PRISMA Mission
An overview & preliminary data analysis

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Outline of the presentation

• Main characteristics of PRISMA (PRecursore IperSpettrale della Missione Applicativa)
• Overview on Level 1 and Level 2 products for aquatic systems (as part of the multiple applications of imaging spectroscopy technology)
• Retrieval of water quality parameters (lakes and coastal zones)
• Summary slide
Main characteristics

- 22-03-19: Vega begins its ascent from the Spaceport in French Guiana, carrying PRISMA
- 31-01-21: end of the commissioning phase

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Details</th>
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<tbody>
<tr>
<td>Orbit altitude reference</td>
<td>615 km</td>
</tr>
<tr>
<td>Field of View (FOV)</td>
<td>2.77°</td>
</tr>
<tr>
<td>Instantaneous FOV</td>
<td>48.34 mrad</td>
</tr>
<tr>
<td>Swath</td>
<td>30 km</td>
</tr>
<tr>
<td>Ground Sampling Distance</td>
<td>Hyperspectral camera: 30 m</td>
</tr>
<tr>
<td></td>
<td>Panchromatic camera: 5 m</td>
</tr>
<tr>
<td>Spectral range</td>
<td>VNIR: 400 – 1100 nm (66 bands)</td>
</tr>
<tr>
<td></td>
<td>SWIR: 920 – 2500 nm (173 bands)</td>
</tr>
<tr>
<td></td>
<td>PAN: 400 – 700 nm</td>
</tr>
<tr>
<td>Signal-to-noise ratio</td>
<td>VNIR: &gt; 160 (450 at 650 nm)</td>
</tr>
<tr>
<td></td>
<td>SWIR: &gt; 100 (&gt; 360 at 1550 nm)</td>
</tr>
<tr>
<td></td>
<td>PAN: &gt; 240</td>
</tr>
<tr>
<td>Spectral Width</td>
<td>≤ 14 nm</td>
</tr>
<tr>
<td>Spectral Calibration Accuracy</td>
<td>± 0.1 nm</td>
</tr>
<tr>
<td>Radiometric quantisation</td>
<td>12 bits</td>
</tr>
<tr>
<td>Repeat cycle</td>
<td>29 days (450 orbits)</td>
</tr>
<tr>
<td>Relook time</td>
<td>&lt; 7 days</td>
</tr>
<tr>
<td>Lifetime</td>
<td>5 years</td>
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</tbody>
</table>
Sea water
Dark water
Floating algae
Soils
Vegetation
Soils
Vegetation

Full VIS-NIR-SWIR range
Coverage

Strip mode (up to 300 km)

60 km

PRISMA Chesapeake Bay, 16 Nov. 2020

Overview after 4 months from the launch
• Background acquisition capability: ASI manages periodic acquisitions on target areas of interest by exploiting long term planning functions

• Foreground acquisition capability: tasking from users
Products

**Level 0** (Hyperspectral / PAN) - formatted data product with appended metadata, including ancillary data and file formatting information

in-flight calibration systematically performed by means of the Internal Calibration Unit (ICU)

**Level 1** (Hyperspectral / PAN) - radiometrically corrected and calibrated radiance data in physical units.
This product provides

- Top-of-Atmosphere Spectral Radiance
- Calibration and characterization data used
- Masks: Cloud, Sun-glint & land-cover classification

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

**Level 2c** Geolocated *At-surface Reflectance* Product (Hyperspectral / PAN).
This product includes: Aerosol Characterization, Water Vapour, Cloud Characterization.

**Level 2d** the geocoded version of the level 2c products (Hyperspectral / PAN)

Simulation of in situ data with 6SV+ S2

In situ data + Sentinel-2, Sentinel-3

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From L2 to aquatic products

PRISMA L1

PRISMA L2D
L1 Products: TOA

In situ: red dots are AERONET-OC, blue is for PANTHYR (->Hypernets) and yellow is for the WISPStation (EOMORES, Water Insight)
Example of TOA radiances from an homogenous open water dark target for computing Signal-to-Noise ratio as in Wettle et al., 2004.

The blue lines show SNR values from two L1 PRISMA products from coastal to open waters (acquired on 27/03/2020 and on 02/07/2020, with SZAs of 35 and 26 degrees, respectively); green bars are values for Sentinel-2 (Pahlevan et al., 2017).
L2 Products

**WISPStation**

- **Lake Trasimeno**
- **Venice Lagoon**
- **Curonian Lagoon**

### Table

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<thead>
<tr>
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<th>R²</th>
<th>RMSE</th>
<th>SAM</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>0.98</td>
<td>0.9-4.7 (mWm⁻²sr⁻¹nm⁻¹)</td>
<td>0.8-3.4</td>
<td>9</td>
</tr>
<tr>
<td>L2D</td>
<td>0.81</td>
<td>0.0012-0.0093 (sr⁻¹)</td>
<td>11-26</td>
<td>21</td>
</tr>
</tbody>
</table>
L2 Products: SNR

- The environmental noise-equivalent reflectance difference $\text{NE}\Delta R(0-)_{E}$ computed from PRISMA scenes (e.g. Lucinda, ) is lower than 0.1% (apart the shortest bands) used as reference for water quality retrieval in Brando & Dekker (2003)
- The PRISMA $\text{NE}\Delta R(0-)_{E}$ noise is definitely lower than Hyperion (also after the low pass filter which aimed to reduce the $\text{NE}\Delta R(0-)_{E}$ from ~0.3 to ~0.1%)

Brando & Dekker, 2003
Preliminary products: shallow waters


PRISMA Venice lagoon, 23 Mar. 2021
Preliminary products: estuaries

Examples of PRISMA spectra in estuaries (Ebro, Spain; Rhone, France; Po, Italy) and of the related chromaticity coordinates

x, y pairs from PRISMA after a spectral convolution based on the response filters of human eye

Coccolithophore? (Organelli et al., work in progress with QAA applied to PRISMA)
The plot shows ranges from turbid to deep clear waters and different bottom types.

PRISMA Lucinda, 25 Jul. 2019

Preliminary products: coastal zones

on-going: aLMI for water quality mapping

Chl-a (mg/m3)

0.01 1

Shallow areas / Turbidity in rivers
Preliminary products: lakes

PRISMA Lake Hume, 22 Apr. 2020, L1 (two sites)

PRISMA Lake Hume, 22 Apr. 2020, L2D (7 sites)

Lake Hume in situ and modelled data

on-going: aLMI for water quality mapping
Preliminary products: phycocyanine

Non-finite or negative values are shown in grey

The normalized difference water index (NDWI) is used with a threshold of 0.1 to identify the water regions.
Supporting studies

1. Sentinel-2-Next Generation (NG)
   PRISMA + in situ

2. CHIME-SBG
   AVIRIS, PRISMA match ups
   (May-June 2021)

https://ares-observatory.ch/esa_chime_mission_2021/

End of May, 2021       Jun. 2021

Turbid productive waters (Trasimeno)       Shallow waters (Venice lagoon)

3. PRISMA Second Generation (PSG)
   PSG Is the operational follow-on of the in-orbit PRISMA mission, to be launched in 2025.
Satellite successfully launched

Open free data policy

The archive already counts thousands of images (capacity of 200 images per day); tasking on pre-defined target is working fine

L1 and L2 are systematically produced on-demand
  - L1 data are accurate shows consistent to data acquired by other missions
  - L2 data show variable degree of accuracy (on-going work: SNR, clear waters, adjacency effects, water quality mapping)

PRISMA overall shows promising data for water resources mapping and monitoring (in synergy with e.g., Sentinel-2, Landsat-8, Sentinel-3 OLCI)

The mission is also supporting developments of future/synergic satellite missions (e.g. Sentinel-2-NG; CHIME, SBG, PRISMA-SG)
Useful links

• 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:
Useful links

Thanks a lot for your attention!

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