Radiometric validation of metre-scale optical imaging missions

Presenter: Kevin RUDDICK (RBINS)

(future-proof terminology, does anyone remember the 1km A**VHR**R and what the acronym means?)

- Part 1: metre-scale optical missions

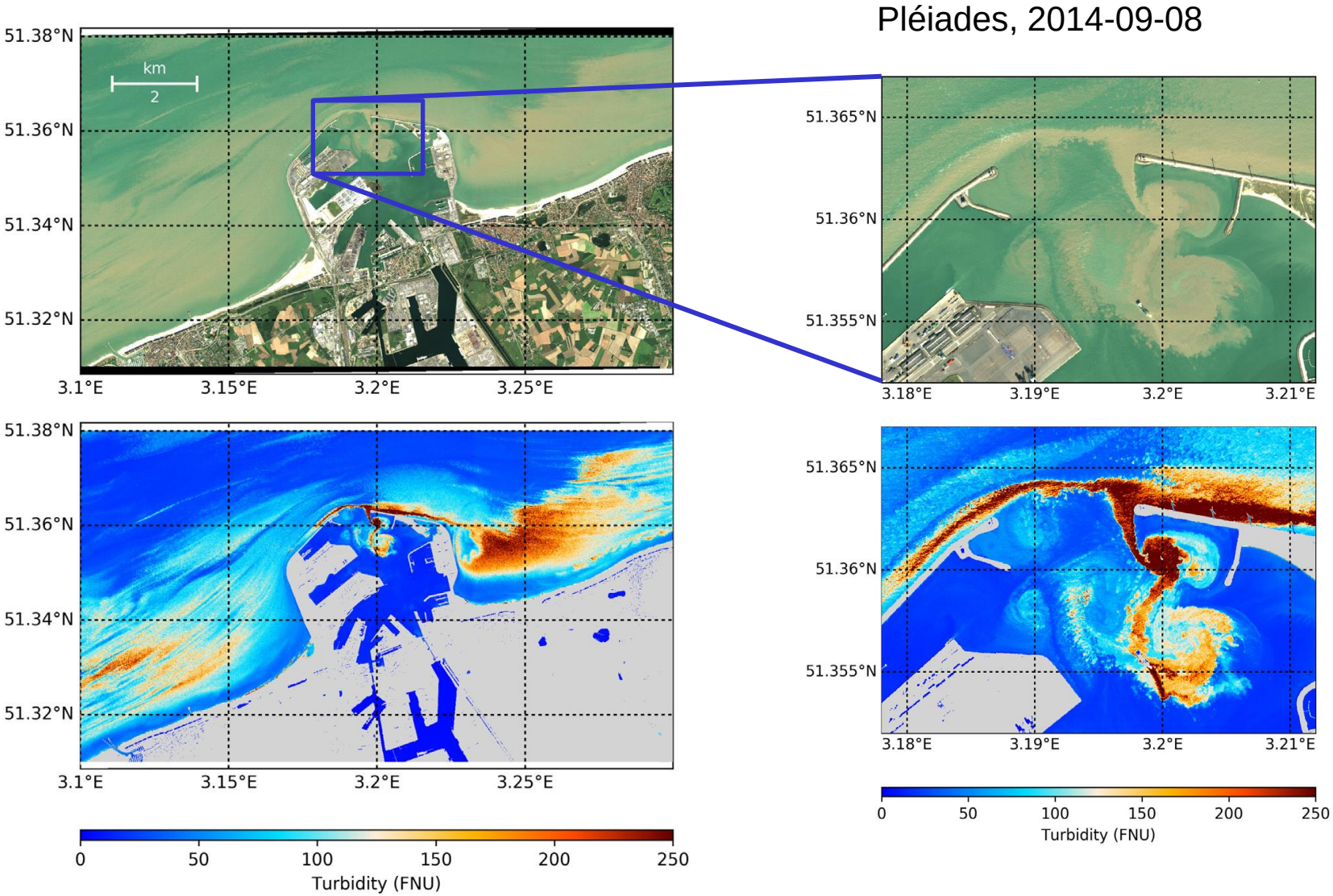
(application potential, atmospheric correction ... need for validation)

by Quinten Vanhellemont and Kevin Ruddick (RBINS) with data from sites run by VLIZ (Dieter Vansteenwegen) and CNR (Vittorio Brando)

- Part 2: HYPERNETS validation network

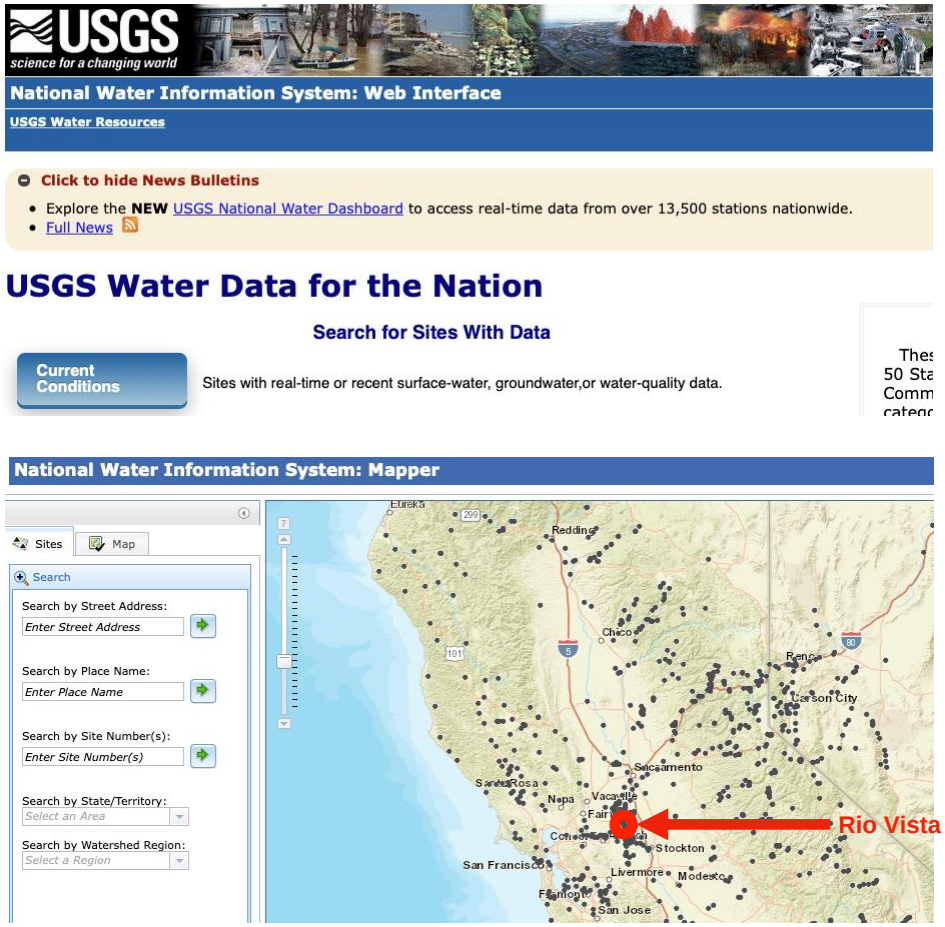
by RBINS, TARTU, LOV, NPL, CNR, GFZ and CONICET

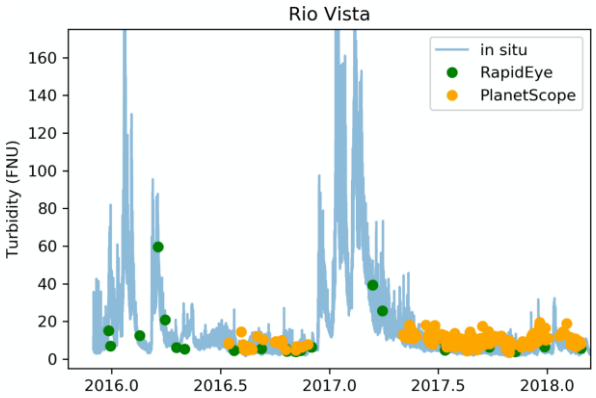
Port of Zeebrugge: tidal inflow of sediments+dredging

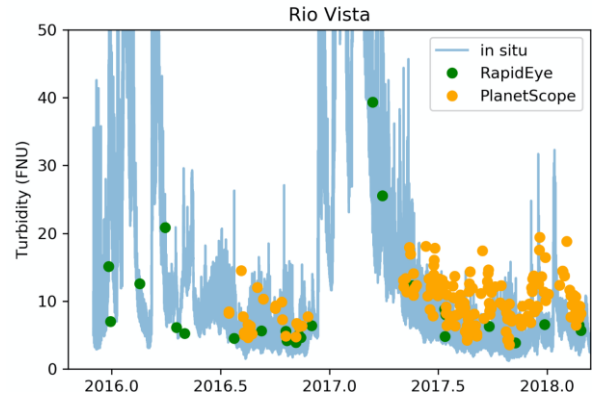


[Vanhellemont & Ruddick (2018) https://doi.org/10.1016/j.rse.2018.07.015
Atmospheric correction of metre-scale optical satellite data for inland and coastal water applications]

USGS Water Data 2016—2018







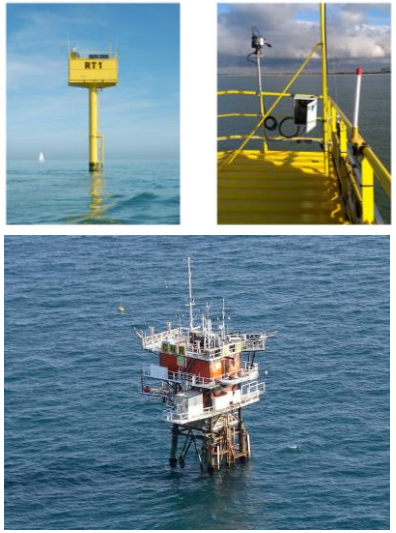
Interoperability!
For larger site add S2, L8, OLCI, ...

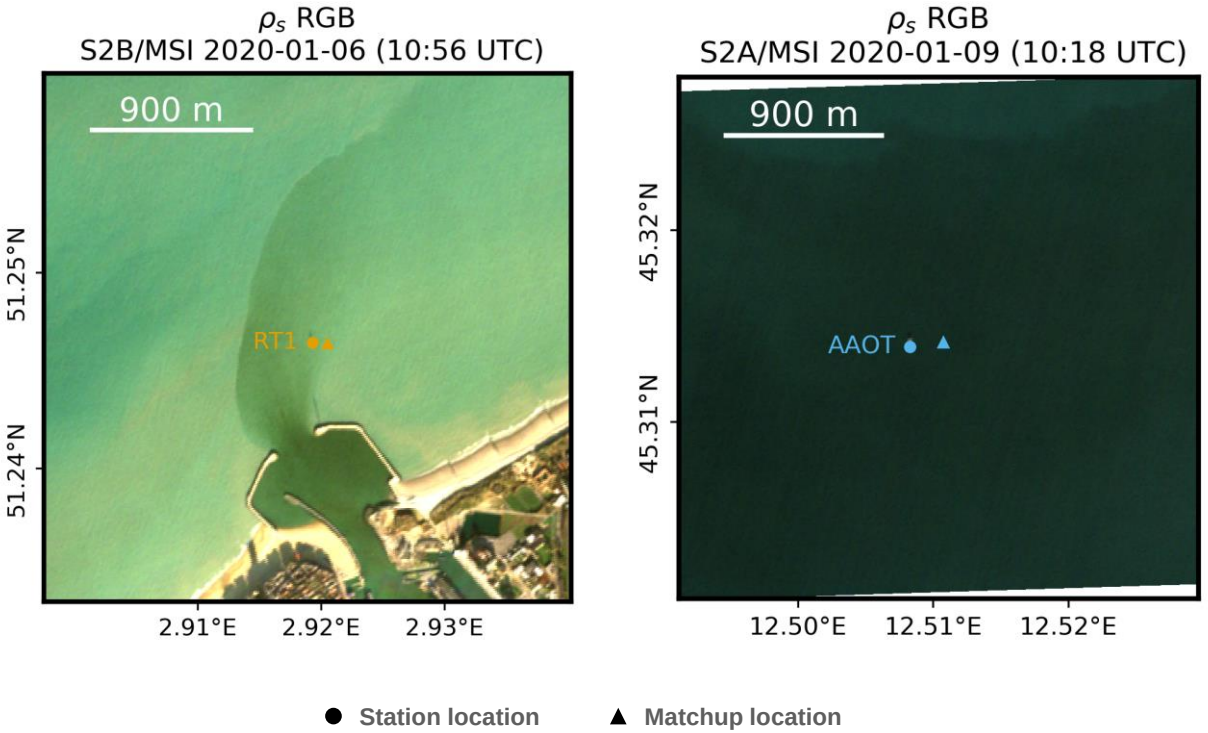
Vanhellemont (2019) https://doi.org/10.1364/OE.27.0A1372

Daily metre-scale mapping of water turbidity using CubeSat imagery

Validation with 2019-2020
PANTHYR data from two sites

RT1 Oostende, Belgium (VLIZ)
AAOT Venice, Italy (CNR)





[Vanhellemont (2020) https://doi.org/10.1364/OE.397456
Sensitivity analysis of the dark spectrum fitting atmospheric correction for metre- and decametre-scale satellite imagery using autonomous hyperspectral radiometry]

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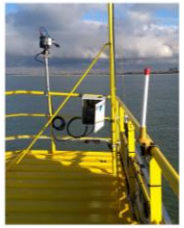
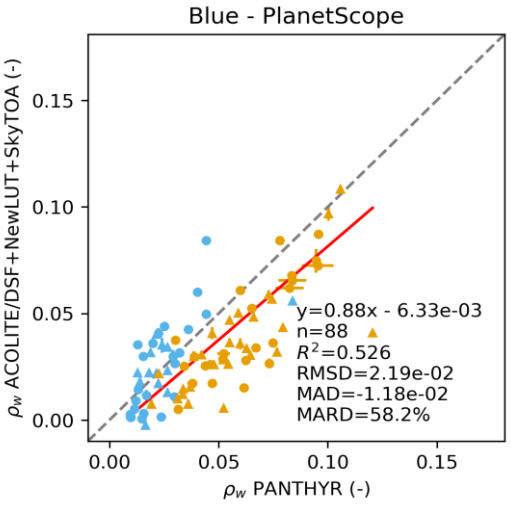
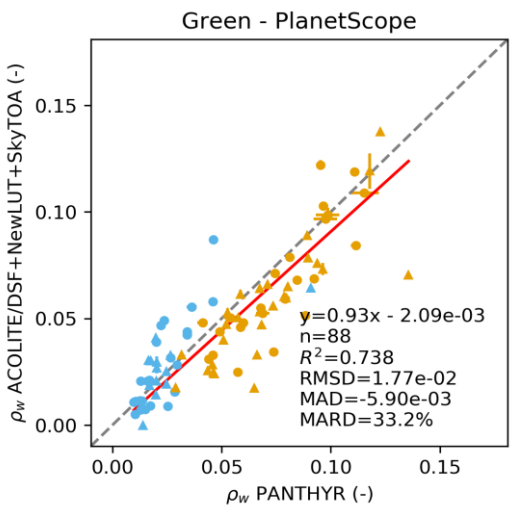
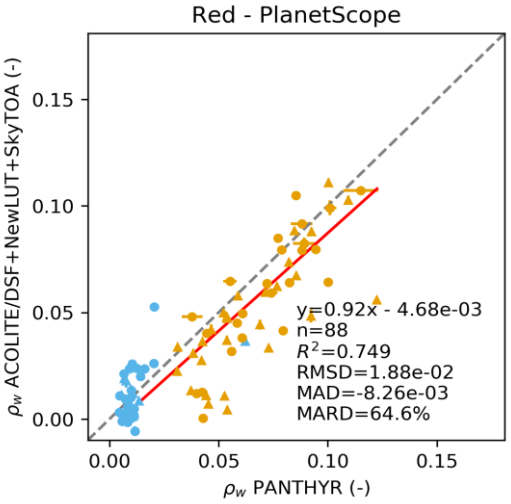
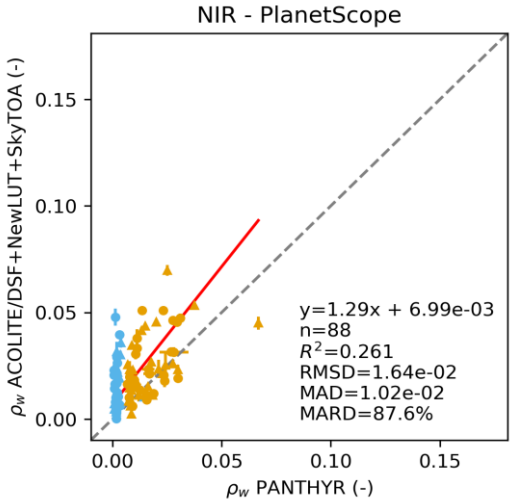










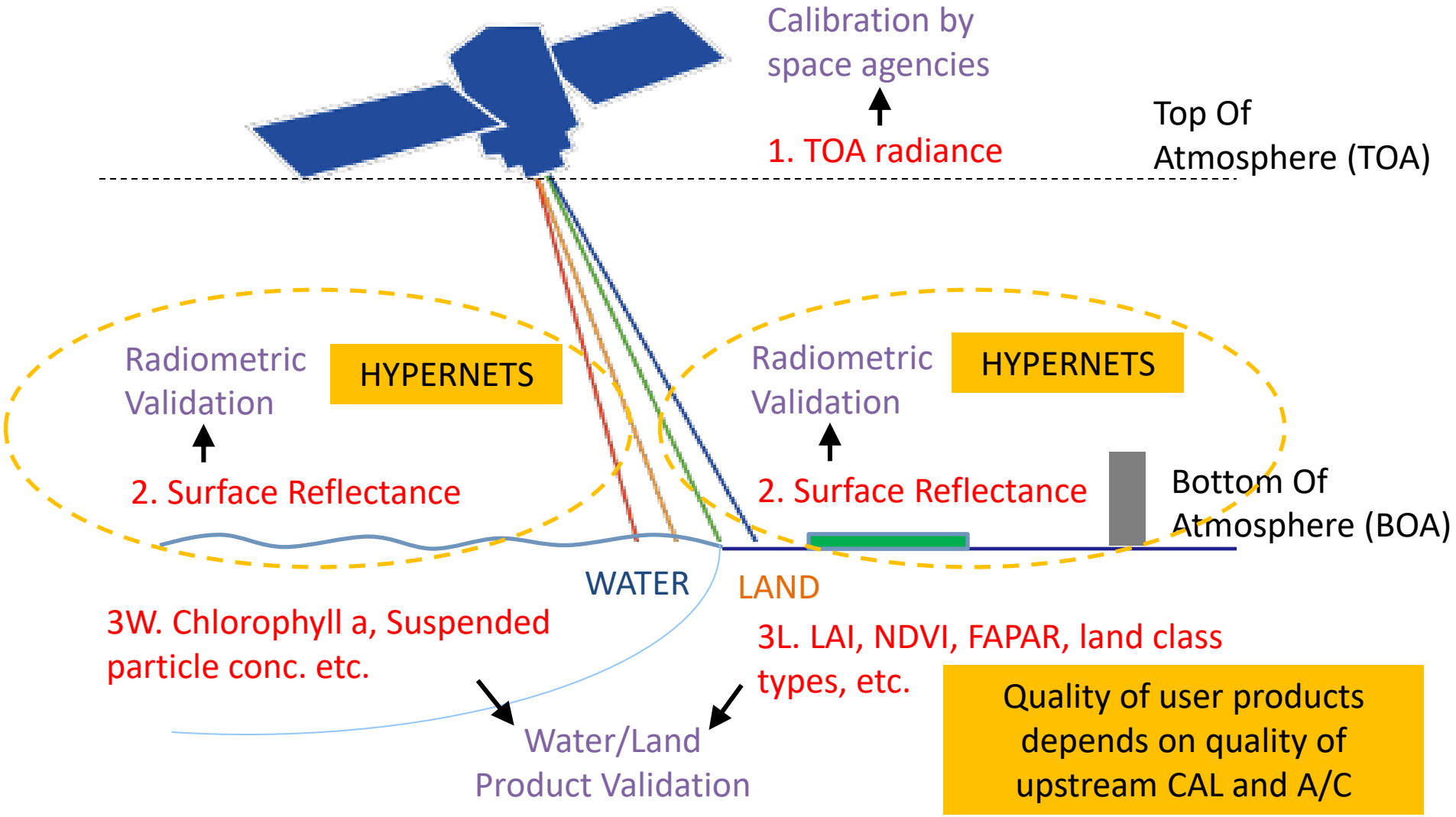
88 matchups
52 different satellites

52 RT1
36 AAOT

Interoperability?
Red+Green usable for turbidity (not NIR)

[Vanhellemont (2020) https://doi.org/10.1364/OE.397456
Sensitivity analysis of the dark spectrum fitting atmospheric correction for metre- and decametre-scale satellite imagery using autonomous hyperspectral radiometry]

Motivation for water and land surface reflectance



The Motivation for land surface reflectance

RBINS Lesson learned from ENVISAT/MERIS and ACIX-1...-2 :

- To compare atmospheric correction algorithm performance need surface reflectance data
- Modelling atmospheric path reflectance from AERONET aerosol measurements is not enough.

Surface reflectance ESSENTIAL (aerosols "nice to have")

[Morton et al, Nature, 2014]

LETTER

doi:10.1038/nature13006

Amazon forests maintain consistent canopy structure and greenness during the dry season

Douglas C. Morton[1], Jyoteshwar Nagol[2,3], Claudia C. Carabajal[1,4], Jacqueline Rosette[1,2,5], Michael Palace[6], Bruce D. Cook[1], Eric F. Vermote[1], David J. Harding[1] & Peter R. J. North[5]

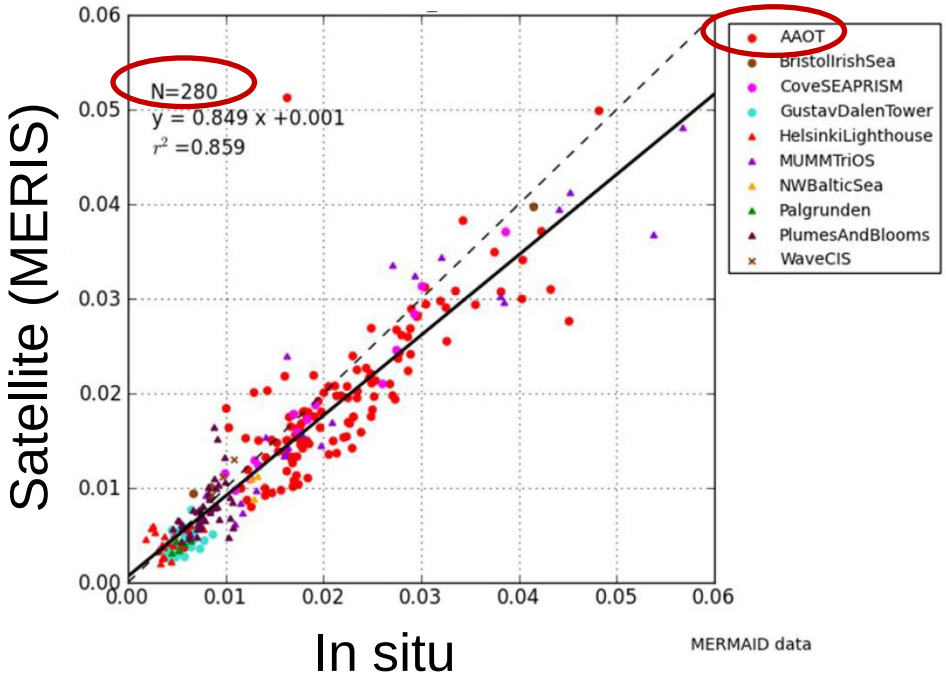
"Correcting optical remote sensing data for artefacts of sun-sensor geometry is essential to isolate the response of global vegetation to seasonal and interannual climate variability."

Need multiple sun/viewing geometries to develop and validate HDRF models

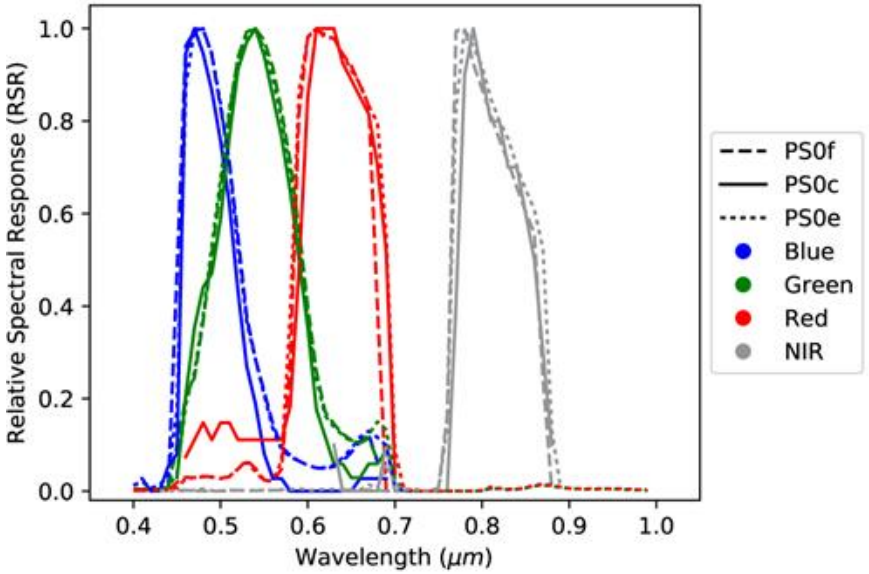
The Motivation for automated hyperspectral

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

Water reflectance 490nm



Planetscope spectral response



Validation Data acquisition must be **AUTOMATED**

[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

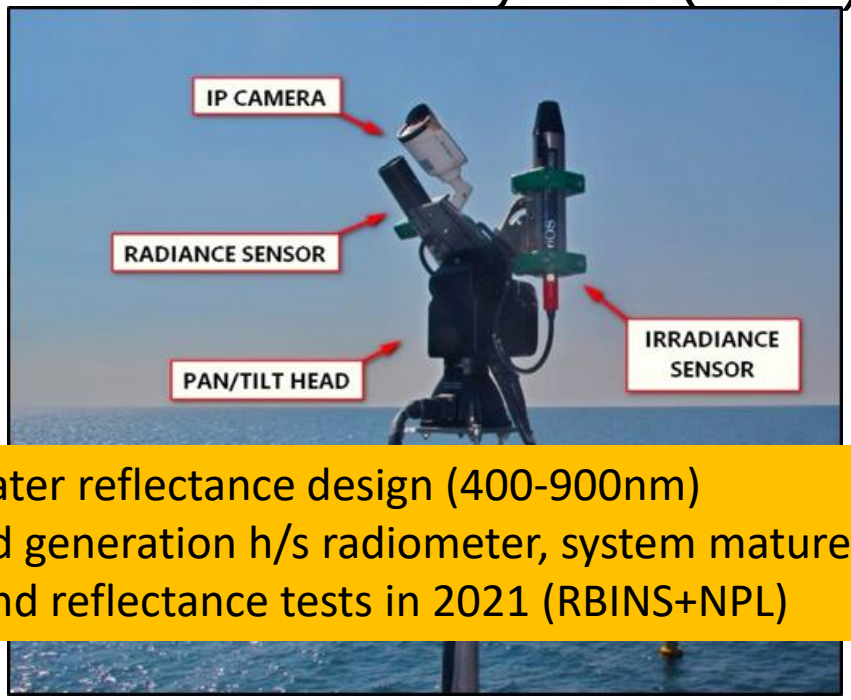
Instrument must be **HYPERSPECTRAL**

[Vanhellemont & Ruddick (2018) https://doi.org/10.1016/j.rse.2018.07.015 Atmospheric correction of metre-scale optical satellite data for inland and coastal water applications]

Radiometer instruments - status

(requirement: radiometer must be mounted on pan-tilt for full zenith- and azimuth-pointing)

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

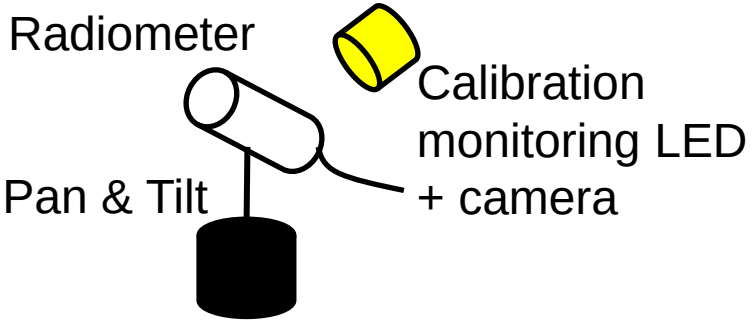


Water reflectance design (400-900nm)
Old generation h/s radiometer, system mature
Land reflectance tests in 2021 (RBINS+NPL)

[D. Vansteenwegen et al, "The pan-and-tilt hyperspectral radiometer system (PANTHYR) for autonomous satellite validation measurements – prototype design and testing", Rem Sens, 2019]

New HYPSTAR® radiometer [TARTU] + pan-tilt sys [LOV]

Land radiometer design has 380-1680nm
New generation h/s radiometer
1st field tests 2021, commercial 2023



Preparation of Next Generation Hyperspectral Radiometric Validation Networks for Water and Land Surface Reflectance - the HYPERNETS project

presented by Kevin Ruddick (RBINS)

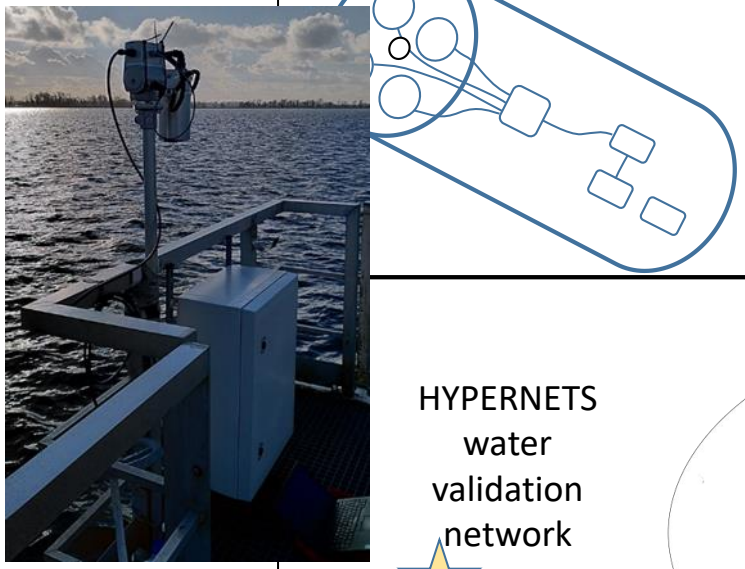
H2020/HYPERNETS

Joel Kuusk, Agnieszka Bialek, Matthew Beck, Vittorio Brando, Javier Concha, Alexandre Corizzi, Pieter de Vis, Ana Dogliotti, David Doxaran, Claudia Giardino, Clémence Goyens, Francisco Grings, Sam Hunt, Kaspars Laizans, Edouard Leymarie, Chris MacLellan, Niall Origo, Christophe Penkerc'h, Pablo Perna, Estefania Piegari, Lucas Rubinstein, Mehdi Saberioon, Morven Sinclair, Daniel Spengler, Quinten Vanhellemont

The HYPERNETS project is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No 775983.
This communication represents only the authors' views. The European Union is not liable for any use that may be made of the information contained therein.

The H2020/HYPERNETS project

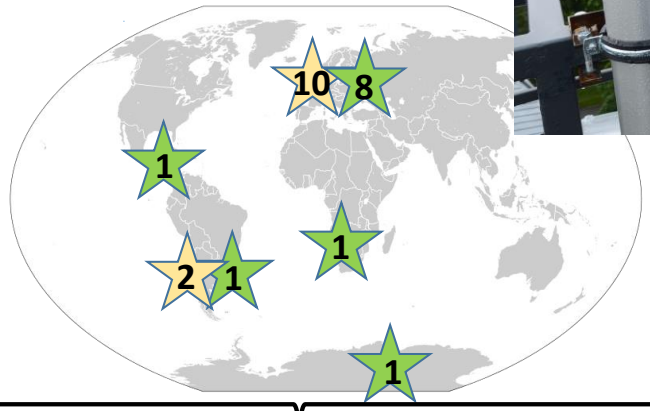
HYPERNETS multi-head hyperspectral Radiometer



HYPERNETS Autonomous System

Radi . Calibration

HYPERNETS water validation network



validation network

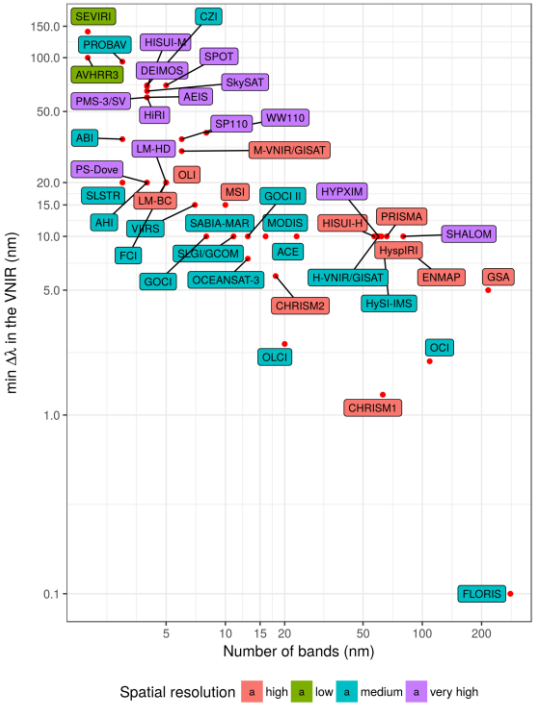
Validation of surface reflectance at all spectral bands of all optical missions inc. Sentinel-2A&B, Sentinel-3A&B, MODIS-A&T, VIIRS, Landsat-8, Pléiades-2A&B, PROBA-V, CHRIS, ENMAP, PRISMA, SABIAMAR, etc. ... + nanosats

[HYPERNETS Proposal, 2017]

[2020 update]
+PlanetDoves
+CHIME
+PACE
+...

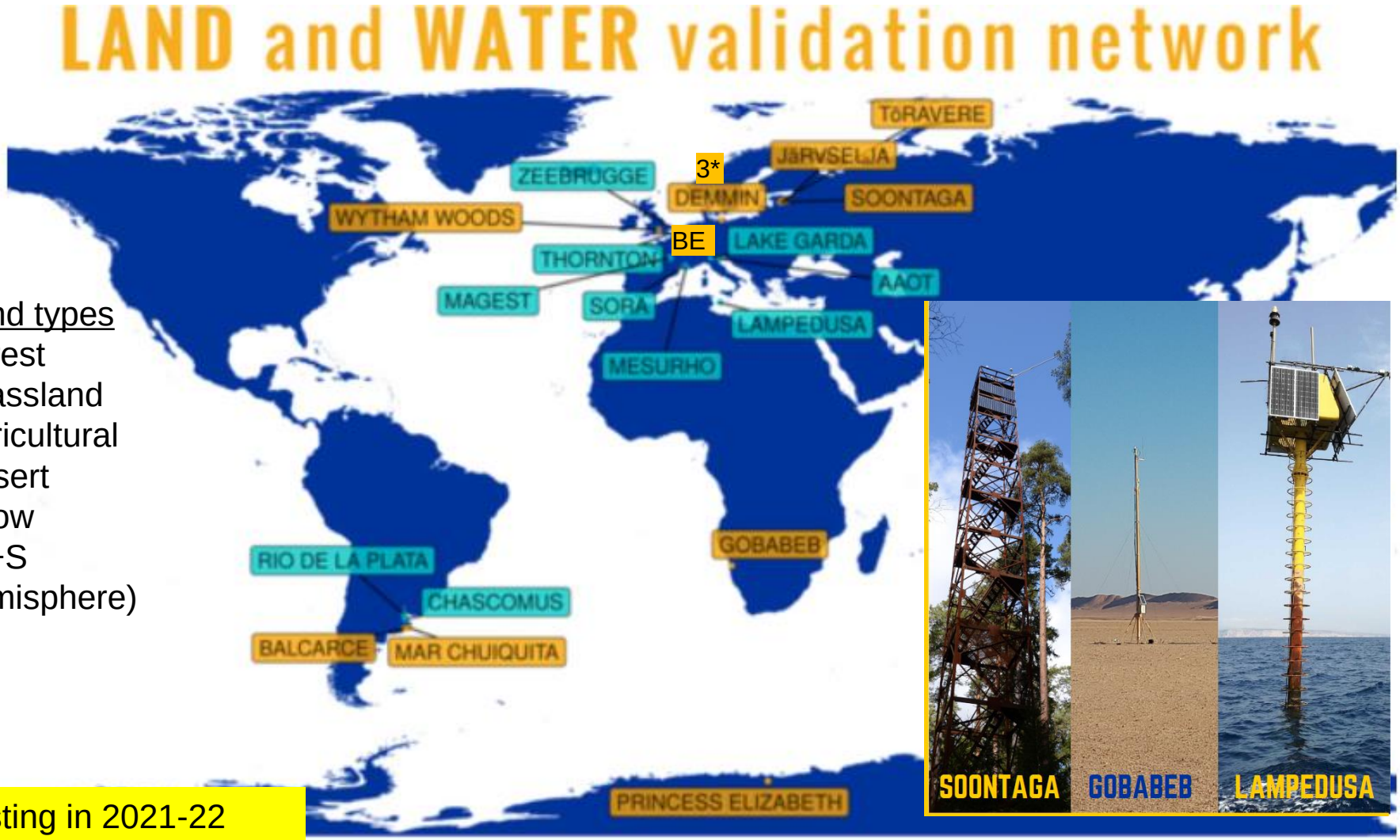
User data requirements - water+land

- Strong need for in situ measurements to validate surface reflectance:
  - VISNIR: 380-1020nm at 5nm (or 1nm!)
  - SWIR: 1000-2500nm at 5-10nm (we had to compromise -1700nm)
  - Temporal: Every ~10-30 minutes during daylight (if no power limit)
  - Spatial/angular:
    LAND: Nadir+"full" nadir/azi up to 60°zen
    WATER: 40° water/sky radiance, azi 90/135°
  - + hemispherical and target cameras
  - Direct/diffuse irradiance ratio
  - Aerosols?



[Goyens et al (2018). Spectral Requirements for the Development of a New Hyperspectral Radiometer Integrated in Automated Networks - the Hypernets Sensor. 1-5. 10.1109/WHISPERS.2018.8747259.]

Validation Test sites

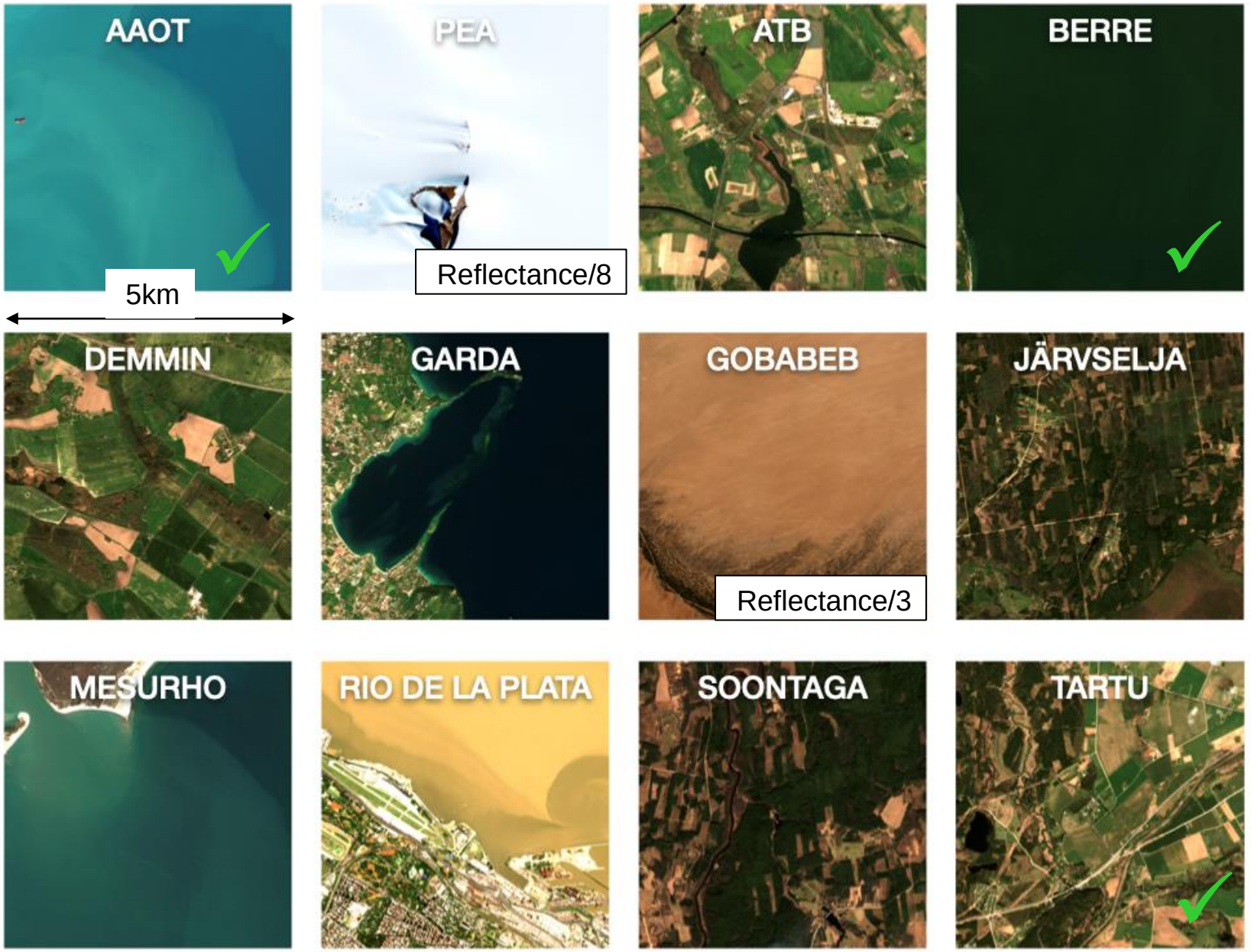


Land types
Forest
Grassland
Agricultural
Desert
Snow
(N+S hemisphere)

Testing in 2021-22

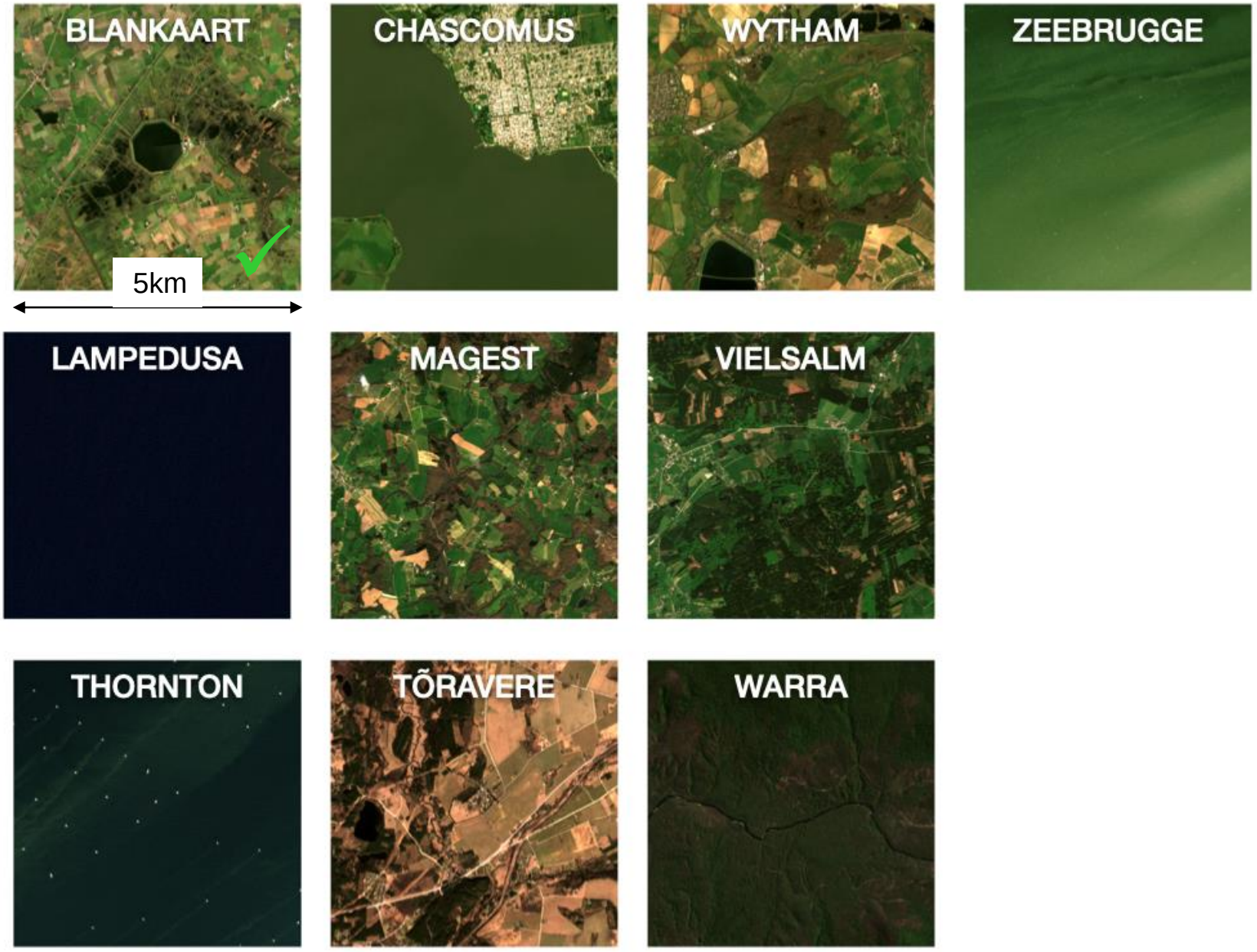
Sentinel-2 imagery of test sites (1/2)

[S2 Data from ESA/EU]



Sentinel-2 imagery of test sites (2/2)

[S2 Data from ESA/EU]



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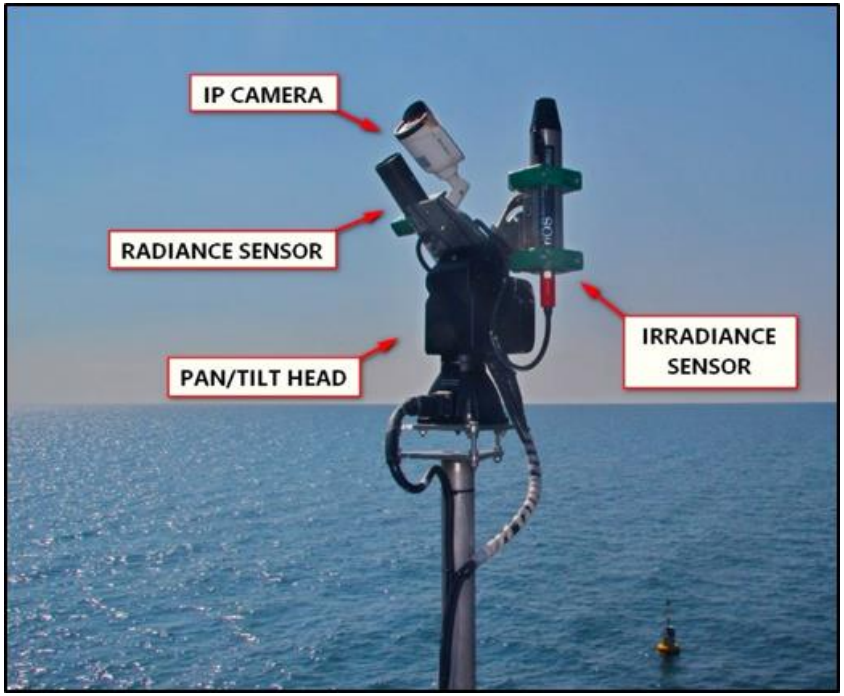

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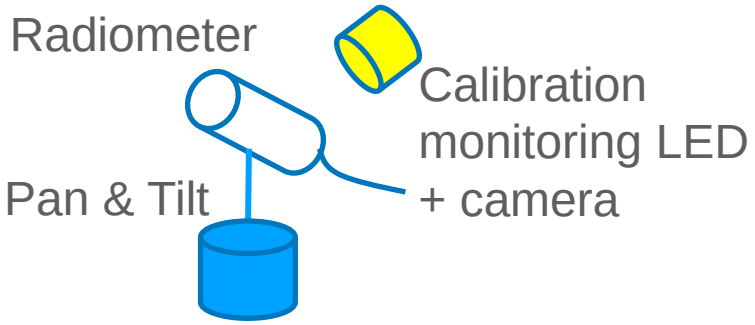
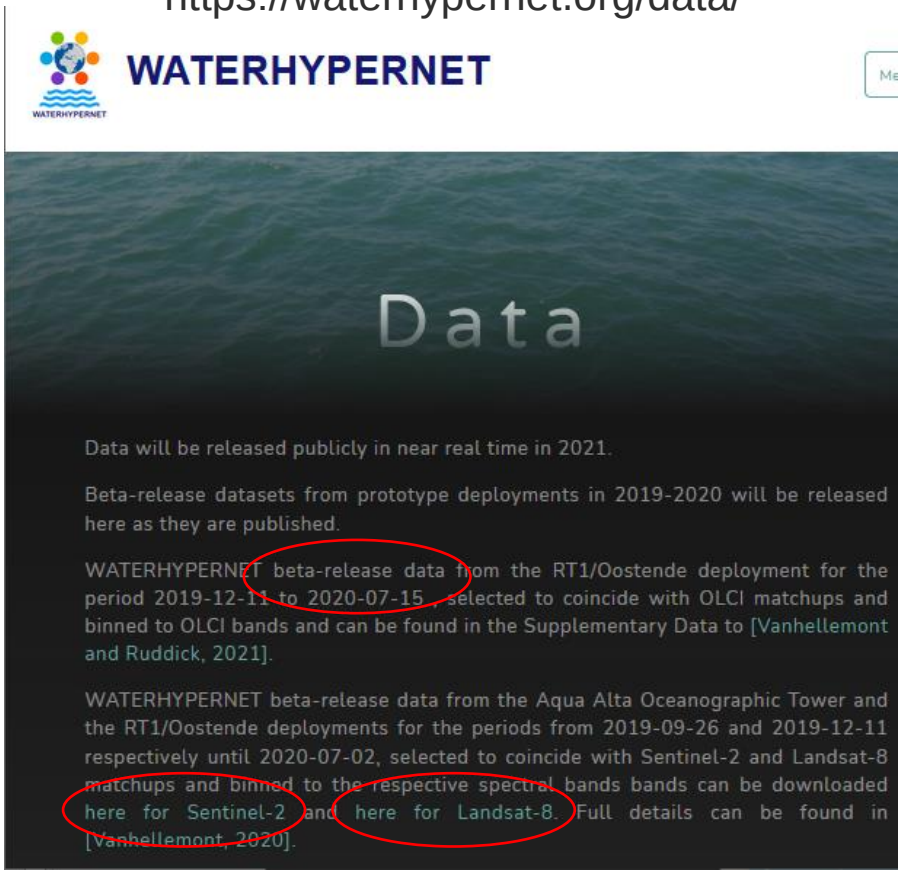


[Project proposal, 2017]

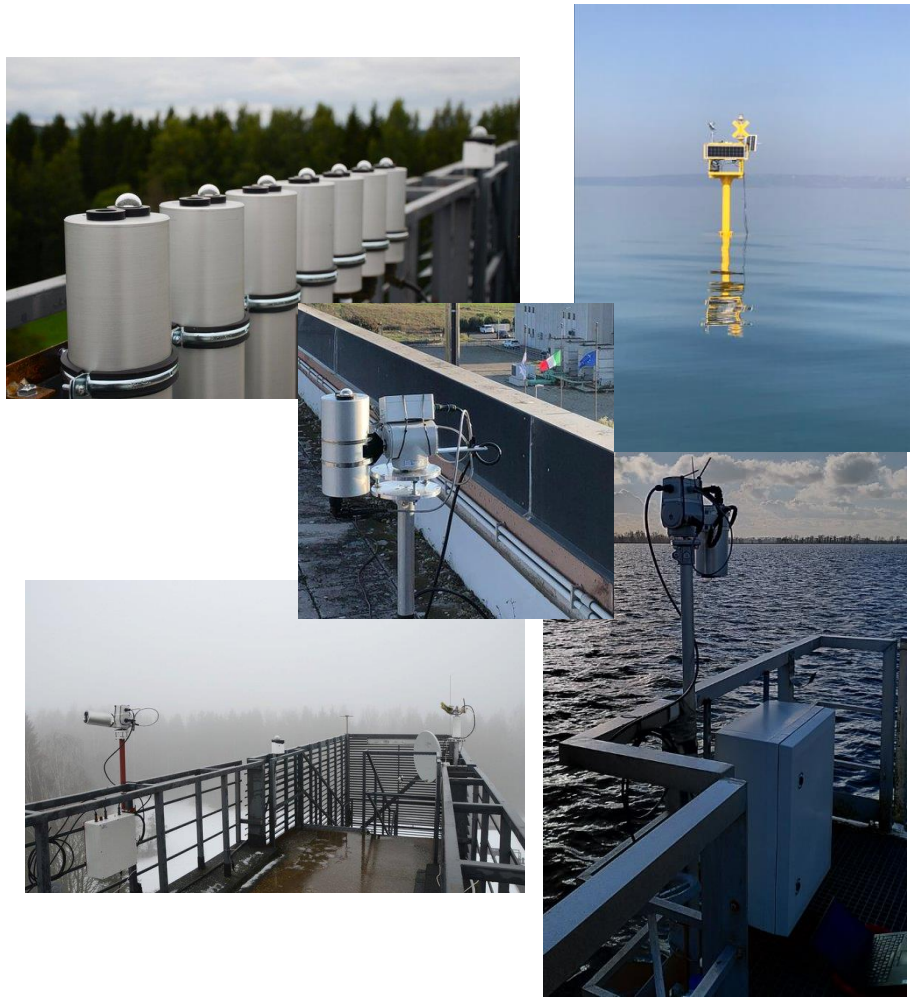
Exciting times...

OLCI, L8 and S2 matchup datasets from 2019-2020 PANTHYR deployments (to be expanded in 2021 ...)

https://waterhypernet.org/data/



The first HYPSTAR® deployments ...



Practical challenges for long-term deployments

- Experience of running 2 AERONET-OC sites since 2012 + (with CNR and VLIZ) 3 WATERHYPERNET sites in 2019-20:
- Equipment
  - spiders, birds
  - atmospheric deposition during deployment
  - cable glands, cables, connectors
  - power supply limitations and outages
  - PCs have an internal clock battery
  - VPN connection/cybersecurity + webcam very useful
- Logistics
  - Transport of equipment (customs if outside EU)
  - Calibration
  - Safety training and equipment (climbing, sea)
  - Site owners' priorities and changes
- Funding (R&D projects)
  - RBINS Thornton and Zeebrugge AERONET-OC have down periods

It takes a lot of energy to keep a site running after the first two years

Conclusions

- Surface reflectance data is essential for water and land product validation

esp. metre-scale constellation interoperability?

- Autonomous hyperspectral network is most cost-effective (multi-mission context)
- Zenith- and azimuth-pointing enables full HDRF for land and extra scenarios for water (as well as "parking" to protect)
- Need for consolidation of protocols and uncertainty estimation (water:FRM4SOC, land:FRM4VEG)

Priority:

The people who create the data and care for its quality

- More deployments, data distribution
- Stabilise long-term funding of val site operations

If no-one is paid to acquire data ... there will be no data to use