

Supported by:

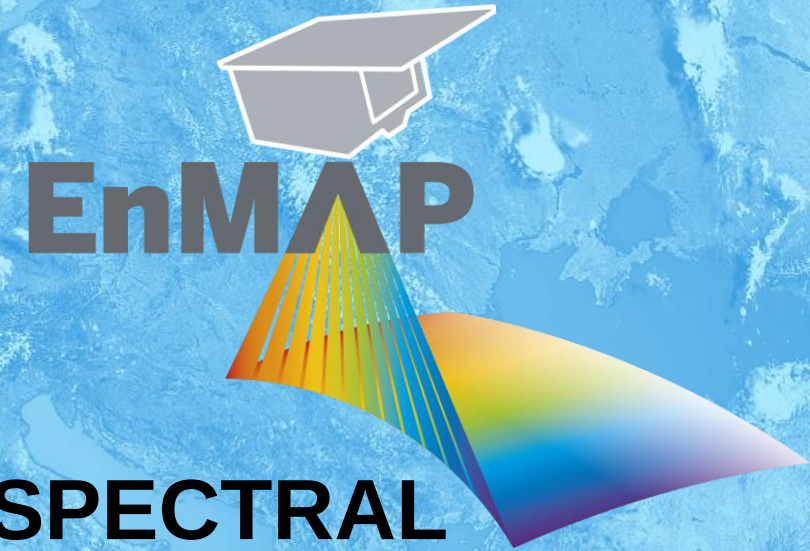


Federal Ministry
for Economic Affairs
and Climate Action

on the basis of a decision
by the German Bundestag



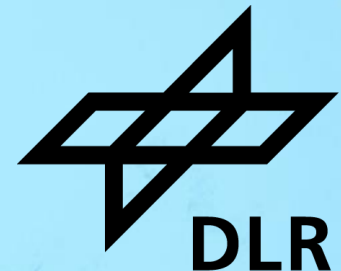
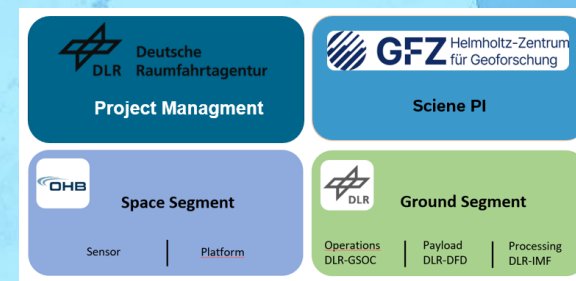
German
Space Agency
at DLR



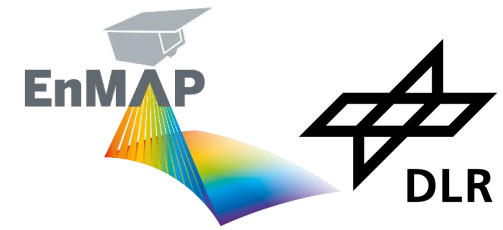
ENMAP SYNERGIES WITH HYPERSPECTRAL MISSIONS AND INTERNATIONAL CAMPAIGNS

Vera Krieger, Mission Science Coordinator, Speaker
Laura La Porta (Mission Manager) and Michael Bock (Data License)
on behalf of the EnMAP Consortium

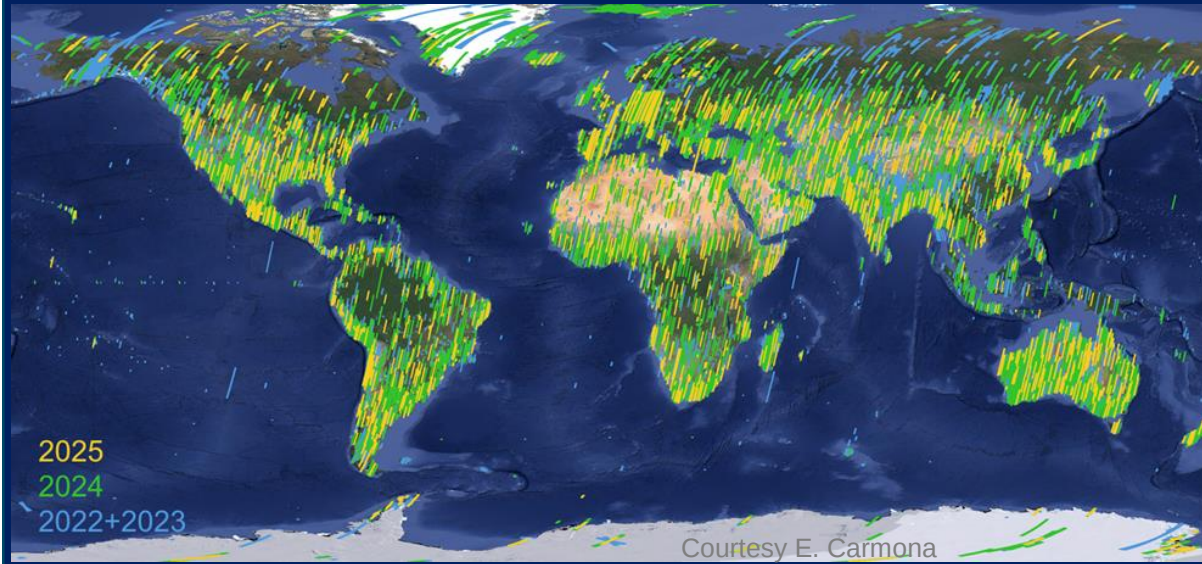
D. Reintsema, R. Wernitz, K. Bagschik, M. Bock, S. Fischer
E. Carmona, D. Schulze, N. Pinnel, S. Baumann, M. Pato, S. Hartung,
M. Habermeyer, S. Engelbrecht, K. Wirth, ...
Science PI: S. Chabrillat, K. Segl, A. Okujeni, P. Reinert ...
R. Feckl, M. Betz, M.S. Guilherme ...



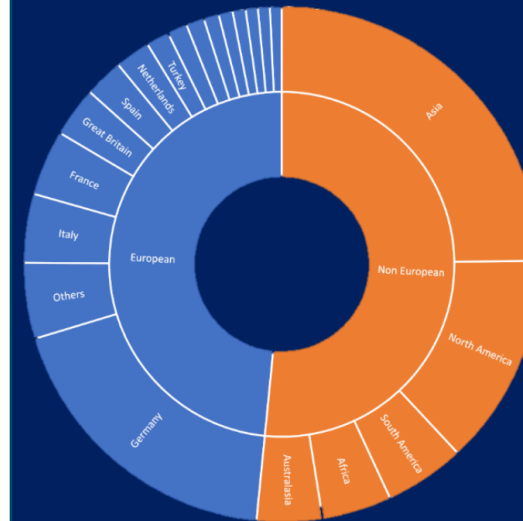
EnMAP – 3 years operational



Growing archive with worldwide data



Growing international user community



About **5000 registered users** from 130 different countries, including 36 European countries

→ Resulting in more than **150.000 products in the archive**

About **800 scientific proposals** have been received for dedicated data recording

EnMAP transitioned from a **pioneering science mission** to a mature operational platform

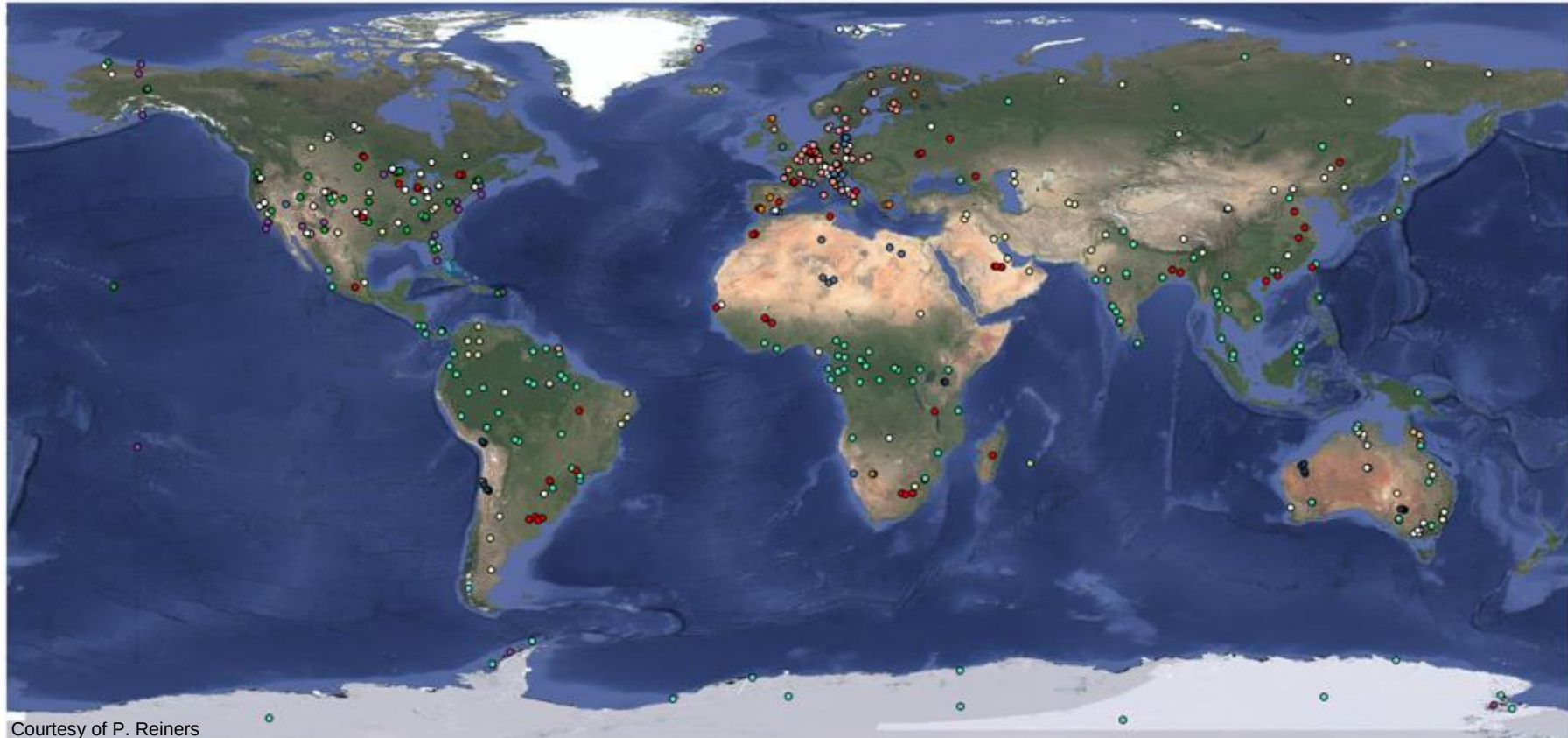
- **Sophisticated tasking mission**
- **strong user support**
- **excellent science program**

- ➔ **international campaign support**
- ➔ **growing worldwide user community**
- ➔ **operational services**

More than 600 International Cal/Val covered by the Background Mission

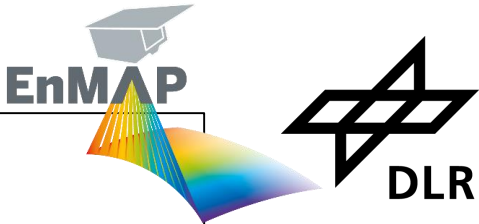
- RadCalNet
- NEON
- JECAM
- MARS
- ICOS
- Hypersense
- Geotrees
- GEOLOGY
- FLUXNET
- Coral Reef
- Volcanoes
- US-LTER
- SOILS
- SNOW

Google Satellite



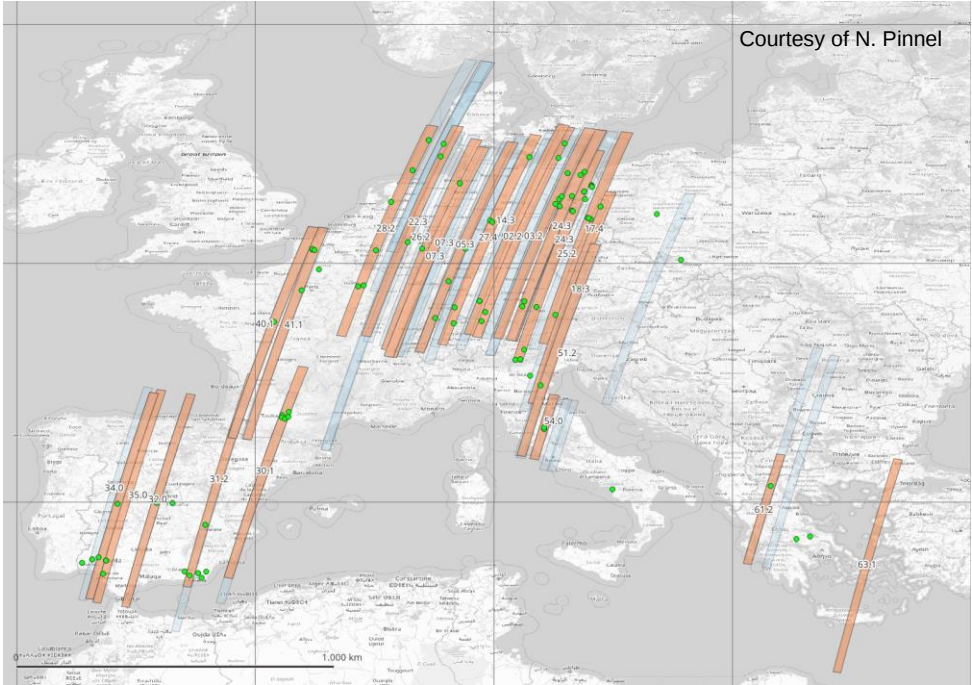
See Poster by **Emiliano Carmona** *Three years of EnMAP Ground Segment Operations*

Foreground Mission



Goals

- optimizing acquisition rate
- generating time series covering EU



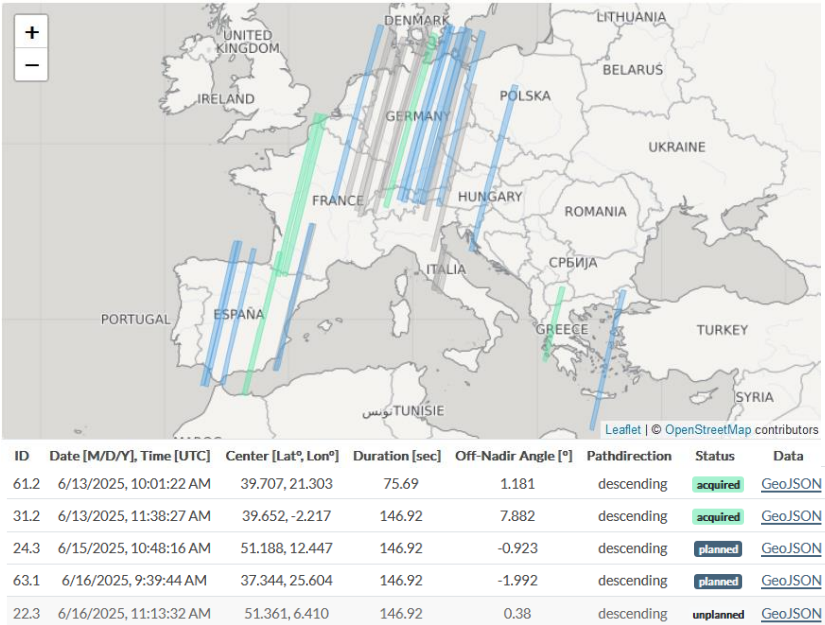
- Started as program in 03/2024
- Stripes ~1000 km long
- Defined with users (workshops, **survey**)
- Updated to take seasons into account
- Assigned max. priority
- Flexible (**campaigns**, weather)

Supported campaigns

- Methane Experiment (USGS)
- Greenland (GFZ)
- Artic (AWI)
- Soil Sites/Demmin (GFZ)
- Oil detection (Mexico) (NASA)
- Aquatic/Agriculture (Uni Valencia)
- Sardegna, Largo di Garda (CNR)
- Jolanda di Savoia (ITC, CNR)
- Namibia (HU Berlin, GFZ)
- Deception Island, Antarctica (GFZ)
- **PUCH-Agri-Rose-L/CARMA campaign**

Coordination by GFZ supported by the Ground Segment Application Support

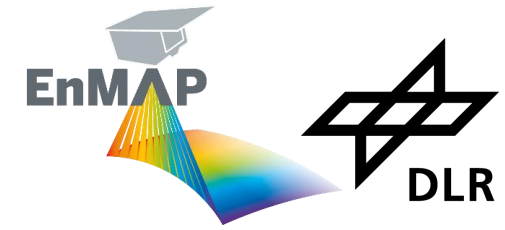
User input is very welcome!



https://www.enmap.org/data_tools/foreground_mission/

See Poster by Nicole Pinnel

International campaign support

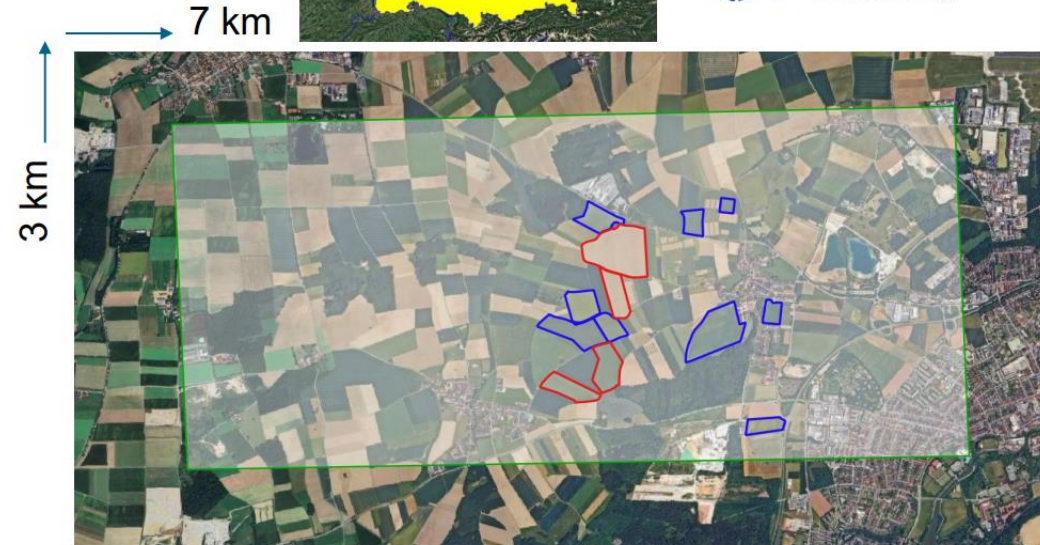


ESA AGRIROSE-L Campaign - Potential for matchups

- ESA campaign in support of ROSE-L and CHIME missions
- Agricultural area Northwest of Munich, Germany
- Observed between 22 April – 21 July 2025
- With several instrumentations:
 - Laboratory + Field (soil + vegetation traits)
 - UAV (fractional vegetation cover)
 - Airborne (F-SAR + HySPEX)
 - Spaceborne (DESIS, EnMAP, PRISMA)
 - (1) Time series
 - (2) Sensor matchups



Partner:



Contact: Tobias Hank (LMU)

International campaign support

ESA Advanced Ocean Training Course 2025

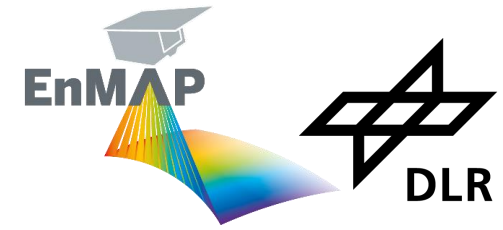
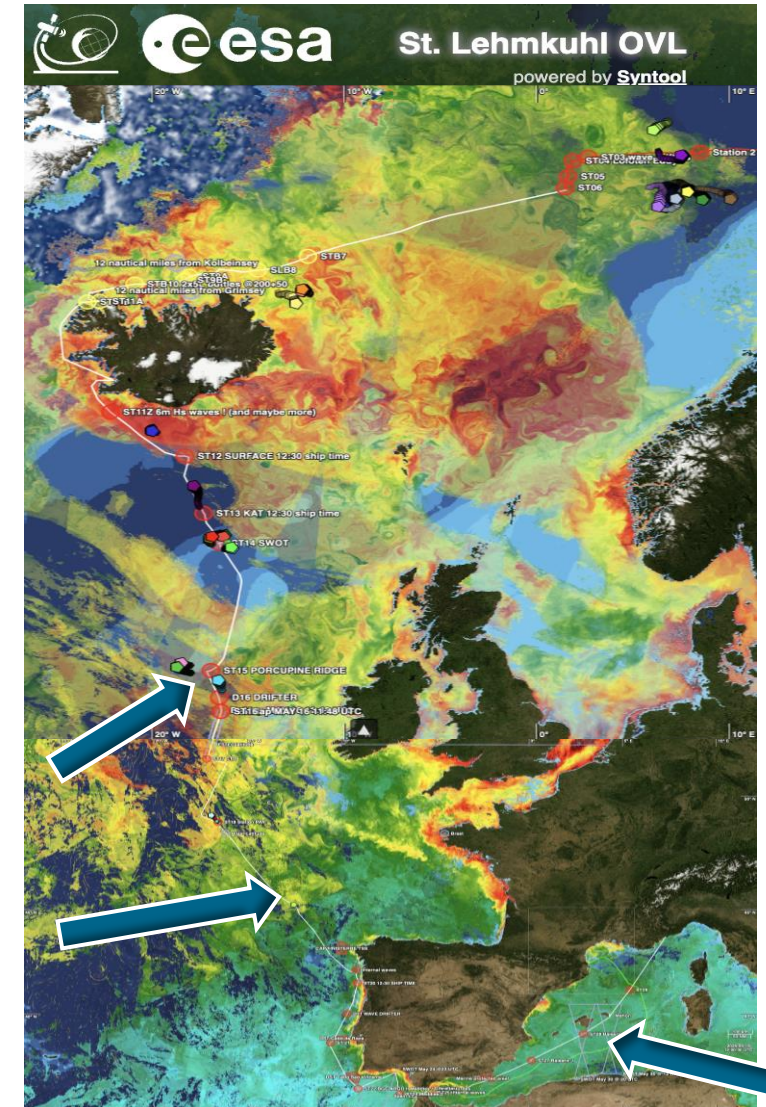
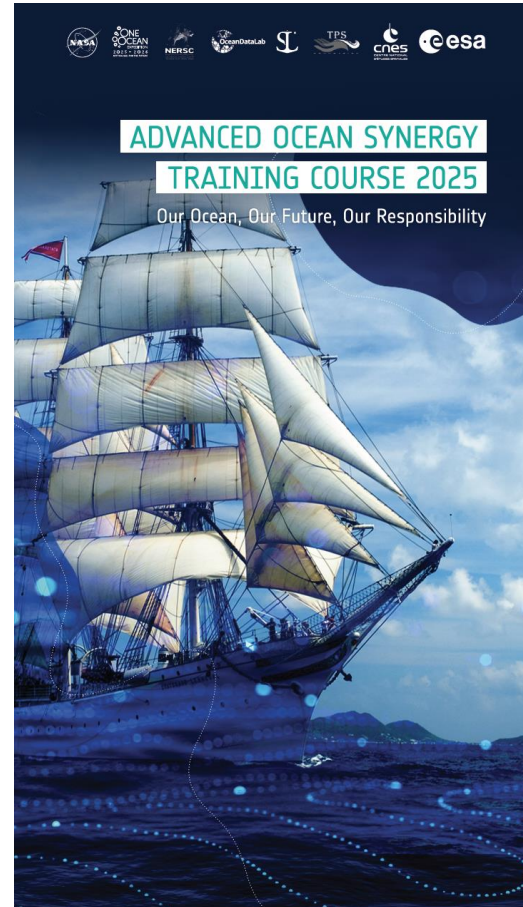
A unique co-located satellite and in situ data set

- 50 students, 21 lecturers, 22 countries
- ~4500 nautical miles
- 46 days at sea
- 1 marine heatwave, 1 marine cold spell
- Amazing biological succession/biodiversity
- 30 Oceanographic stations
- 63 CTD profiles
- 61 Phytoplankton nets
- 43 Zooplankton nets
- 157 ocean current drone flights
- 2 BGC-ARGO deployments
- 55 drifting buoys (35 wave drifters) deployed
- 38 lectures at sea
- Continuous sampling underway
- >15 Tb data acquired on the ship
- satellite imagery/data from Sentinel-1, -2, -3, -6,

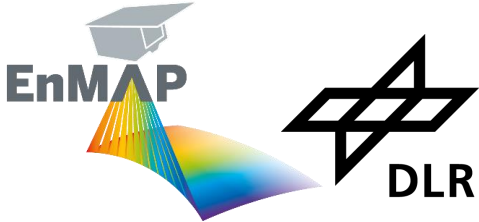
→ EnMAP (16.05., 19.05. and 28.05.2025)

- First test of Sentinel-1C AIS with in-situ application
- >8 Journal articles in preparation

Slide courtesy: Craig Donlon and
Vannesa Keuck, ESA



Collaboration with USGS



EnMAP as a pathfinder for Landsat Next Science product development



science for a changing world

EnMAP as a pathfinder for Landsat Next science product development in the Landsat Collection 3 era

April 2, 2025

Christopher J. Crawford¹, Saeed Arab², Pat Scaramuzza², Ben-Roberts Pierel³, Raymond Kokaly⁴, Nathan Roberts², Benjamin Page³, Shannon Franks², Calli Jenkerson², Danika Wellington¹

¹ U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD 57198, USA
² KBR, contractor to the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD 57198, USA
³ ESTS, contractor to the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD 57198, USA
⁴ U.S. Geological Survey (USGS) Geology, Geophysics, Geochemistry Science Center Spectroscopy Lab, Lakewood, CO 80225, USA

Work performed under USGS Contract [140G0121D0001]

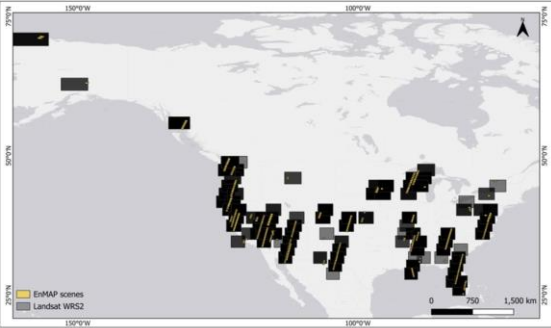
Corresponding Author: cjcrawford@usgs.gov

U.S. Department of the Interior
U.S. Geological Survey

2nd EnMAP User Workshop 2025: Munich, Germany, April 2-4, 2025

Coincident imaging Acquisition Tool (CAT)

- Coincident acquisition tool (CAT 2.0) finds past spatial/temporal coincidence for (same day within 24 hours):
 - Landsat 8/9
 - EnMAP
 - Sentinel-2
 - EMIT
- Future projections available for Landsat 8/9 and target instruments
 - Based on past acquisition times at ROI
- Built on top of STAC APIs
- Supports tasking requests for EnMAP and PRISMA



578 coincident (± 1 hour) acquisitions between Landsat 8/9 and EnMAP for January 2023 – August 2024

2nd EnMAP User Workshop 2025: Munich, Germany, April 2-4, 2025

Slide courtesy: Christopher J. Crawford, USGS

Planned datatakes over Nevada 06-08/2025

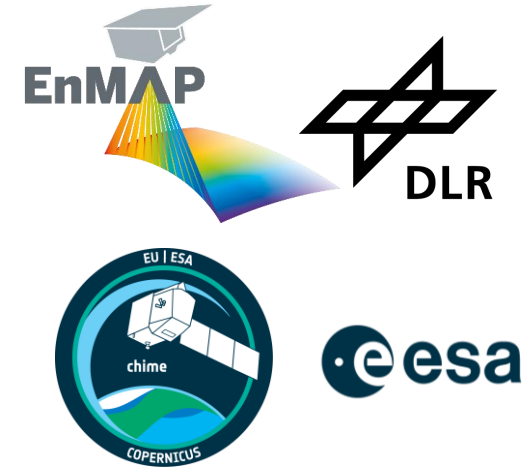


Contact: Akpona Okujeni (GFZ)

EnMAP as a pathfinder for ESA-CHIME mission

CHIME - Copernicus Hyperspectral Imaging Mission

- EnMAP heritage instrumental to define CHIME mission requirements in early phase
- EnMAP heritage at the core of the CHIME Level-2 prototyping activities



CHIME Key Specifications

- Carpet-mapping observations of land and coastal areas
- $SZA < 84^\circ$
- Spectral range: 400 – 2500 nm
- $FWHM \approx 10 \text{ nm}$, $SSI \approx 8.4 \text{ nm}$
- Ground Resolution: 30 m
- Swath $\approx 130 \text{ km}$
- Revisit 11 days (w/ 2 satellites)
- High radiometric accuracy and SNR, low spectral/spatial mis-registration

User data products:

- Top-of-atmosphere (TOA) radiance in sensor geometry
- Ortho-rectified TOA reflectance
- Bottom-of-atmosphere (BOA) land surface and aquatic reflectance both in sensor and ortho-rectified geometry

>> with associated uncertainties

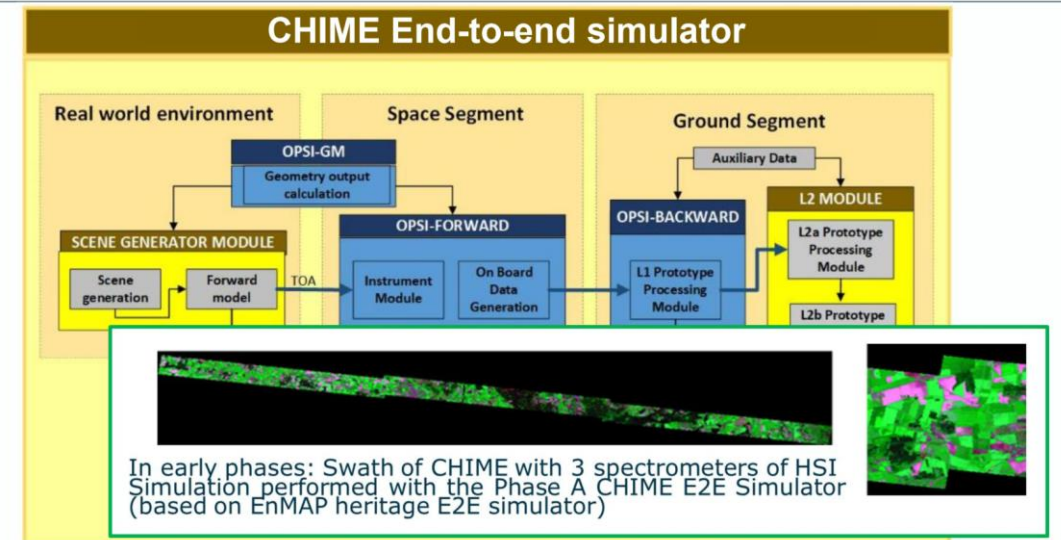
Current baseline documentation:

- MRD (ESA-EOPSM-CHIM-MRD-3216) version 3.0
- SSRD (CHIM-RS-ESA-PM-0002) version 2.1

EnMAP heritage instrumental to define CHIME mission requirements in early phase

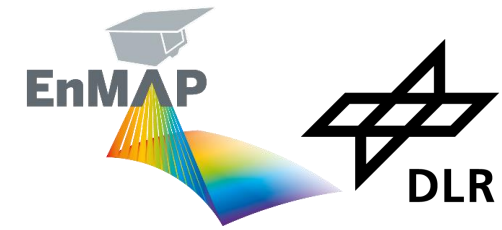
EnMAP heritage at the core of the CHIME Level-2 prototyping activities

CHIME End-to-End Simulator

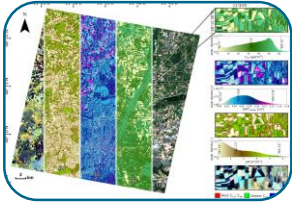


Slide courtesy: Marco Celesti, ESA

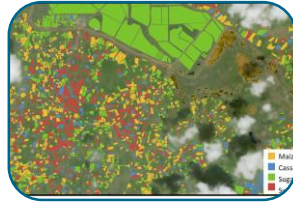
EnMAP Community: Expanding into New Frontiers



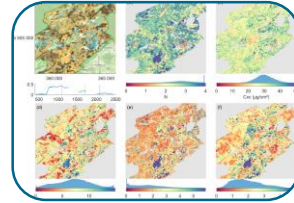
From applied scientific research



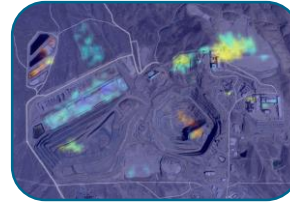
Agricultural practice and crop forecasts



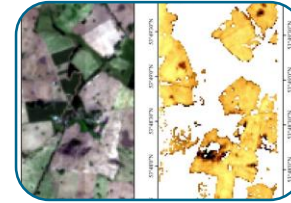
Crop type classification



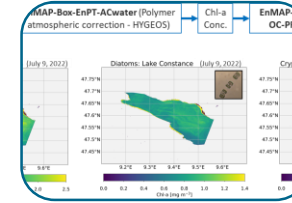
Forest monitoring



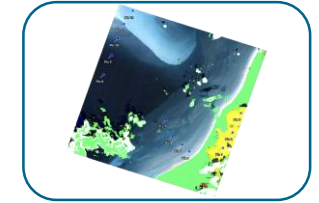
Raw material detection



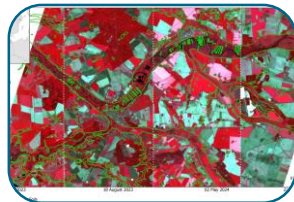
Soil quality - soil degradation, numerical estimation of soil organic carbon (SOC)



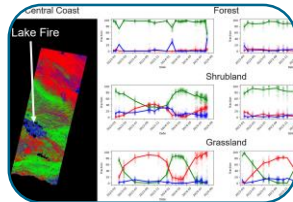
Water quality



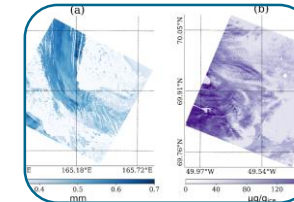
Algae classification



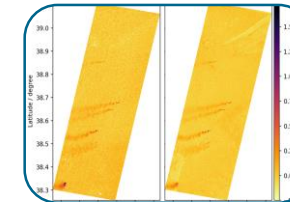
Rewetting of peatlands



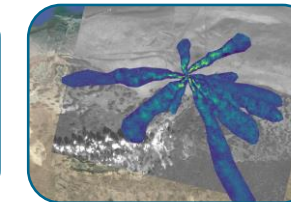
Fire ecosystems: Fire risk assessment, fire consequences, regeneration processes



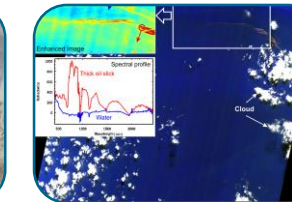
Snow and ice characterization, glacier monitoring



Methane plumes



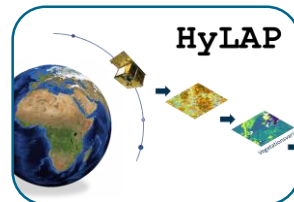
Methane leakage: detection and quantification



Oil spills



Detection of illegal waste dumps



Agricultural information products as a service



Mangroves monitoring (blue carbon market)



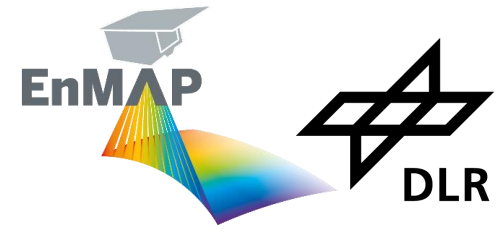
Seagrass monitoring

... to applications as commercial services

Support for commercial sector:
Companies in German consortia have been able to task EnMAP data since Feb 2025

EnMAP data ©DLR
Courtesy images: GFZ, LMU, AWI, Universität Bremen, Universität Heidelberg, Brockmann Consult, Universität Greifswald, HU Berlin, OHB, EOMAP

Summary and outlook



Hyperspectral national mission synergies: EnMAP – DESIS – PRISMA

→ Continued coordination of acquisitions

Upcoming ESA CHIME Mission

→ Support on agency, science and ground segment level

PACE and EMIT and upcoming FLEX Mission

→ Started conversations (ESA WICSIS Workshop 2024/11)

International campaigns

→ Ongoing support

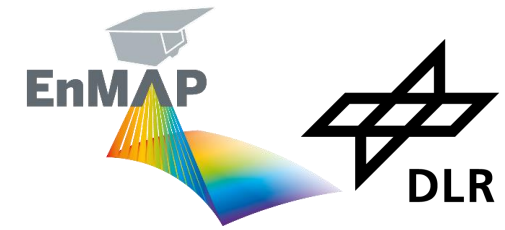
→ Remote Sensing of Environment Special Issue in preparation

Looking forward to further collaborations with operational and upcoming (hyperspectral) missions to exploit the full potential of hyperspectral EO data.

→ Mission extension envisioned



The EnMAP session at LPS25



C.05.05 The German EnMAP Mission

*3 Years of hyperspectral data –
From Science to Environmental Applications*

Oral Session

Wednesday, Jun 25, 2025

16:15 – 17:45

Hall N1/N2



Poster Session

Wednesday, Jun 25, 2025

17:45 - 19:00

X5 - Poster Area



Follow all our conference
activities at enmap.org



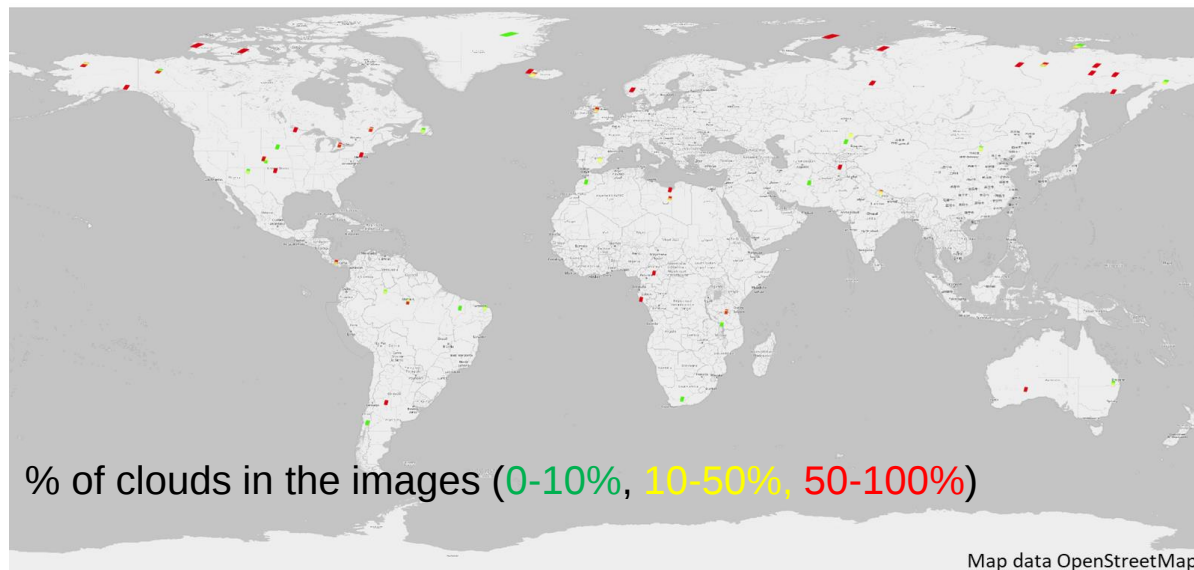
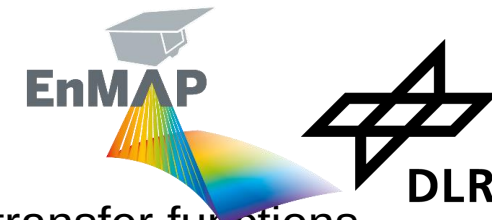
A satellite with a gold-colored body and a large white rectangular panel is shown in space. It is positioned in the upper left quadrant of the frame. The background is a deep black space filled with numerous small, distant stars. Below the satellite, the curved horizon of the Earth is visible, showing a mix of blue oceans and brown/tan landmasses. The satellite appears to be pointing towards the Earth.

Thank you !

In view of an envisioned EnMAP Mission Extension beyond 2027:

- For how long would continued EnMAP data acquisition benefit your application or research?**
- From which perspective do you see the greatest value in a mission extension?
e.g. scientific research, commercial use, public sector benefit, or institutional/space agency priorities)**

EnMAP & PRISMA match-ups



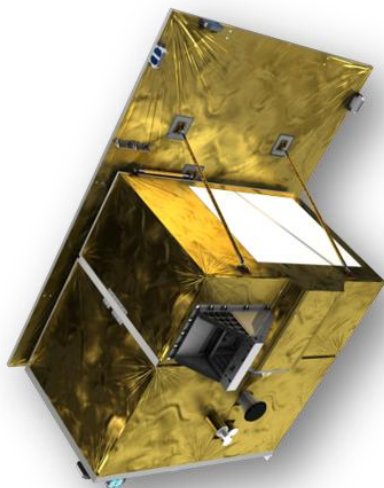
% of clouds in the images (0-10%, 10-50%, 50-100%)

Courtesy of E. Carmona

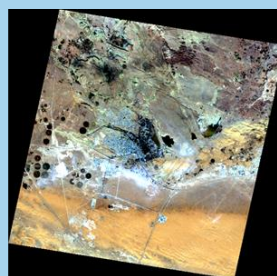
Map data OpenStreetMap

- **Goal:** development of L1/L2 transfer functions for multi-sensor time-series analyses and/or cross-calibrations
- > 165 common acquisitions globally distributed (including science or network sites in the frame of cal/val or thematic campaigns)
- Regular meeting to identify/select match-ups
- Schedule prepared 1x month

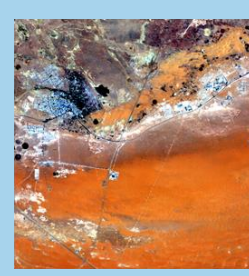
Workflow well established → ongoing work!



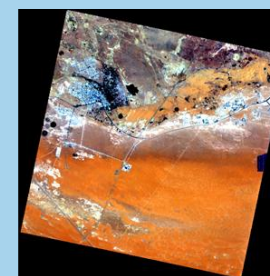
EnMAP L1C



EnMAP L2A



PRISMA L1

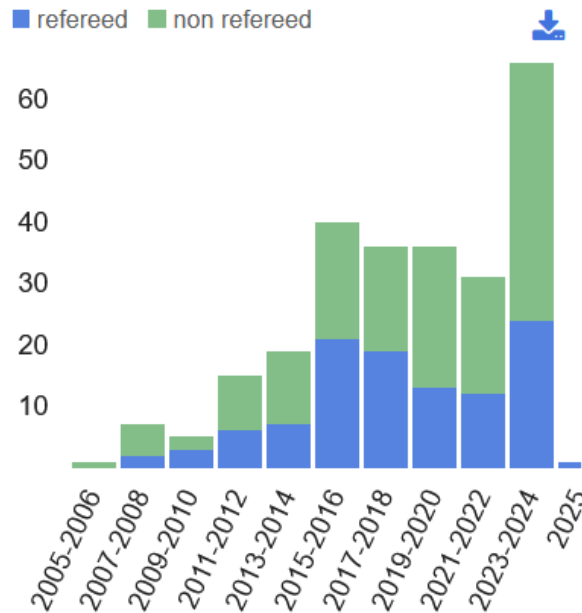


PRISMA L2D

Courtesy of K. Segl

Preliminary results show good agreement!

Publications



Source: NASA ADS

Special Issue on RSE in preparation!
Submission of papers
end 2025/beginning 2026
Get ready!

Asadzadeh, S., Koellner, N., Chabrillat, S. (2024), **Detecting rare earth elements using EnMAP hyperspectral satellite data: a case study from Mountain Pass, California**. Scientific Reports, 14, 20766.

doi: [10.1038/s41598-024-71395-2](https://doi.org/10.1038/s41598-024-71395-2)



Full mission evaluation of EnMAP reflectance products using the correction processors

MARIANA A. SOPPA,¹ MAXIMILIAN BRELL,¹ SABINE CHABRILLAT,^{2,3} LEONARDO M. A. ALVARADO,^{1,4} PETER GEGE,⁵ STEFAN PLATTNER,⁵ IAN SOMLAI-SCHWEIGER,⁵ THOMAS SCHROEDER,⁵ FRANÇOIS STEINMETZ,⁷ DANIEL SCHEFFLER,² VITTORIO E. BRANDO,⁸ MARIANO BRESCIANI,⁹ CLAUDIA GIARDINO,⁹ SIMONE COLELLA,⁸ DIETER VANSTEENWEGEN,¹⁰ MAXIMILIAN LANGENBACH,¹¹ EMILIANO CARMONA,¹¹ MARTIN MIGUEL PATO,¹¹ SEBASTIAN FISCHER,¹¹ AND ASTRID BRACHER^{1,13,*}

Detecting methane emissions from palm oil mills with airborne and spaceborne imaging spectrometers

Adriana Valverde^{1,*}, Javier Roger¹, Javier Gorroño¹, Itziar Irakulis-Loitxate^{1,2} and Luis Guanter^{1,3}

Evaluation of EnMAP imagery for predictive modelling of soil salinity in highly saline soils

Francisco M. Canero¹, Diego Lopez-Nieto¹, and Victor Rodriguez-Galiano¹
University of Seville, Department of Physical Geography, Seville, Spain (fcanero@us.es)

Gaussian Process Regression Hybrid Models for the Top-of-Atmosphere Retrieval of Vegetation Traits Applied to PRISMA and EnMAP Imagery

by Ana B. Pascual-Ventoe^{1,*}, Jose L. Garcia¹, Katja Berger^{1,2}, José Estévez¹, Jorge Vicent^{1,3}, Adrián Pérez-Suay¹, Shari Van Wittenberghe¹ and Jochem Verrelst¹

Identification of a Potential Rare Earth Element Deposit at Ivanpah Dry Lake, California Through the Bastnäsite Indices

by Otto C. A. Gadea¹ and Shuhab D. Khan^{2,*}

Department of Earth and Atmospheric Sciences, University of Houston, Houston, TX 77204, USA

* Author to whom correspondence should be addressed.

Remote Sens. 2024, 16(23), 4540; <https://doi.org/10.3390/rs16234540>

Hajaj, S., Harti, A.E., Pour, A.B. et al. Recurrent-spectral convolutional neural networks (RecSpecCNN) architecture for hyperspectral lithological classification optimization. Earth Sci Inform 18, 125 (2025). <https://doi.org/10.1007/s12145-024-01534-w>

Moon calibrations

- Moon observations for calibration & cal/val studies
- Along-track scanning strategy
- 8 acquisitions since launch
- 2-monthly acquisitions, close in time to Sun calibrations
- Data not publicly available
- Collaborations with external partners for Moon data exploitation (e.g. CNES)



10.04.2025



Background Mission targets

