



# PRISMA mission

## An overview & preliminary data analysis

Claudia Giardino & CNR team



Consiglio Nazionale  
delle Ricerche



istituto per il rilevamento  
elettromagnetico  
dell'ambiente

PACE meeting, 18 September 2020

## Presentation Outline

- Mission overview
- PRISMA data products
- First evaluation of data on water targets
- Conclusions
- Links

## PRISMA mission overview



22-03-19

Vega begins its ascent from the Spaceport in French Guiana, carrying PRISMA (image credit: Arianespace)

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## System main characteristics

<b>Orbit</b>	SSO 615 km 10:30 LTDN
<b>Lifetime</b>	5 years
<b>Relook time</b>	<7 days
<b>Onboard Data Storage</b>	448 Gbit
<b>Downlink data rate</b>	310 Mbps
<b>Imaging capacity</b>	200.000 km <sup>2</sup> /day Pushbroom, strip $\leq$ 1800km
<b>Pointing accuracy</b>	0.5 km
<b>Response time</b>	< 14 days
	Acquisition latency < 9.5 days
	Processing latency < 4.5 days
<b>Target access opportunities over the Primary AoI</b>	duration/day: 235 minutes (average, off nadir pointing) distributed over the full daily orbits
<b>Mass P/L + P/F</b>	~ 830 kg (including contingency and balance masses)
<b>Repeat cycle</b>	29 days (430 orbits)
<b>Average eclipse [minutes]</b>	~ 34

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PRISMA satellite shall be able to manoeuvre in order to capture two images at a maximum distance of 1000 km in a single pass (from worst case left to right side looking and viceversa).

## PRISMA mission overview

PRISMA reference mission requirements values and actual performances estimated by Leonardo Space & Airborne Systems (V reports the Verification method: F= in-flight, G=on ground).

### Instrument main characteristics

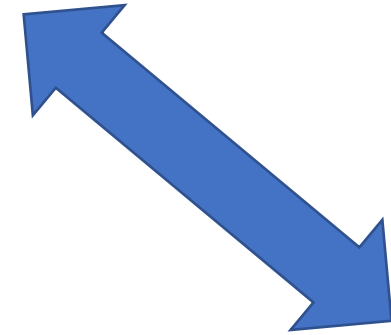
	<b>Requirement</b>	<b>VNIR</b>	<b>SWIR</b>	<b>PAN</b>	<b>V</b>
<b>Swath</b>	≥30 km	31 km	31 km	31 km	<b>F</b>
<b>Ground Sampling Distance (GSD)</b>	≤31 m (VNIR-SWIR) (*) ≤5.1 m (PAN) (*)	31 m	31 m	5.1 m	<b>F</b>
<b>Spectral Range</b>	400-2500 nm	400–1010 nm	920–2500 nm	400–700 nm	-
<b>Number of bands</b>	-	66	174	1	-
<b>Image quality MTF</b>	≥0.3 (VNIR-SWIR) ≥0.2 (PAN)(x2 bin) (*)	0.30	0.32	0.25	<b>F</b>
<b>Spatial co-registration (GSD=30 m)</b>	≤0.1 GSD	0.04 GSD	0.04 GSD	0.06 GSD	<b>F</b>
<b>Spectral Sampling Interval (SSI)</b>	≤11 nm (*)	7.2-11 nm	6.5-11 nm	-	<b>G</b>
<b>Spectral Resolution</b>	≤15 nm (*)	9-13 nm	9-14.5 nm	-	<b>G</b>

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Swath	≥30 km	31 km	31 km	31 km	F
Ground Sampling Distance (GSD)	≤31 m (VNIR-SWIR) (*)	31 m	31 m	5.1 m	F
	≤5.1 m (PAN) (*)				
Spectral Range	400-2500 nm	400–1010 nm	920–2500 nm	400–700 nm	-
Number of bands	-	66	174	1	-
Image quality MTF	≥0.3 (VNIR-SWIR) ≥0.2 (PAN)(x2 bin) (*)	0.30	0.32	0.25	F
Spatial co-registration (GSD=30 m)	≤0.1 GSD	0.04 GSD	0.04 GSD	0.06 GSD	F
Spectral Sampling Interval (SSI)	≤11 nm (*)	7.2-11 nm	6.5-11 nm	-	G
Spectral Resolution	≤15 nm (*)	9-13 nm	9-14.5 nm	-	G



The standard size of a single imagery is 30 x 30 km with but the system can acquire full-resolution payload data up to 1800 km x 30 km (i.e. the maximum length of a single EO acquisition)



# PRISMA mission overview

## Instrument main characteristics

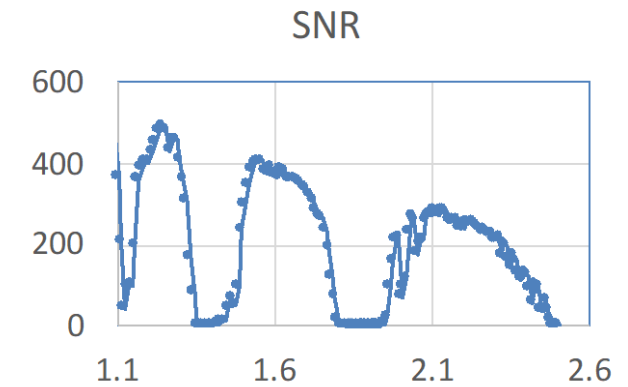
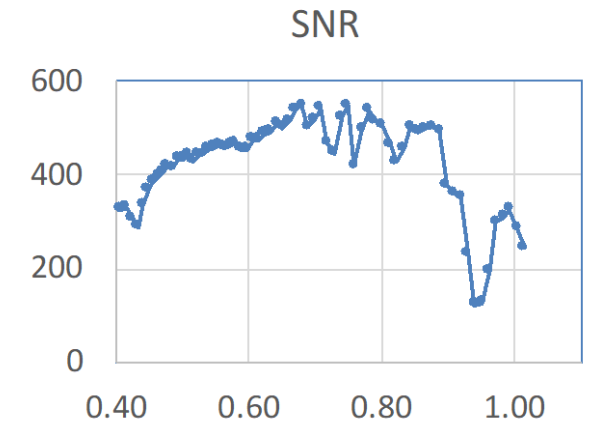
	Requirement	VNIR	SWIR	PAN	V
SNR	≥160-200 (400-450 nm) (*)	161-209 (400-450 nm)			
	≥200 (450-1000 nm) (*) (930-970 nm NA)	200-450 (450-1000 nm)	--	--	<b>G</b>
	≥200 (1000-1750 nm) ≥100 (1950-2350 nm) (NA in absorption bands)	-	300-800 (1000-1300 nm) 200-400 (1500-1750 nm) 100-200 (1950-2350 nm)	-	<b>G</b>
	≥190 (PAN) (*)	-	-	191	<b>G</b>
<b>Spectral centroid knowledge Accuracy</b>	≤±0.1 nm	±0.1 nm	±0.1 nm	-	<b>G</b>
<b>Absolute Radiometric Accuracy</b>	≤5%	≤5% (Stability≤±1%)	≤5% (Stability≤±1%)	-	<b>F</b>



# PRISMA mission overview

## Instrument main characteristics

Requirement	VNIR	SWIR	PAN	V
<div style="border: 2px solid blue; padding: 2px; display: inline-block; margin-bottom: 5px;">SNR</div> ≥160-200 (400-450 nm) (*) ≥200 (450-1000 nm) (*) (930-970 nm NA)	161-209 (400-450 nm)	--	--	<b>G</b>
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≥190 (PAN) (*)	-	-	191	<b>G</b>
<b>Spectral centroid knowledge Accuracy</b>	≤±0.1 nm	±0.1 nm	±0.1 nm	<b>G</b>
<b>Absolute Radiometric Accuracy</b>	≤5%	≤5% (Stability≤±1%)	≤5% (Stability≤±1%)	<b>F</b>



# PRISMA cal/val (ASI-Industry contract & ASI-CNR contract, started Oct. 2019, 3 years)

Commissioning phase: Mar. 2019 - Jan. 2020

Mission Requirements document (hundreds of requisites)

**Flat Field in-flight Calibration**

FF vicarious calibration approach exploiting acquisitions on PICSs has been investigated

**Validation by means of Sun irradiance comparison**

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FF vicarious calibration approach exploiting acquisitions on PICSs has been investigated

Validation by means of Sun irradiance comparison

Validation on natural targets

Thematic areas	Site
Coastal Water	Lampedusa, Venezia
Snow	Torgnon, Plateau Rosa
Inland water	Lago Trasimeno, Lago di Garda
Agricultural areas	Grosseto, Basilicata, Tavoliere delle Puglie, Ferrara
Forests	Lavarone



# PRISMA data discovery and download - ASI Portal: catalog

Layers

Product search

BBOX12

UTC Time Range

From: 2020-04-15 00:00:00

To: 2020-04-16 00:00:00

Place Search

Placemarks

Selection Info

Area of interest

Name: BBOX12

Area: 384529482.375 km<sup>2</sup>

Lower corner:

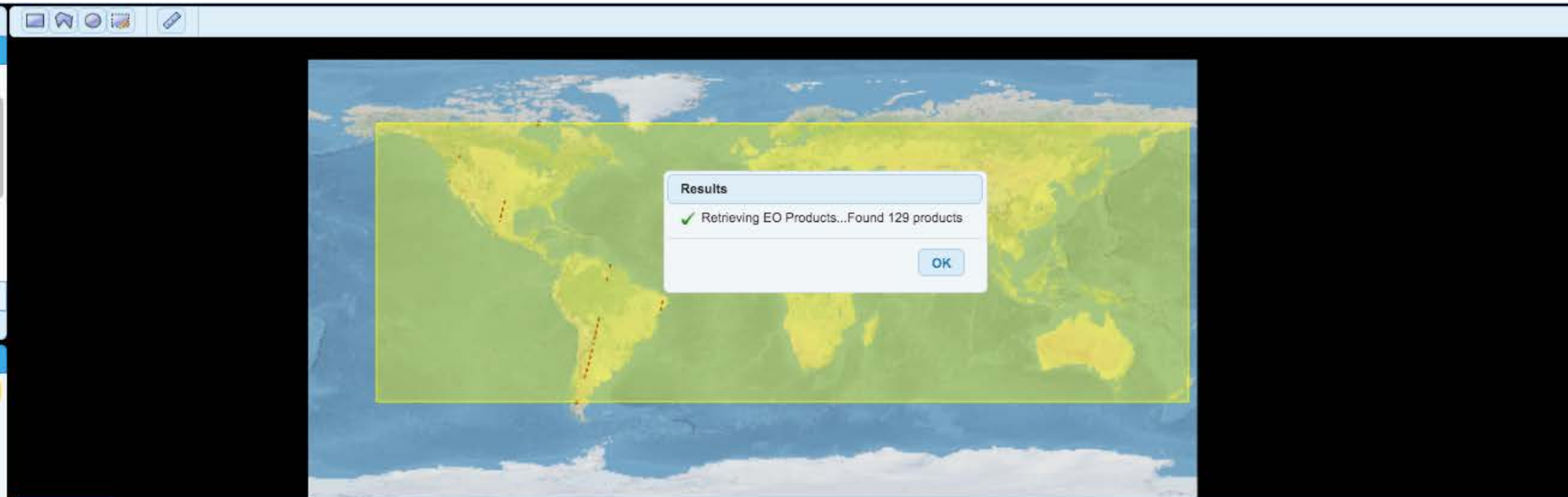
Lon: 152°18'29"W

Lat: 48°21'38"S

Upper corner:

Lon: 176°20'52"E

Lat: 64°13'40"N



EO Products

Product StartTime	Product StopTime	File Type	Sensor Mode	Inventory date	Cloud coverage	Archived
2020-04-15 14:38:12.572Z	2020-04-15 14:38:16.882Z	PRS_L0__EO	N/A	2020-04-15 21:10:09.559Z	0.0803231	true
2020-04-15 14:36:38.748Z	2020-04-15 14:36:43.058Z	PRS_L0__EO	N/A	2020-04-15 21:10:11.619Z	15.5537	true
2020-04-15 14:36:15.497Z	2020-04-15 14:36:19.807Z	PRS_L0__EO	N/A	2020-04-15 21:10:12.527Z	32.4955	true
2020-04-15 12:55:46.248Z	2020-04-15 12:55:50.558Z	PRS_L0__EO	N/A	2020-04-15 21:10:12.948Z	0.797012	true
2020-04-15 14:38:46.530Z	2020-04-15 14:38:50.840Z	PRS_L0__EO	N/A	2020-04-15 21:10:13.704Z	24.8037	true

# PRISMA data discovery and download - ASI Portal: catalog

The screenshot displays the ASI Portal interface for PRISMA data discovery. On the left, the 'Layers' panel shows a 'Product search' section with a search box containing 'BBOX12'. Below it, the 'UTC Time Range' section is highlighted with a red box, showing a search for data from 2020-04-15 00:00:00 to 2020-04-16 00:00:00. The 'Selection Info' panel shows details for the 'Area of interest' BBOX12, including its name, area (384529482.375 km²), and corner coordinates.

The main map area shows a satellite view of the Earth with a yellow rectangular bounding box over the South American continent. A 'Results' dialog box is overlaid on the map, indicating that 129 products were found.

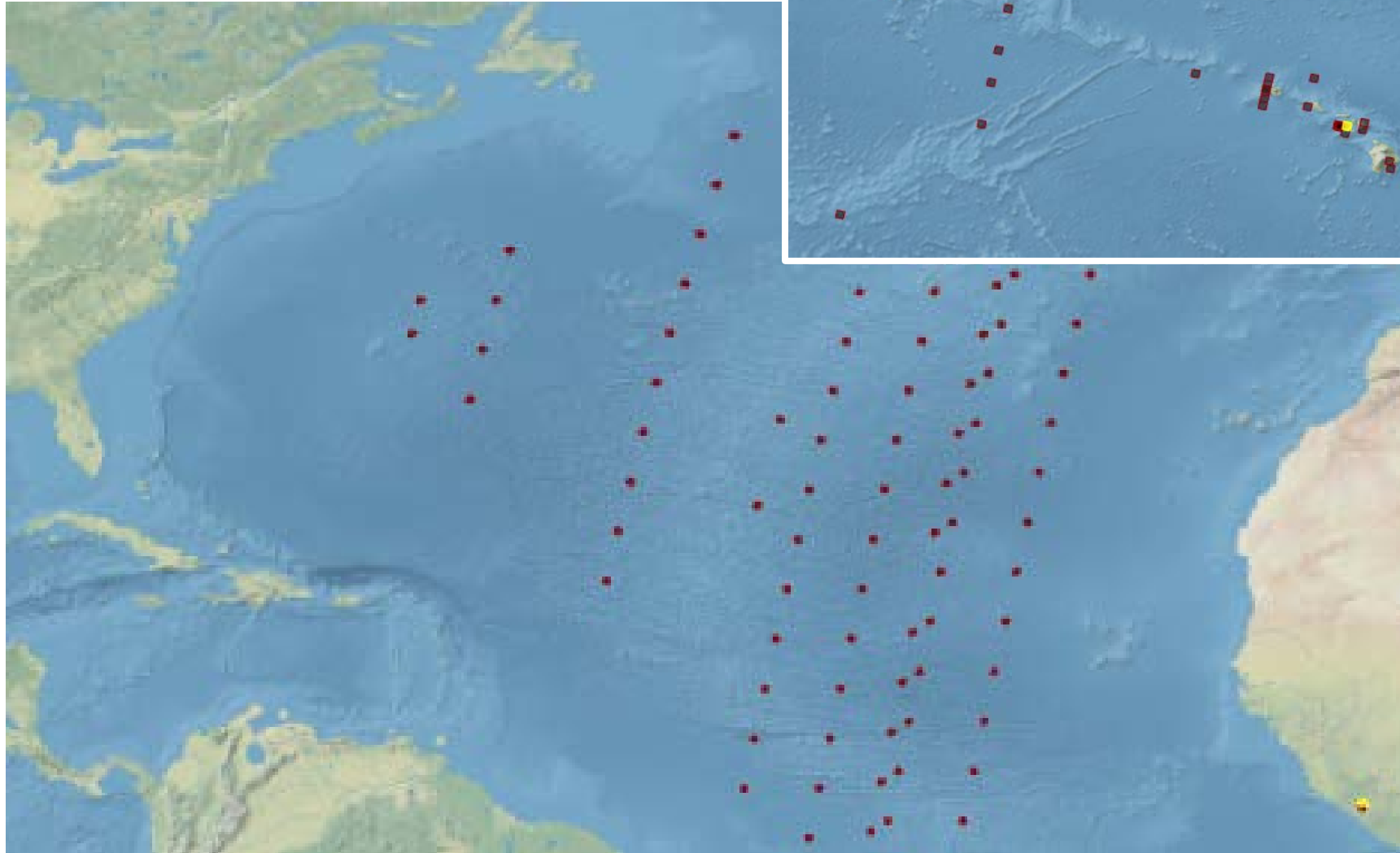
At the bottom, the 'EO Products' table lists search results with columns for Product StartTime, Product StopTime, File Type, Sensor Mode, Inventory date, Cloud coverage, and Archived status.

Product StartTime	Product StopTime	File Type	Sensor Mode	Inventory date	Cloud coverage	Archived
2020-04-15 14:38:12.572Z	2020-04-15 14:38:16.882Z	PRS_L0__EO	N/A	2020-04-15 21:10:09.559Z	0.0803231	true
2020-04-15 14:36:38.748Z	2020-04-15 14:36:42.058Z	PRS_L0__EO	N/A	2020-04-15 21:10:11.610Z	15.5537	true
2020-04-15 14:36:15.497Z	2020-04-15 14:36:18.807Z	PRS_L0__EO	N/A	2020-04-15 21:10:13.661Z	32.4955	true
2020-04-15 12:55:46.248Z	2020-04-15 12:55:50.558Z	PRS_L0__EO	N/A	2020-04-15 21:10:15.712Z	0.797012	true
2020-04-15 14:36:12.572Z	2020-04-15 14:36:16.882Z	PRS_L0__EO	N/A	2020-04-15 21:10:17.763Z	24.8037	true

A second 'Results' dialog box is overlaid on the table, also indicating that 129 products were found.

# PRISMA data discovery and download - ASI Portal: catalog

15 Sep- 15 December. 2019 PRISMA scenes over ocean



Pacific Ocean

Atlantic Ocean



# PRISMA data discovery and download - ASI Portal: Tasking

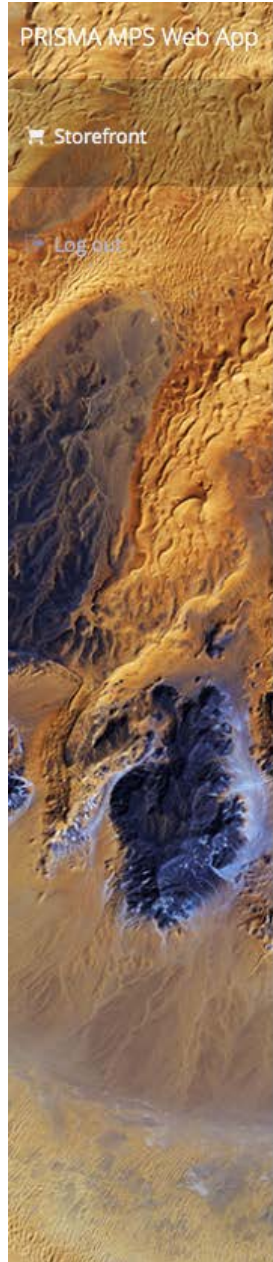
PRISMA MPS Web App

Programming Request Status Filter: ANY PR id     Include past

Due Da...	Summary	Order Stat...	Last stage detected
6 Mar 12:00	Order Id: 1345 Number of Programming Requests: 1	COMPLETED	
6 Mar 12:00	Order Id: 1346 Number of Programming Requests: 1	COMPLETED	
	Programming Request Id: 4194 Latitude[deg]: -39.14801; Longitude[deg]: -61.72201; Product ty	COMPLETED	The image screening has shown good quality
15 Mar 12:00	Order Id: 1390 Number of Programming Requests: 1	COMPLETED	
16 Mar 09:00	Order Id: 1383 Number of Programming Requests: 1	COMPLETED	
19 Mar 12:00	Order Id: 1379 Number of Programming Requests: 1	COMPLETED	
20 Mar 12:00	Order Id: 1391 Number of Programming Requests: 1	COMPLETED	
20 Mar 16:00	Order Id: 1380 Number of Programming Requests: 1	COMPLETED	
22 Mar 09:00	Order Id: 1384 Number of Programming Requests: 1	COMPLETED	
26 Mar 12:00	Order Id: 1401 Number of Programming Requests: 1	COMPLETED	

Storefront

Log out





# PRISMA Standard products (L1 and L2 in HDF5 format)

Courtesy Lopinto et al. LPS, Milano, 2019

## Level 0 (Hyperspectral / PAN)

- formatted data product with appended metadata, including ancillary data and file formatting information (Archived data)

## Level 1 (Hyperspectral / PAN) radiometrically corrected and calibrated radiance data in physical units

- Top-of-Atmosphere Spectral Radiance
- Cloud mask
- Sun-glint Mask
- Calibration and characterization data
- Classification Mask

## Level 2b Geolocated at Ground Spectral Radiance Product (Hyperspectral / PAN)

## Level 2c Geolocated At-surface Reflectance Product (Hyperspectral / PAN)

- Aerosol Characterization Product (VNIR)
- Water Vapour Map Product (Hyperspectral)
- Cloud Characterization

## Level 2d Geocoded version of the level 2c products (Hyperspectral / PAN)

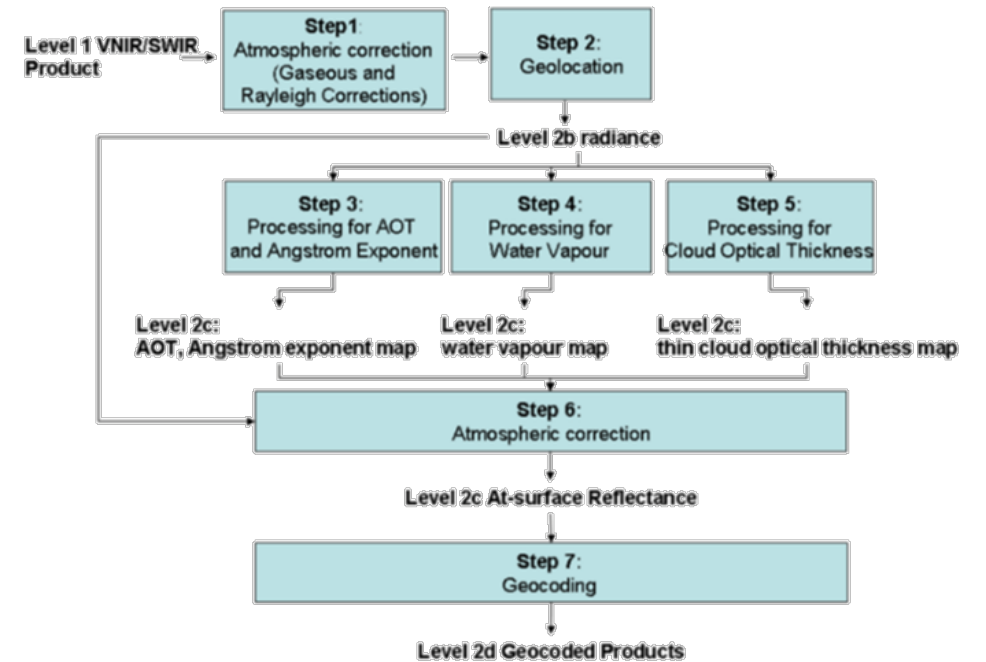


Figure 8-1: Level 2 processing scheme

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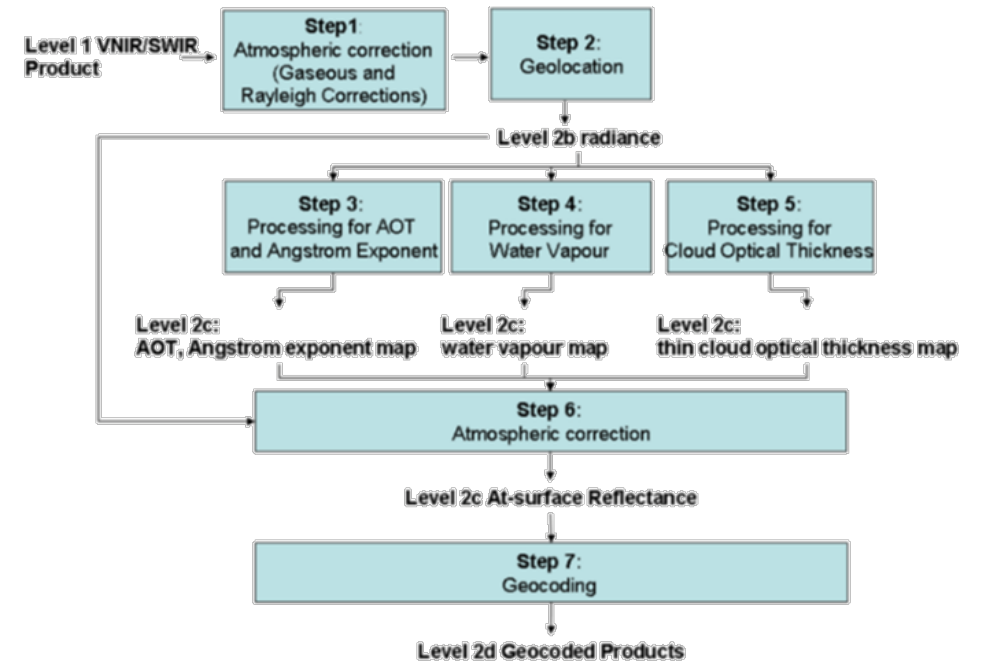
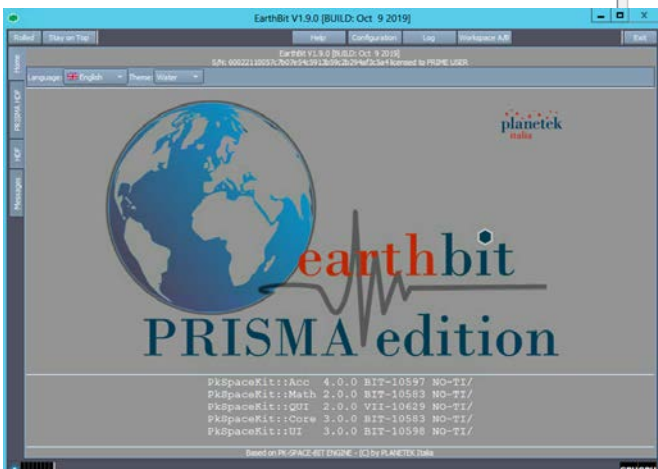
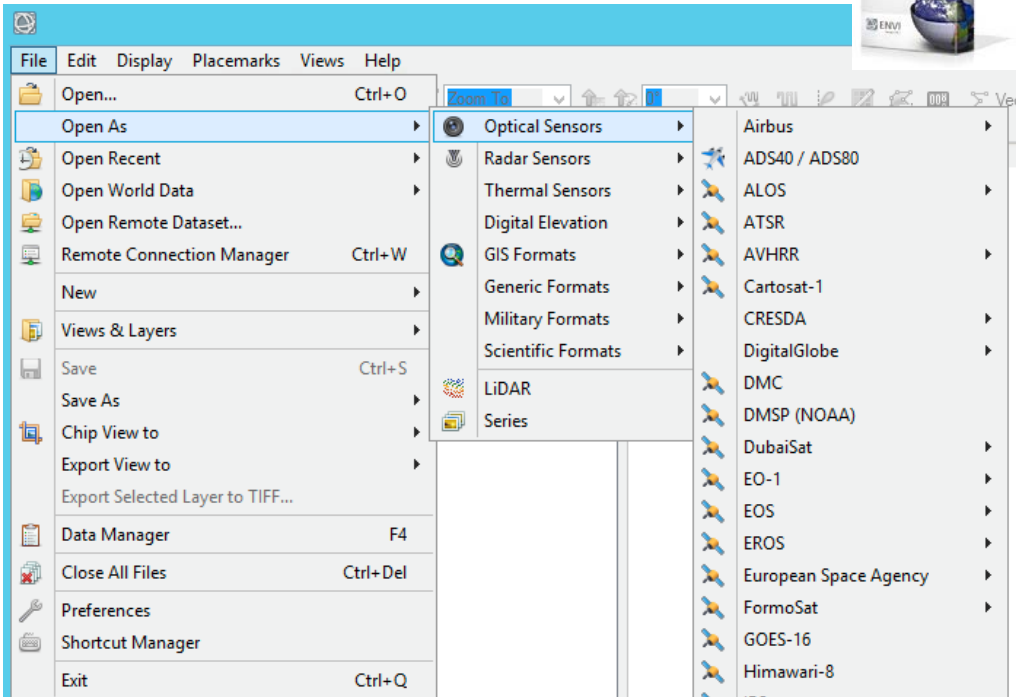


Figure 8-1: Level 2 processing scheme

The PRISMA products are stored in HDF-EOS5 (Hierarchical Data Format - Earth Observing System) files which contains the panchromatic, VNIR and SWIR datasets.

# PRISMA data reader



<https://lbusett.github.io/prismaread/>



## prismaread

prismaread allows easily importing PRISMA hyperspectral data (<http://www.prisma-i.it/index.php/it/>) from the original data provided by ASI in HDF format, and convert them to a easier to use format (ENVI or GeoTiff). It also provides functionality for automatically computing Spectral indexes from either the original HDF data or from hyperspectral data already converted using function `pr_convert`, and for easily and quickly extracting data and computing statistics for the different bands over areas of interest.



prismaread is developed and maintained by Lorenzo Busetto and Luigi Ranghetti, *Institute of Remote Sensing of Environment - National Research Council - Italy (CNR-IREA)*

## Installation

You can install the last stable version of prismaread from GitHub using:

```
# install.packages("remotes")
remotes::install_github("lbusett/prismaread", ref = "v1.0.0")
library(prismaread)
```

, or the last development version using:

```
# install.packages("remotes")
remotes::install_github("lbusett/prismaread")
library(prismaread)
```

## Usage

See the **Articles** section of the website for detailed info on usage.

- Instructions for importing PRISMA **L1** and **L2**
- Instructions for **computing spectral indexes**
- Info about **Output format and Naming Conventions**
- Instructions for **extracting Data from PRISMA images over features of a vector dataset**

## Future Work

- Improve speed of writing FULL hyperspectral cubes
- Clean up code

## Citation

To cite prismaread please use:

Busetto, L., Ranghetti, L. (2020) prismaread: A tool for facilitating access and analysis of PRISMA L1/L2 hyperspectral imagery v1.0.0, URL: <https://lbusett.github.io/prismaread/>, doi: <https://doi.org/10.5281/zenodo.4019081>



## Links

Browse source code at <https://github.com/lbusett/prismaread/>

Report a bug at <https://github.com/lbusett/prismaread/issues>

## License

Full license

GPL-3

## Community

Code of conduct

## Citation

Citing prismaread

## Developers

Lorenzo Busetto

Author, maintainer

Luigi Ranghetti

Author

## Dev status

build passing

lifecycle beta

DOI 10.5281/zenodo.4019081

codecov 90%



# PRISMA imagery

Venezia,  
2020-02-08

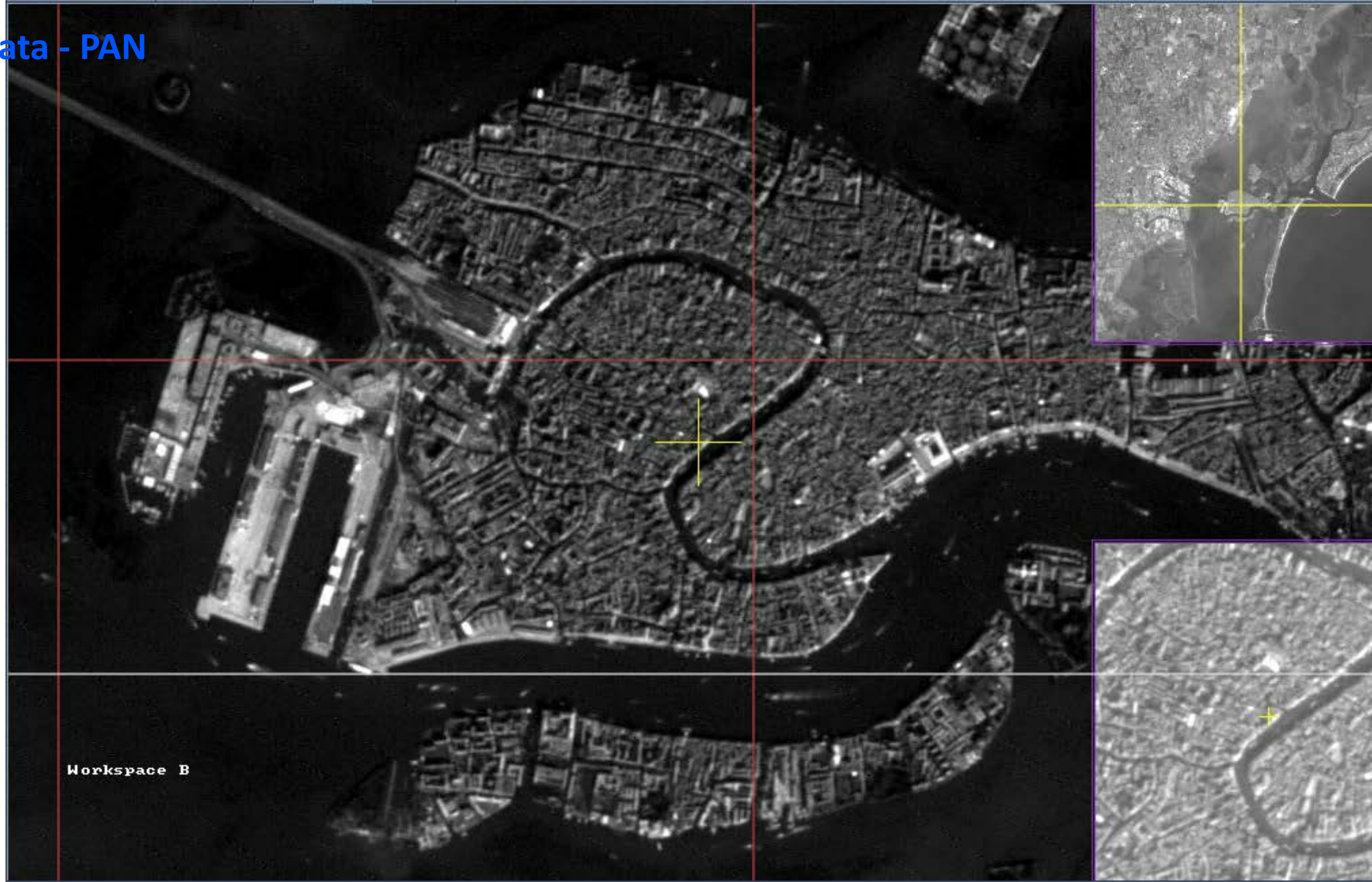


Workspace A



# PRISMA data - PAN

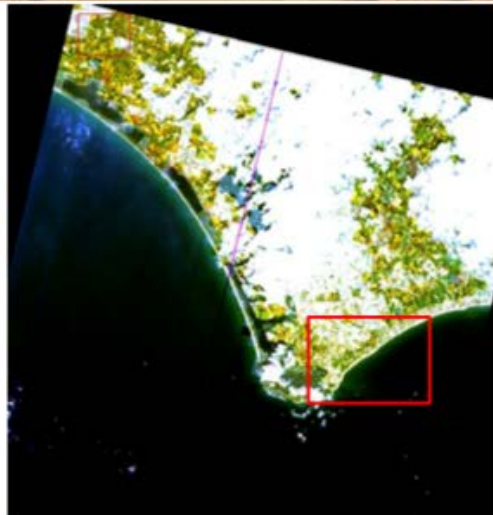
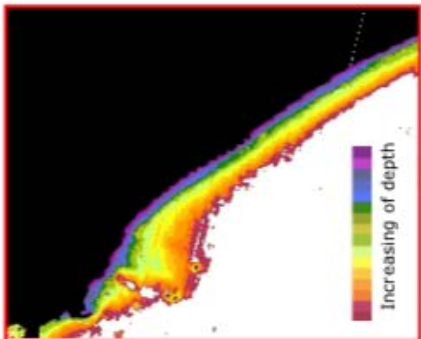
Venezia,  
2020-02-08



Workspace B



# Site: Italy, Sabaudia



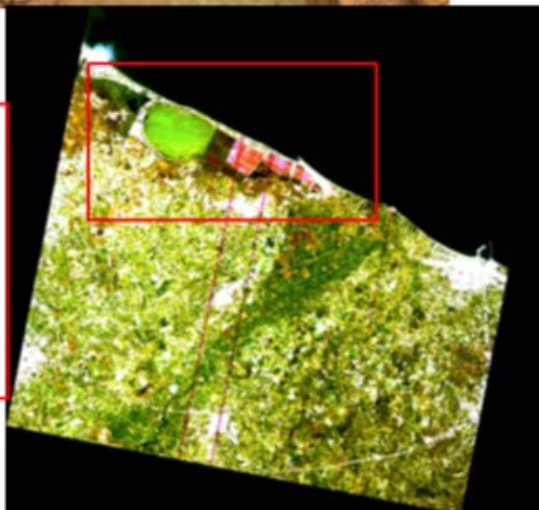
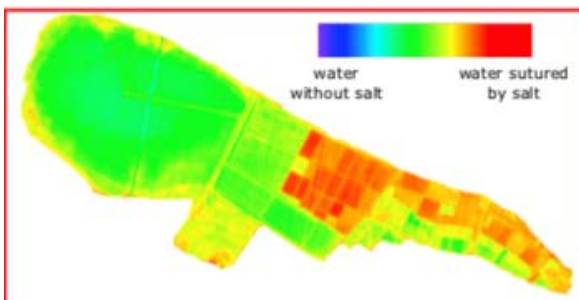
# Site: Italy, Trasimeno Lake



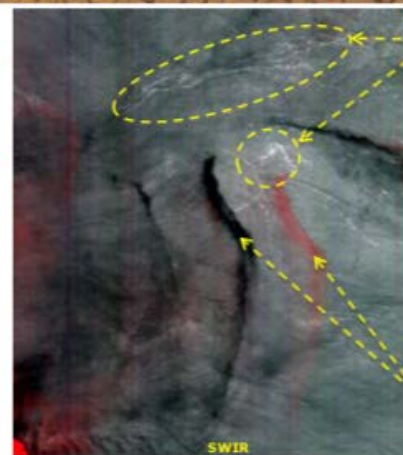
## Product: Turbidity map



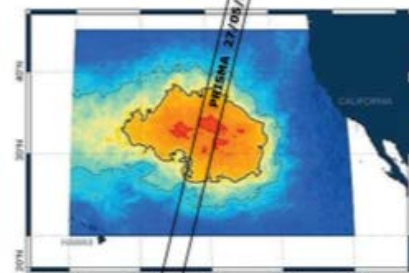
# Product: water properties and salt features



# Great Pacific Garbage Patch (GPGP)



Hypothetic "floating plastic debris" on SWIR Datacube

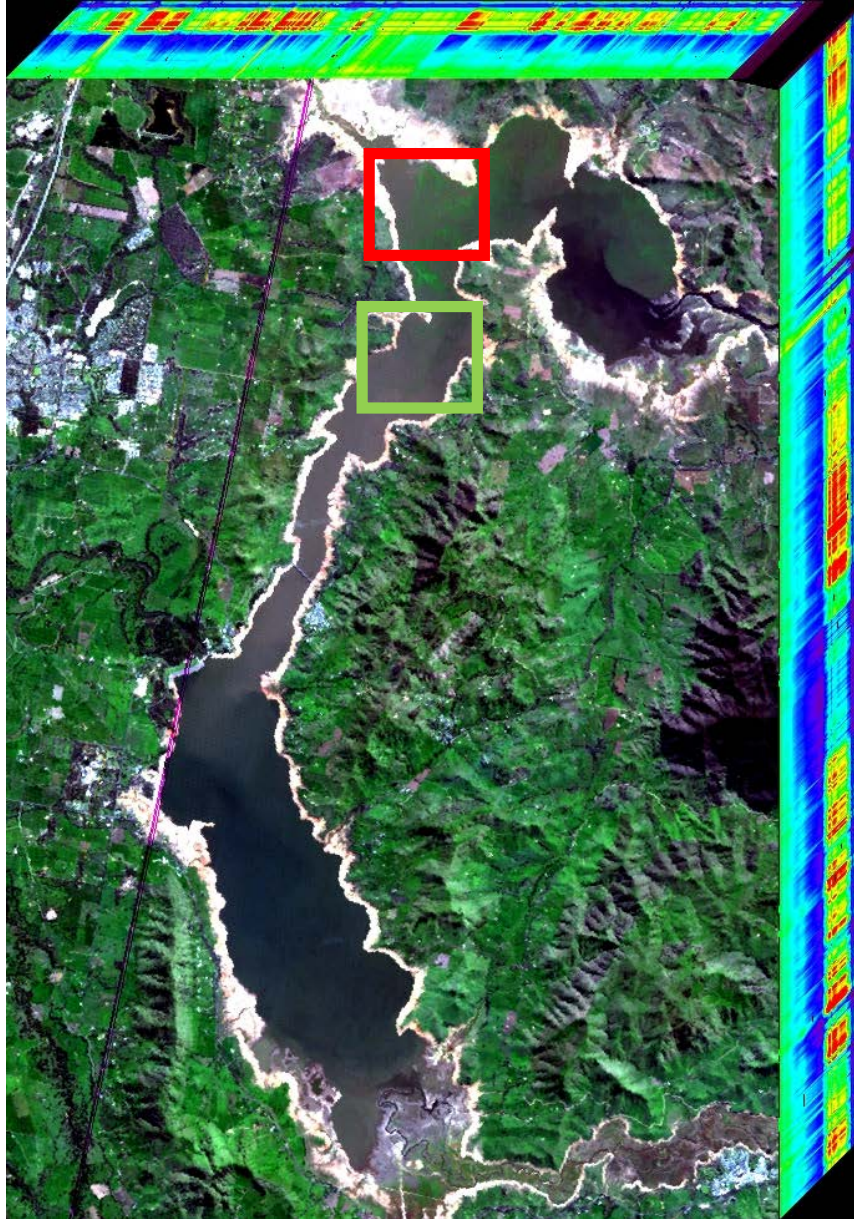


Clouds and shadows (black and red pixels)

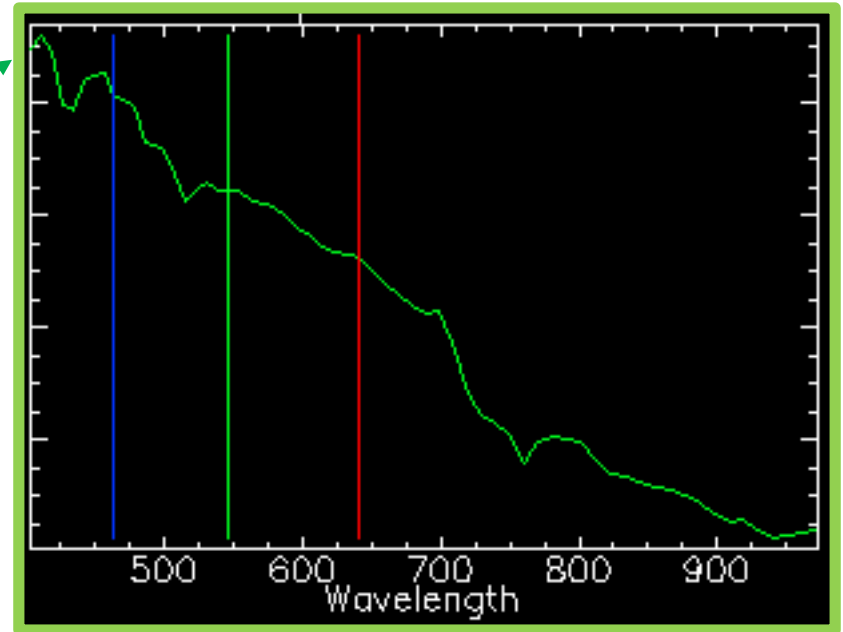
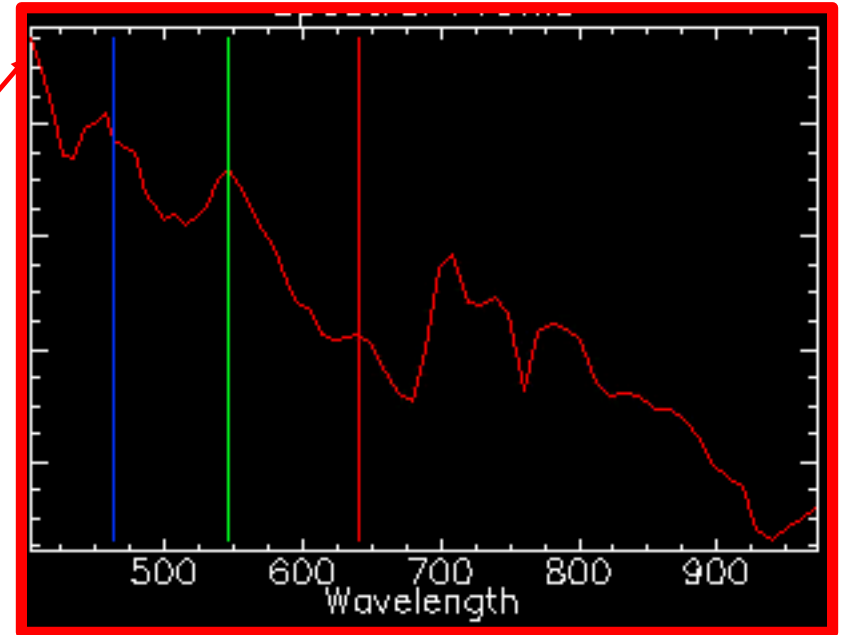
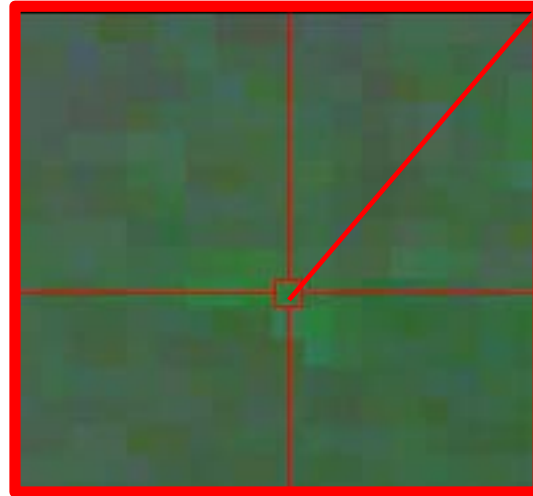
## PRISMA data – TOA and BOA water spectra

- Level 1 (L1): TOA (Top Of Atmosphere) radiometrically and geometrically calibrated HYP and PAN radiance images
- Level 2 (L2D): Geolocated and geocoded atmospherically corrected HYP and PAN images

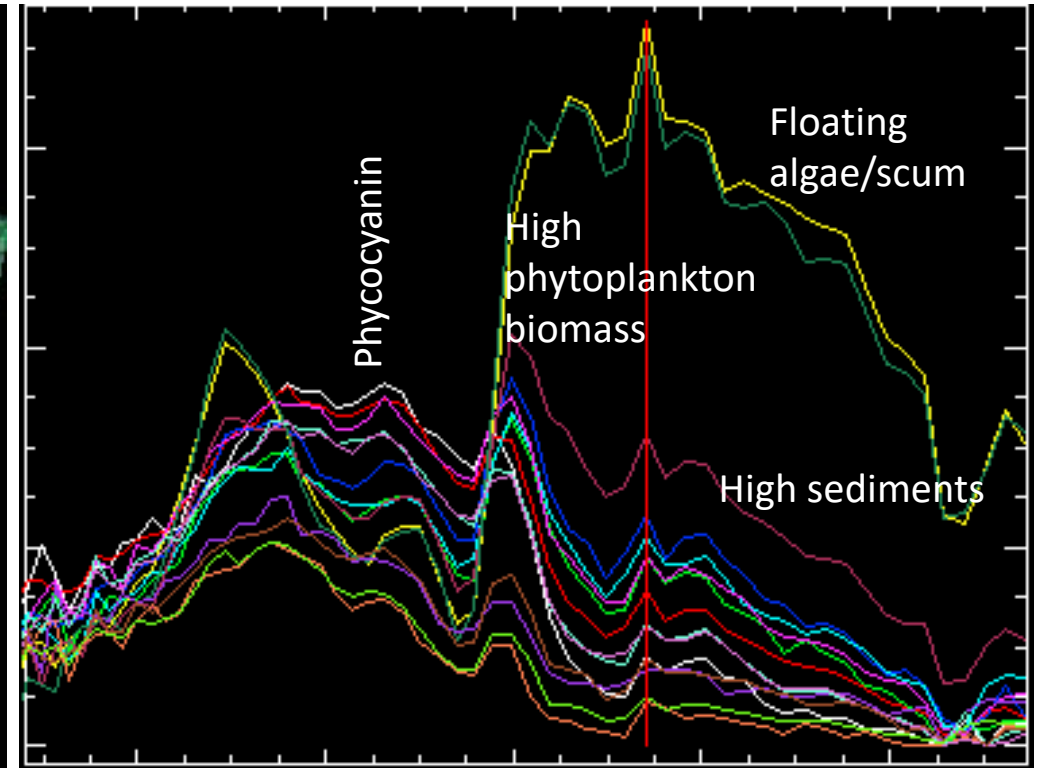
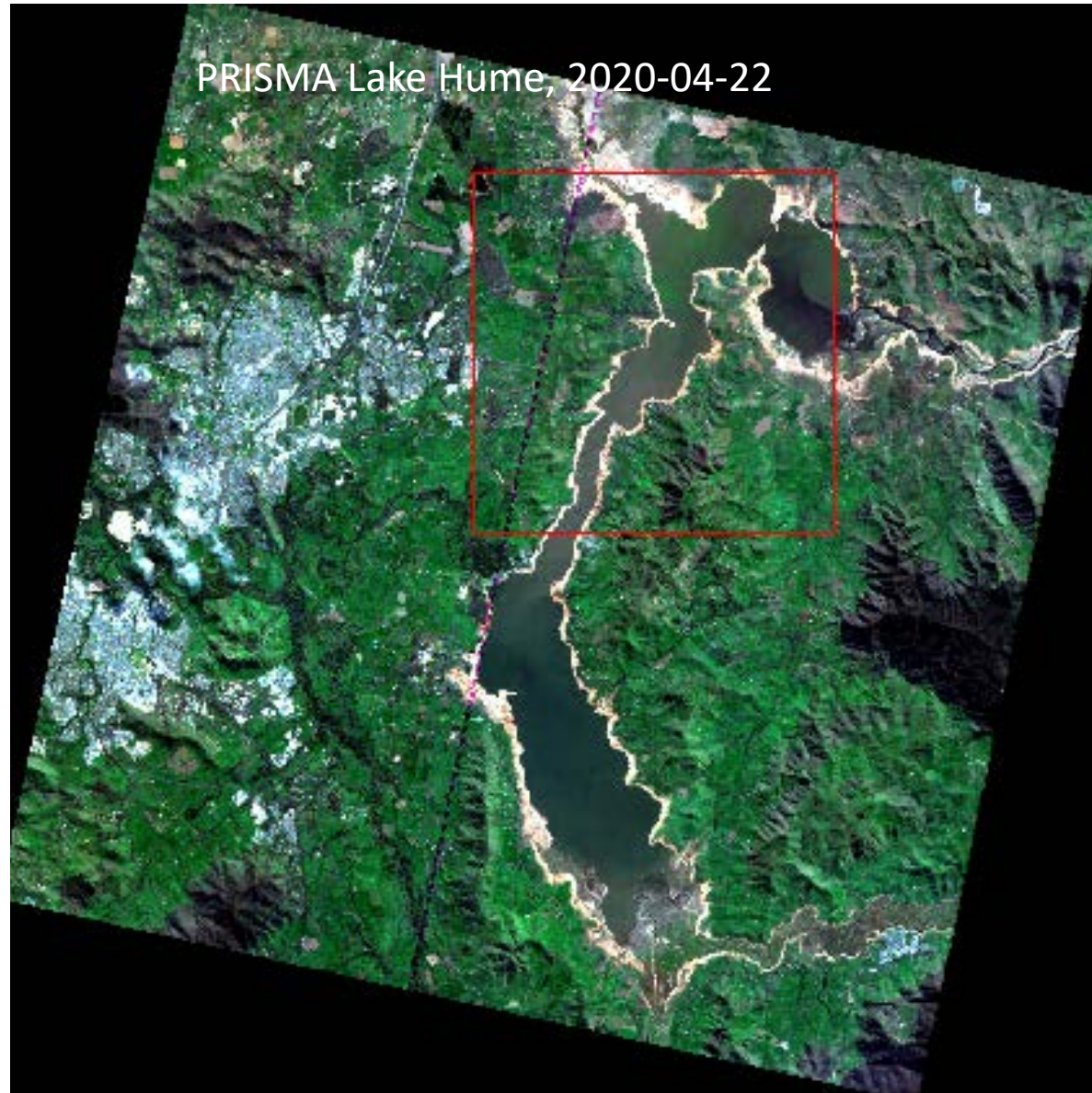




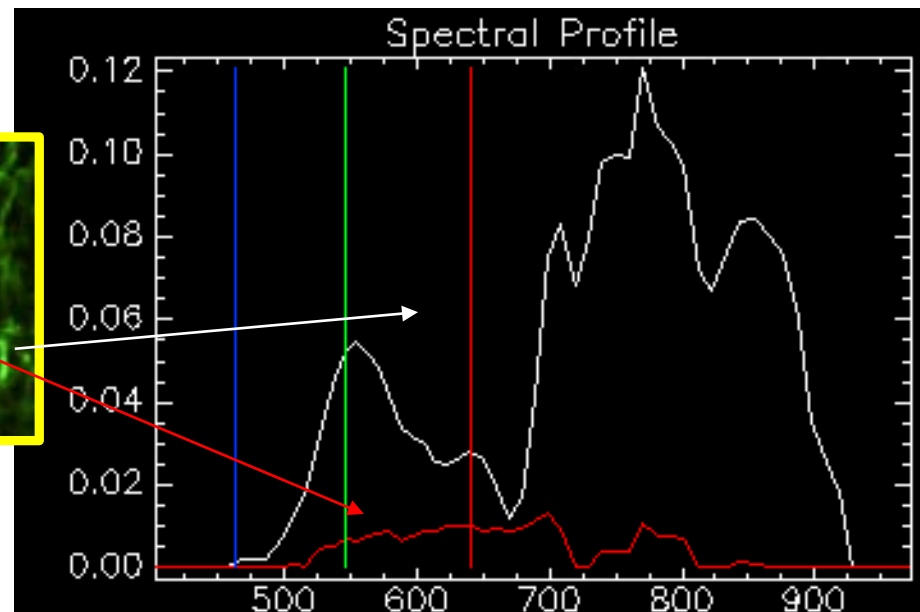
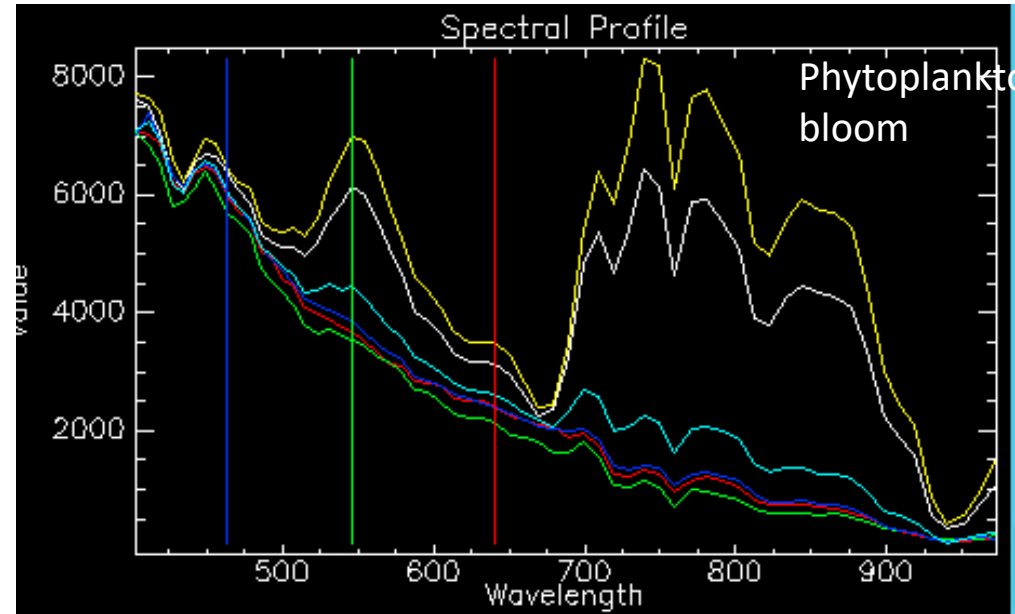
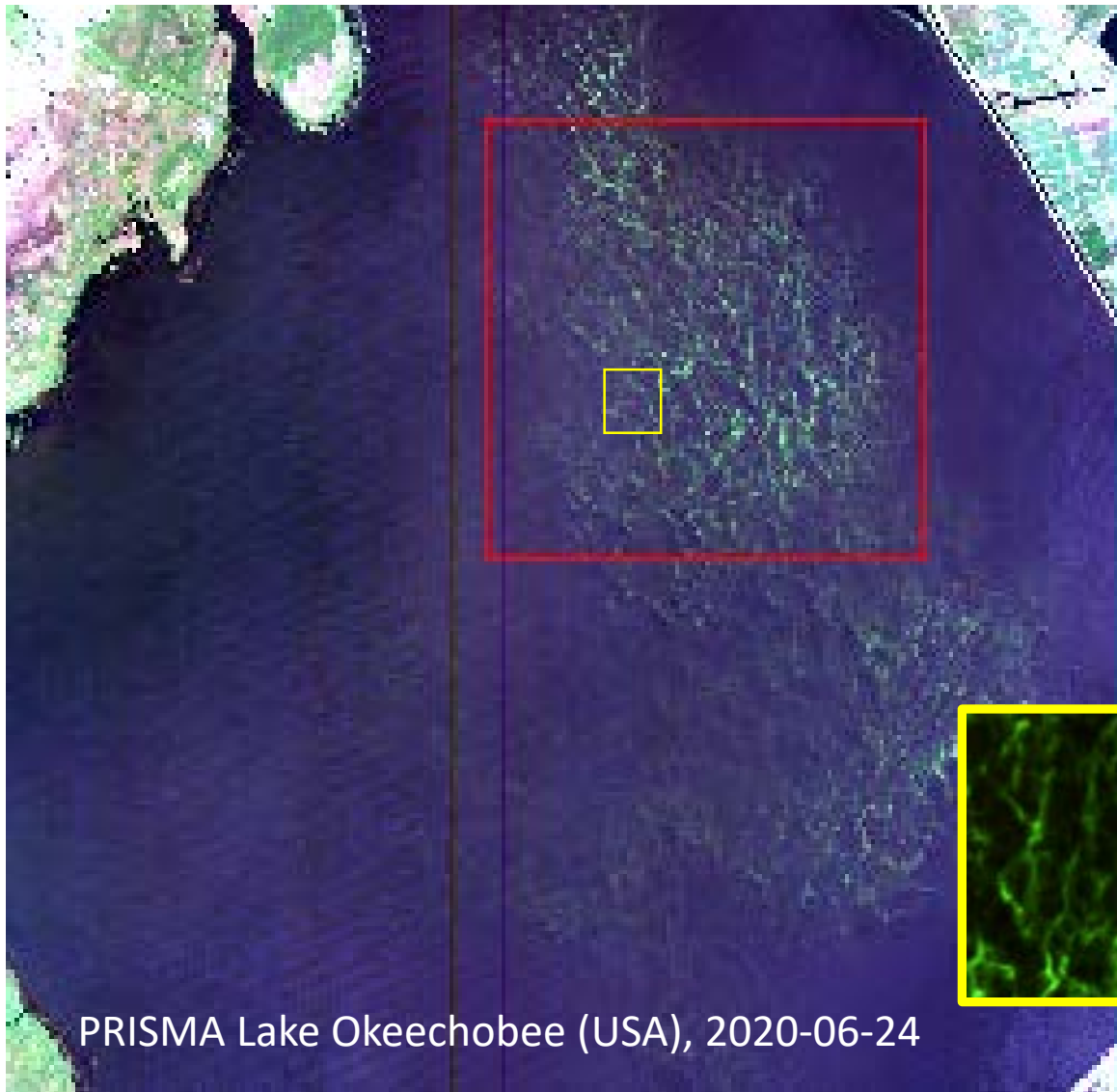
PRISMA Lake Hume, 2020-04-22



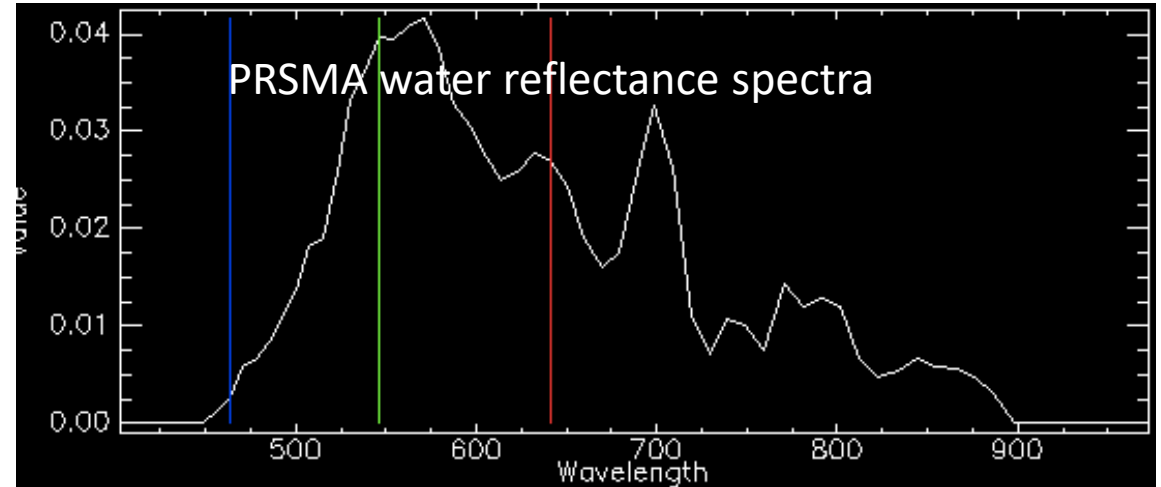




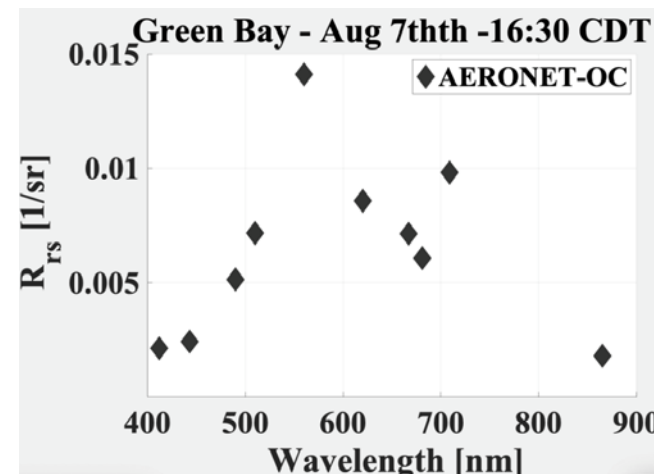
The red bar shows effects of O<sub>2</sub> bands not well corrected for





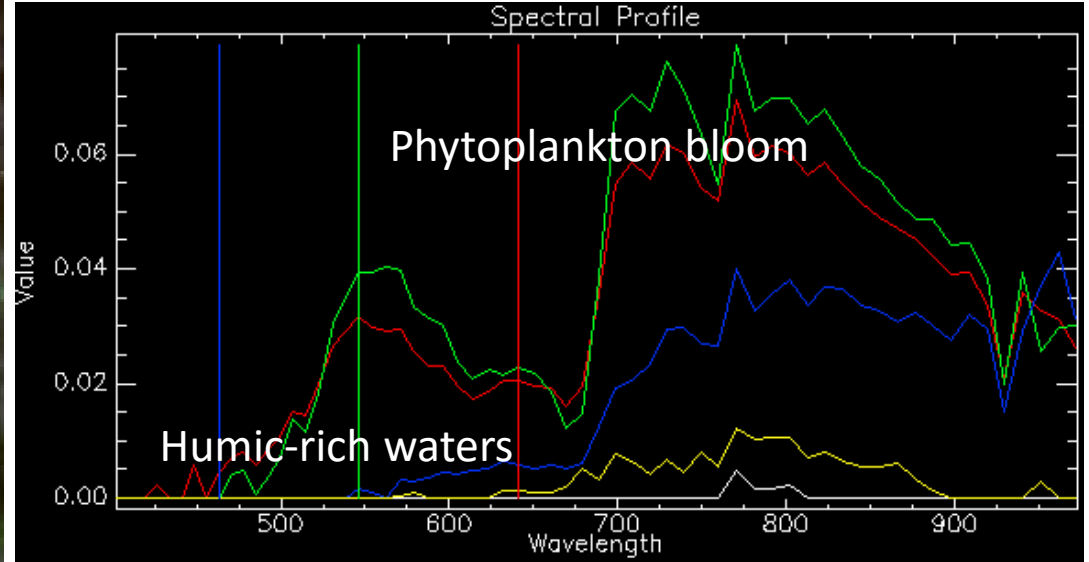
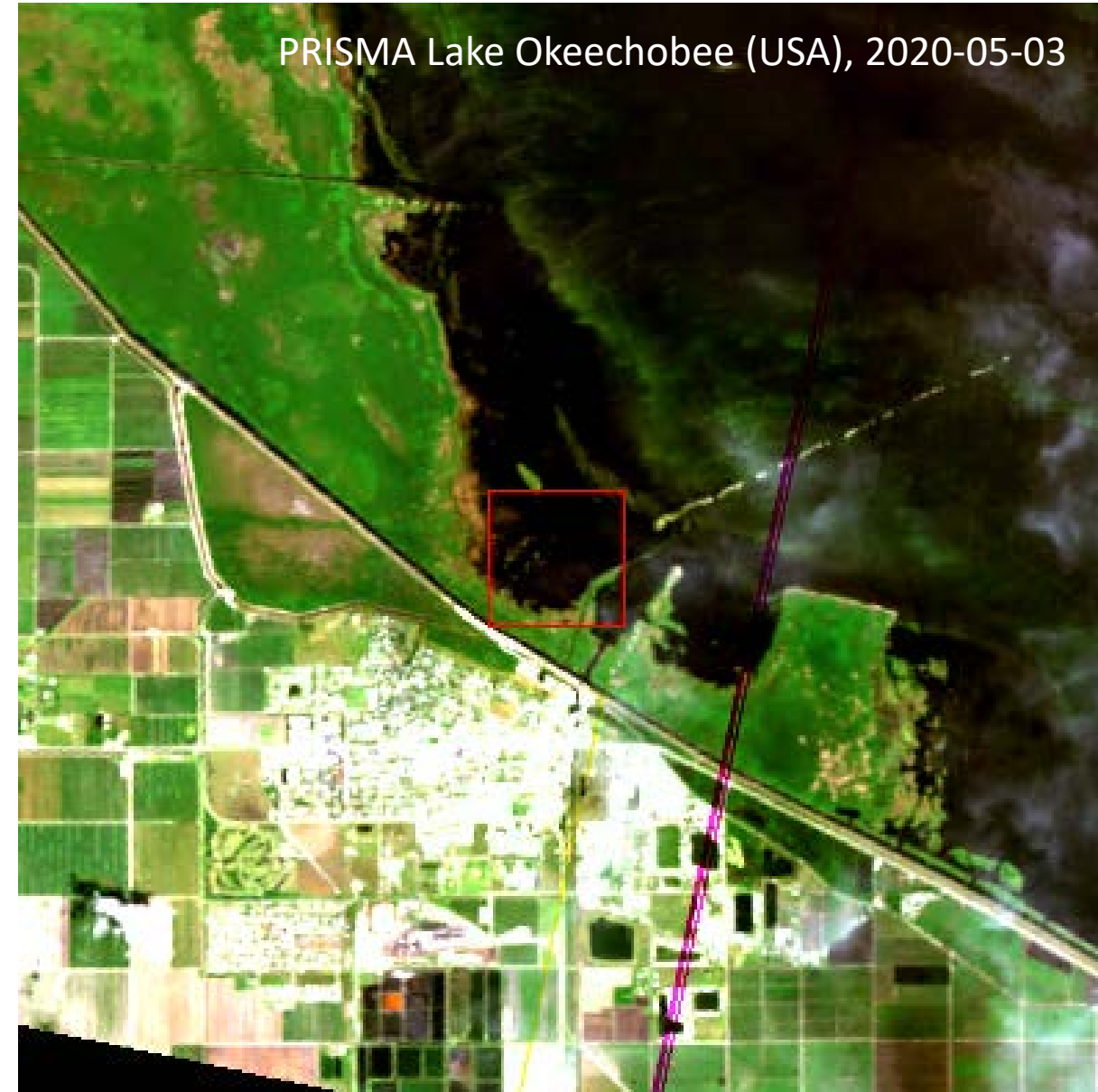


PRISMA spectra with peaks/dips due to phytoplankton pigments: chlorophyll-a, cyanobacteria



In situ water reflectance spectra (thanks to Nima Pahlevan)

PRISMA Lake Okeechobee (USA), 2020-05-03

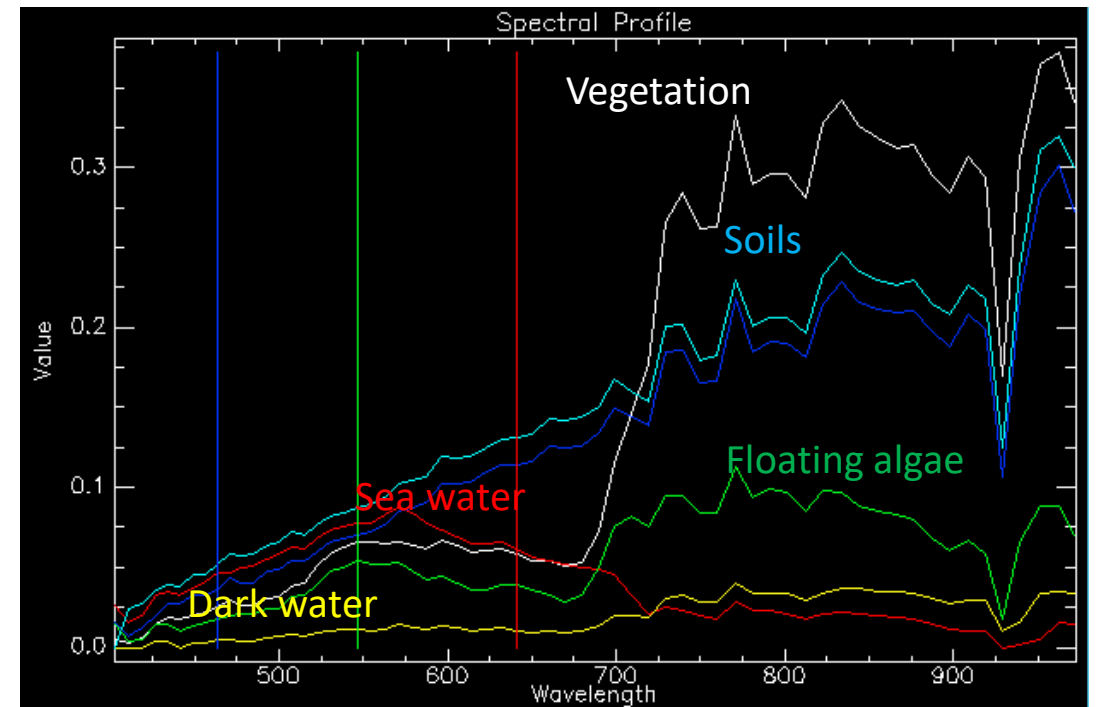
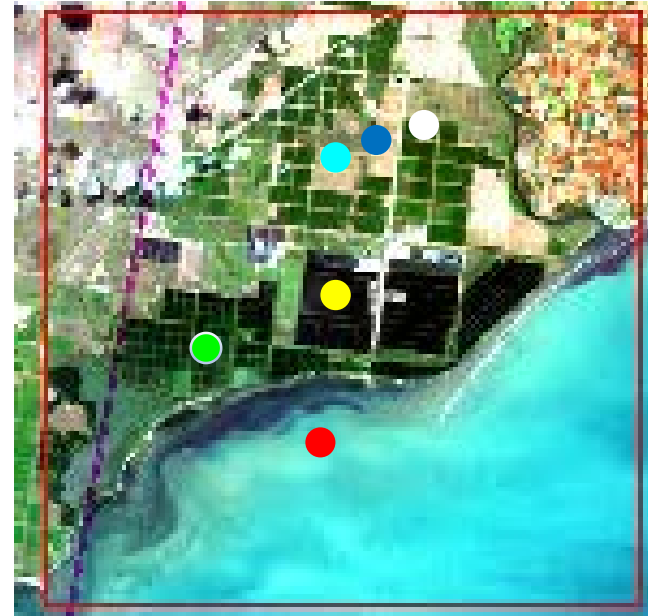


# PRISMA data - wetlands



PRISMA Melbourne, 2020-02-13

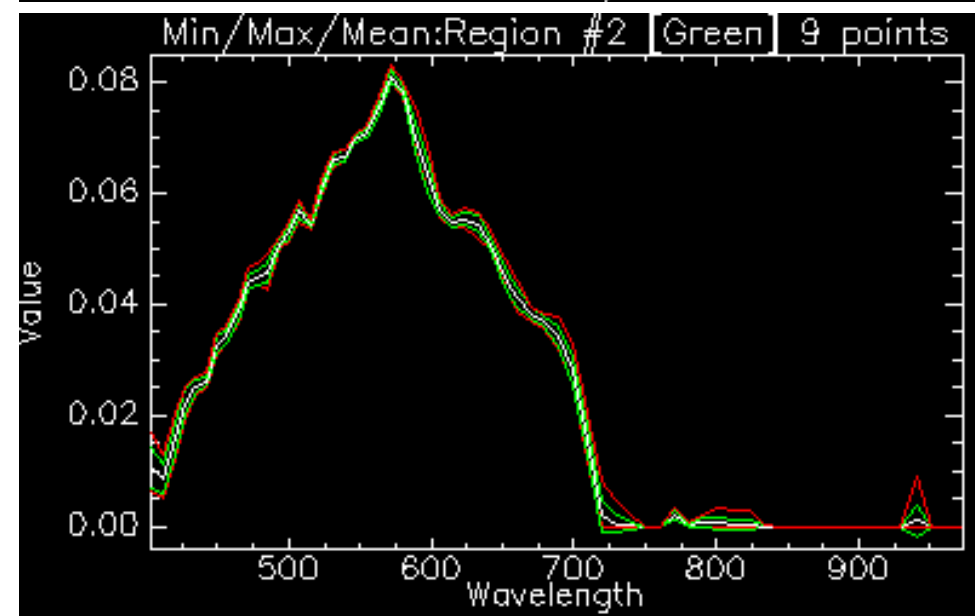
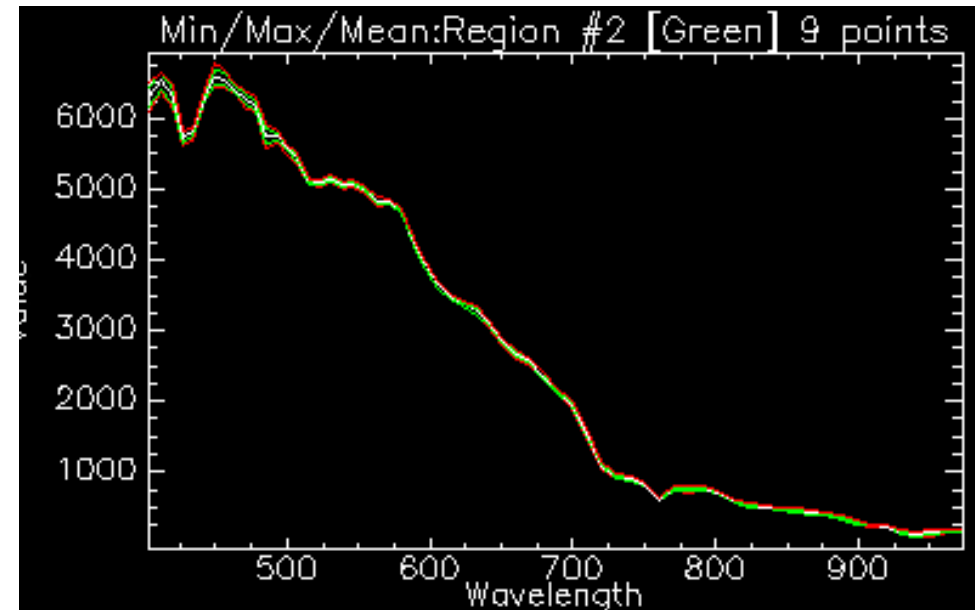
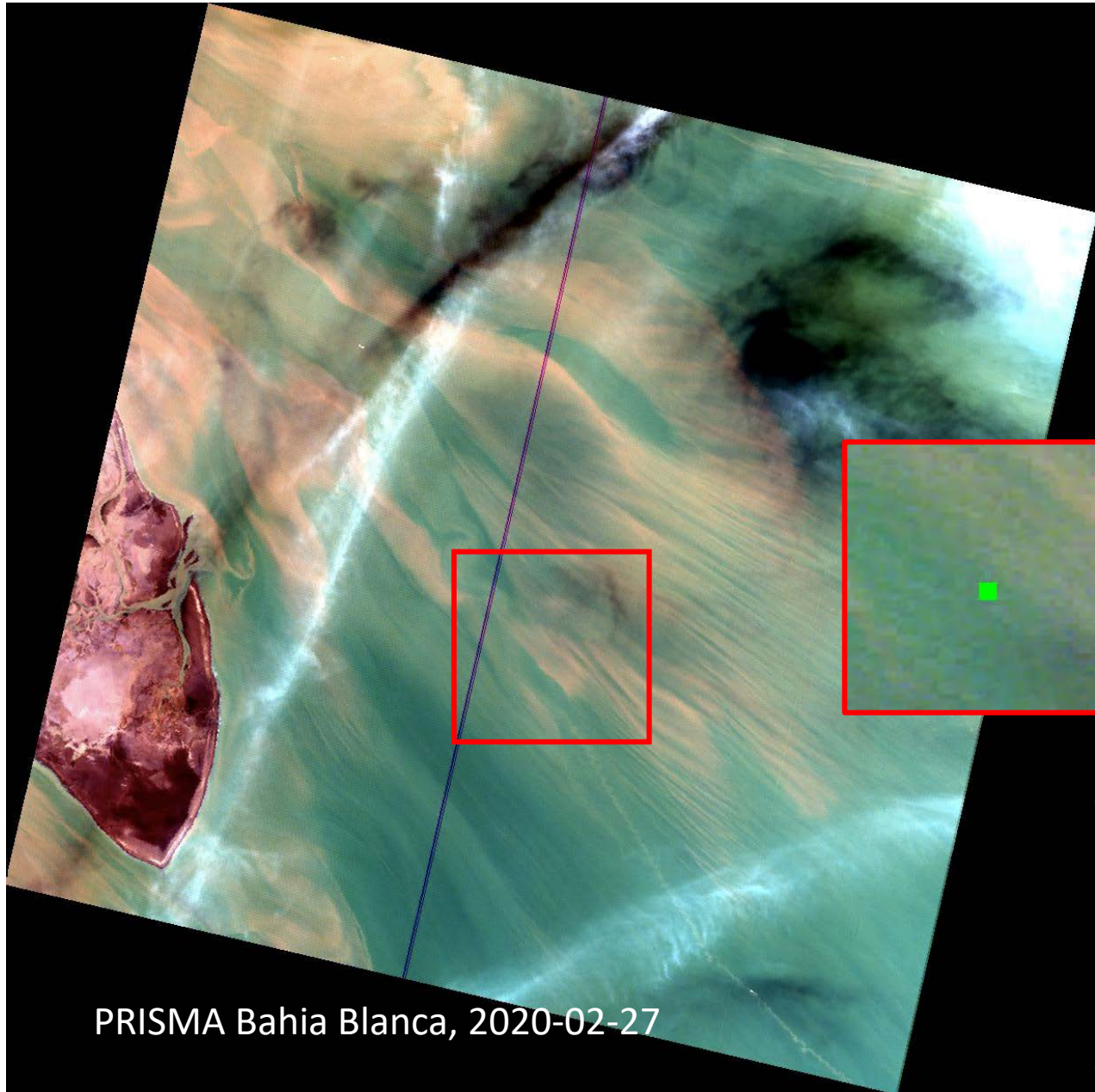
# PRISMA – Level 2



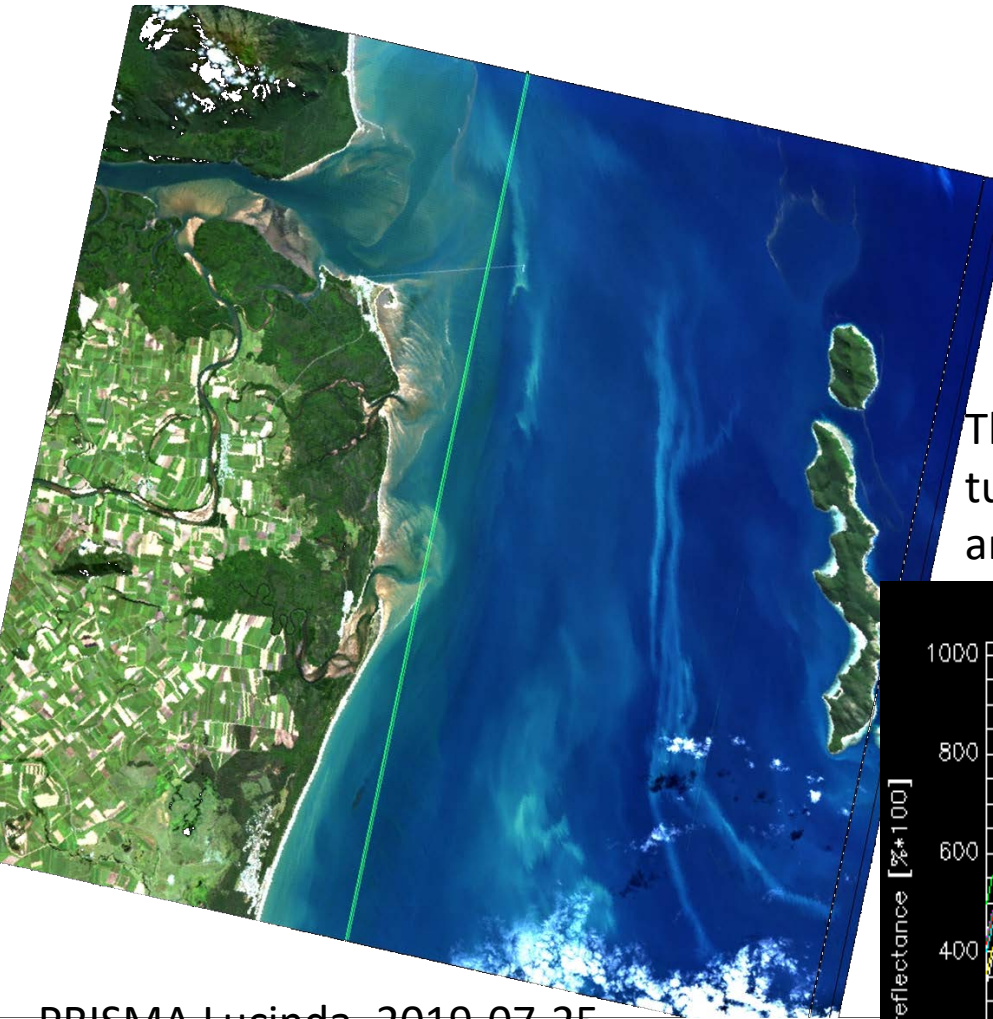


# PRISMA data - estuaries

# PRISMA – Level 1 & 2



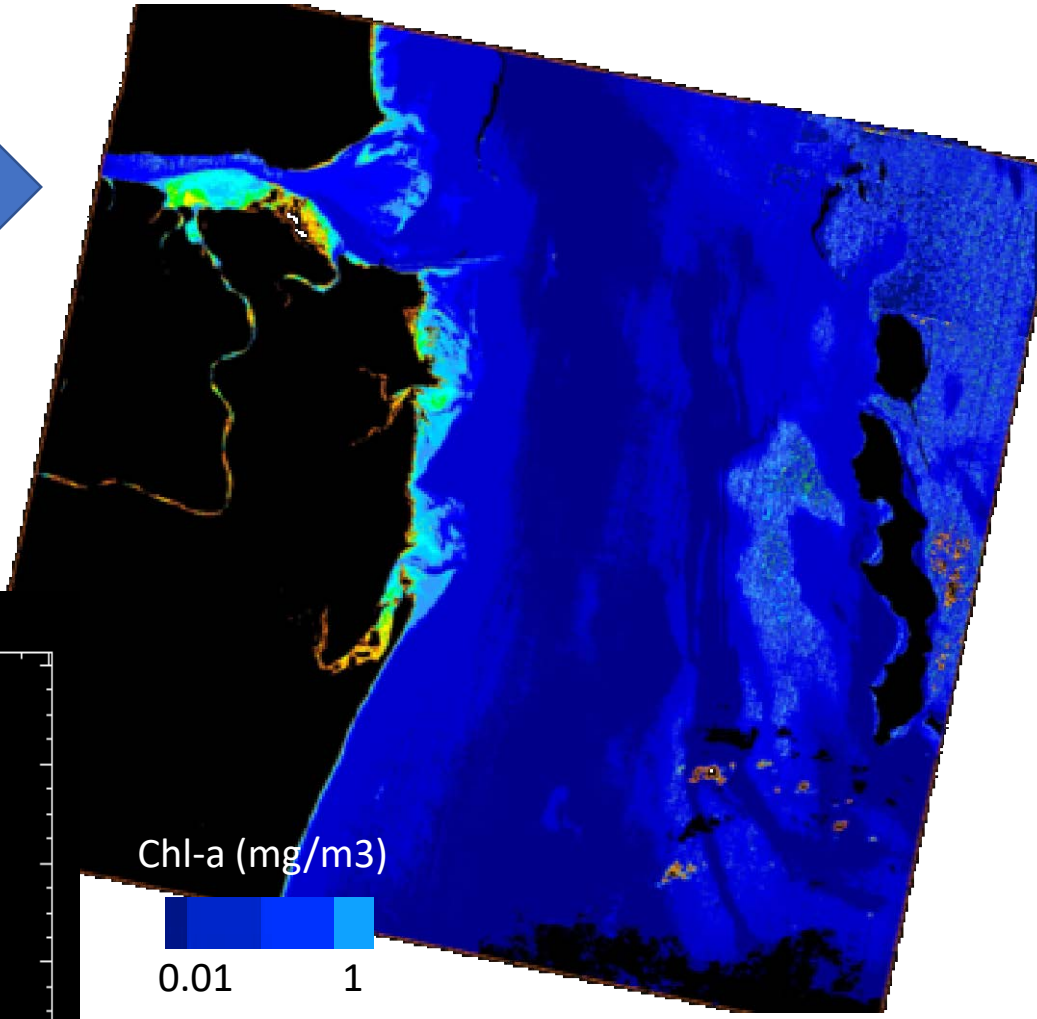
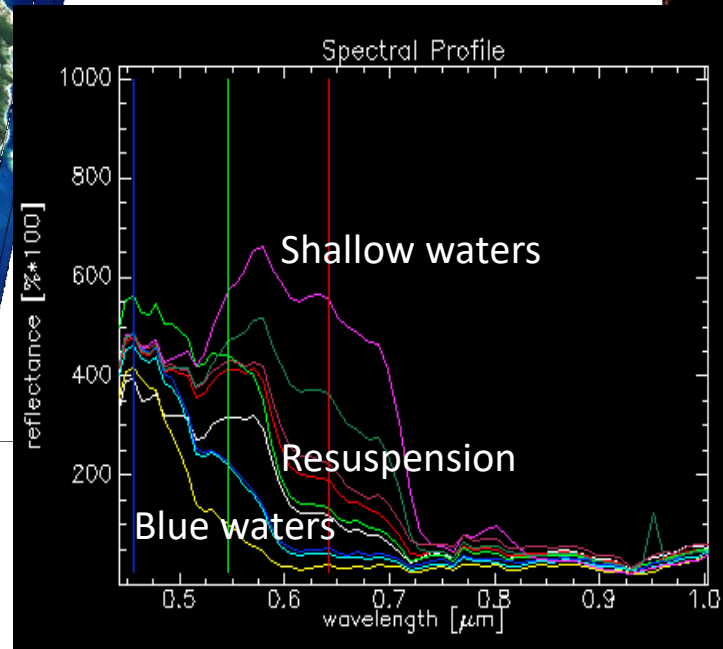




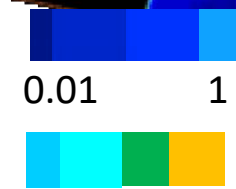
PRISMA Lucinda, 2019-07-25



The plot shows ranges from turbid to deep clear waters and different bottom types



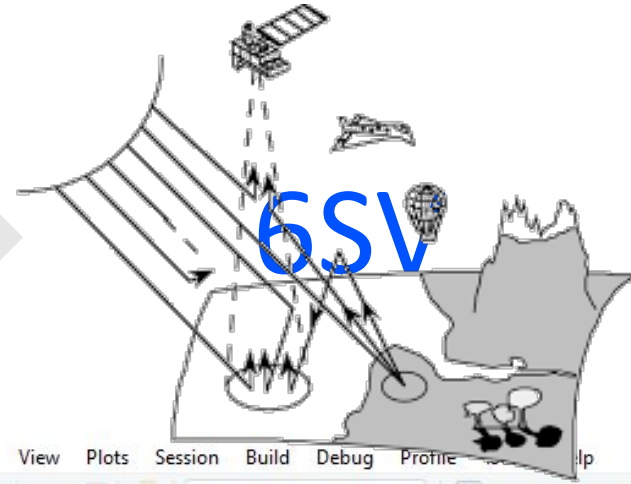
Chl-a (mg/m3)



Shallow areas / Turbidity in rivers

# PRISMA Level 1 data vs simulation of TOA radiances (TOA L) from in situ data

In situ

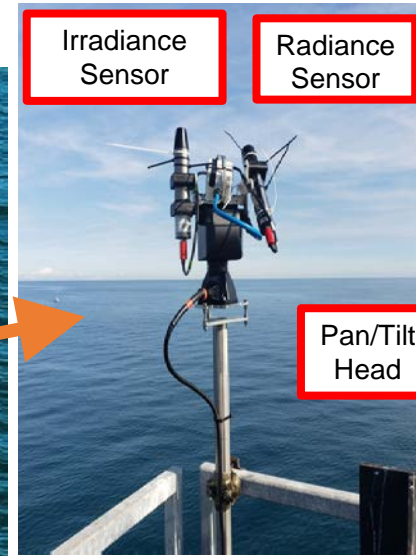


TOA L

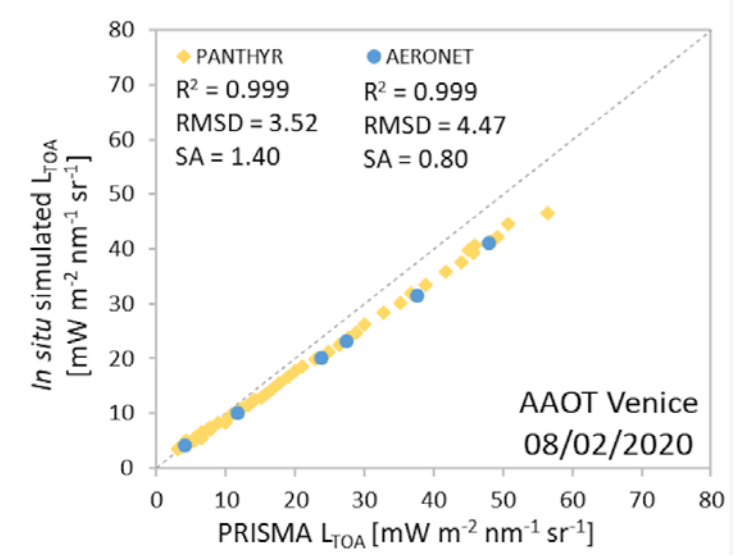
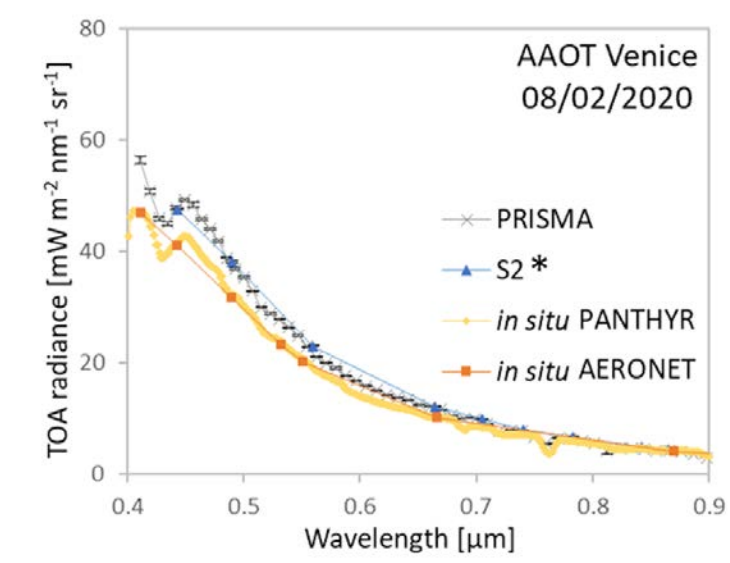
```
RStudio
File Edit Code View Plots Session Build Debug Profile Help
Go to file/function Addins
input6S.r x
Source on Save
52
53 for ( j in 1 : 11)
54
55   output_name <- file.path (.wdir, subDir,
56     paste0 (colnames(ground_REF)[.sp+1], "_", j, ".txt" )
57   )
58
59   output_content <- c (
60     "0", #user defined sensor
61     "54.95 156.01 5 278 02 06", #geometry (Sun Zenith, Sun Azimuth, sensor
62     # "8", # #option for water vapor and ozone
63     # "0.185 0.27", # #water vapor and ozone
64     "3", #Atmospheric model (Midlatitude summer
65     "2", #Aerosol model (2=maritime; 1=contine
66     "0", #
67     "0.12", #AOD value
68     "-0.002", #target level (km), negative value
69     "-1000", #sensor level
70     "0", #constant filter function
71     b.int[j], #band start/end
72     "0", #Homogeneous surface
73     "0", #No directional effects
74     "0", #constant value for reflectance
75     ground_REF[j, .sp+1], #reflectance value @ band
76     "-1" ) #No atm. corrections selected
77
78   writeLines(output_content, output_name)
79 }
```



# PRISMA Level 1 data vs simulation of TOA radiances (TOA L) from in situ data

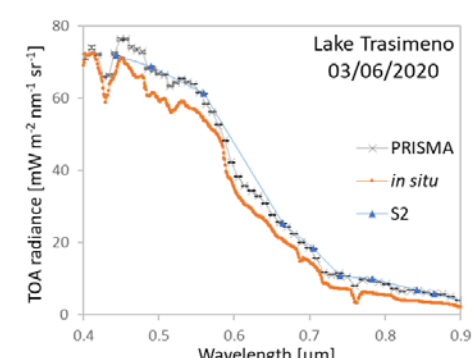
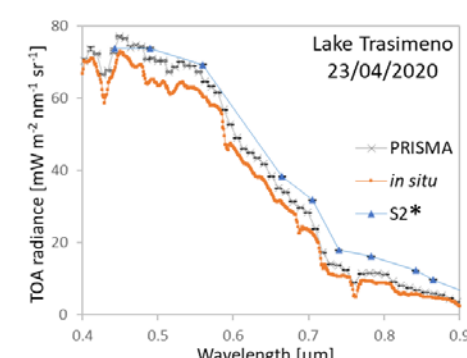
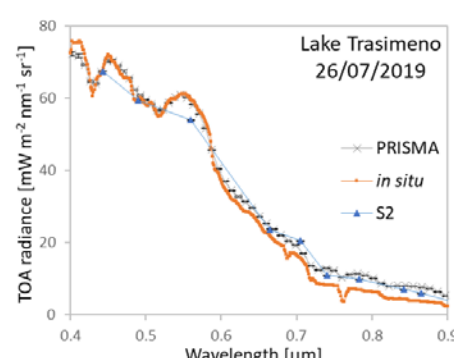
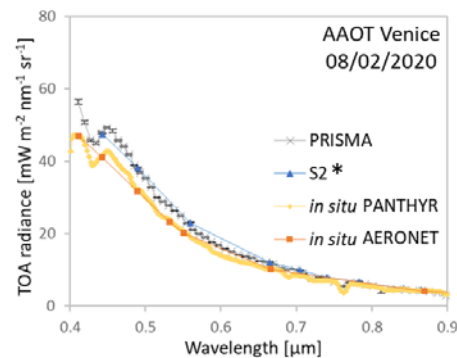
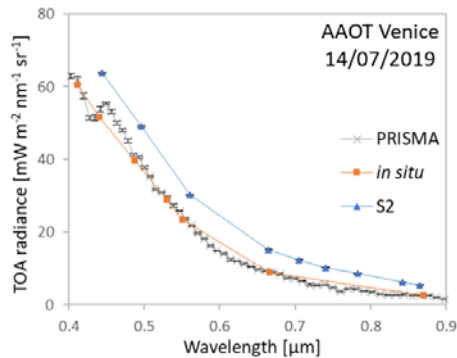
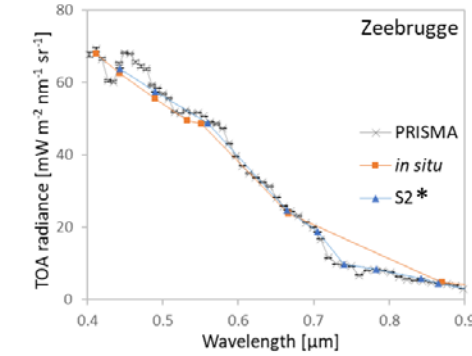
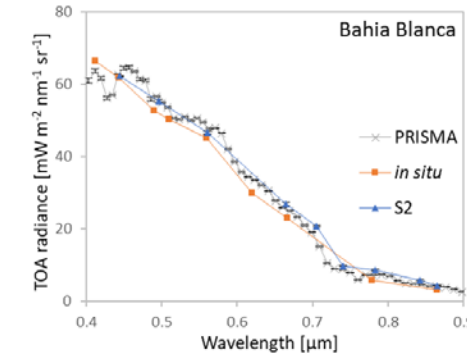
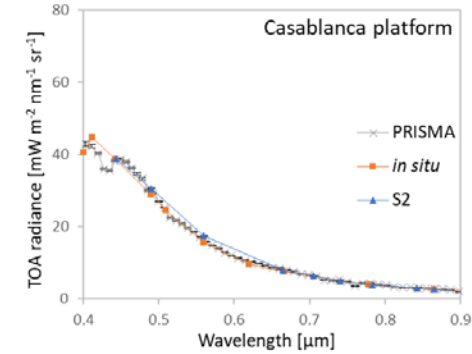
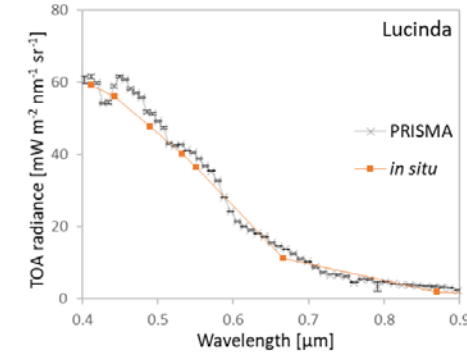
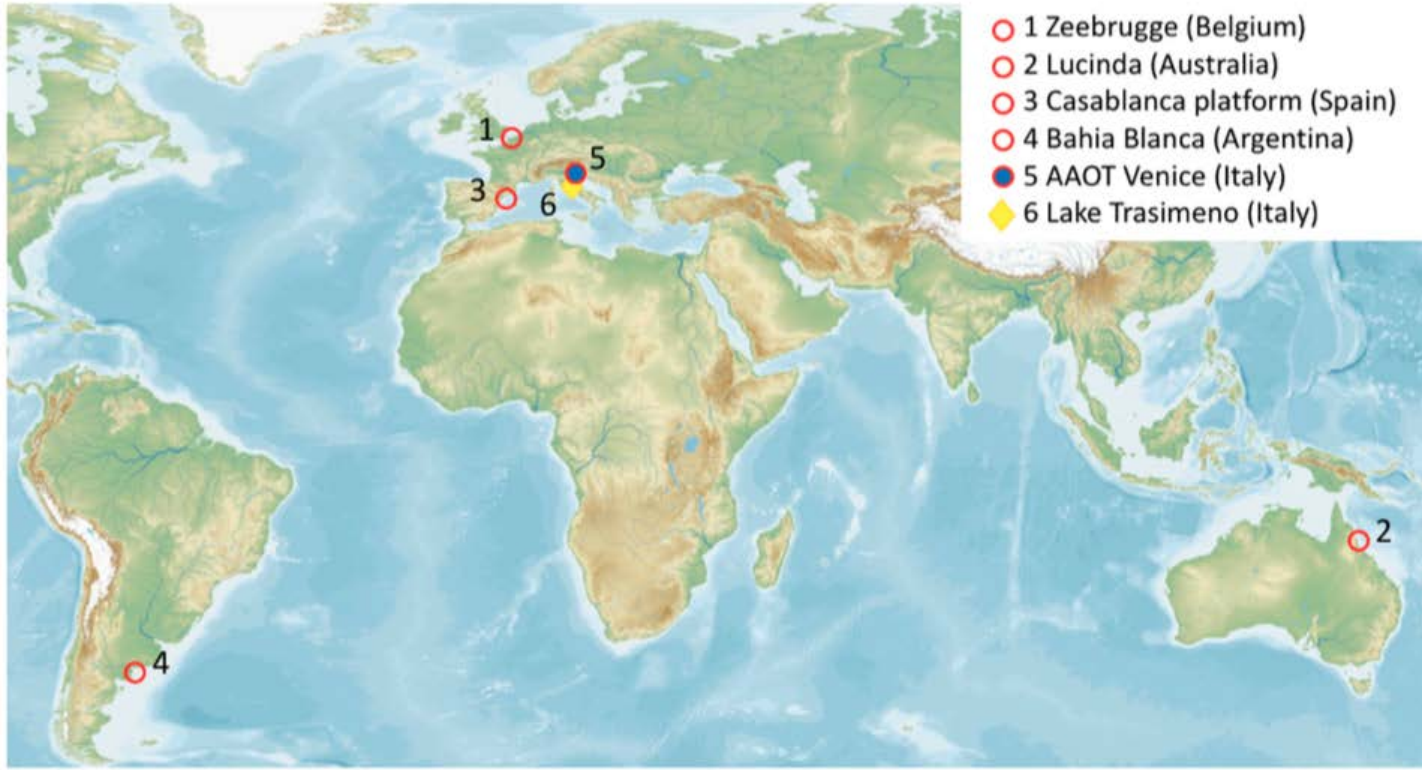


PANTHYR@AAOT / AERONET OC



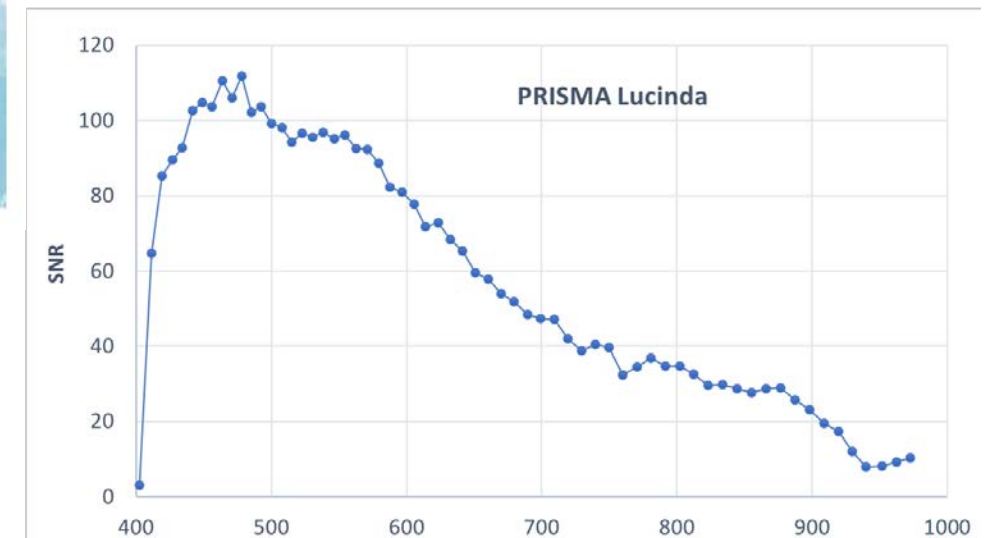
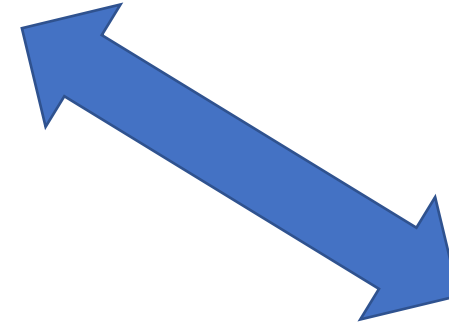
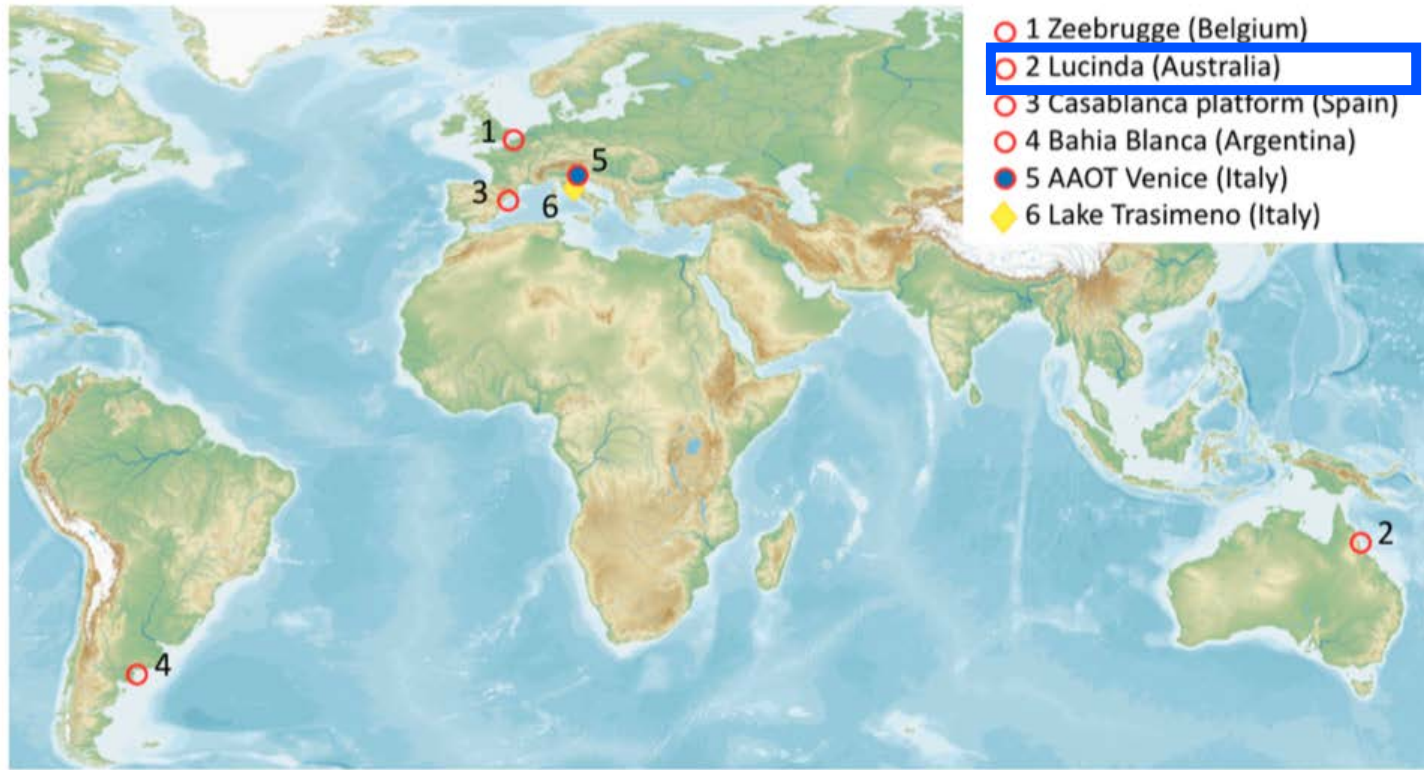
WATERHYPERNET/PANTHYR data

# PRISMA Level 1 data vs simulation of TOA radiances (TOA L) vs Sentinel-2



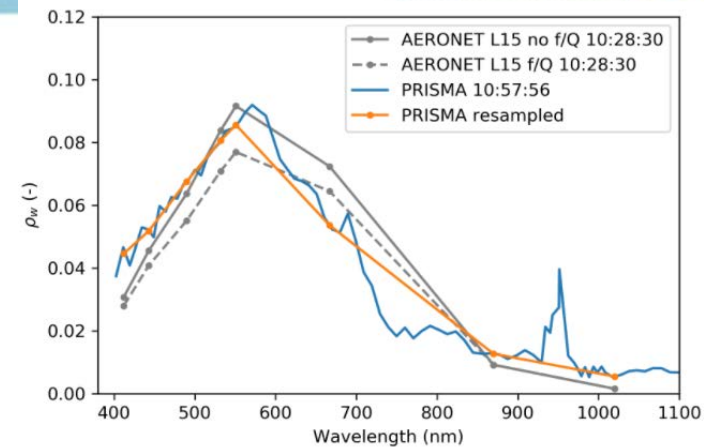
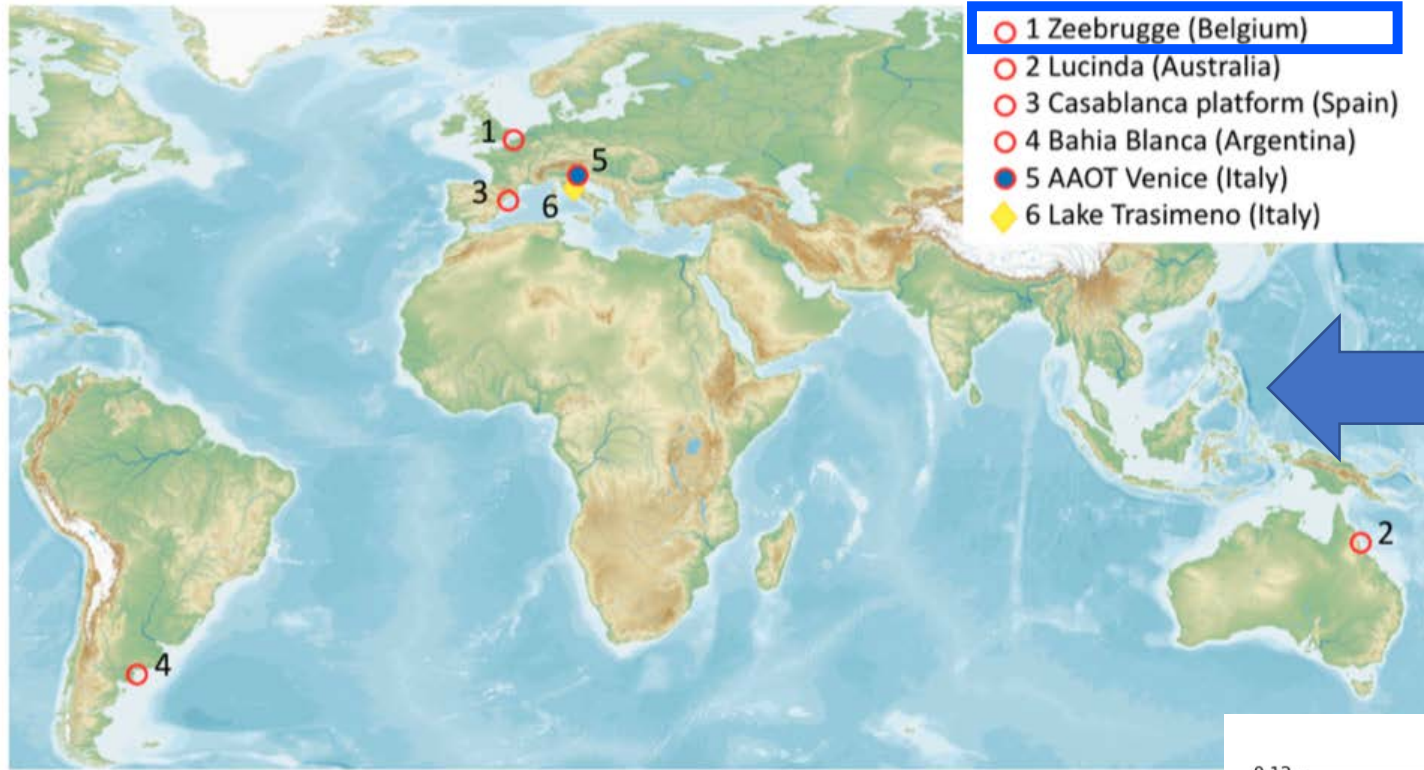


# PRISMA Level 1 data – on going: SNR; PRISMA Level 2 data



# PRISMA Level 1 data – on going: SNR; PRISMA Level 2 data

Zeebrugge, Belgium, 2019-07-23



Thanks to Kevin  
Ruddick,  
Quinten  
Vanhellemont



# PRISMA Level 1 data – on going: SNR; PRISMA Level 2 data

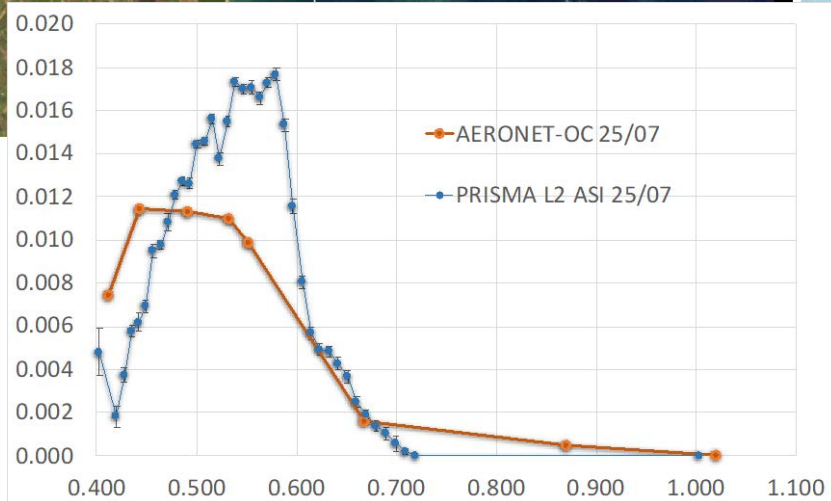
Lake Trasimeno, Italy, 23/04/2020



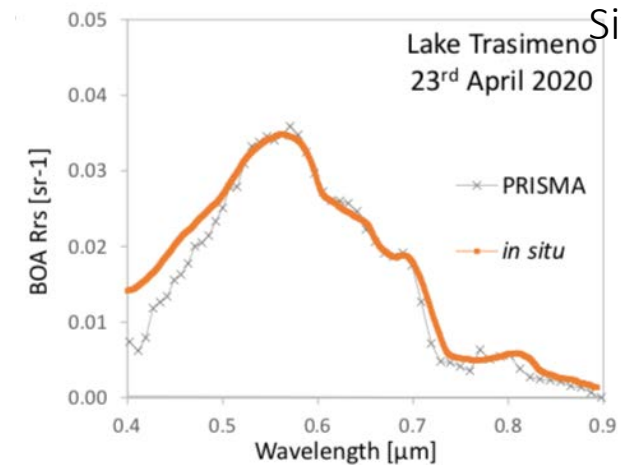
- 1 Zeebrugge (Belgium)
- 2 Lucinda (Australia)
- 3 Casablanca platform (Spain)
- 4 Bahia Blanca (Argentina)
- 5 AAOT Venice (Italy)
- 6 Lake Trasimeno (Italy)



IMOS LJCO  
AERONET-  
OC site



WISPStation  
Site





## Conclusions

- Satellite successfully launched
- Commissioning phase ended with hundreds of requirements passed
- PRISMA archive already counts thousands of images (capacity of 200 per day)
- L1 and L2 are produced
- Open free data for all (apart for commercial uses)

## Conclusions

- Everyone is more than welcome to subscribe and use the data; a lot of research activity has to be undertaken for:
  - characterising the sensor and the products and so on (SNR, L2 validation, masking, geo-coding, etc)
  - exploit the data in multiple thematic application (soils agriculture, snow, forestry, mining, water etc.; PAN-HYPER fusing)
  - develop algorithms (for water applications, rugged terrains, etc)
  - synergy with other missions (e.g. Sentinel-2)
  - testing of future imaging spectrometry (EnMap, CHIME, PACE,..)
  - etc.

## Web sites

- The link for registration is: <https://prismauserregistration.asi.it/>
- After registration, the PRISMA documentation (e.g., PRISMA Product Specifications) is also available in the same portal for data search and download at: <https://prisma.asi.it>
- The PRISMA web page can be found here: <http://www.prisma-i.it/index.php/en/>

## Web sites



Agenzia Spaziale Italiana

- The link for registration is: <https://prismauserregistration.asi.it/>
- After registration, the PRISMA documentation (e.g., PRISMA Product Specifications) is also available in the same portal for data search and download at: <https://prisma.asi.it>
- The PRISMA web page can be found here: <http://www.prisma-i.it/index.php/en/>

# Thanks!

