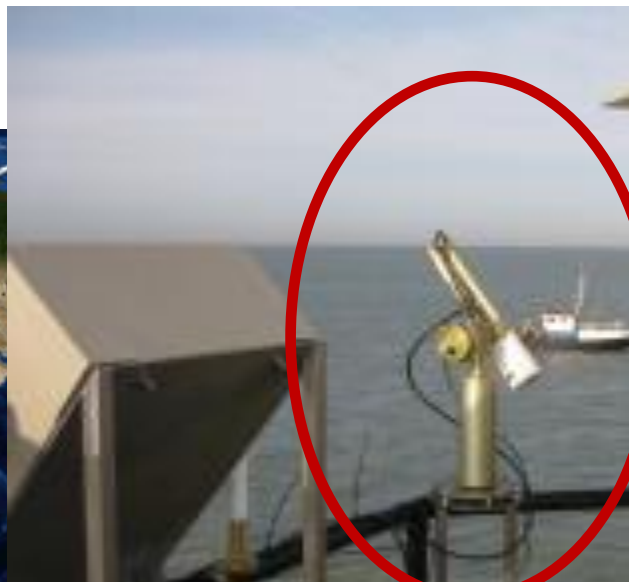
- VLIZ (Dieter Vansteenwegen, André Cattrijsse)
- RBINS (Quinten Vanhellemont, Matthew Beck, Clémence Goyens, Dimitry Van der Zande)

And H2020/HYPERNETS consortium:

- TARTU (Joel Kuusk, Riho Vendt et al)
- LOV (David Doxaran, Edouard Leymarie, Christophe Penkerc'h)
- CNR (Vittorio Brando et al), CONICET (Ana Dogliotti et al), NPL (Agnieska Bialek et al), GFZ (Daniel Spengler et al)

Radiometric Validation State of the Art: AERONET-OC

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



Mature, Operational, Used!

So what improvements are: a) needed? b) possible?



Blyth_NOAH (55N,1W)	Galata_Platform (43N,28E)	Gloria (44N,29E)
Gustav_Dalen_Tower (58N,17E)	leodo_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)

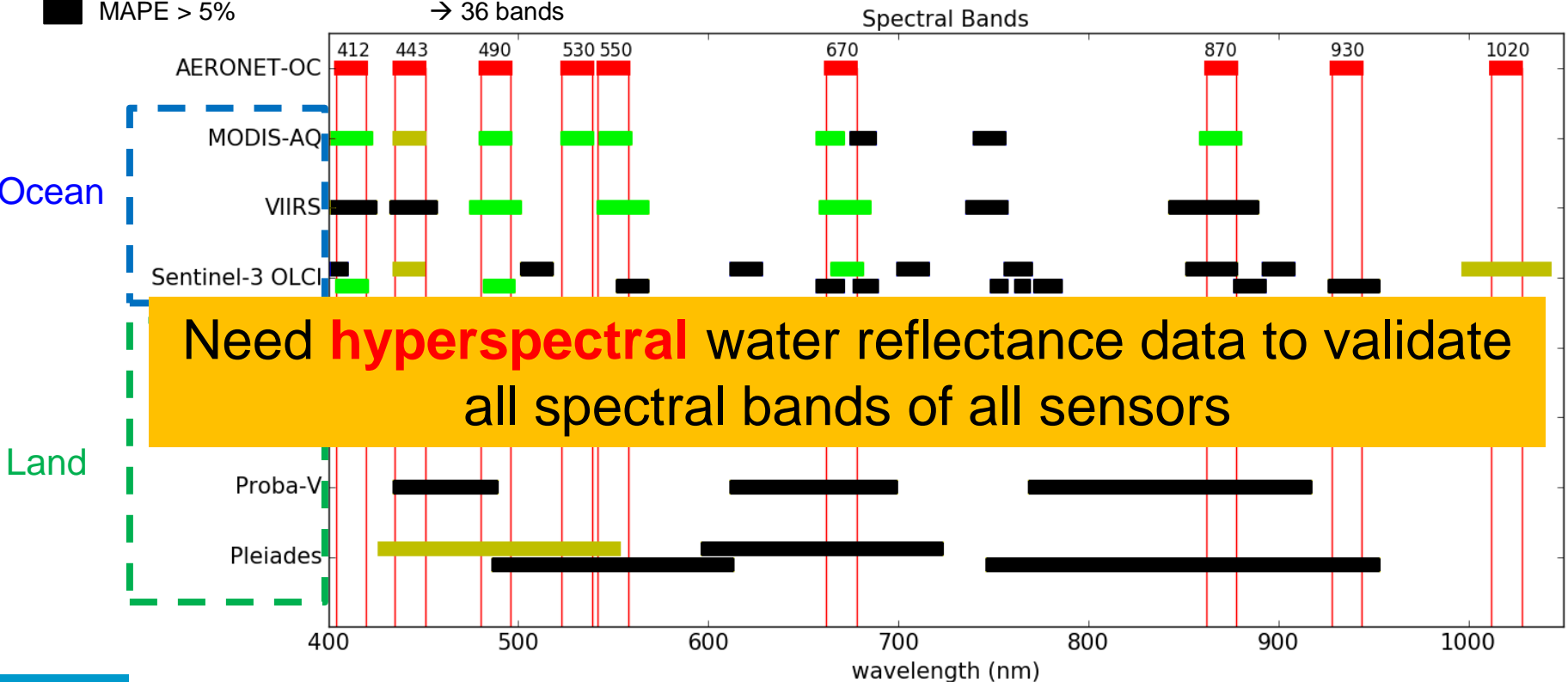
[aeronet.gsfc.nasa.gov]

Emerging Tech since 2013: Sat val needs

- 2013: ~~MERIS~~, MODIS, VIIRS, GOCI-1, SEVIRI, CHRIS-PROBA
- 2019: MODIS, VIIRS, Sentinel-3AB, Sentinel-2AB, Landsat-8, PRISMA, Pléiades, PlanetScope/Doves, HY-1ABC, S-GLI, CHRIS-PROBA, ...
- Near future: ENMAP, MTG, GOCI-2 ... CHIME, PACE, Sentinel-3CD, Sentinel-2CD, HY-1DEF, ...

- MAPE < 3% → 12 bands
- 3% < MAPE < 5% → 8 bands
- MAPE > 5% → 36 bands

[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]



Emerging Tech since 2013: Measurement systems

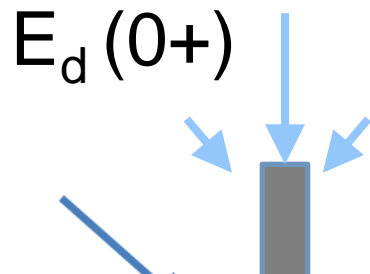
- Spectrometer cost+size improvements (use in other industries)
 - BUT beware thermal sensitivity, straylight, nonlinearity, etc.
- Hyperspectral imaging cameras
- COTS pointing systems cost reduction (video surveillance!)
- Data transmission speed and cost (4G ...)
- Robust PC cost+power reduction
- Stable LED light sources (cal monitoring)
 - BUT beware thermal sensitivity

New components => potential for new measurement systems

[NASA/TM–2010–215856. "Advances in Measuring the Apparent Optical Properties (AOPs) of Optically Complex Waters" by J.H.Morrow et al.]

Emerging Tech since 2013: abovewater radiometry

- Main challenge for abovewater radiometry is **removal of skylint, L_r**



Baseline model: $L_r = \rho_F(\text{Wind}) * L_{\text{sky}}$

[Mobley, 1999]

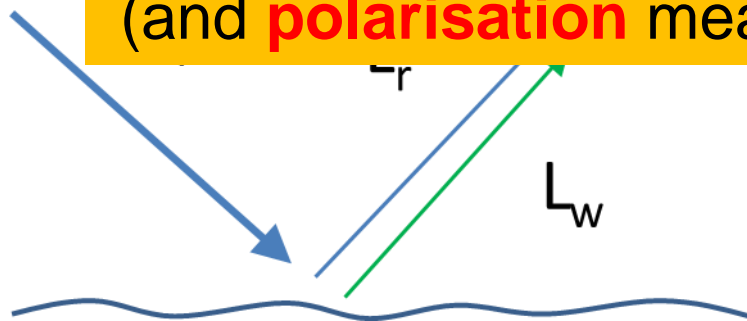
With time-filtering of $L_u = L_r + L_w$

E.g. [Hooker et al, 2002]

And possible NIR residual corrections

E.g. [Morel, 1980; Ruddick et al, 2006]

It could be useful to make **L_u and L_{sky} measurements at more angles to characterize sky and waves** (and **polarisation** measurements could also be useful)



AND New modelling approaches

[Simis, 2013; Groetsch, 2017]

- Waves not Cox-Munk (e.g. fetch-limited/inland waters)
- L_r not just from one L_{sky} direction
- L_r contains sunlint flashes with different spectrum from L_{sky}

[Zhang, 2017]

WATERHYPERNET network concept

Validation Site operators

(similar functionality to NASA/JRC AERONET-OC network but hyperspectral)

Space Agencies & Validation entities

Site 1

Site 2

Site n

RBINS

WATERHYPERNET
Data Processing,
Web Distribution and
Archiving facility

Radiometer calibration
and characterisation

Sentinel-3AB

Sentinel-2AB

MODIS-A/T

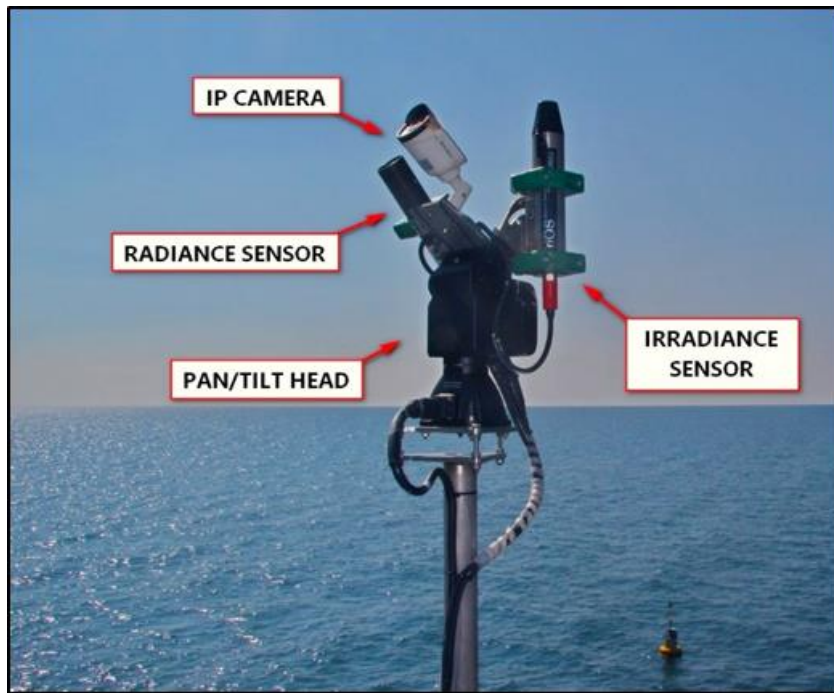
VIIRS

PROBA-V

L8, Pléiades, etc.

WATERHYPERNET measurement systems

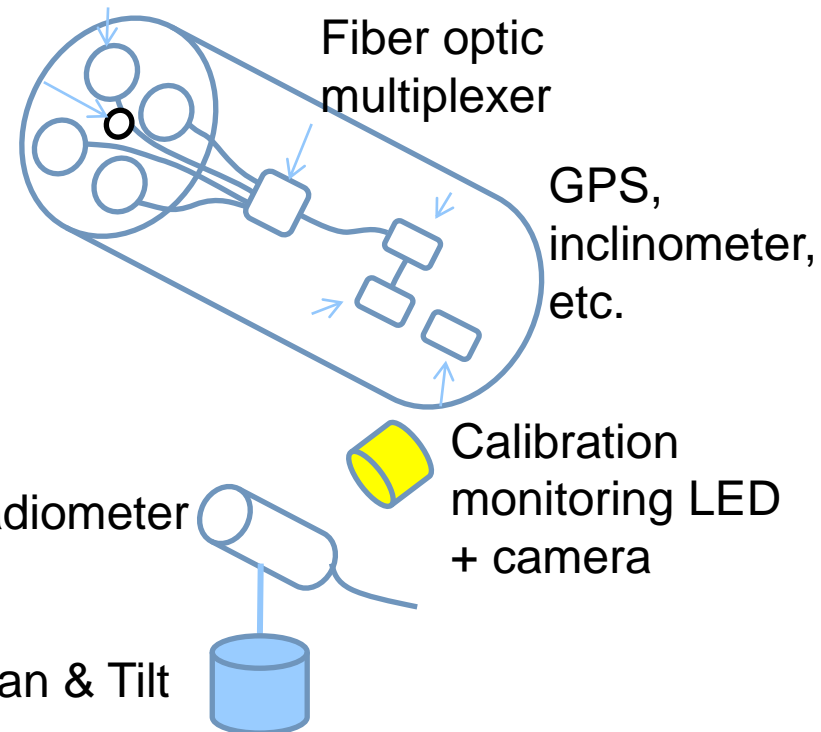
Existing TRIOS radiometer (2000)
New "PANTHYR" system (2018)



[D. Vansteenwegen et al, "The pan-and-tilt hyperspectral radiometer system (PANTHYR) for autonomous satellite validation measurements – prototype design and testing", in prep.]

New radiometer (2020)
New system (2020)

Multiplexed multi-head foreoptics
(radiance, irradiance, optional polarized radiance, etc) + Camera



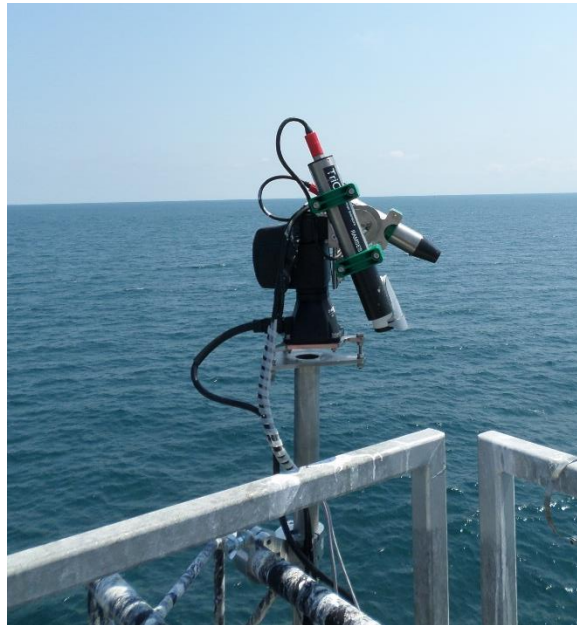
[H2020/HYPERNETS consortium: RBINS, TARTU, LOV, GFZ, CNR, NPL, CONICET]

Acqua Alta 2018 prototype testing

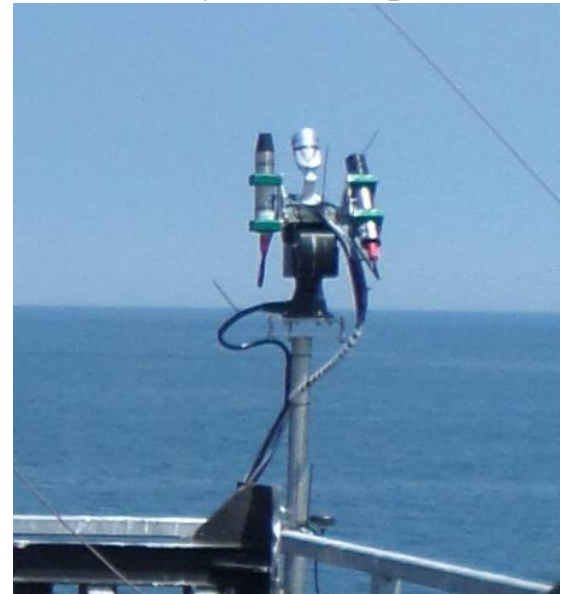
- FRM4SOC Project field intercomparison exercise in July 2018 with 8 Validation Teams
(Chief scientist: PML, Gavin Tilstone)



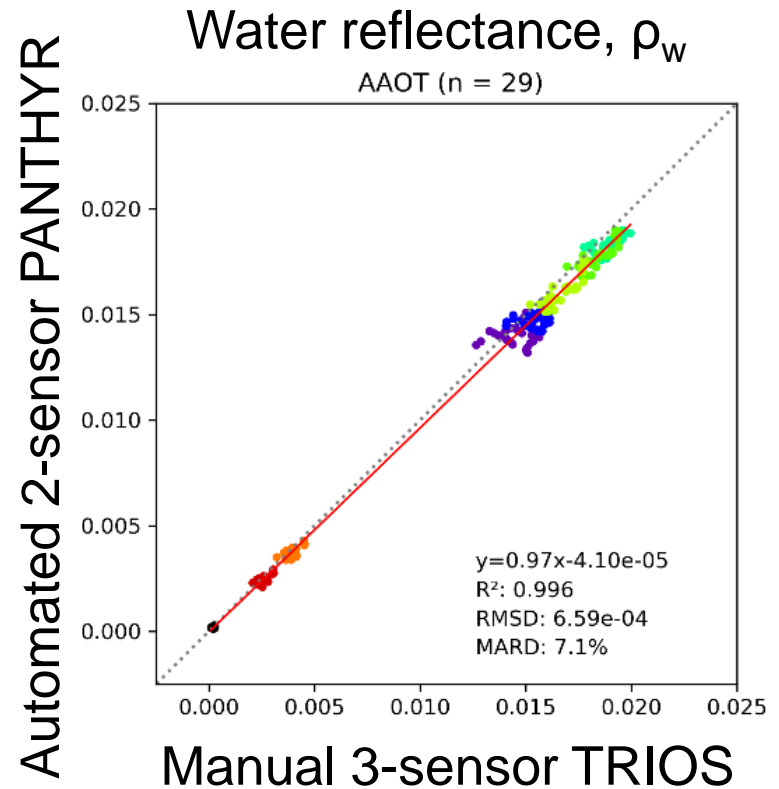
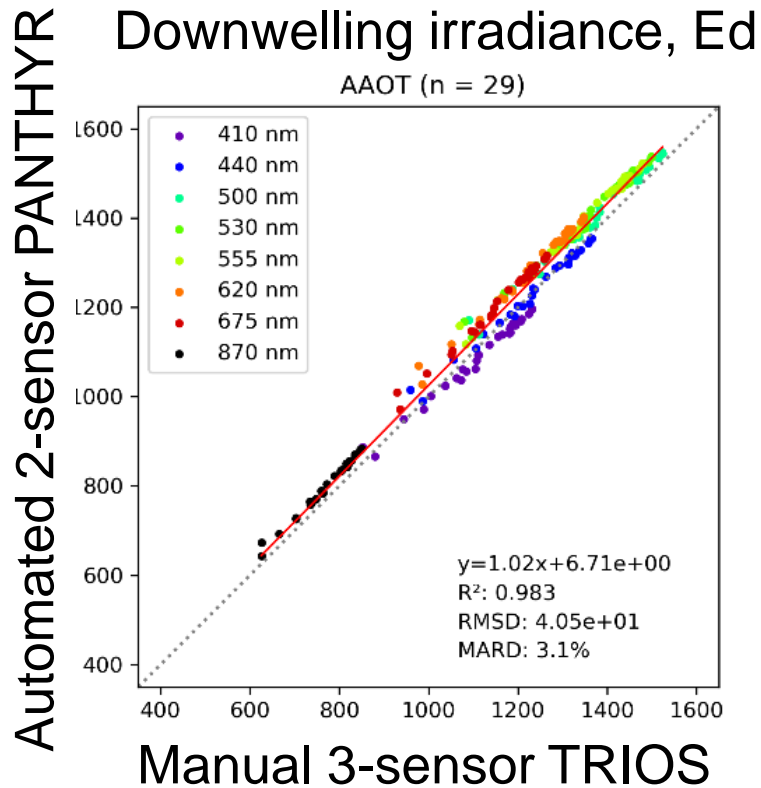
Parked/Sleep position



Downwelling irradiance
and sky radiance position



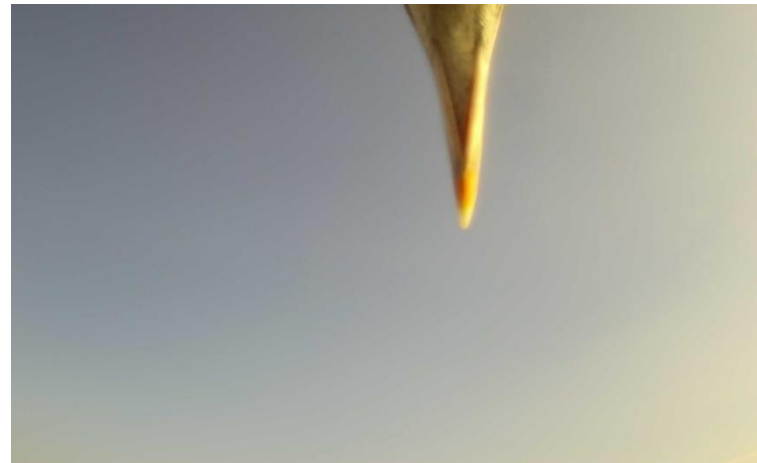
Prototype testing Acqua Alta July 2018 (6 days, 29 stations)



- Hardware is robust and functional, Data quality excellent
- Radiometer calibration and characterization is v important

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 radiometers: 1. TRIOS/RAMSES and 2. New "H2020/HYPERNETS"
- Prototype tested successfully July 2018, Acqua Alta [Poster 89]
- Imaging camera is quite useful



Abovewater radiometry - for discussion

- How to improve skylint correction?
 - Multi-angle sky measurements at more angles
 - Multi-angle water measurements (waves!)
 - Imaging cameras to characterize waves
 - Polarisation measurements [Poster 27, Gilerson]
 - **Modelling**
 - Combine fast (multispectral) and slow (hyperspectral)
- How to improve radiometers?
 - Calibration and **characterization monitoring**
 - Dealing with **thermal sensitivity, straylight, non-linearity, angular (cosine) response**, etc.

THE END