

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

presented by Kevin Ruddick (RBINS)

H2020/HYPERNETS

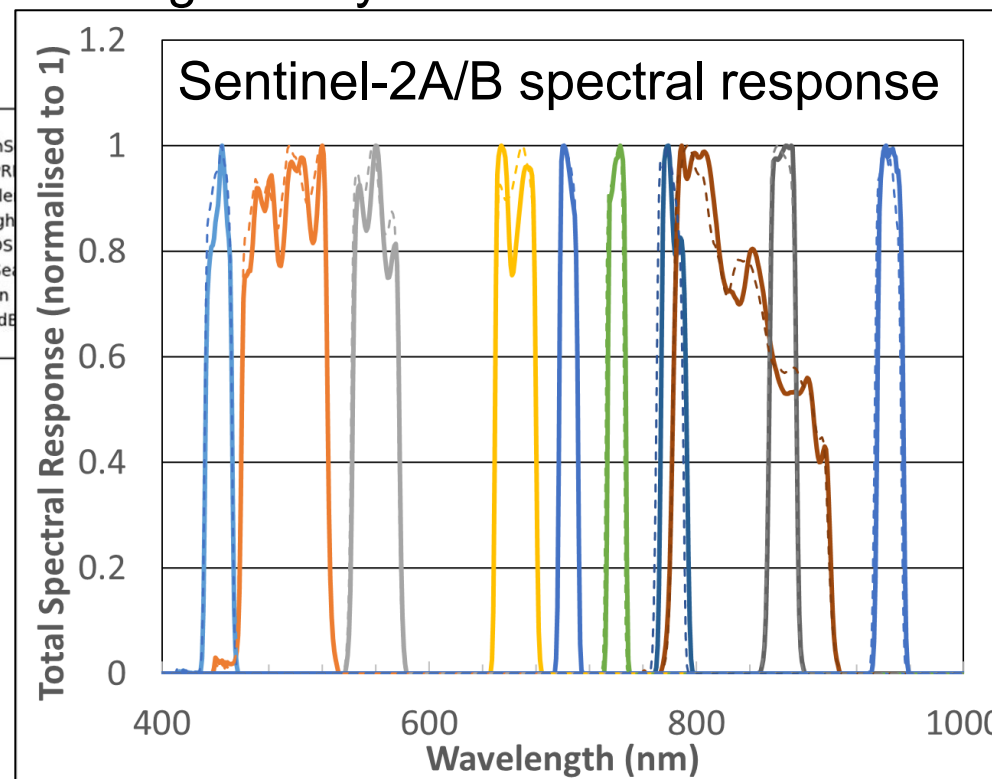
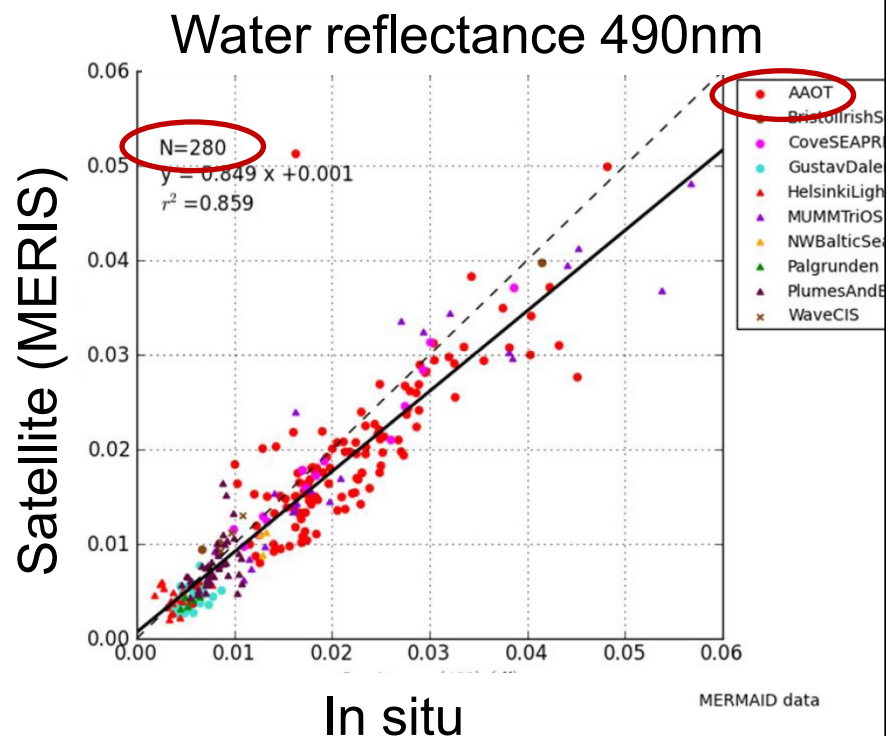
Joel Kuusk, Matthew Beck, Agnieszka Bialek, Vittorio Brando, Javier Concha, Alexandre Corizzi, Pieter de Vis, Ana Dogliotti, David Doxaran, Boubaker Elkilani, Ken Flight, Anabel Gammaru, Claudia Giardino, Luis Gonzales Vilas, Clémence Goyens, Francisco Grings, Sam Hunt, Kaspars Laizans, Edouard Leymarie,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

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The Motivation for automated hyperspectral

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



Data acquisition must be
AUTOMATED

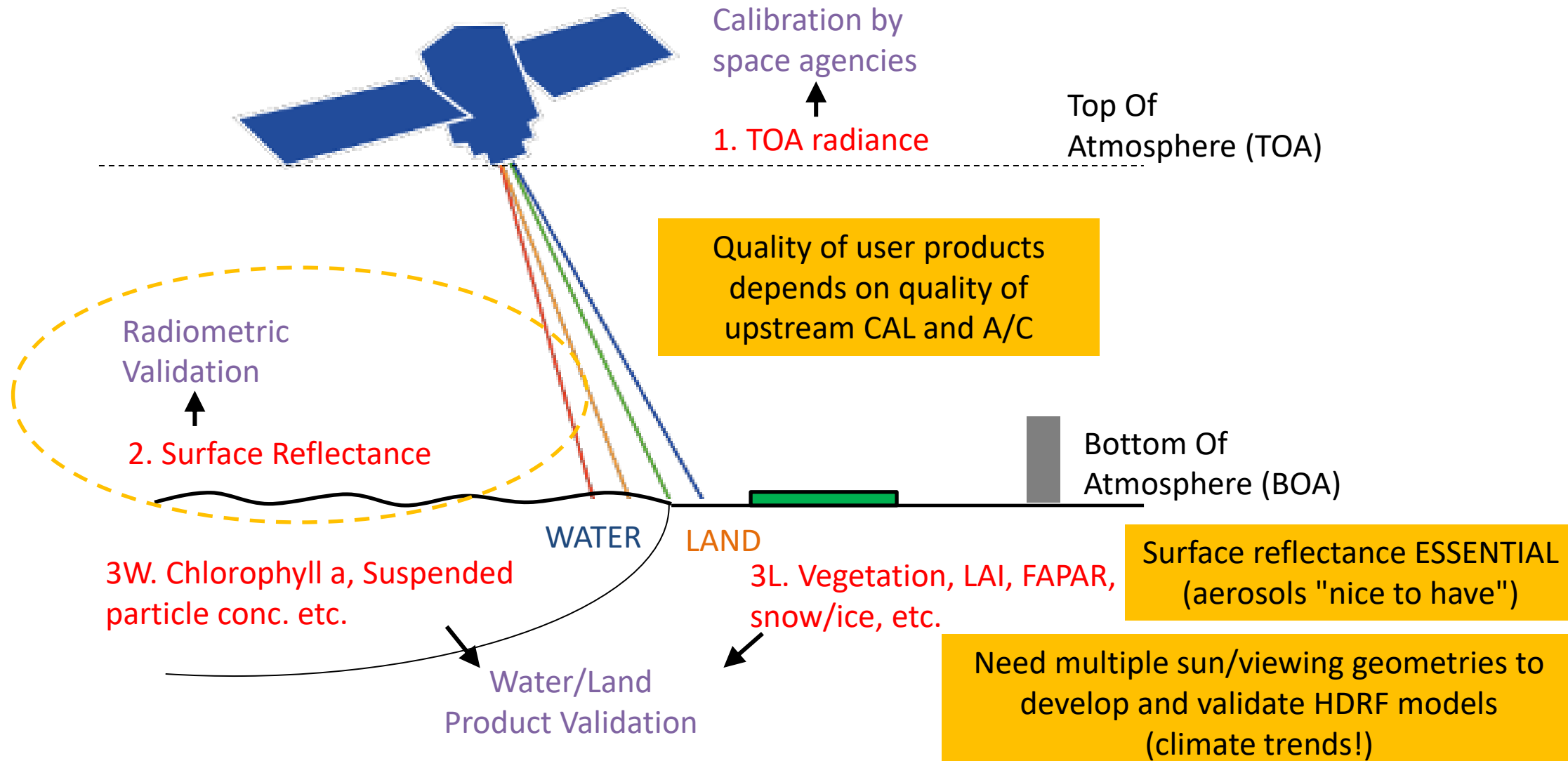
Instrument should be
HYPERSPETRAL

[MERIS 3rd reprocessing data via
Data courtesy of PIs (D. McKee,
Zibordi, G. Schuster, S. Kratzer,

Sites preferably
NETWORKED

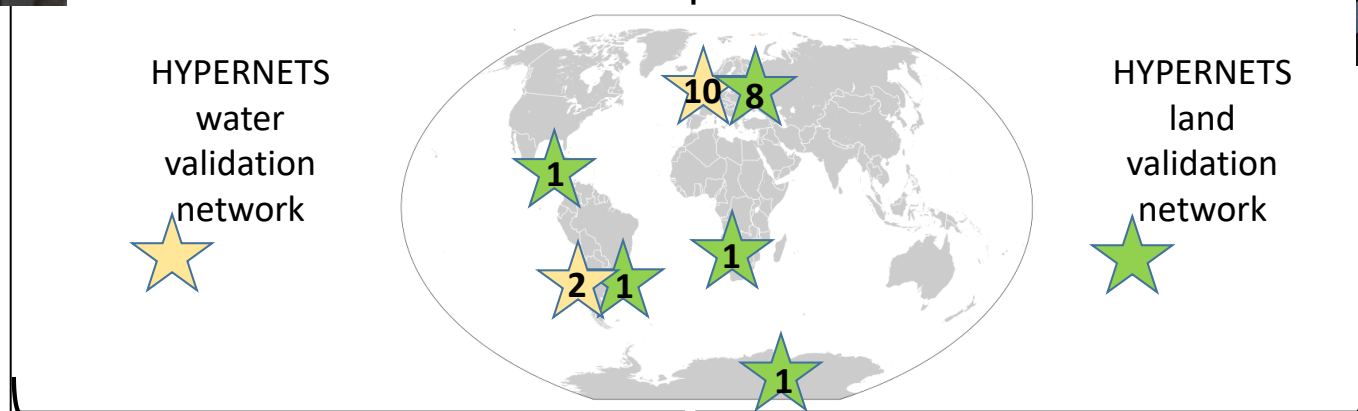
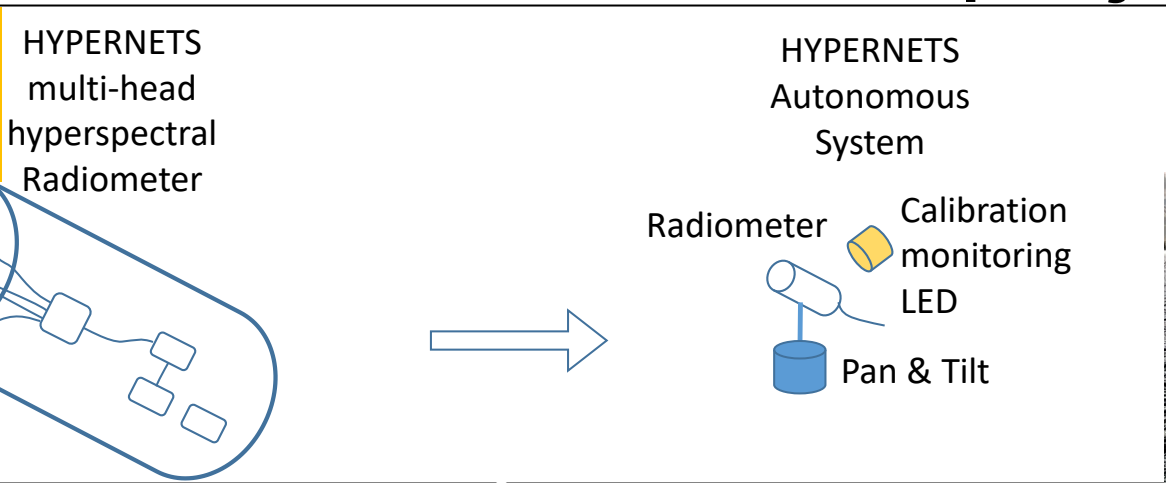
atzer) and AERONET-OC PIs (G.
MERMAID

Motivation for radiometric validation



The H2020/HYPERNETS project

14 prototypes produced
17 more in prep



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]

[2022 update]
+PlanetDoves
+L9
+...
+PACE+SBG
+MTG+GLIMR
+CHIME
+Newspace
+...

HYPSTAR® instrument spec (XR=land version)

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

SR=water version
VISNIR (380-900nm),
2° FOV

Typically measuring every 30 mins during daytime for a year before recalibration

[\[www.hypstar.eu\]](http://www.hypstar.eu)

Validation Test sites

LAND and WATER validation network

Land types

- Forest
- Grassland
- Agricultural
- Desert
- Snow
- (N+S hemisphere)

Water types

- Clear ... Xturbid
- Inland ... Offshore
- Oligo ... Hypertrophic

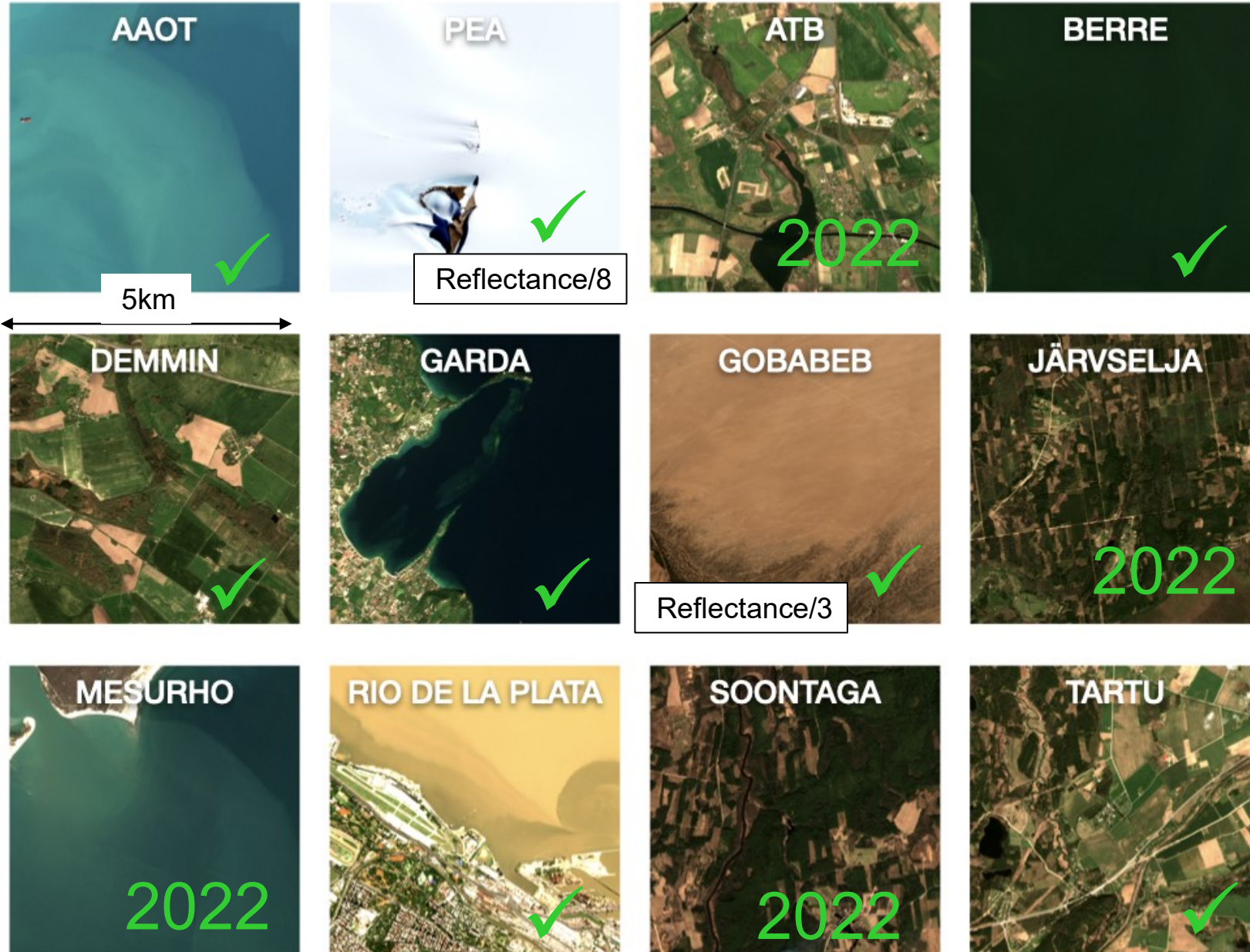




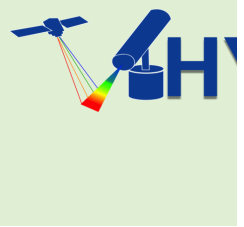
Sentinel-2 imagery of test sites (1/2)



[S2 Data from ESA/EU]



(not all functioning ctsly)



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

[S2 Data from ESA/EU]



(not all
functioning
ctsly)

Blankaart reservoir - example matchup, HYPSTAR® prototype

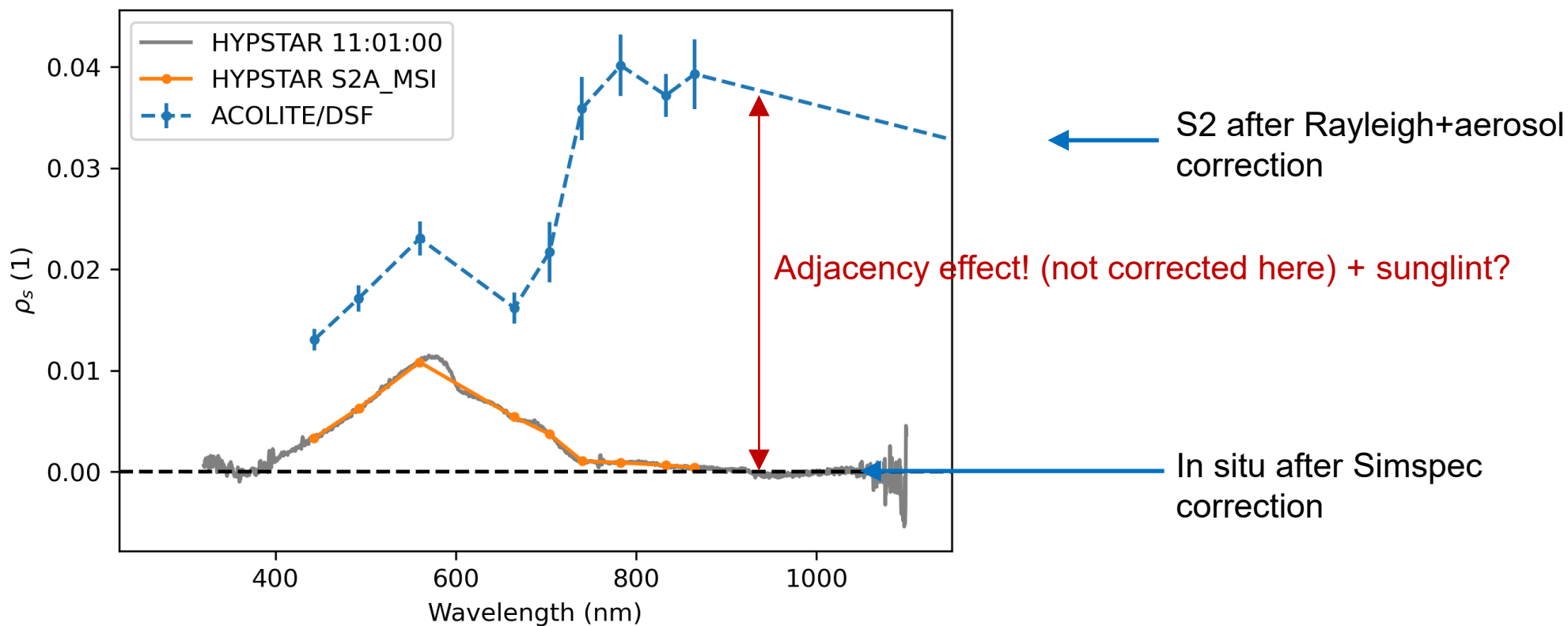
RBINS HYPSTAR® deployment and S2 processing

Also used for validation of L8, L9, PlanetDoves, ...

Good site for difficult adjacency effects!



S2A/MSI 2021-04-08T11:01:50
50.9886°N 2.8357°E



Etang de berre - 1 year matchups, HYPSTAR® prototype

LOV HYPSTAR® deployment and S2 processing

Feb 2021 - Feb 2022

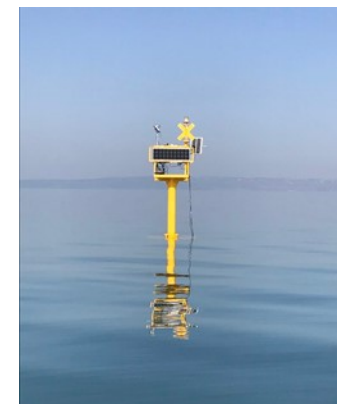
SAT: no cloud, spatial heterogeneity < 20%, RHOw > 0

Matchup window = +/- 1 hour

18 matchups out of 60 potential matchups

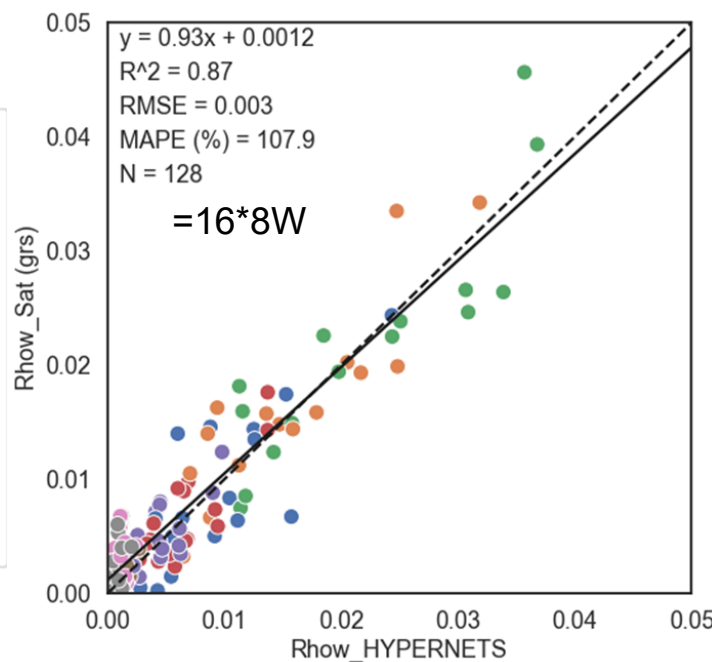
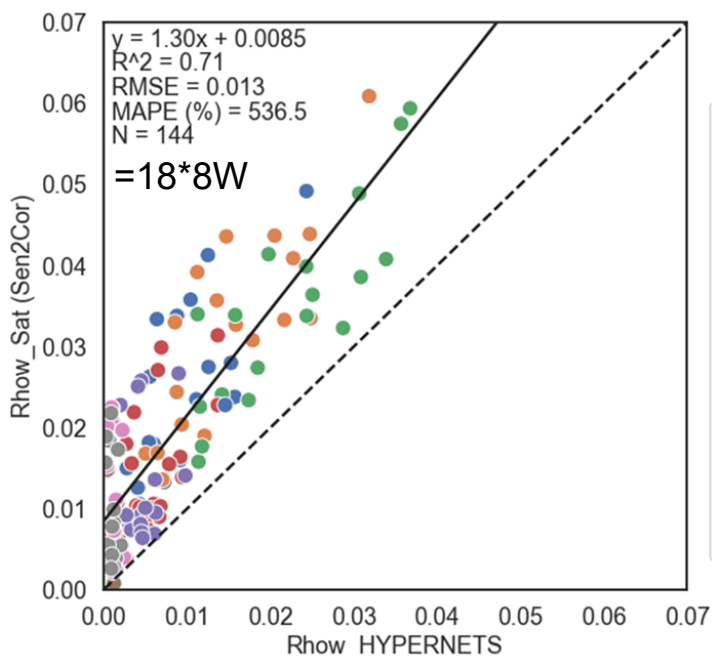
Algos: Sen2cor, GRS, C2RCC, ACOLITE, POLYMER, ICOR

Also used for validation of L8 and OLCI



[LOV:
Doxaran]

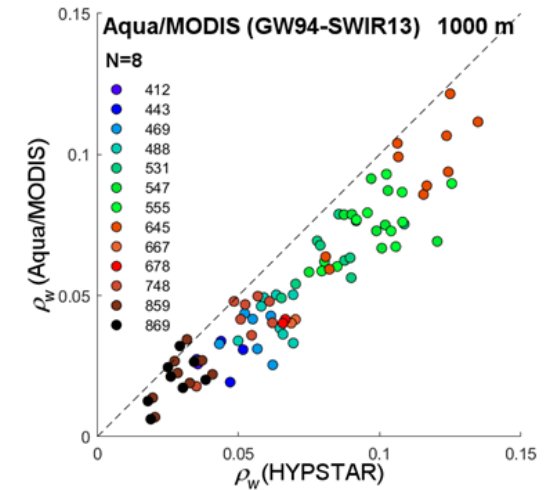
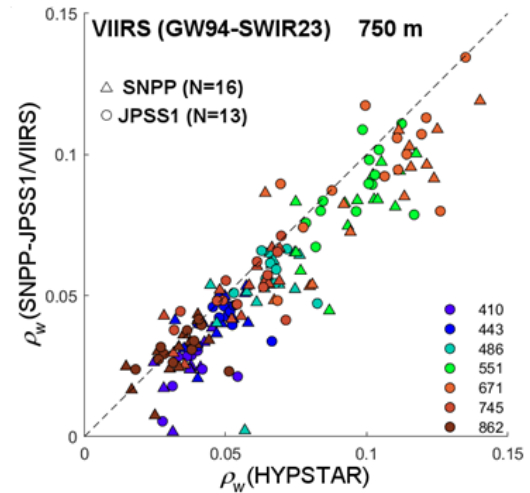
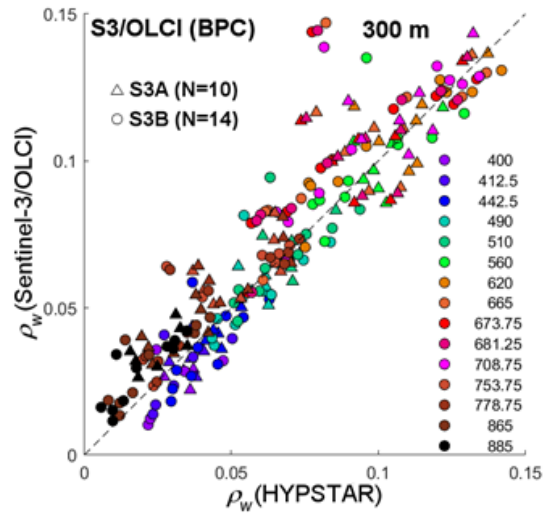
Good site for difficult sunglint!



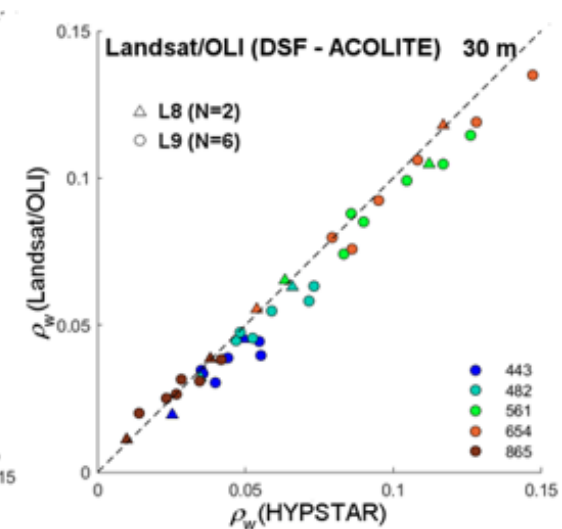
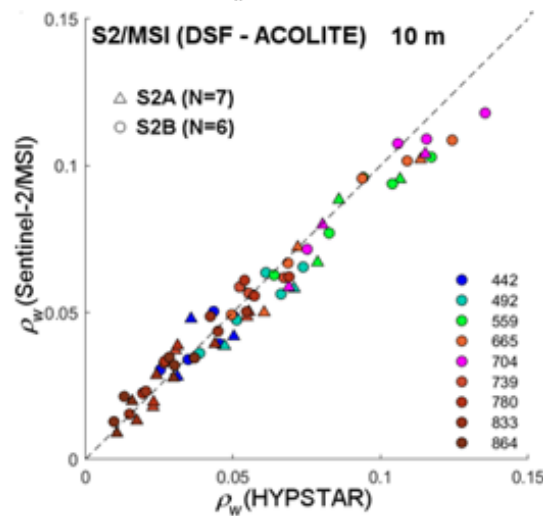
Early results:

- C2RCC performs well: (good A/C and Glint)
- Conclusions may be different in productive/turbid parts of lagoon)

And for 9 missions here (Mar 2022) ...



La Plata
[CONICET/A.Dogliotti]

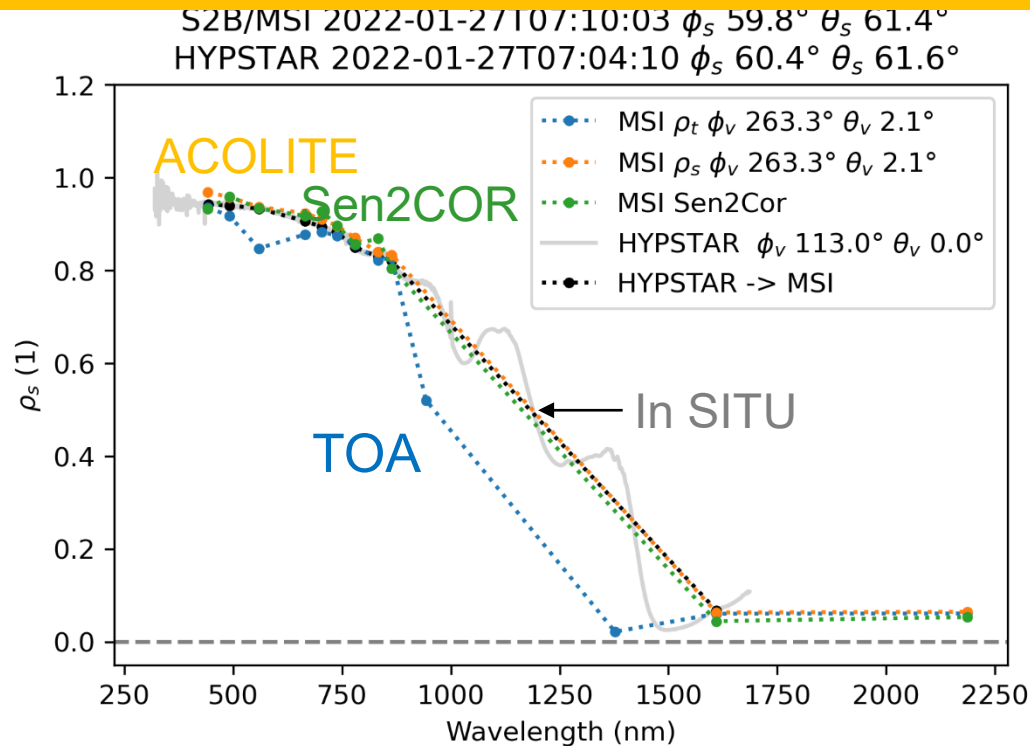


"One month of automated HYPSTAR® = 5 years of shipborne matchups"

BE Antarctica base (IPF) - example matchup, HYPSTAR® prototype

RBINS HYPSTAR® deployment and S2 processing
 Also to be used for validation of L8, L9, OLCI, ...
 Jan-Feb 2022

Good site for snow properties, HDRF, cloud detection over snow, vcal?, user interest ...



S2B/MSI 2022-01-27 07:10:03
 ρ_s RGB

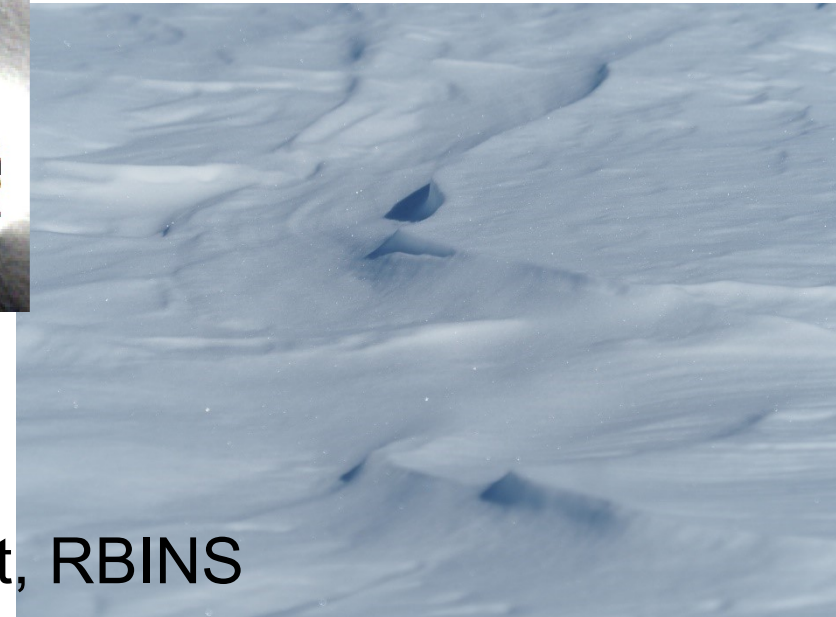
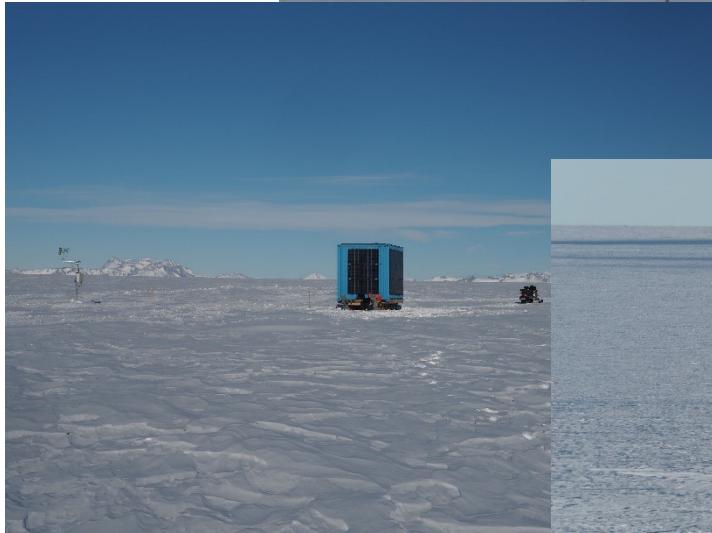
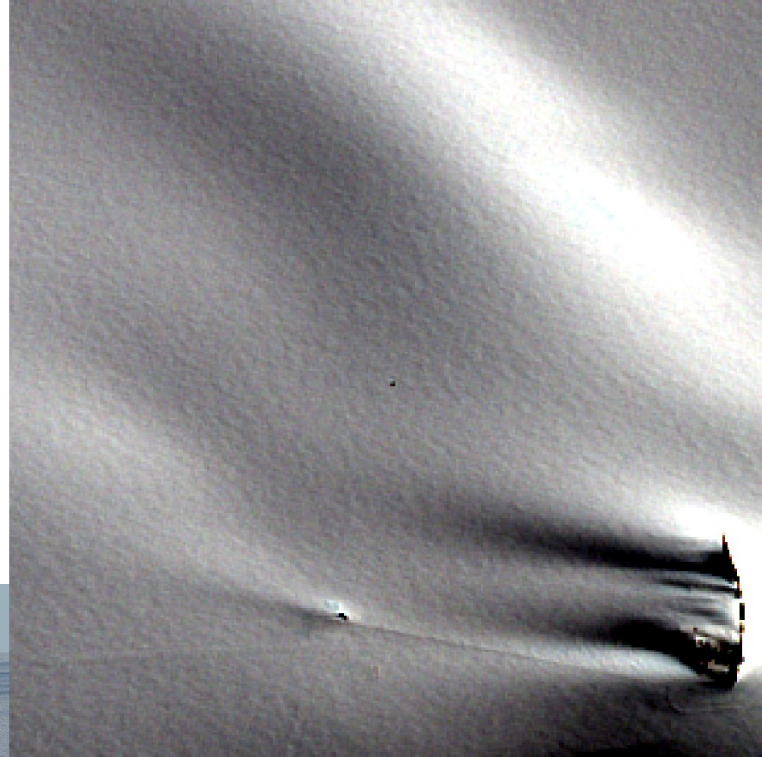


~3km

Spin-off: high potential for snow properties



S2 contrast enhanced (~3km)

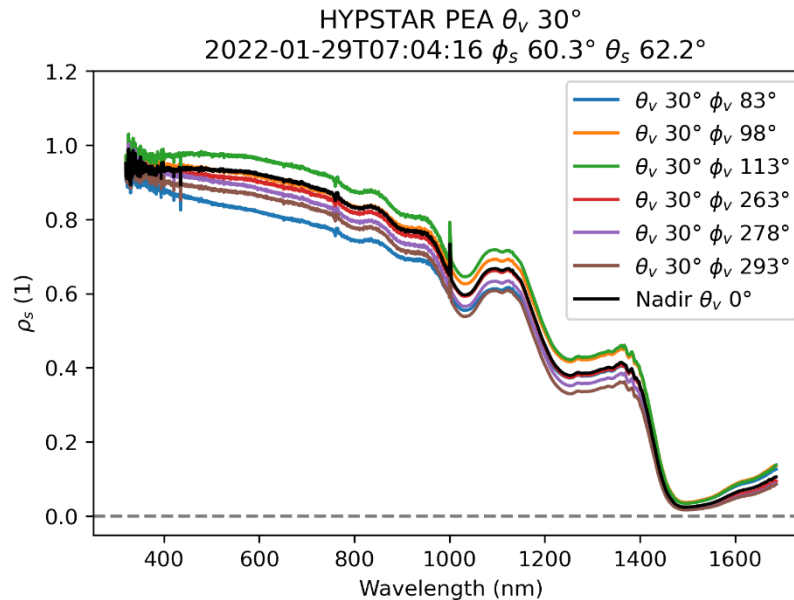


Photos: Q.Vanhellemont, RBINS

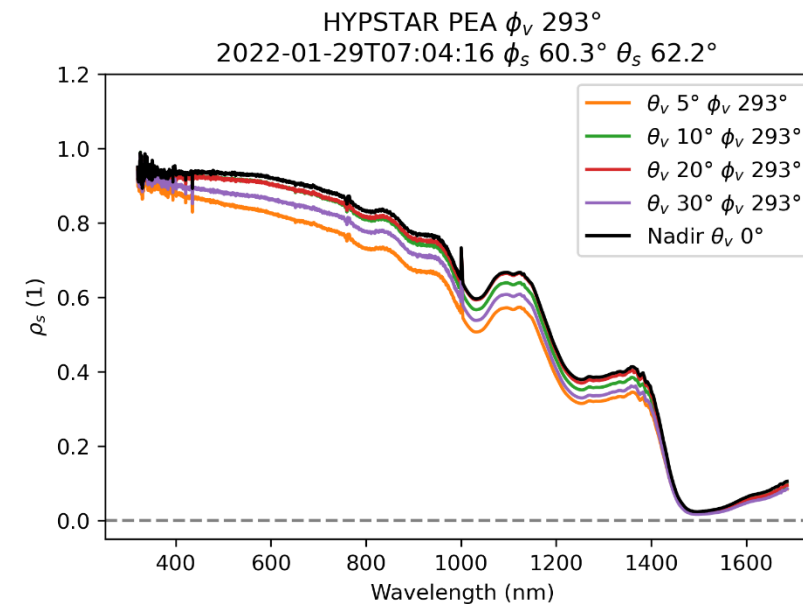
BE Antarctica base - multi-angular, HYPSTAR® prototype

[Q.Vanhellemont]

VZA=30°, 6 different VAA



VAA=293°, 5 different VZA



1. Data acquisition protocol currently designed for sat val (cross-track azimuthal viewing), but could do full HDRF ...
2. Might become a RADCALNET vcal site ...
3. Also UMaryland dual skycam for clouds ...

More sites recently started ...

GFZ: Marquardt



NPL: Wytham Woods



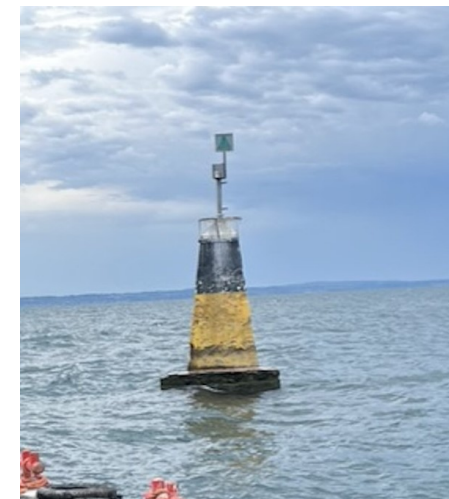
GFZ: DEMMIN



CNR: Acqua Alta



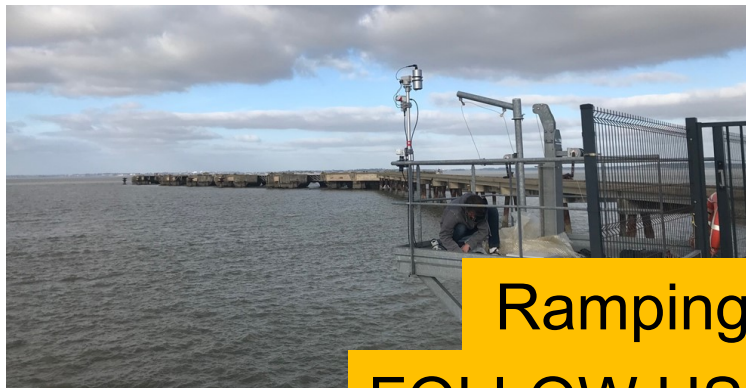
CNR: Lake Garda



NPL: GOBABEB!



LOV: Gironde



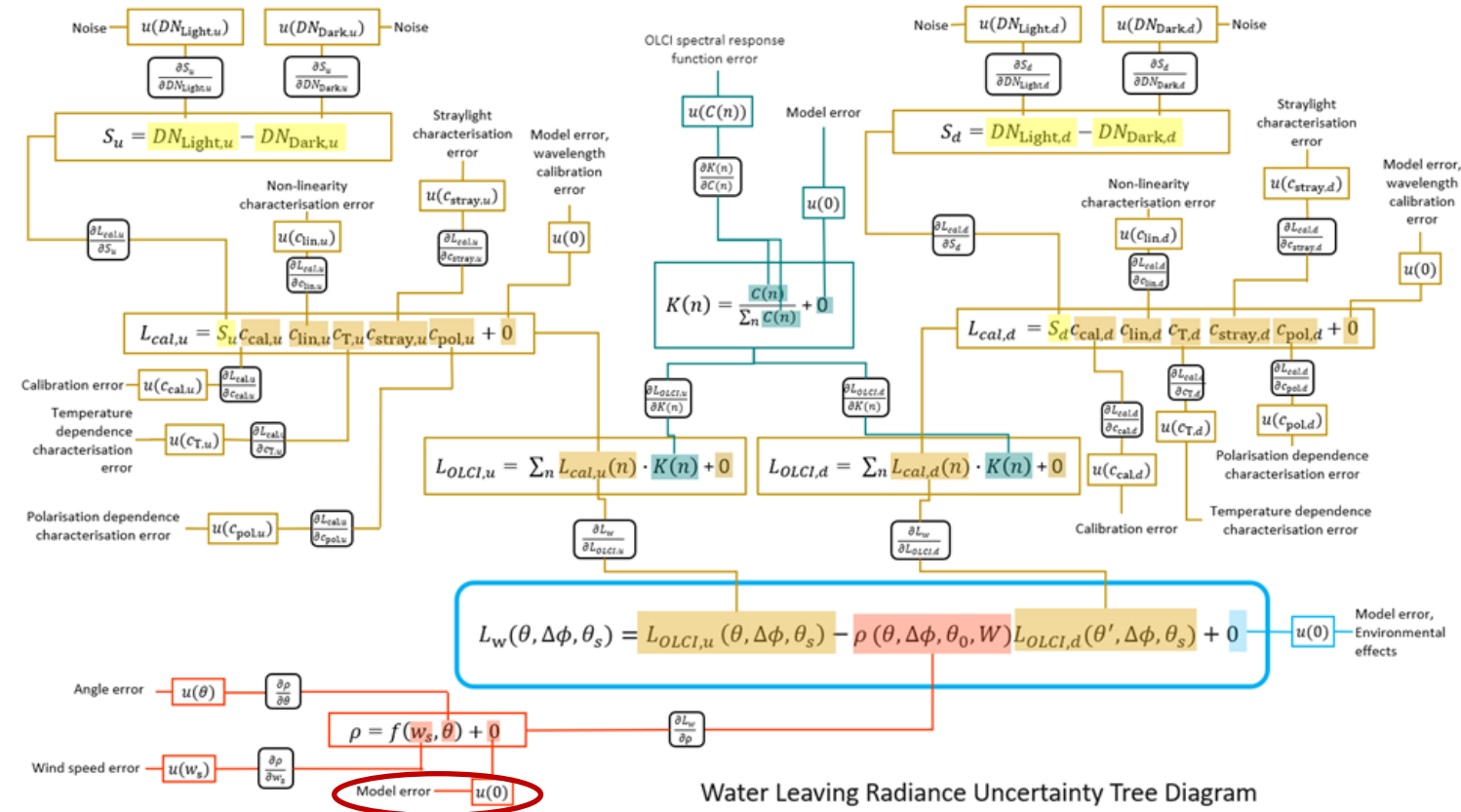
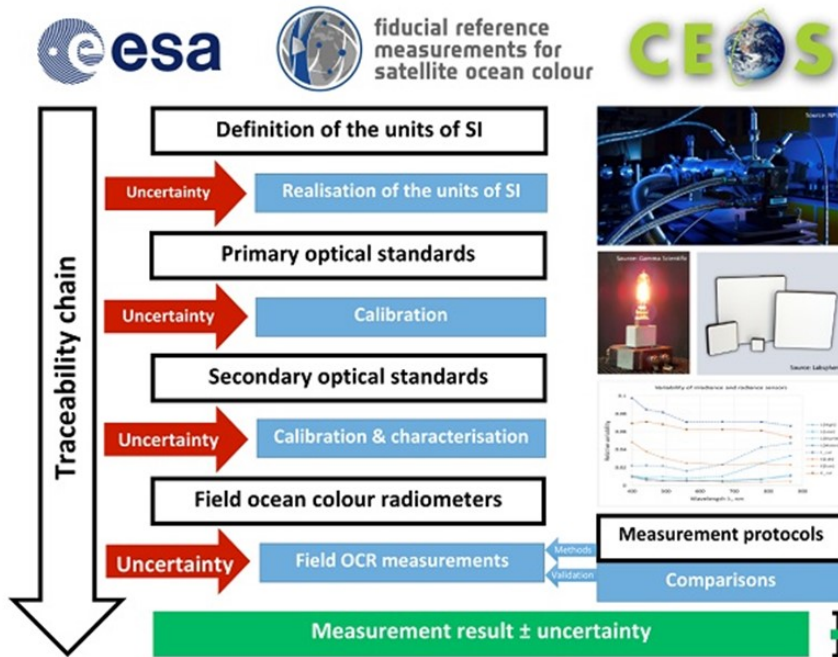
CONICET: La Plata



Ramping up to 12 WATER + 12 LAND by Dec 2022 ...
FOLLOW US on https://twitter.com/Hypernets_H2020 !

A slide on measurement uncertainties

- Uncertainty tree diagram for water-leaving radiance [Bialek, 2020]
- GUM methodology and propagation software mature



[Banks et al. "Fiducial Reference Measurements for Satellite Ocean Colour (FRM4SOC)". Remote Sens. 2020, 12, 1322. <https://doi.org/10.3390/rs12081322> and <https://frm4soc.org>]

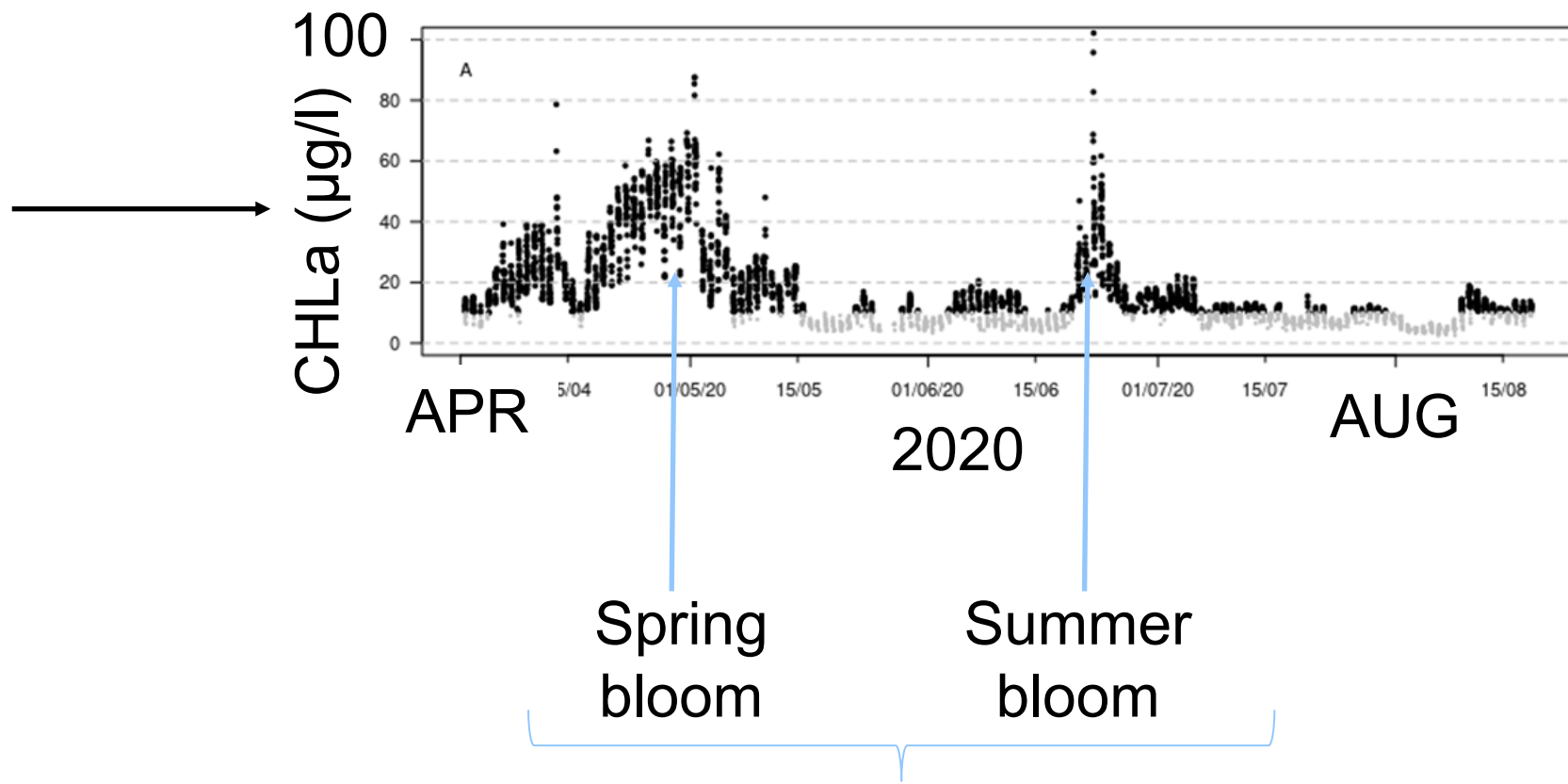
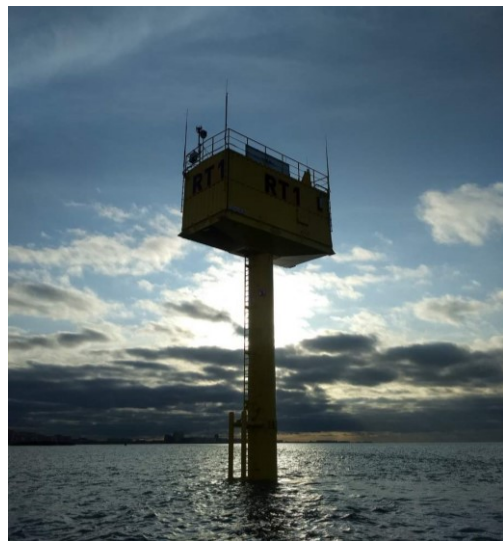
One problem is model error input for effective Fresnel "rho-factor" [D'Alimonte et al, 2021]

BONUS: hyperspectral radiometry is not just sat val



v2.0

PANTHYR system
[Vansteenkoven et al, 2019]
on RT1/Oostende (VLIZ)



Different species [Lavigne et al, subm] ...

Colocation of HYPERNETS radiometry with other water/land/aerosol instruments very powerful ...

Surface reflectance data is essential for water and land product validation

Autonomous hyperspectral network is most cost-effective (multi-mission context)

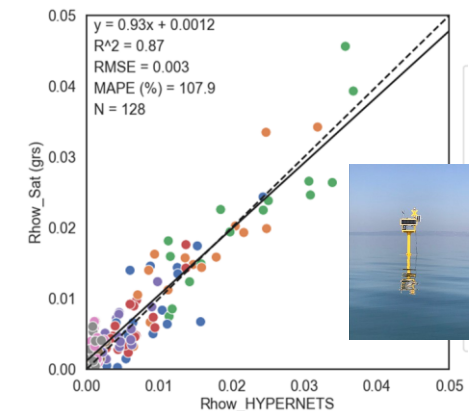
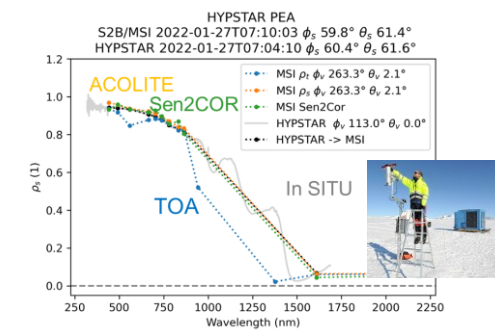
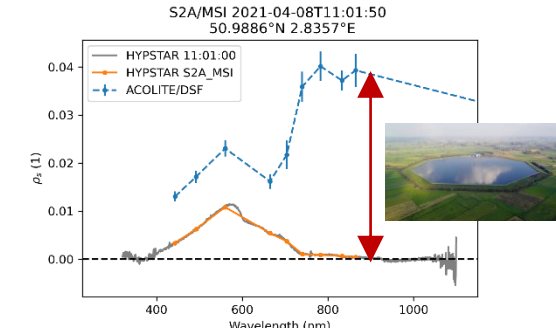
Zenith- and azimuth-pointing enables full HRDF for land and extra scenarios for water (as well as "parking" to protect)

Useful for other applications (not just sat val) ...

Early prototype HYPSTAR® data looks very useful ...

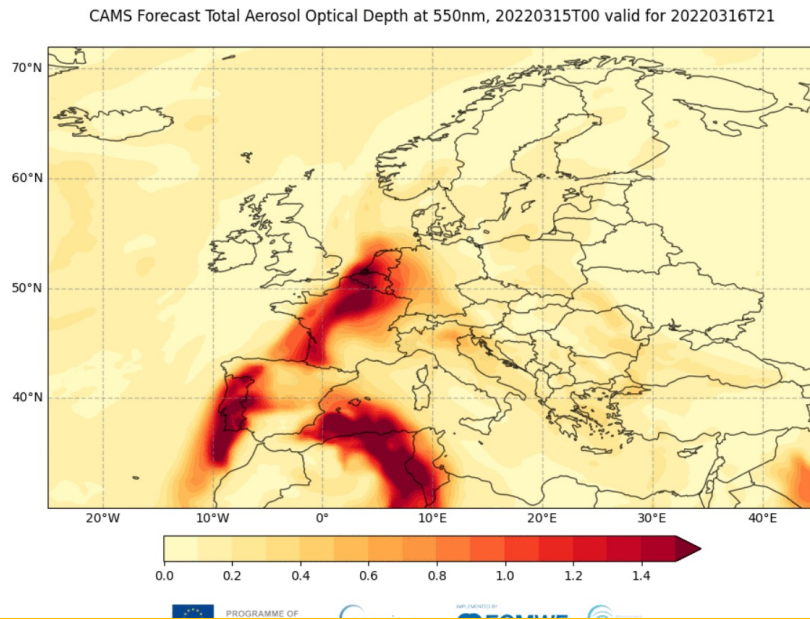
Diverse water and land HYPERNETS validation sites should provide good basis for validation of S2A&B

(and L8&9 and S3A&B and CHIME and PRISMA and ENMAP and NewSpace and ...)



CHALLENGE : Keeping optical surfaces clean! [experiment by F.Ortenzio, RBINS]

First week of Deployment



1. Experiment to understand contamination processes
2. Parking downwards to protect (+rain sensor)
3. Continuous cal monitoring : LED, Rayleigh sky, ...

