



VH-RODA 2023 Workshop  
27 – 30 November 2023 | ESA – ESRIN | Frascati (RM),  
Italy

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**Update on calibration reference networks - SARCalNet, HyperNET and RadCalNet**

*Muriel Pinheiro, Philippe Goryl*

*ESA / ESRIN*

- SARCALNET
- RADCALNET
- HYPERNET

# The SAR Calibration Network: SARCalNet

# SAR Calibration and Validation

## Radiometric Calibration

- Calibration constants
- Antenna patterns estimation/compensation

## Geometric Calibration

- Compensation of shifts
- Compensation of known environmental effects

## Interferometric Calibration

- Calibration of phase offsets
- Calibration of phase screens in general
- Stack de-biasing

## Polarimetric Calibration

- Correction of cross-talk
- Correction of channel imbalance

## Instrument Calibration

- Range delay
- Drifts (e.g., oscillator frequency)
- Noise estimation and compensation

## Quality assessment

- SLC
- Interferometric
- Polarimetric
- Geophysical (e.g., deformation; ocean state)

# SAR Calibration and Validation

Radiometric Calibration	Geometric Calibration	Interferometric Calibration
<ul style="list-style-type: none"> <li>• Calibration constants</li> <li>• Antenna pattern estimation</li> </ul>	<ul style="list-style-type: none"> <li>• Compensation of shifts</li> <li>• Compensation of known</li> </ul>	<ul style="list-style-type: none"> <li>• Calibration of phase offsets</li> <li>• Calibration of phase general</li> </ul>
<p>Reliable reference data are needed and might have different requirements for each cal type!</p>		
Polarimetric	Geometric	Quality Assessment
<ul style="list-style-type: none"> <li>• Correction of cross-talk</li> <li>• Correction of channel imbalance</li> </ul>	<ul style="list-style-type: none"> <li>• Range delay</li> <li>• Drifts (e.g., oscillator frequency)</li> <li>• Noise estimation and compensation</li> </ul>	<ul style="list-style-type: none"> <li>• SLC</li> <li>• Interferometric</li> <li>• Polarimetric</li> <li>• Geophysical (e.g., deformation; ocean state)</li> </ul>



# What is there

Currently, the CEOS WGOV/SAR subgroup hosts a target database:

<http://calvalportal.ceos.org/point-distributed-targets-db>

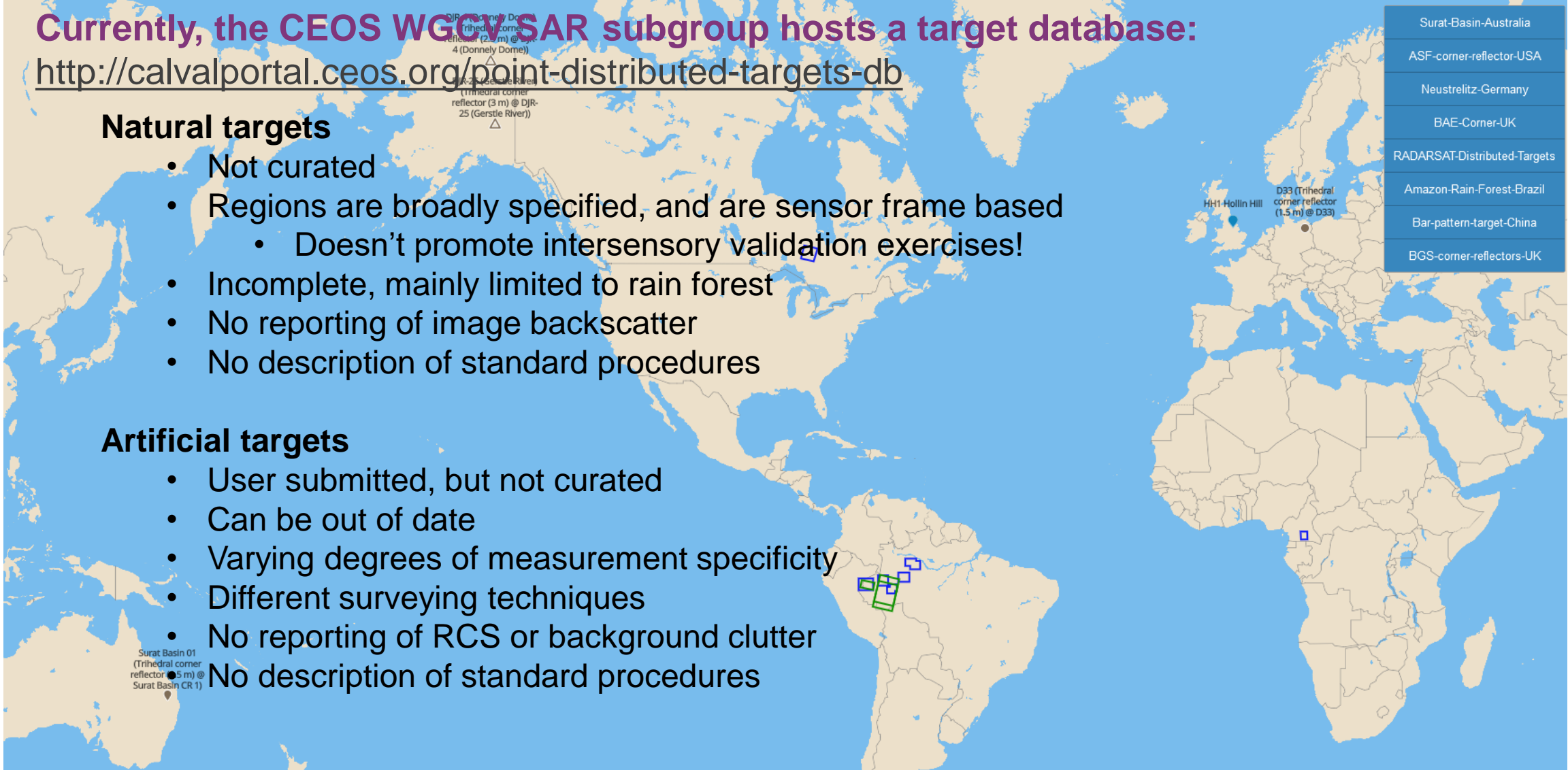
## Natural targets

- Not curated
- Regions are broadly specified, and are sensor frame based
  - Doesn't promote intersensory validation exercises!
- Incomplete, mainly limited to rain forest
- No reporting of image backscatter
- No description of standard procedures

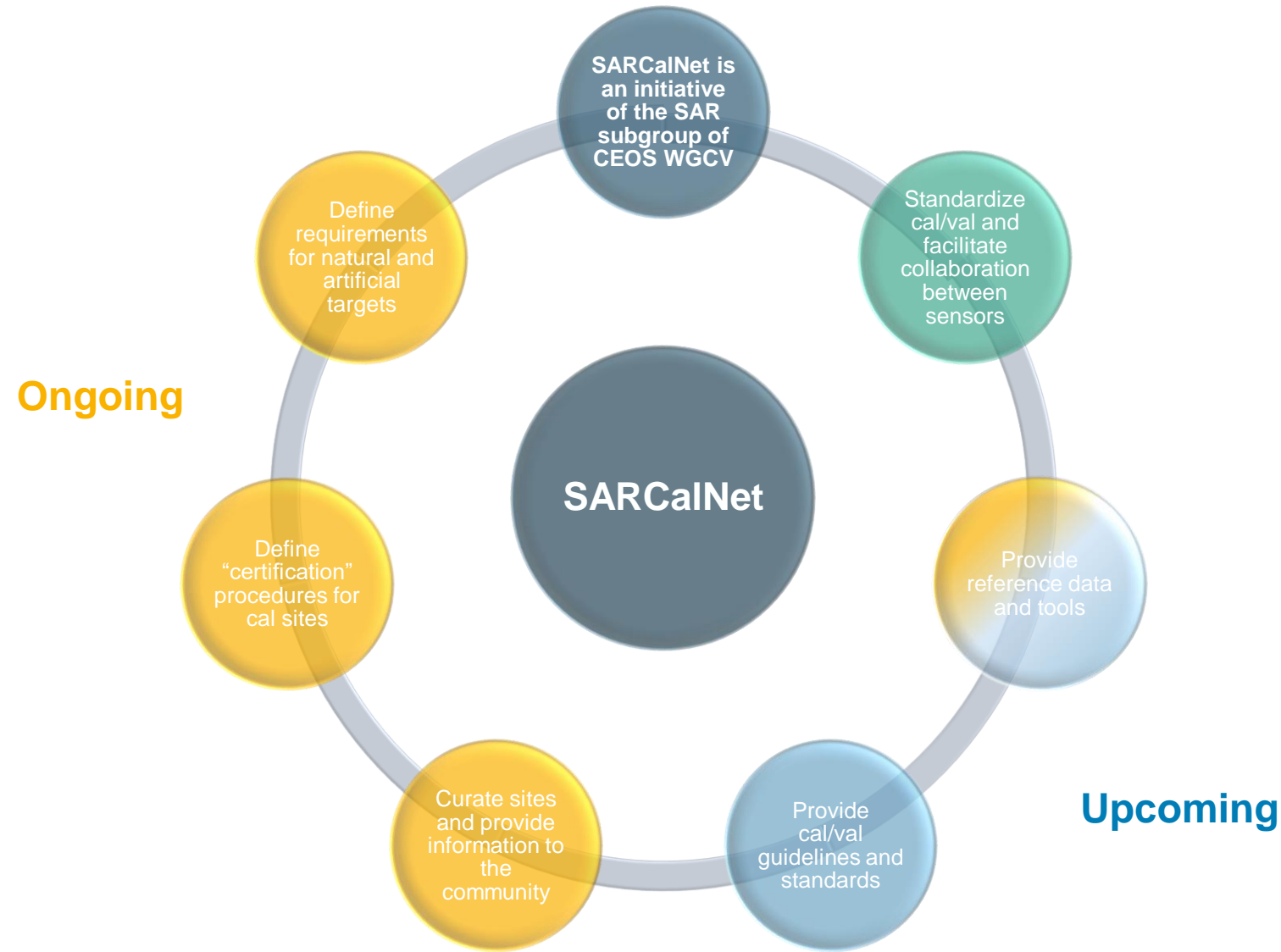
## Artificial targets

- User submitted, but not curated
- Can be out of date
- Varying degrees of measurement specificity
- Different surveying techniques
- No reporting of RCS or background clutter
- No description of standard procedures

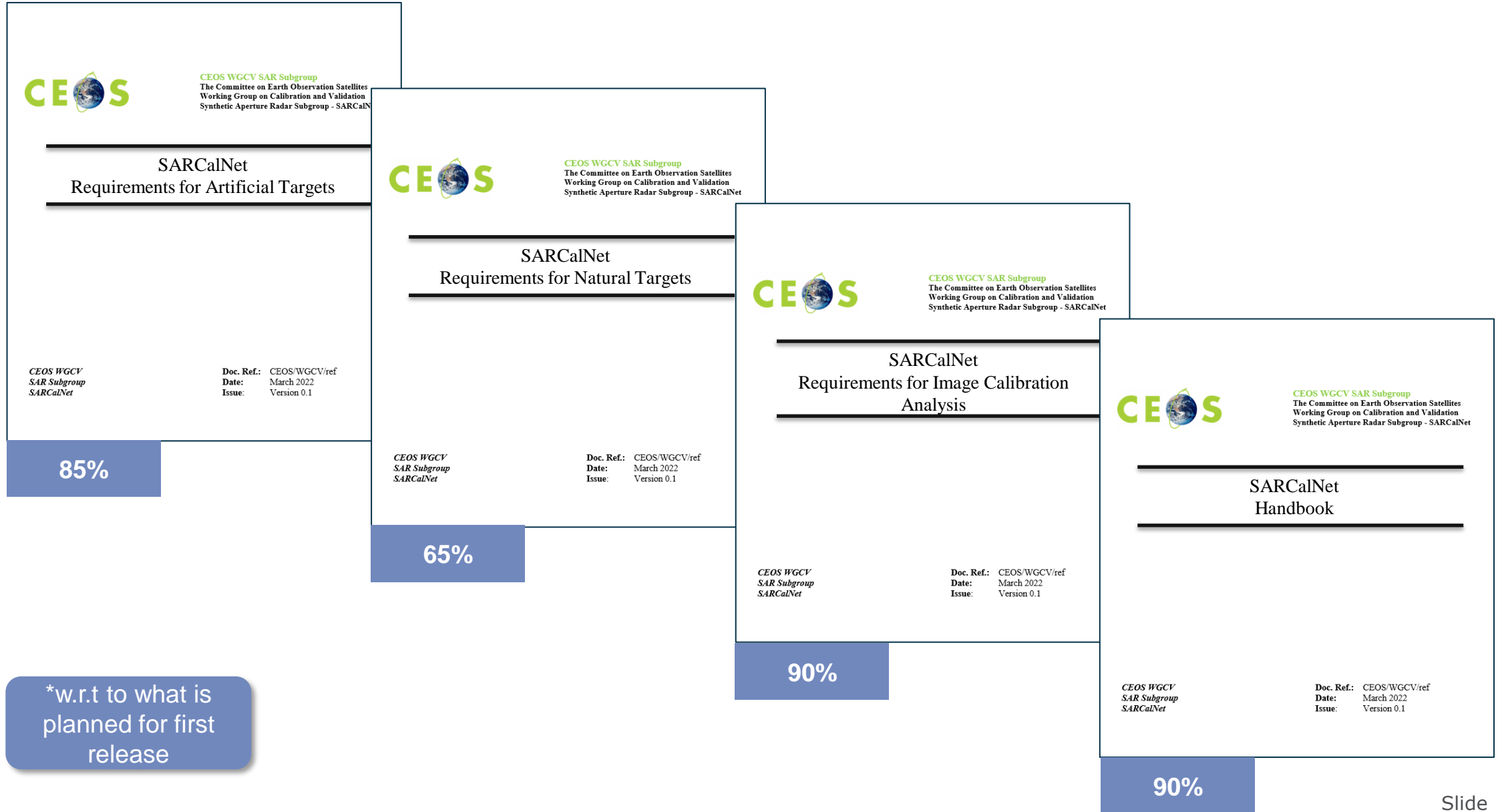
Surat-Basin-Australia
ASF-corer-reflector-USA
Neustrelitz-Germany
BAE-Corer-UK
RADARSAT-Distributed-Targets
Amazon-Rain-Forest-Brazil
Bar-pattern-target-China
BGS-corer-reflectors-UK



# The CEOS SARCalNet initiative



# Update since last VHRODA: documents



\*w.r.t to what is planned for first release



# Update since last VHRODA: templates

AutoSave Off harmonised\_calibration\_site\_template For ESA Official Use Only (ESA UNCLASSIF... Last Modified: 4m ago Muriel Pinheiro

File Home Insert Page Layout Formulas Data Review View Automate Add-ins Acrobat

Clipboard Font Alignment Number Styles Cells Editing Analysis Sensitivity Add-ins Adobe Acrobat

	J	K	L	M	N	O	P	S	T
1								For Artificial Targets only	
2	landcover	dates active	primary frequency band	primary sensor	Site owner (institutional provider)	POC name	POC email	willing to consider special requests	website
3	farmland	June 2021-present	L	NISAR-L	JPL	Brad Illston	<a href="mailto:illston@ou.edu">illston@ou.edu</a>	Yes	<a href="https://uavsar.jpl.nasa.gov/cgi-bin/calibration.pl">https://uavsar.jpl.nasa.gov/cgi-bin/calibration.pl</a>
4	farmland	Aug 2021-present	L	NISAR-L	JPL	Wade Albright	<a href="mailto:rwalbright@alaska.edu">rwalbright@alaska.edu</a>	No	<a href="https://uavsar.jpl.nasa.gov/cgi-bin/calibration.pl">https://uavsar.jpl.nasa.gov/cgi-bin/calibration.pl</a>
5									
6									
7									
8	For artificial this is the background landcover, e.g., farmland.								
9	For natural targets it could be rainforest, desert, doldrums								

AT and DT site submission template have been further consolidated and harmonized

AT (CR): 90%  
DT: 60 %

# Update since last VHRODA: templates



File Home Insert Page Layout Formulas Data Review View Automate Add-ins Acrobat

Clipboard Font Alignment Number Styles Cells Editing Analysis Sensitivity Add-ins Adobe Acrobat

P1 | how RCS accuracy was determined

target type	apprx latitude (deg)	apprx longitude (deg)	primary direction	side_length	operational	Purpose of target (radiometric, geometric, etc)	measured RCS (with sensor, expected accuracy, boresite angle, wavelength and bandwidth)	how RCS accuracy was determined	angle dependency available?	composition
<p>Data type: enumeration Possible values: CR - Corner Reflector DT - Distributed target PS - (opportunity) Point Scatterer TP - TranPonder LB - Low Backscatter area ... possible more (TBD)</p>	fails if value is < 90 or > 90 deg	fails if value is < 180 or > 180 deg	"East", "West", "South" and "North"	from 0 to 30 m	<p>Data type: boolean Possible values: * True * False</p>	<p>Data type: enumeration Possible values: Geometric Calibration Absolute Radiometric Calibration Antenna Pattern Characterization Noise Level Assessment Relative Radiometric Calibration ... possible additional ones (TBD)</p> <p>Note: it could make sense to allow multiple selections (TBC)</p>	<p>RCS value in dBm2 Expected RCS accuracy value in dBm2 Data type: float Range: e.g. [-100, +100]</p> <p>Note: the values defining the measurement conditions should be moved to separate columns</p> <p>Boresight angle Units: deg Data type: float Range [-180, +180] (or [0, 360])</p> <p>Wavelength Units: m Data type: float</p>	<p>Data type: enumeration (TBC) Possible values: * simple analytical model * accurate EM model * ... additional methods (TBD)</p>	<p>Data Type: boolean Possible values: * True * False</p>	

CR and survey sheets further consolidated, requirement mapping and quality checks added and currently under development



# Update since last VHRODA: portal

The screenshot shows a web browser window with the URL <https://www.sarcalnet.org>. The page features a navigation menu with links for Home, Calibration Sites, Library, Glossary, Resources, and Contact. The main content area has a blue background with the text "SARCalNet" in a purple box, followed by "Network of Calibration Sites for SAR" in large white font. A blue callout box contains the URL <https://www.sarcalnet.org/> and the note "At the moment only open to SARCalNet group". At the bottom, there is a grayscale SAR image of a field with two white circles highlighting specific areas.



# Update since last VHRODA: portal

CalNet x +

https://www.sarcalnet.org/?page\_id=440 110% ☆

Home ▾ Calibration Sites ▾ Library ▾ Glossary Resources ▾ Contact

This page gives an overview of all calibration sites currently registered in the SARCalNet.

Download shown sites as CSV

Site filters

+ -  
 ■

**Calibration Site alaska**  
 Artificial targets: 0  
 Natural targets: 2  
 Primary sensor: NISAR-L  
 Primary frequency band: L  
 Primary usage: geometric\_calibration  


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 Endorsement: Under review

# Update since last VHRODA: portal

The screenshot shows a web browser window with the URL [https://www.sarcalnet.org/?page\\_id=449&site\\_id=31](https://www.sarcalnet.org/?page_id=449&site_id=31). The page features a navigation menu with links for Home, Calibration Sites, Library, Glossary, Resources, and Contact. The main content is divided into three sections: Geolocation, Site description, and Maintainer contact.

**Geolocation**

A map of Alaska is shown with a blue rectangular area highlighting a specific region. Two green polygons are overlaid on the map, representing the site's location. A blue location pin is visible on the map.

**Site description**

Sitename	alaska
Country	USA
Province / State / Region	AK
Primary target type identifier	MX
Primary sensor	NISAR-L
Primary frequency band	L
Landcover	badland
Primary usage	geometric_calibration
Institutional provider	
Endorsement state	Under review

**Maintainer contact**

Points of Contact	Mail
Wade Albright	<a href="mailto:rwalbright@alaska.edu">rwalbright@alaska.edu</a>
Bruce Chapman	<a href="mailto:bruce.d.chapman@jpl.nasa.gov">bruce.d.chapman@jpl.nasa.gov</a>

**Target Info**



## Next steps

- Further consolidation of templates
- Finalization of documents and publication
- Coordination with SARCalNet group members-maintainers for submission of pilot sites
- Finalization of portal and database
- Finalization of beta review and opening to the public

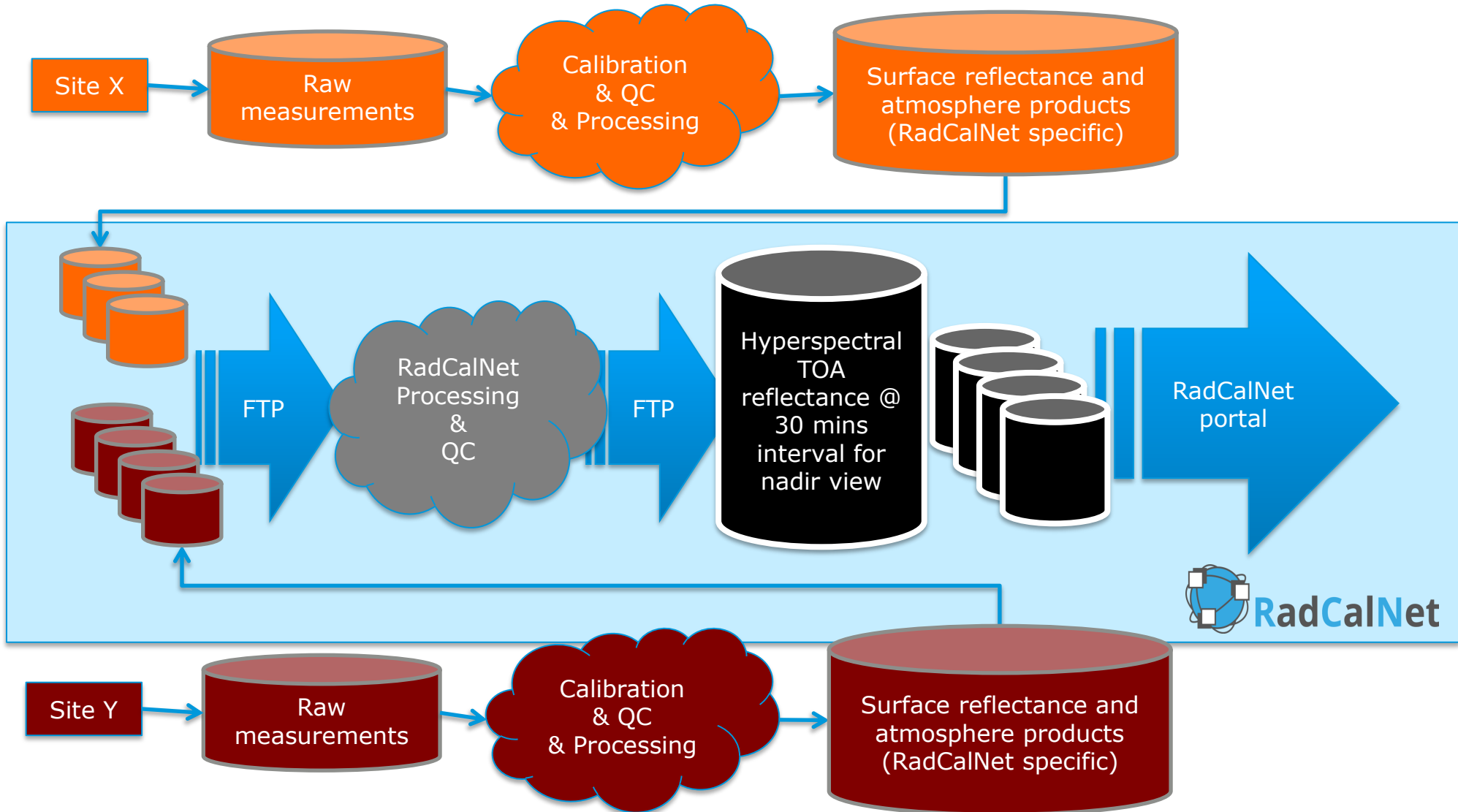


# The Radiometric Calibration Network: RadCalNet

*M. Bouvet on behalf of the RadCalNet WG (CEOS/WGCV/IVOS)*



# What is RadCalNet?





# The RadCalNet sites



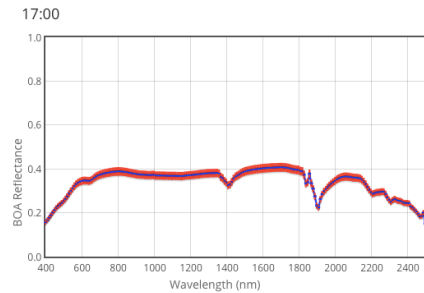
Today 5 sites (+ more in preparation)



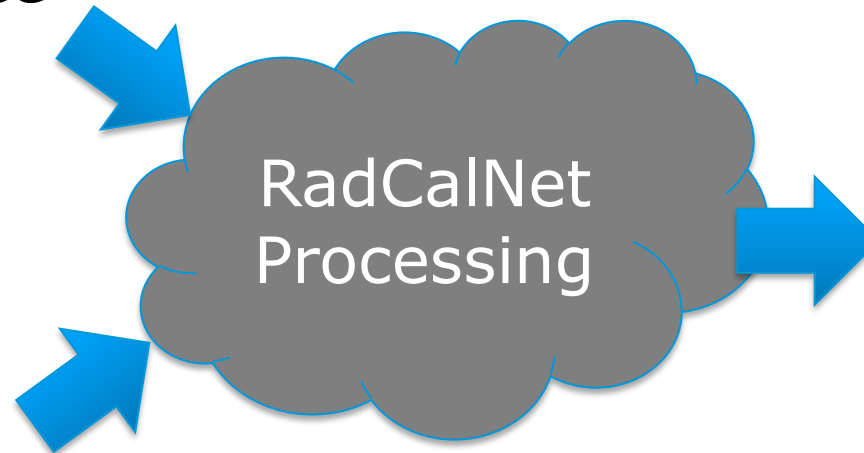
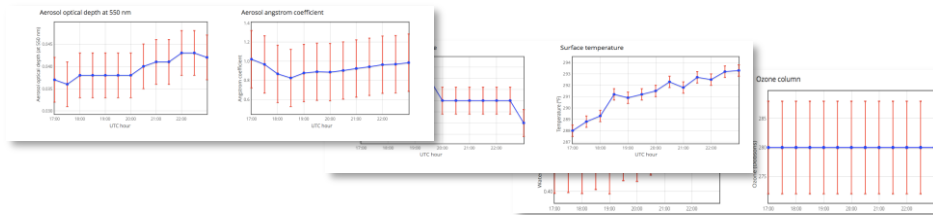
# The RadCalNet processing

- Propagation of surface/atmospheric measurements to top-of-atmosphere nadir reflectance via MODTRAN 6
- Associated uncertainties results from propagation of the surface / atmosphere uncertainties via pre-computed Montecarlo runs of the radiative transfer

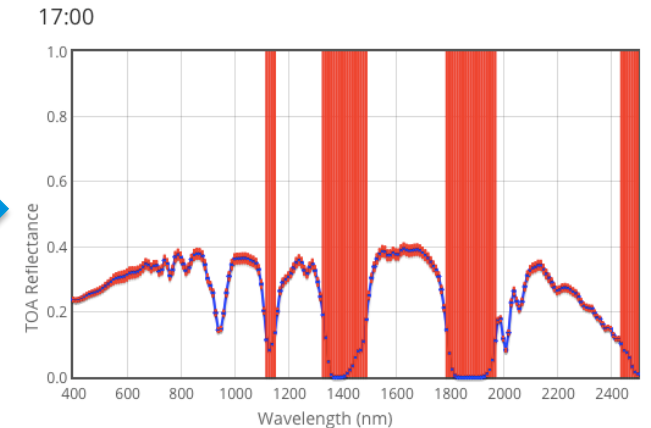
Surface reflectance



Atmospheric measurements



TOA reflectance

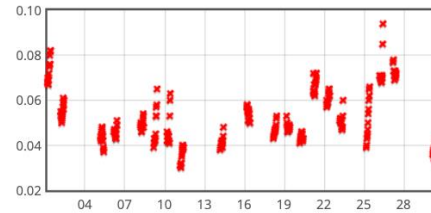


# The portal

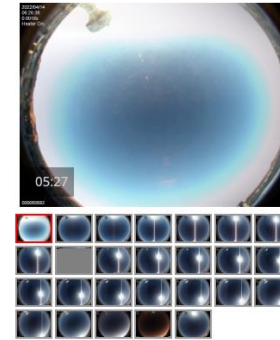
RadCalNet   Committee on Earth Observation Satellites esa



Monthly Aerosol Optical Depth at 550nm (Month 04)



Webcam views for the day

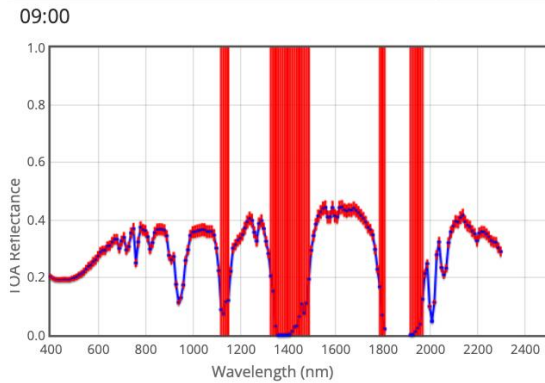


- All TOA simulations available for this day (every 30 mins between 9:00 and 15:00 Local Standard Time)
- TOA simulations only partially available for this day

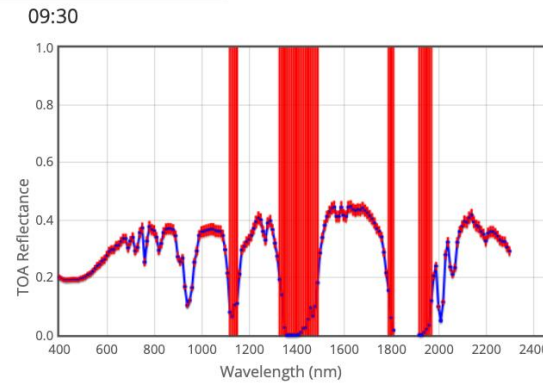
[Download daily data for all instruments](#)

Sensor : 01      Input version : 07      Output version : 04

Atmospheric parameters



BOA Reflectance



TOA Reflectance



[Contact Admin](#)

# Forum

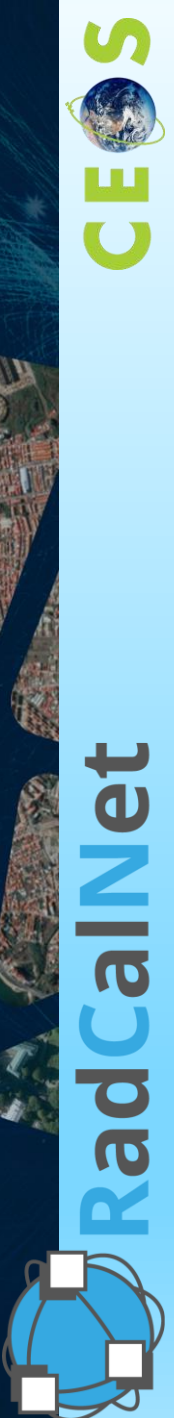


Do you want live notifications when people reply to your posts? [Enable Notifications](#)

all categories ▾ all tags ▾ **Categories** Latest Unread (3) Top + New Topic

Category	Topics
<b>Announcements</b> Announcements of general interest to the entire RadCalNet community will be posted under this section.	27
<b>FAQ</b> Description of the RadCalNet Forum and the various categories	1
<b>Documentation</b> Topic related to RadCalNet documentation	6
<b>Data</b> Discussion on RadCalNet data and Sites ■ BOA and Atmosphere for BTCN ■ BOA and Atmosphere for RVUS ■ BOA and Atmosphere for LCFR ■ BOA and Atmosphere for GONA ■ TOA for all sites 1 unread	36 2 unread
<b>Site Review</b> This category is created for discussion between the new site owner and the RadCalNet Working Group based on the review of the requested documentation and data . ■ Baotou Sandy Site Review 1 unread	4 1 unread
<b>Uncategorized</b> Topics that don't need a category, or don't fit into any other	5

Latest		
GONA missing data from 13th August 2023 ■ BOA and Atmosphere for GONA	0	20d
Data delay at RVUS as of 4 Aug 2023 continues ■ BOA and Atmosphere for RVUS	0	29d
MODTRAN's use of BOA refl. to simulate TOA refl <sup>1</sup> ■ Data	7	Aug 23
LCFR missing data in 2022 ■ Data	3	Aug 22
Data delay at RVUS (4 Aug 2023) ■ BOA and Atmosphere for RVUS	0	Aug 13
RVUS data delayed due to ozone product delay ■ BOA and Atmosphere for RVUS	1	Aug 6
RadCalNet data reprocessing: Collection 2023 available	0	

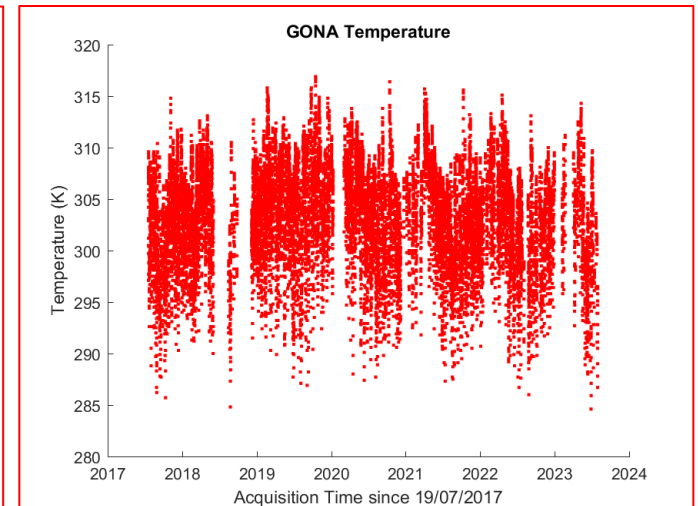
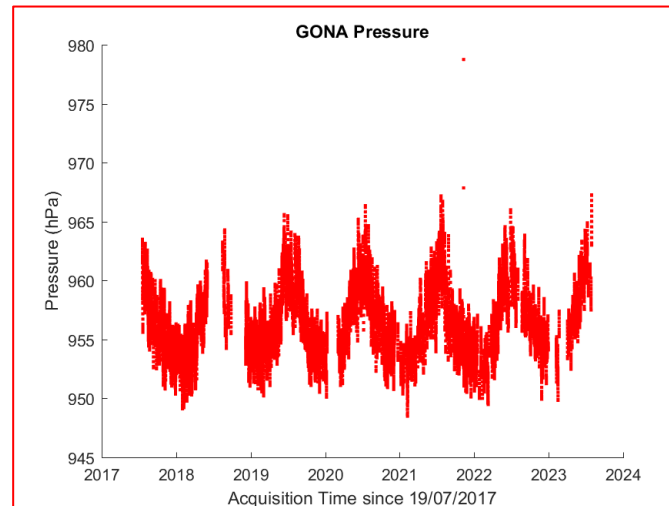
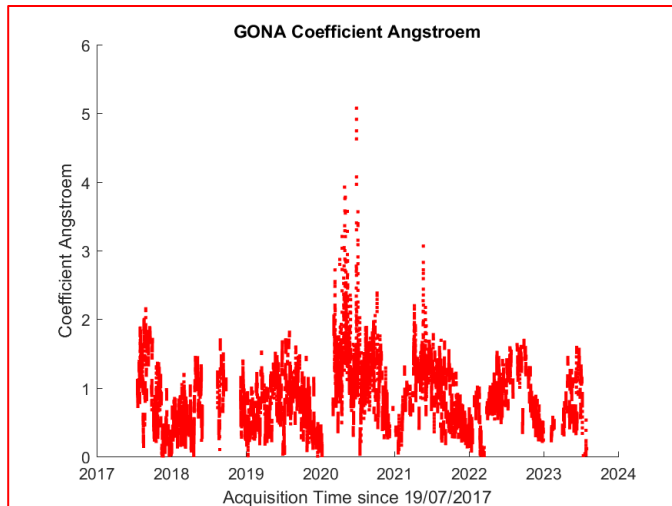
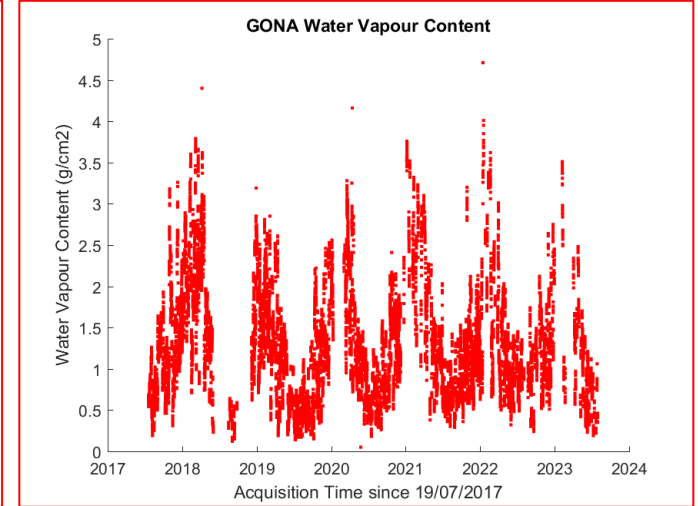
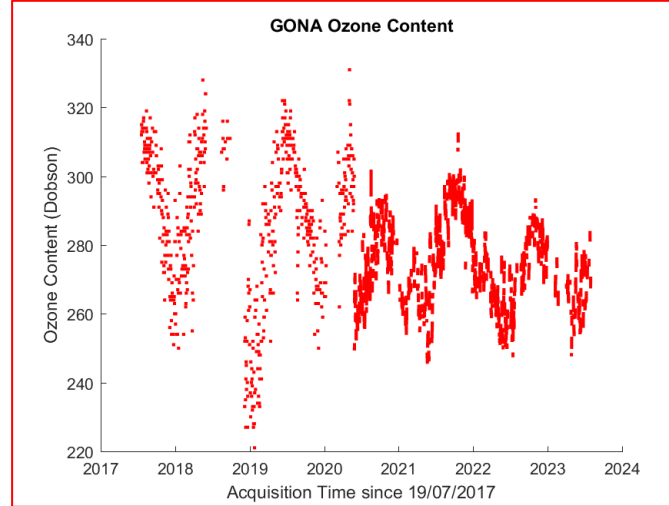
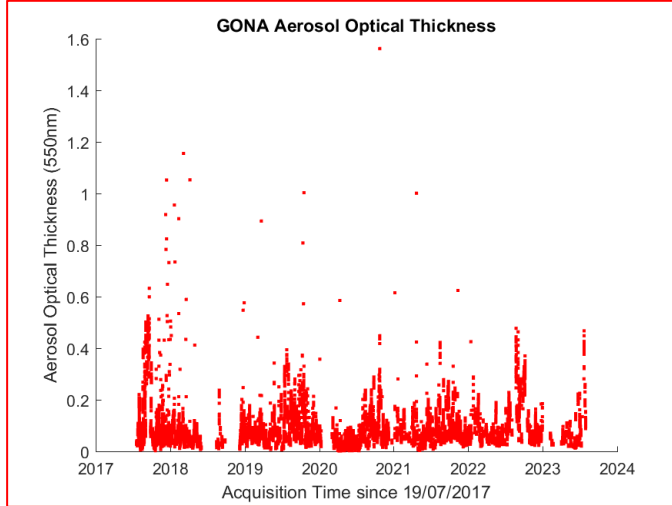


# Collection 2023

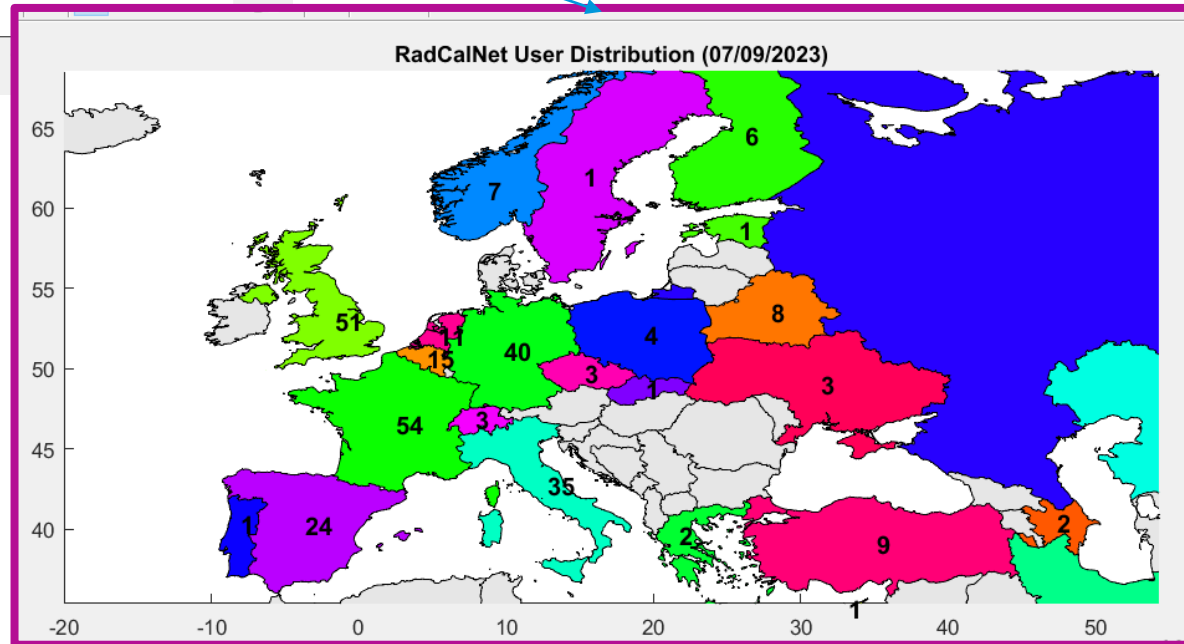
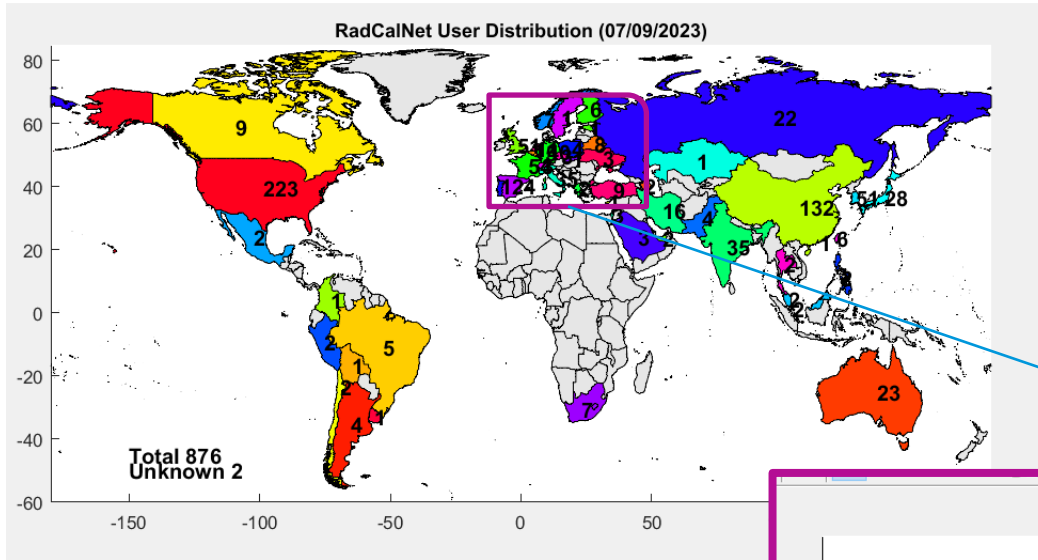
- Collection 2023 released on 12th of July 2023
- Reprocessing of the full archive of 4 out of the 5 RadCalNet sites (all but RVUS)
- Release note:  
[https://www.radcalnet.org/documentation/RadCalNetProcessing/2023\\_Data\\_Collection\\_Release\\_Note\\_v20230710.pdf](https://www.radcalnet.org/documentation/RadCalNetProcessing/2023_Data_Collection_Release_Note_v20230710.pdf)
- Number of days with data available:

06/09/2023													
	<b>2023</b>												
		<b>2013</b>	<b>2014</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>	<b>Total</b>
<b>RVUS</b>		193	237	225	222	264	246	246	263	250	292	<b>113</b>	<b>2551</b>
<b>LCFR</b>		0	0	100	125	128	99	132	115	102	100	<b>56</b>	<b>957</b>
<b>BTCN</b>		0	0	0	52	76	108	102	30	85	63	<b>49</b>	<b>565</b>
<b>GONA</b>		0	0	0	0	129	157	259	218	226	192	<b>61</b>	<b>1242</b>
<b>BSCN</b>		0	0	0	0	15	41	73	40	80	68	<b>43</b>	<b>360</b>
		<b>193</b>	<b>237</b>	<b>325</b>	<b>399</b>	<b>612</b>	<b>651</b>	<b>812</b>	<b>666</b>	<b>743</b>	<b>715</b>	<b>322</b>	<b>5675</b>

# Quality control: GONA atmospheric data

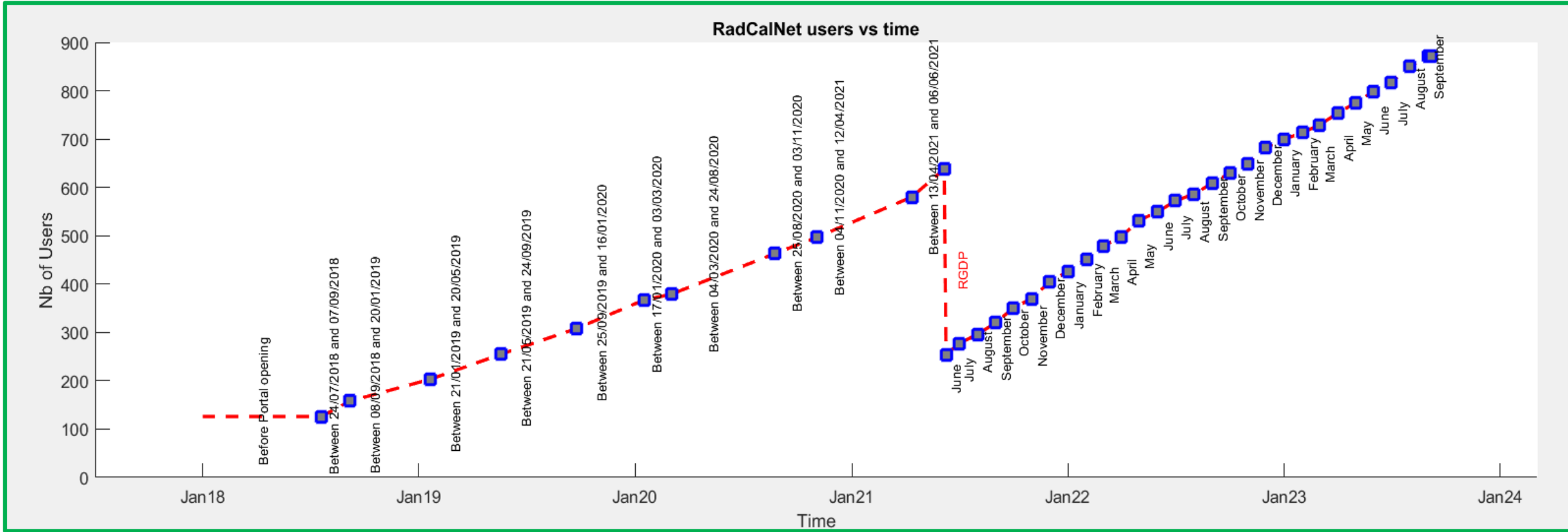


# Users



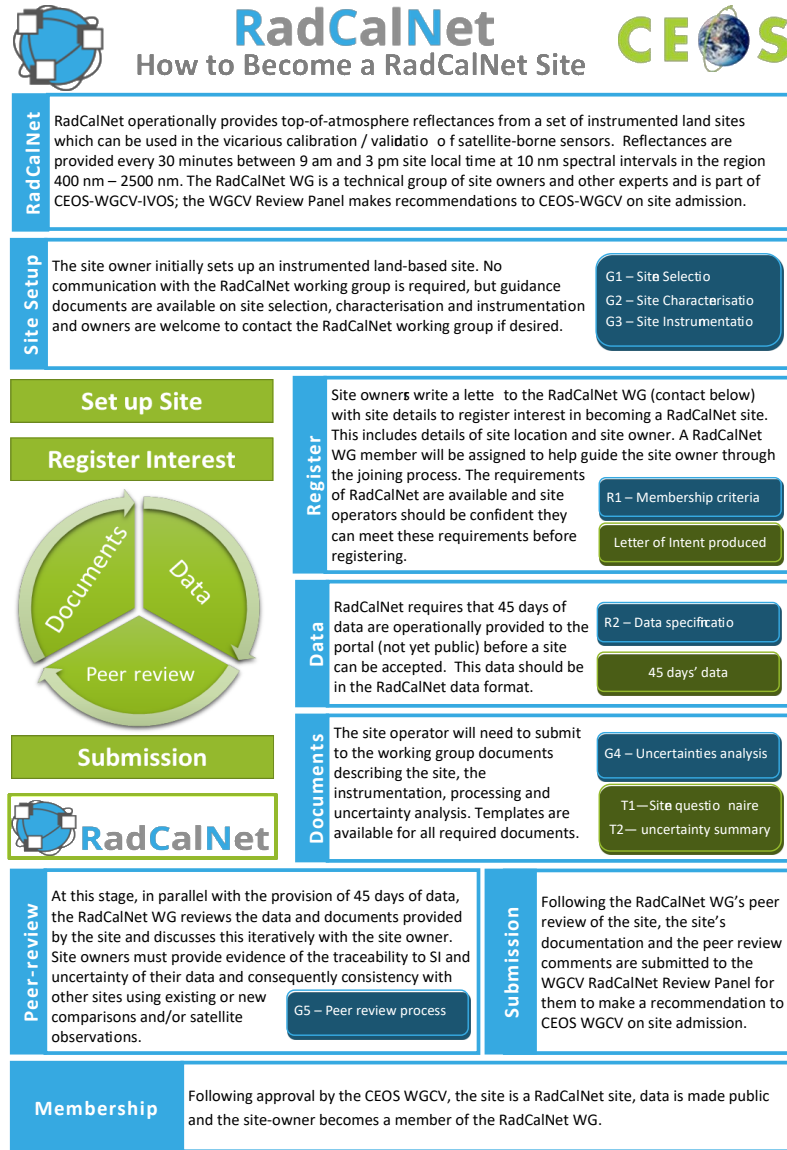


## Users





# Acceptance process for new sites

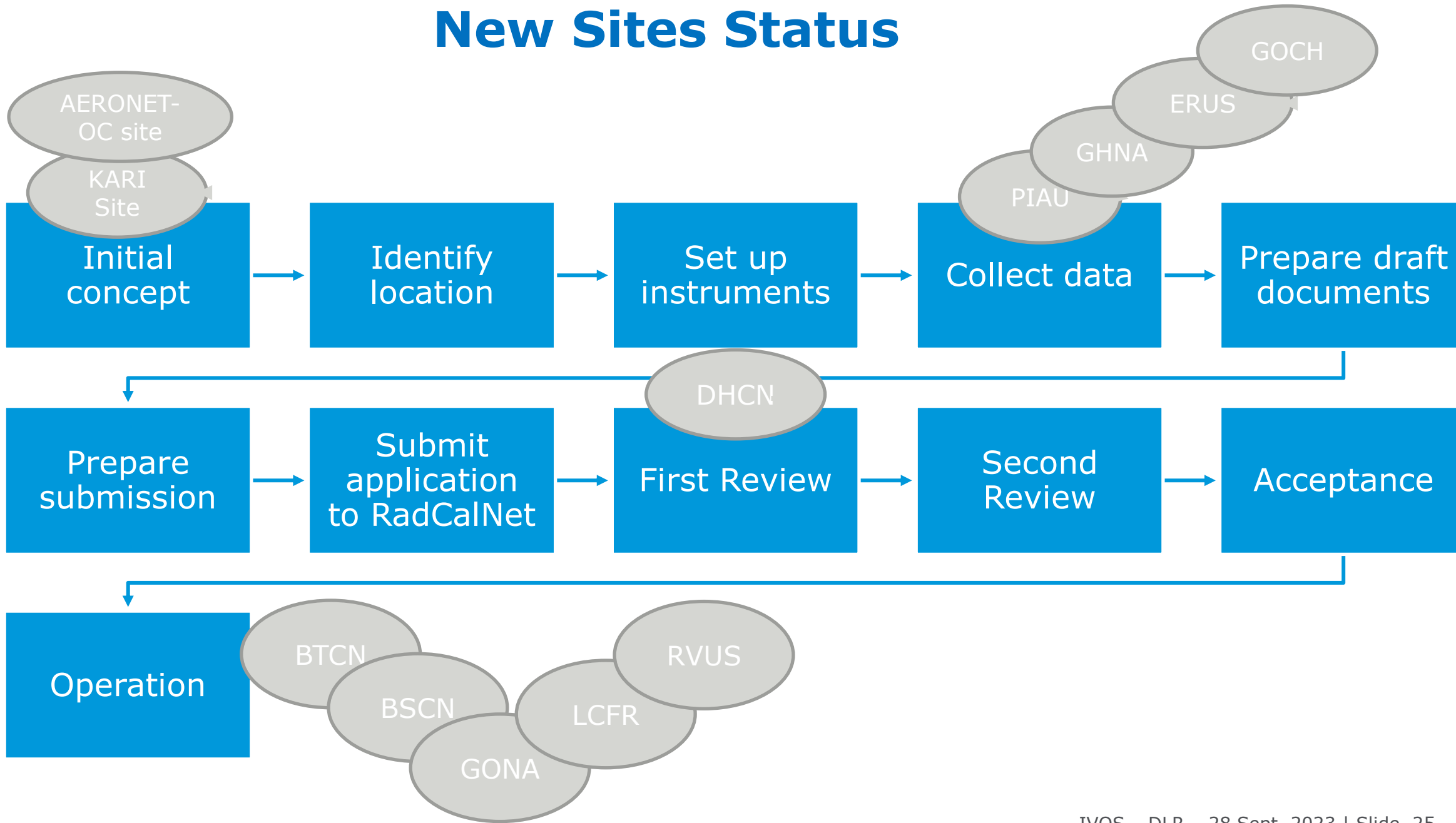


RadCalNet Helpdesk: [admin-radcalnet@magellium.fr](mailto:admin-radcalnet@magellium.fr)

Version 1.0—May 2017

- RadCalNet WG members contribute to the review
- Process overseen by WGCV
- Through an acceptance panel reporting to WGCV

# New Sites Status



# Conclusion

- Collection 2023 available since July 2023
- Continuous efforts to improve data quality and monitor sites
- 5 sites currently providing data. New sites expected to join the network.
- Growing user base
- 6 years of successful RadCalNet operation

# Hyperspectral Network: Hypernet

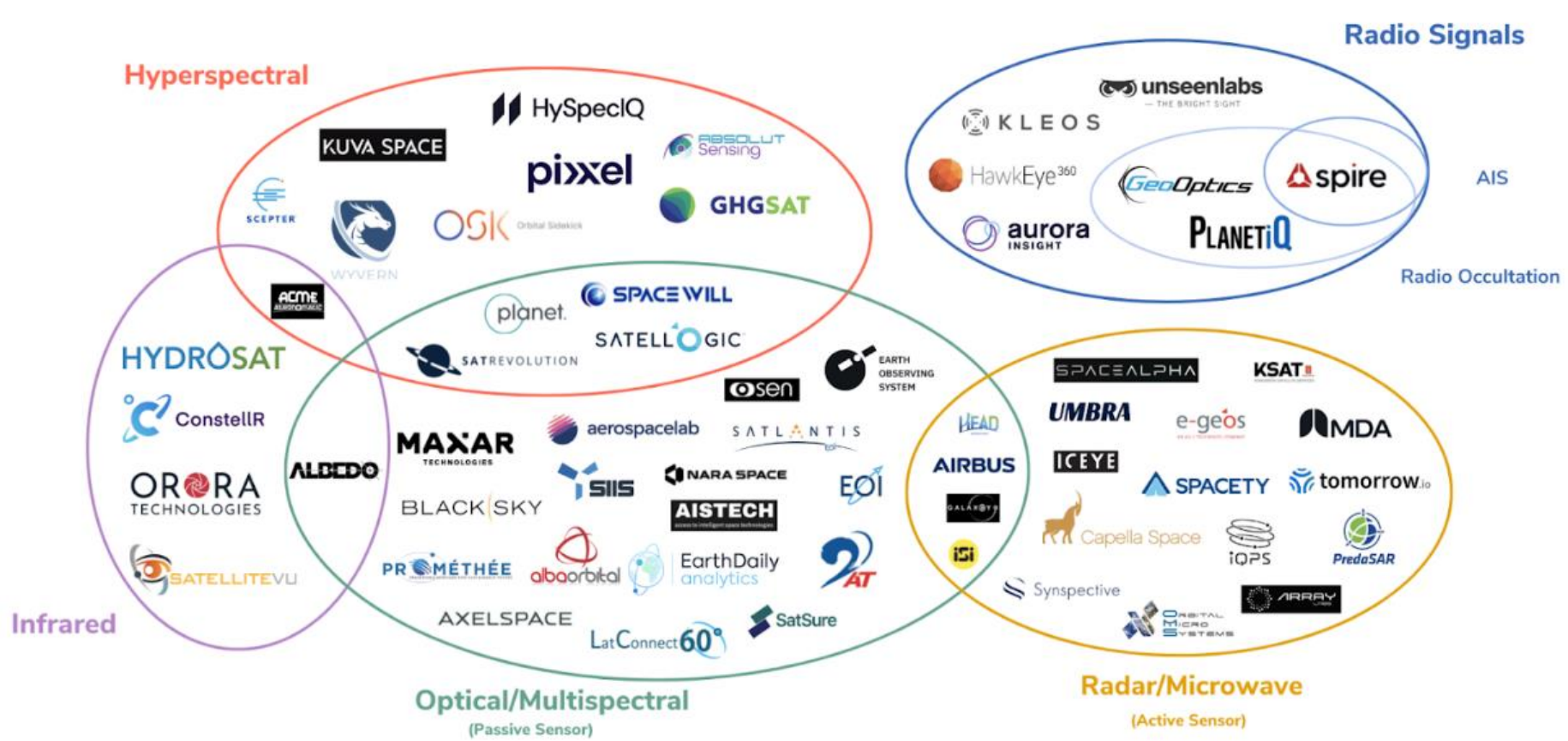
A new hyperspectral radiometer integrated in automated networks of water and land bidirectional reflectance measurements for satellite validation



# Hyperspectral Imaging - context



HYPERSPECTRAL DOMAIN IS GROWING → Newspace



Updated August 2022

© TerraWatch Space, by Aravind

terrawatchspace.com

## Hyperspectral imaging

has been identified as a key technology

for monitoring important bio-geophysical and bio-geochemical properties of the Earth's surface.



Hyperspectral imaging technology has already been successfully used on-board airplanes



**National prototype** hyperspectral satellite missions covering the VNIR and SWIR spectral domain have been recently launched:

- ✓ PRISMA mission, by ASI
- ✓ EnMAP mission, by DLR
- ✓ EMIT instrument installed on ISS, by NASA

Those missions are currently providing **important information, preliminary data** and **insightful experience** on hyperspectral data and related satellite mission concepts

# HYPERNETS

## INSTRUMENTS

Automated hyperspectral measurements



PANTHYR system  
[Vansteenkoven et al, 2019]  
400-900nm, 10nm FWHM



HYPSTAR® system  
[https://hypstar.eu]  
380-1700nm, 3-10nm FWHM

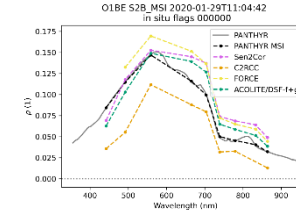
## NETWORK

RBINS (BE, coordinator)  
+ VLIZ (BE), CNR (IT), LOV (FR),  
NPL (UK), GFZ (D), TARTU (ES),  
CONICET (ARG)



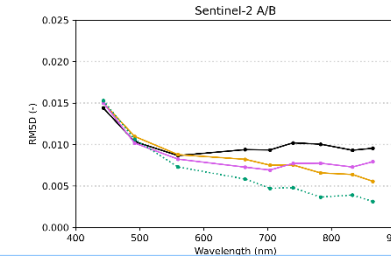
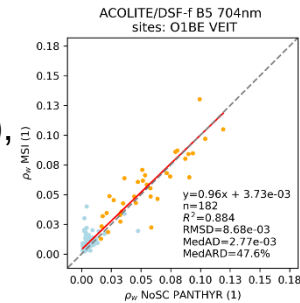
12 water and 7 land sites by Nov 2023  
Many international requests to join in 2024 ...

## DATA PROCESSING and ANALYSIS



e.g. one matchup

one band (S2/704nm),  
many matchups



spectral stats,  
many matchups

Prototype network has provided validation data and information to:

Sentinel-2A&B, Sentinel-3  
Maxar/Worldview ...

in progress for:

MODIS-A&T, VIIRS-1&

and preparing for:

MTG, CHIME, LSTM (vis. Channels), PACE, GLIMR, SBG, PROBAV-CC, various New Space, ...

**OBJECTIVE:** To validate all VIS/NIR spectral bands (400-1700nm, @3nm FWHM) for all satellite missions measuring water or land surface reflectance

**For HYPERSPECTRAL AND MULTISPECTRAL Satellites !**

## Water sites currently/recently running

✓ = suitable for validation

VLIZ: Oostende



RBINS: Blankaart



CNR: Lake Garda



CNR: Acqua Alta



RBINS: Zeebrugge



CONICET: La Plata



LOV: Etang Berre



RBINS: Thornton



LOV: Gironde



TARTU: Vortsjävän



+ USA Chesapeake Bay co-located AERONET-OC July 2023 ...  
+ UK Wraysbury reservoir July 2023 ...  
+ ...

esa will support 5 water sites to 2027



## Land sites currently/recently running

✓ = suitable for validation

NPL: Wytham



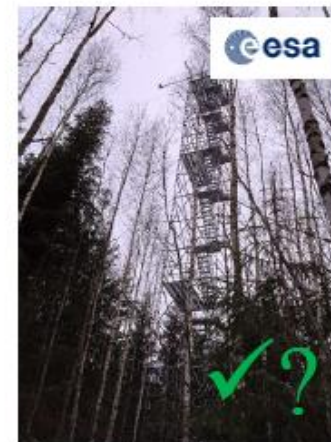
GFZ: ATB



RBINS: PE Antarctica  
(Dec-Jan)



TARTU: Järvelja



RBINS: Lonzee



GFZ: DEMMIN



NPL: Gobabeb



NPL/RBINS: Barrax  
(Jul 2022)



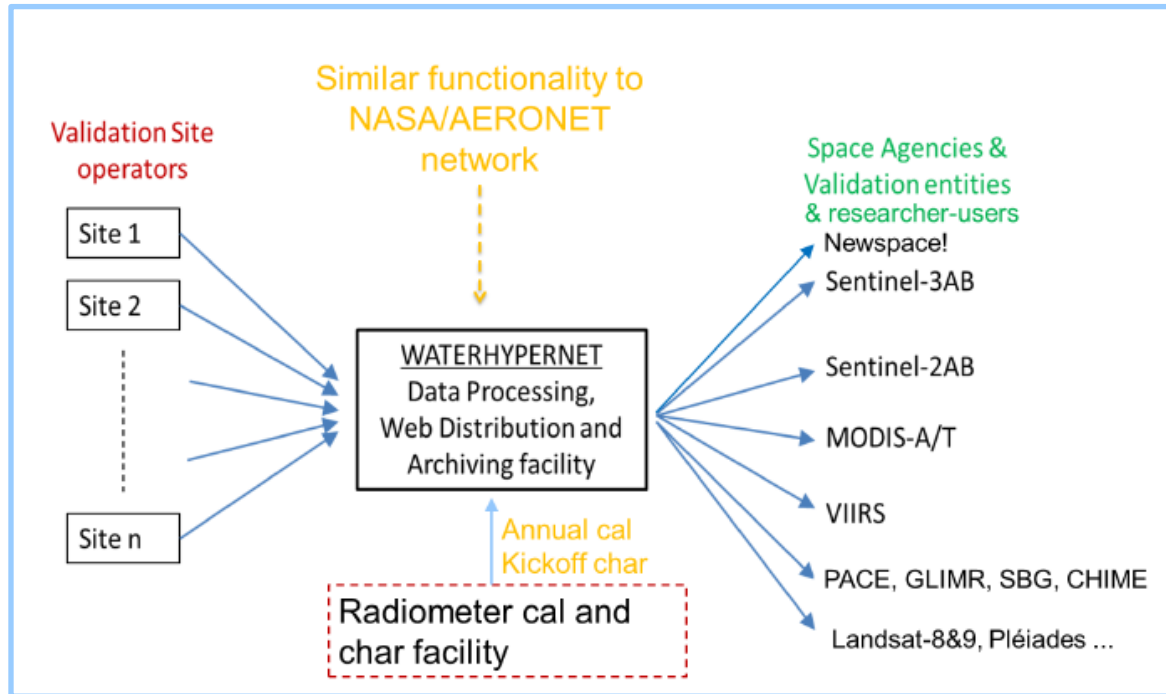
TARTU: Soontaga



+   
CNR: Jolanda di Savoia 2023 ...  
+ ...



# HYPERNET federated network stakeholders - conclusion



## Data distribution

### Prototype data portals

#### WATERHYPERNET:

- First 4 PANTHYR sites uploading in NRT to waterhypernet.org
- (AAOT, Oostende, Blankaart, Thornton)
- Prototype tested for one HYPSTAR

#### LANDHYPERNET:

- Prototype tested for HYPSTARS

**CURRENTLY** restructuring and automating data processors  
**THEN (2024)** reorganize data portals

Links to ZENODO datasets at

<https://waterhypernet.org/data/>

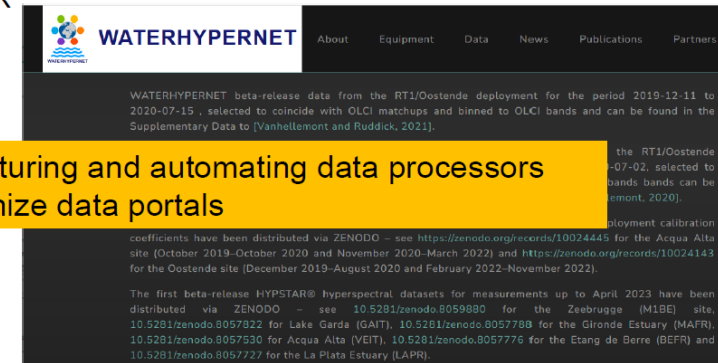
### Beta-release datasets (zenodo.org)

#### WATERHYPERNET:

- 6 HYPSTAR sites (to 2023-04) on zenodo
- 2 PANTHYR sites on zenodo

#### LANDHYPERNET:

- 6 HYPSTAR sites (to 2023-04) on zenodo



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 HDRF for land and for water

Need for consolidation of protocols and uncertainty estimation (water:FRM4SOC, land:FRM4VEG)

Toward **FIDUCIAL REFERENCE MEASUREMENTS**

**Thanks to AERONET-OC which serves as an example and remains a reference network for water reflectance Xspectral.**