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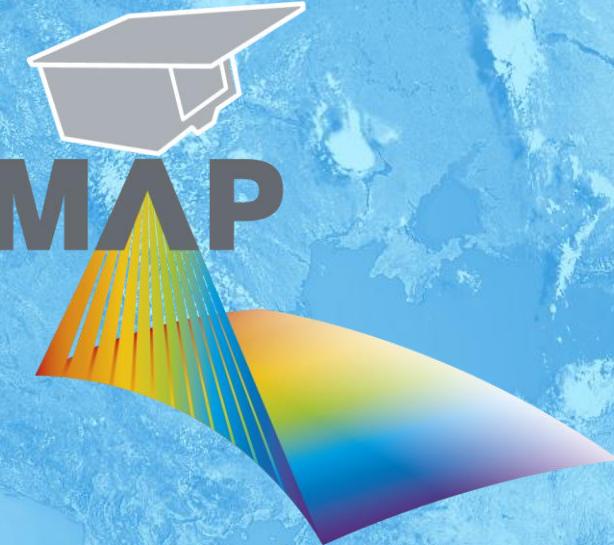


Bundesministerium
für Forschung, Technologie
und Raumfahrt

on the basis of a decision
by the German Bundestag



German
Space Agency
at DLR



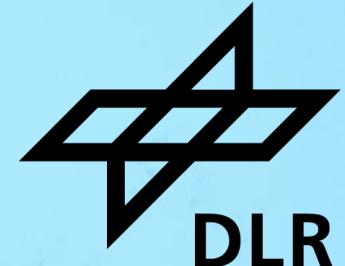
DIE ENMAP MISSION

Vera Krieger, Mission Science Coordinator

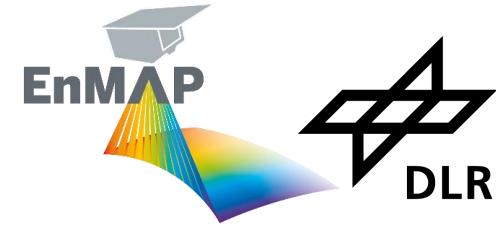
Im Namen des EnMAP Consortium

Geoforum 11. November 2025

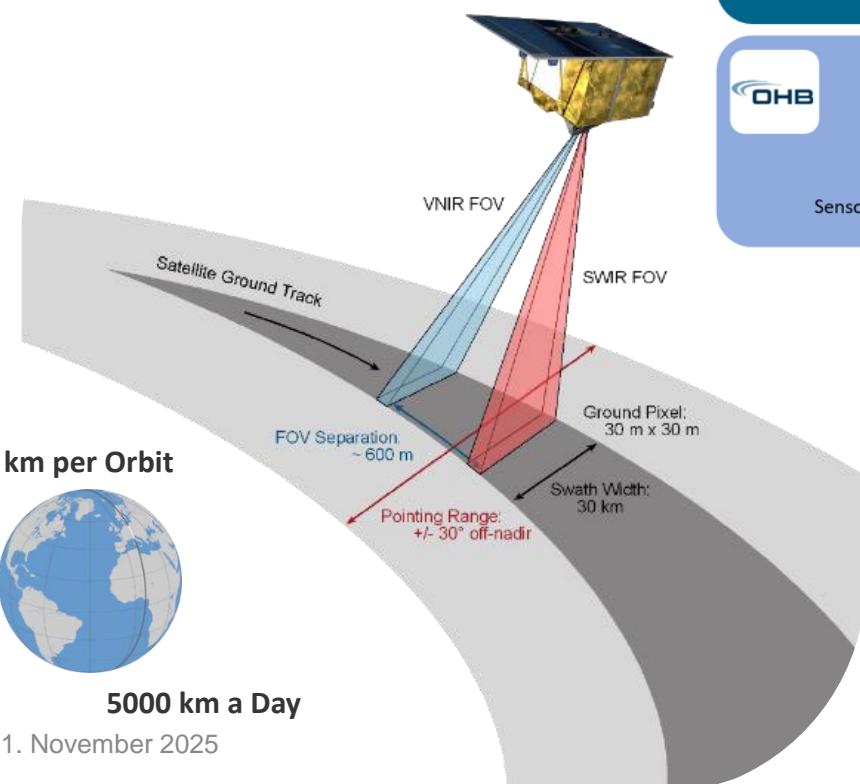
Laura La Porta (Mission Manager) and Michael Bock (Data License)
D. Reintsema, R. Wernitz, K. Bagschik, M. Bock, S. Fischer
E. Carmona, D. Schulze, N. Pinnel, S. Baumann, M. Pato, S. Hartung,
M. Habermeyer, S. Engelbrecht, K. Wirth, ...
Science PI: S. Chabrilat, K. Segl, A. Okujeni, P. Reiners ...
R. Feckl, M. Betz, M.S. Guilherme ...



EnMAP – Mission and Sensor Charakteristik



Orbit characteristics	
Orbit / Inclination	sun-synchronous / 97.96°
Target revisit time	27 days (VZA ≤ 5°) / 4 days (VZA ≤ 30°)
Equator crossing time	11:00 h ± 18 min (local time)
Instrument characteristics	
VNIR	
Spectral range	420 - 1000 nm
Number of bands	91
Spectral sampling interval	6.5 nm
Spectral bandwidth (FWHM)	8.1 ± 1.0 nm
Signal-to-noise ratio (SNR)	> 400:1 @ 495 nm
Spectral calibration accuracy	0.5 nm
Ground sampling distance	30 m (at nadir; sea level)
Swath width	30 km (field-of-view = 2.63° across track)
Acquisition length	1000 km/orbit - 5000 km/day



Supported by:

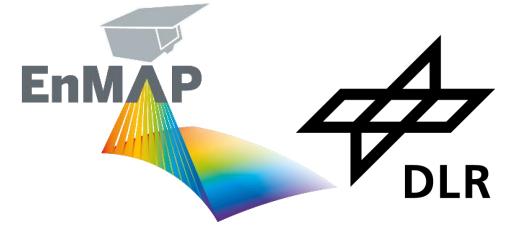


Federal Ministry
for Economic Affairs
and Climate Action

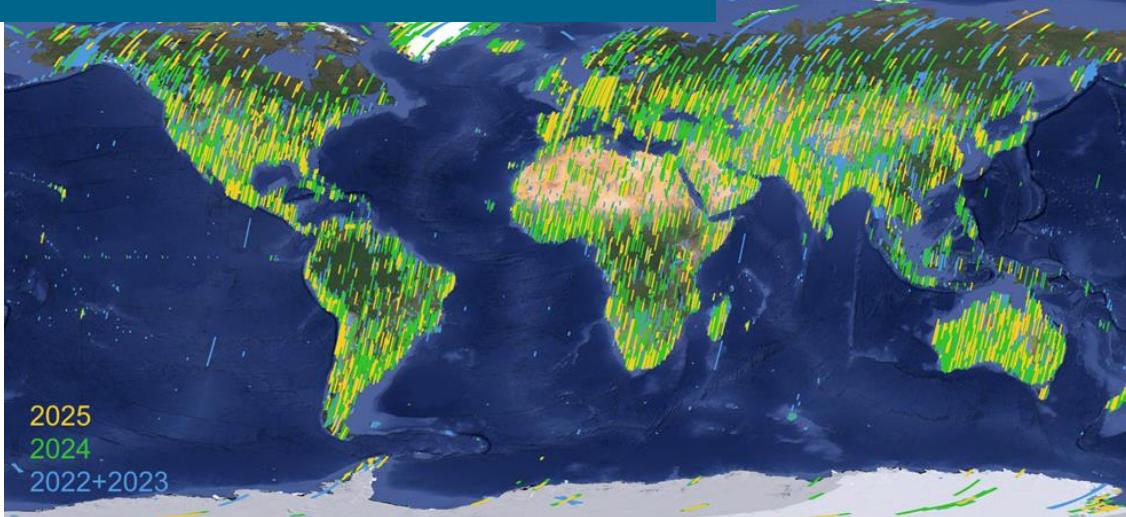
on the basis of a decision
by the German Bundestag

www.enmap.org

EnMAP – 3 Jahre operationell

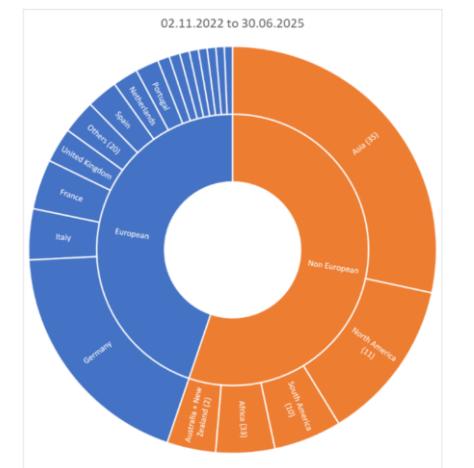


Wachsendes Archiv mit weltweiten Daten



Wachsende internationale Nutzergemeinschaft

- > 5.100 registrierte Nutzer, aus 130 unterschiedlichen Ländern, darunter 36 europäische Länder
- > 150.00 Produkte im Archiv
- > 800 wissenschaftliche Proposals sind eingegangen zur Datenaufnahme



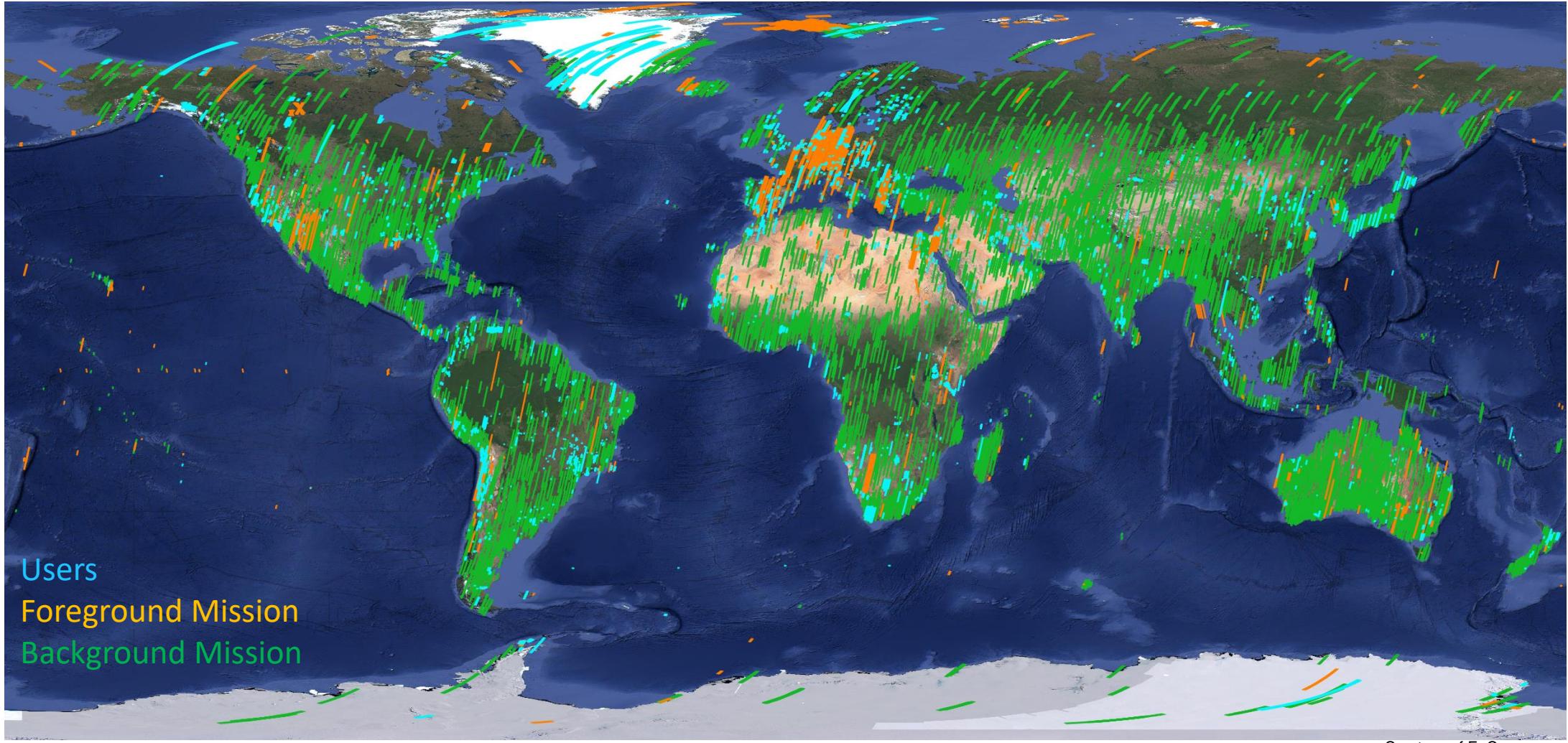
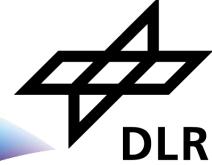
EnMAP hat sich von einer wissenschaftlichen Mission zu einer ausgereiften operativen Plattform entwickelt.

- Anspruchsvolle Tasking mission
- Intensive Unterstützung der Nutzer, Internationaler Kampagnen-support
- Exzellente Datenqualität demonstriert durch starkes Wissenschaftsprogramm

Pathfinder for
ESA's CHIME
Mission

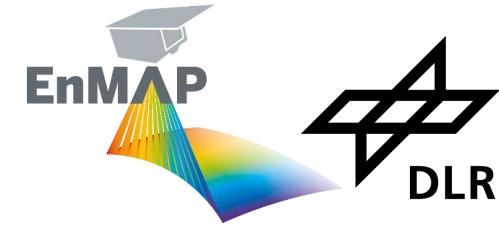


User Tasking, Foreground und Background Mission



Courtesy of E. Carmona

Foreground Mission *Currently in 'winter mode'*



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

- Gestartet 03/2024
 - ~1000 km lange Streifen
 - Definiert durch Nutzerbedarfe (Workshops, Umfragen)
 - Aktualisierung während Laufzeit
 - Höchste Priorität
- ! Flexible (Kampagnen, Wetter)

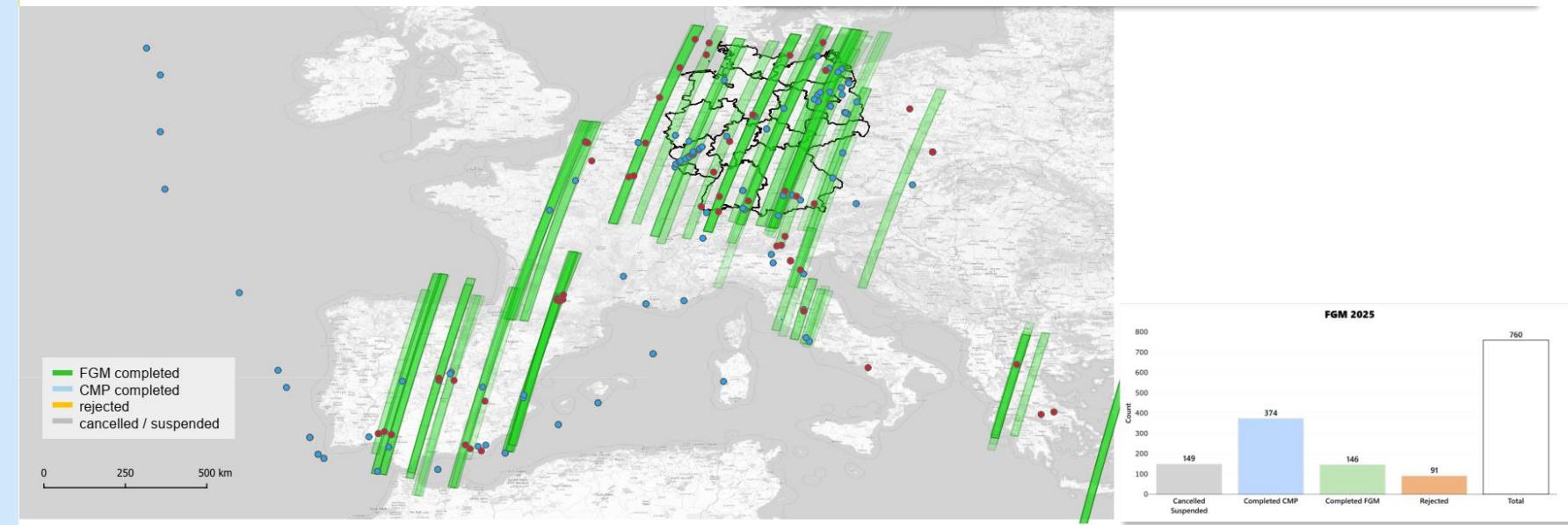
Ziel

- Optimisierung der Aufnahmerate
- Zeitreihen über Europa

Unterstützte Kampagnen

- 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
- ESA Advanced Ocean Training Course 2025

Koordination GFZ mit Ground Segment Application Support

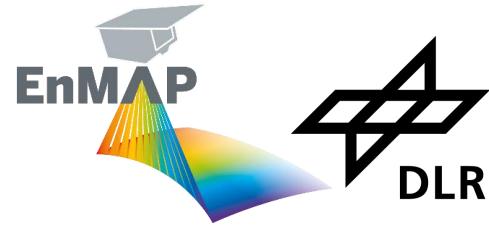


Courtesy Nicole Pinnel

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

Kooperation mit dem USGS

EnMAP as a pathfinder for Landsat Next Science product development



USGS
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

¹U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD 57198, USA
²KBR, contractor to the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD 57198, USA
³ESTS, contractor to the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD 57198, USA
⁴U.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 (\pm 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

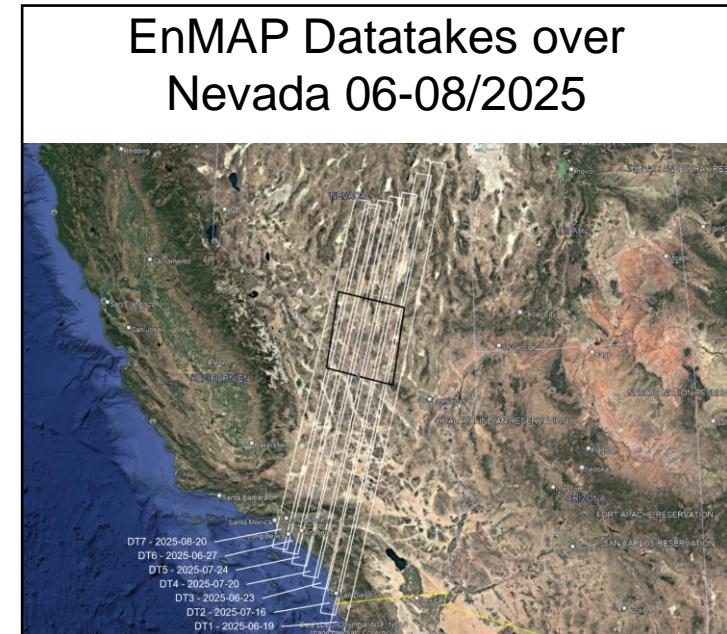
USGS

GEMx

NASA and the USGS have embarked on a multi-year survey to map critical minerals in the Western US

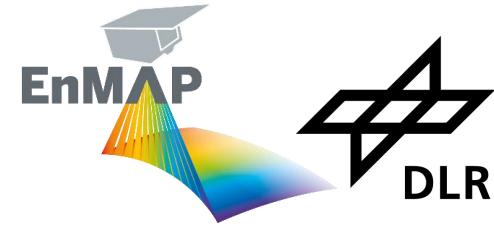
● ACTIVE MISSION

The Geological Earth Mapping Experiment (GEMx) is a joint effort between NASA and the U.S. Geological Survey (USGS) to advance our knowledge of critical mineral resources in the Western United States.



Slides: Christopher J. Crawford, USGS – April 25

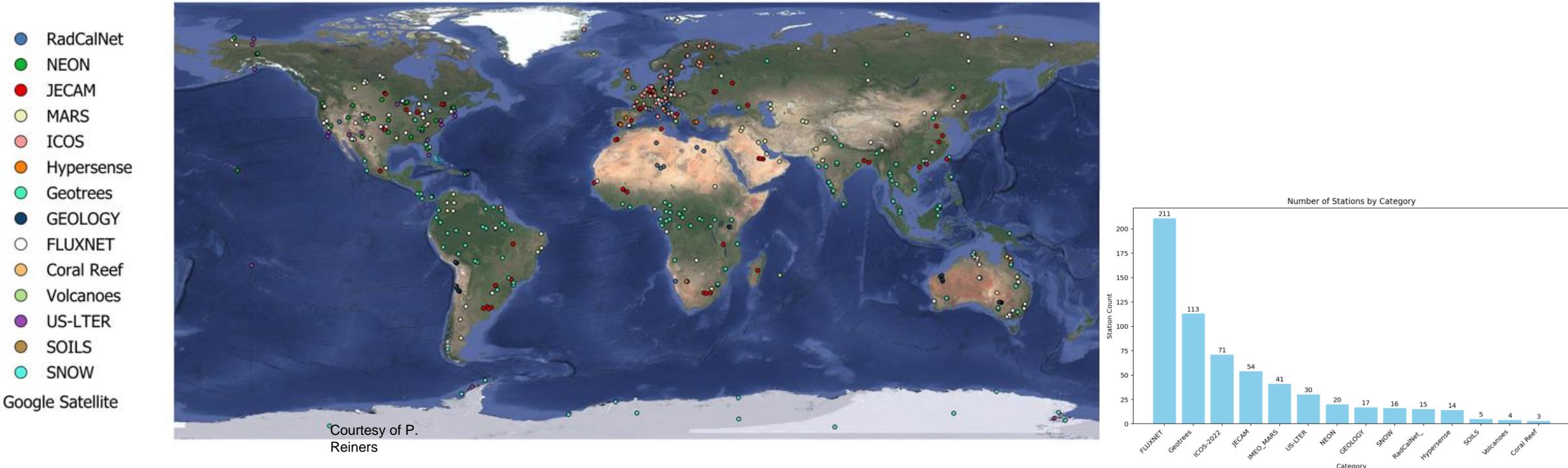
Mehr als 600 Internationale Cal/Val sites in der Background Mission



Ziel

- Fokus Zeitreihen
- Räumliche Abdeckung

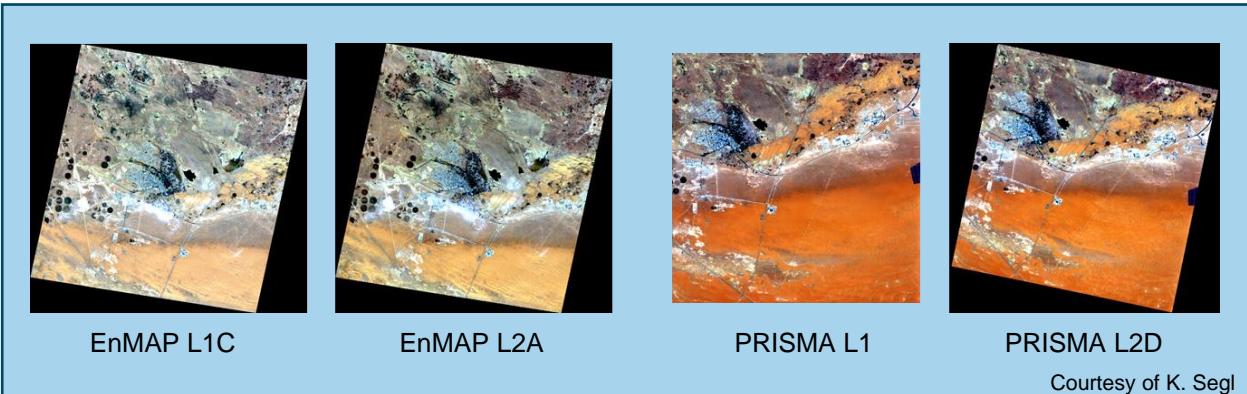
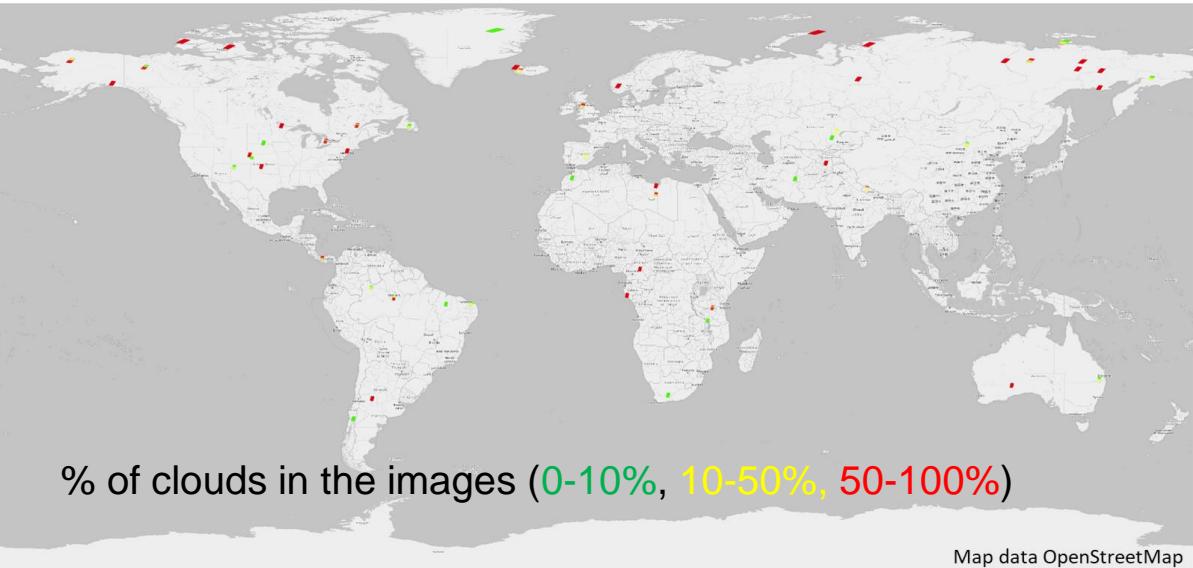
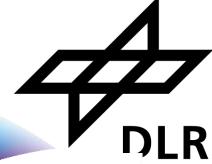
Globale Liste der Ziele (Networking sites) (> 600 sites)



EnMAP & PRISMA match-ups

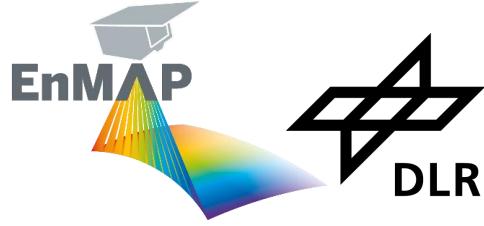
Ziel: Entwicklung von L1/L2-Transfer functions für Multi-Sensor-Zeitreihenanalysen und/oder Cross-Calibration exercises

- > 165 gemeinsame Erfassungen weltweit verteilt (einschließlich Wissenschafts- oder Netzwerkstandorte im Rahmen von Cal/Val oder thematischen Kampagnen)
- Regelmäßige Treffen zur Identifizierung/Auswahl von Match-ups
- Zeitplan wird 1x monatlich erstellt

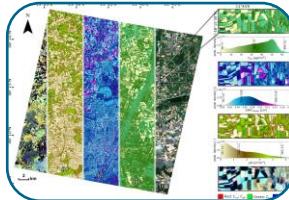


Erste Ergebnisse
zeigen gute
Übereinstimmungen

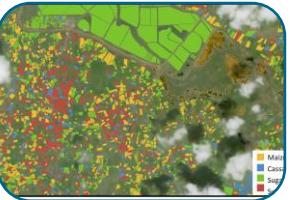
EnMAP – Anwendungsbeispiele



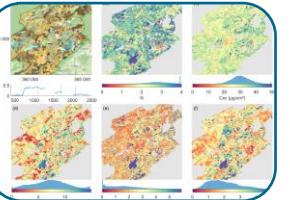
Von wissenschaftlicher Grundlagenforschung ...



Landwirtschaftliche Praxis erleichtern und Erntevorhersagen



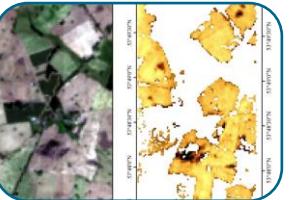
Feldfrucht-Erkennung in Kenia



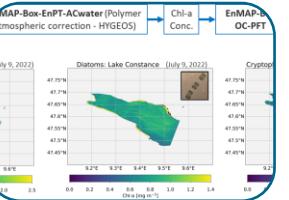
Waldmonitoring



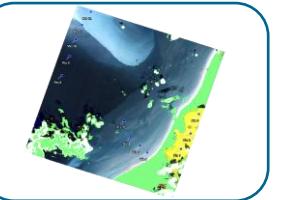
Detektion und Klassifizierung von Rohmaterialien



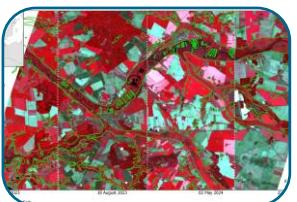
Bodengüte – BodenDegradation, Numerical Soil Organic Carbon Estimation



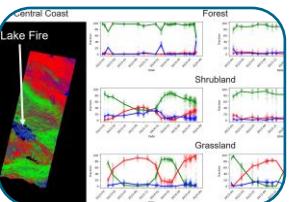
Gewässergüte



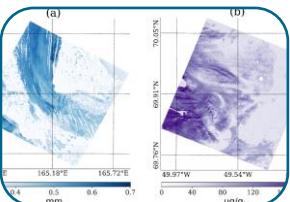
Klassifizierung von Algentypen



Moorökosysteme: Überwachen der Wiedervernässung



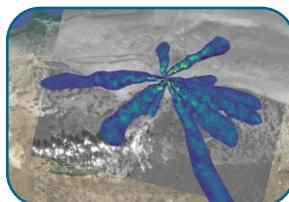
Feuerökosysteme: Brandrisikoeinschätzung, Brandfolgen, Regenerationsprozesse



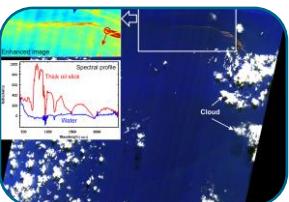
Schnee und Eischarakterisierung, Gletschermonitoring



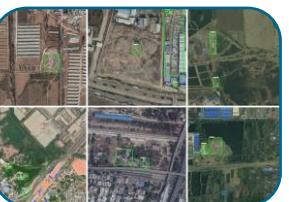
Überwachung von Treibhausgasemissionen



Methanleaks: Erkennung und Quantifizierung

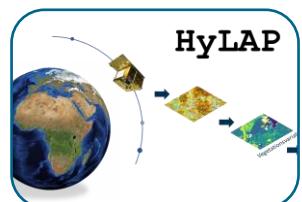


Erkennung eines Ölteppich nach Schiffsunglück



Identifikation von illegalen Müllkippen

... bis hin zu Anwendungen als kommerzielle Services



Landwirtschaft – Managementempfehlungen



Blue Carbon Market – Mangroven



Seegrasmonitoring



The EnMAP spaceborne imaging spectroscopy mission: Initial scientific results two years after launch

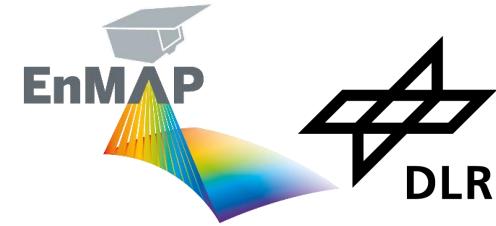
Deutsche Firmen können seit Februar 2025 EnMAP Aufnahmen als **kommerzielle Nutzer** Aufnahmen tasken

EnMAP data ©DLR

Bildredits: GFZ, LMU, AWI, Universität Bremen, Universität Heidelberg, Brockmann Consult, Universität Greifswald, HU Berlin, OHB, EOMAP

EnMAP – Bodenqualität

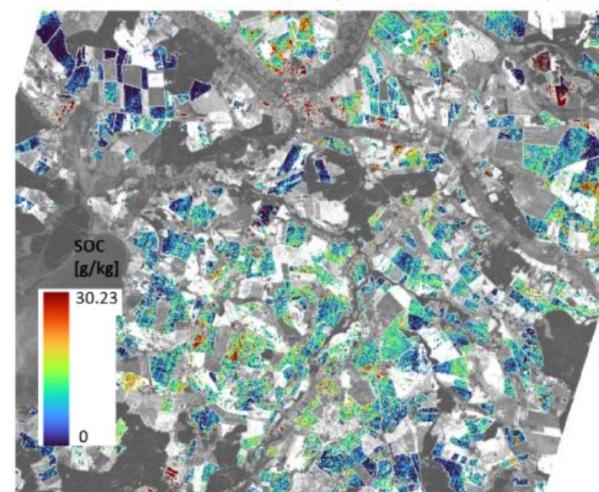
Boden ist der größte terrestrische Kohlenstoffspeicher



Boden degradation is Europe and worldwide a serious problem

- Auswirkungen auf Ernährungssicherheit und Klimawandel
- z.B. Reduzierung des Gehalts an organischem Kohlenstoff (SOC) im Boden
- Bodenkohlenstoff ist eine der wesentlichen Klimavariablen (ECVs) von GEOSS.
- SOC wichtig für z.B. für Bodenfruchtbarkeit und Wasserspeicherung
- EU-Gesetz zur Bodenüberwachung: EU auf dem Weg zu gesunden Böden bis 2050 → Kohlenstoffwirtschaft
- SDGs: SOC als relevanste Bodeneigenschaft im Hinblick auf Klimaregulierungen, Überwachungsstatus sollte verbessert werden

EnMAP ermöglicht die Quantifizierung des Kohlenstoffgehalts im Oberboden → Kalibrierte Daten, hohe spektrale Auflösung und hoher SNR, auch im SWIR sind für die meisten Bodenanwendungen entscheidend

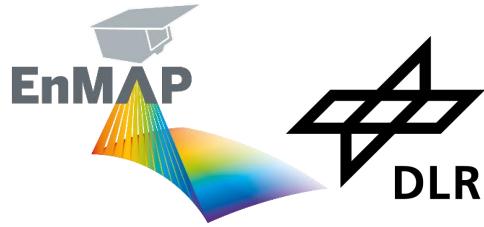


Data: EnMAP L2A
Demmin, Germany,
22.09.2024

Map of the soil organic carbon content (g/kg) based on predominantly bare soil pixels

Copernicus web page
EnMAP example
Courtesy K. Ward

Mineraliendetektion mit EnMAP

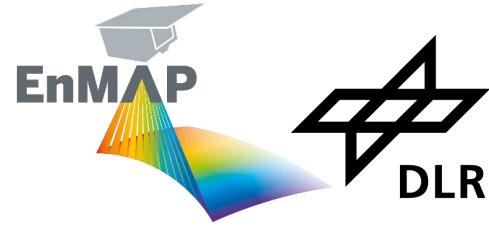


Deposit type	Metal endowment*
Porphyry Copper	Cu ± Mo ± Au ± Re ± Te ± Se
Iron Oxide-Copper-Gold (IOCG)	Cu ± Au ± U ± Co ± REE**
Volcanogenic massive sulfide (VMS)	Zn-Cu ± Pb ± Ag ± Au ± Se ± In
Epithermal gold (low/high S)	Au-Ag ± Sb ± Cu
Pegmatites	Li ± Be ± Sn ± W ± Ta
Carbonatites	P ± REE ± Nb ± Th
Orthomagmatic Ni-Cu-(PGE)	Ni-Cu ± PGE***
Skarns	Fe ± Cu ± W ± Zn ± Sn
Mississippi valley type (MVT)	Zn-Pb ± Cd ± Ge ± In ± Ga
Sedimentary exhalative (SEDEX)	Zn-Pb ± Ag ± Co
Bauxites	Al ± V
Lithium volcano-sedimentary	Li ± B

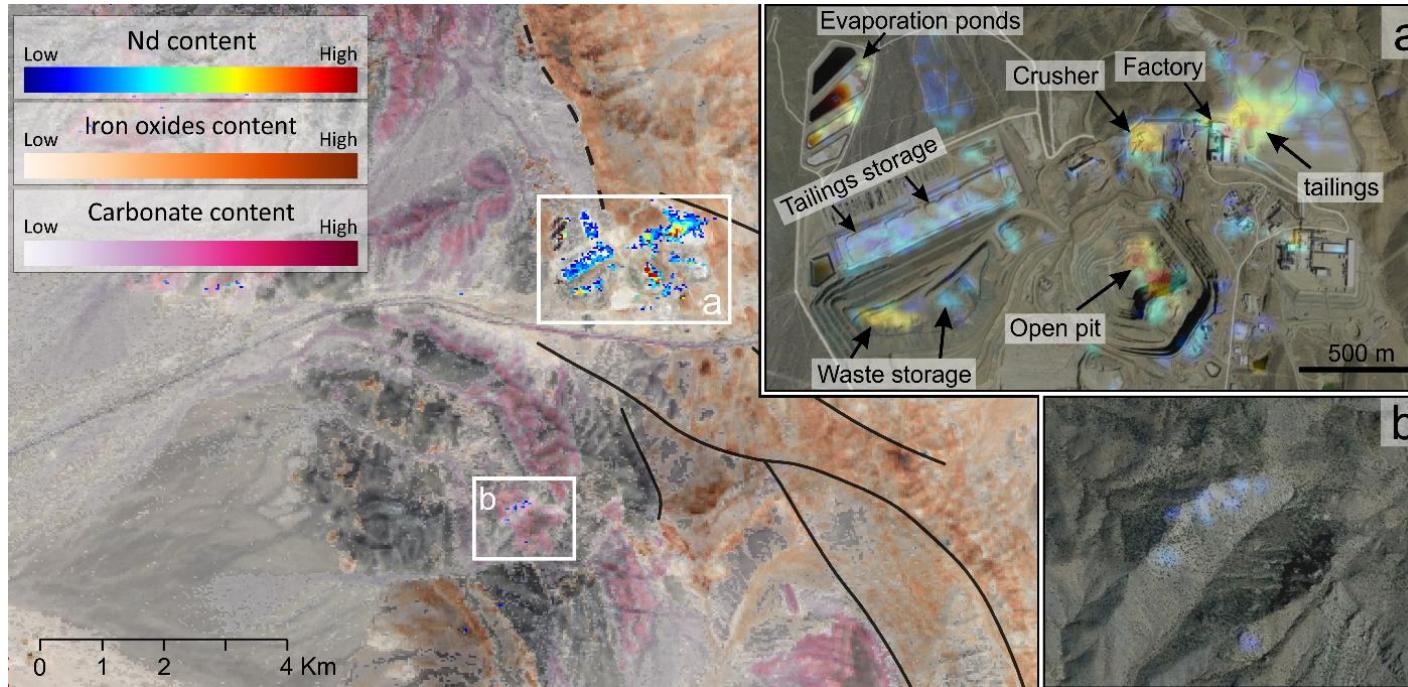
EnMAP deckt ein breites Spektrum an Mineralisierungssystemen und Minenstandorten ab:

- 250+ Ziele in 40+ Ländern auf 5 Kontinenten
- 10+ Lagerstättentypen.
- Viele wichtige Rohstoffe: Cu, Au, Mo, Al, Pb, Zn, Ni, Mn, Li, und REEs.

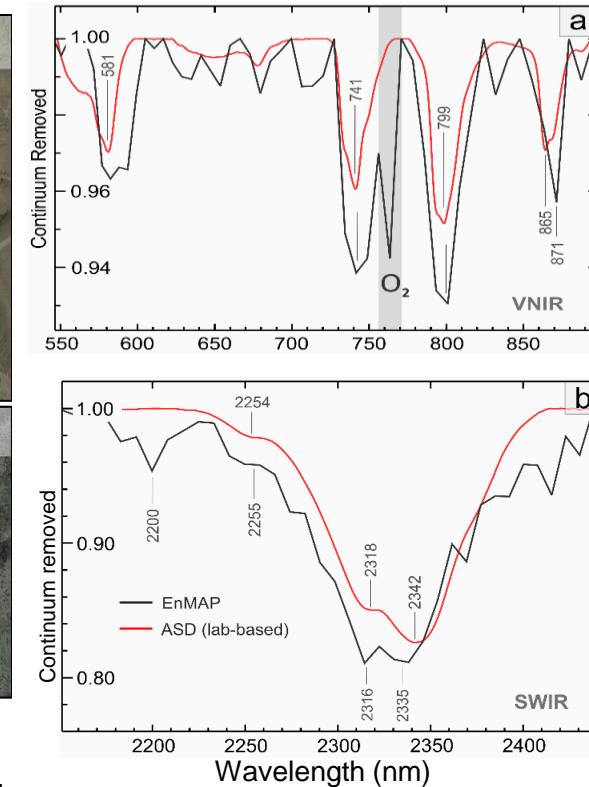
EnMAP: REE's - Seltene Erden



Ausläufer von Nd-haltigem Bastnaesit bei Mountain Pass wurden erfolgreich mit EnMAP entdeckt.

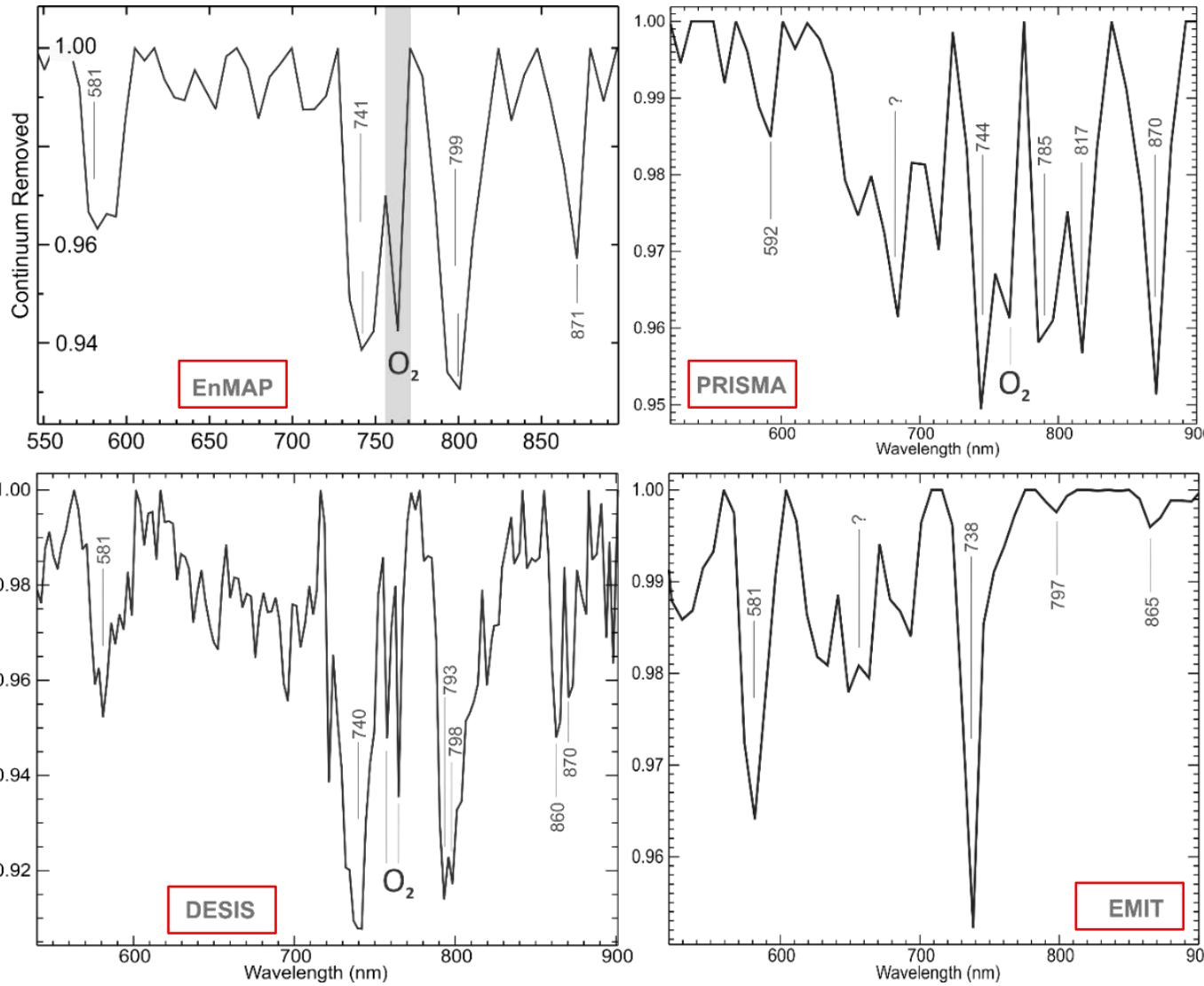


Asadzadeh et al.
Scientific Rep. 2024



Source: Wikipedia

Vergleich mit anderen Sensoren

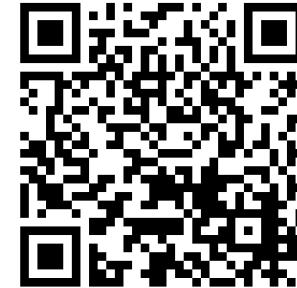


- EnMAP liefert Ergebnisse, die mit denen des hochspektralen DESIS-Sensors vergleichbar sind.
- Die atmosphärische Korrektur von EMIT eliminiert die REE-Merkmale (ISOFIT-Bias).
- PRISMA zeigt die schlechteste Leistung bei der REE-Erkennung.
- Wasserdampf und O₂ bei 720 und 760 nm sind die größten Hindernisse für die REE-Fernerkundung.

EnMAP – HYPERedu

The screenshot shows the 'Beyond the Visible - Introduction to Hyperspectral Remote Sensing' course on the EO college platform. The course title is prominently displayed. Below it, there's a thumbnail image of a hyperspectral image showing a landscape with various geological features. A speech bubble from a participant says: "I think one of the best remote sensing MOOCs I've ever attended". Another speech bubble from another participant says: "I had a lot of fun taking this course. I am experienced in the field, but I have learned a lot. Congrats!" The course page includes sections for 'View Course details', 'HYPERedu', and 'HYPER EDU Education Initiative'. On the right side, there's a detailed 'Definition of Imaging Spectroscopy or Hyperspectral Remote Sensing' section with text and a 3D visualization of a soil sample with a color-coded spectrum overlay.

HYPERedu YouTube



youtube.com/@HYPERedu_GFZ

HYPERedu MOOC “Beyond the Visible”

>2000 Participants!



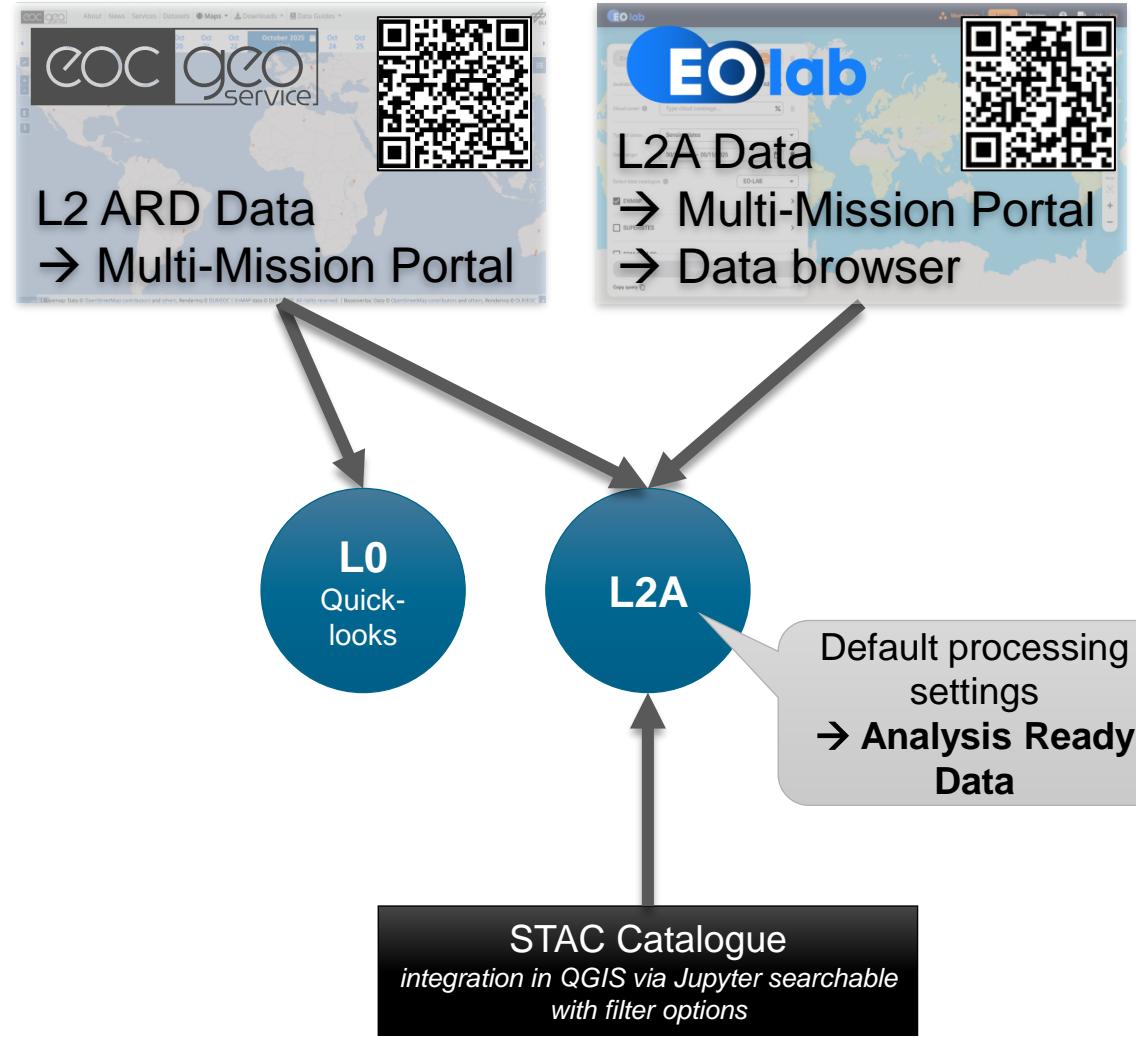
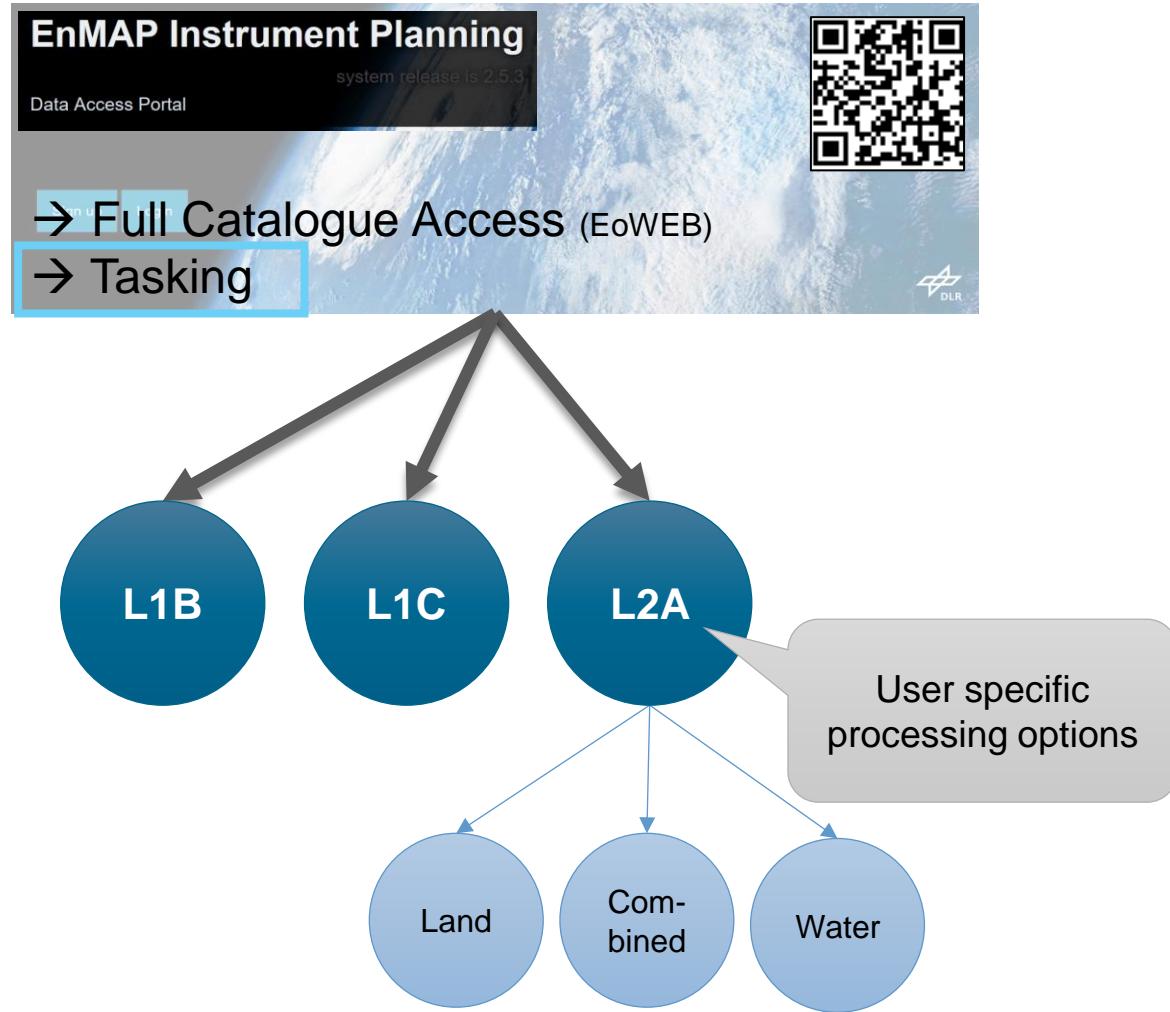
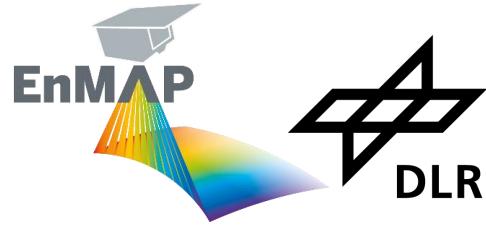
- from different countries and continents
- young (25-45 years)
- 30 % previous MOOC experience
- 60 % no contact with hyperspectral data before

[https://eo-college.org/
courses/beyond-the-visible/](https://eo-college.org/courses/beyond-the-visible/)



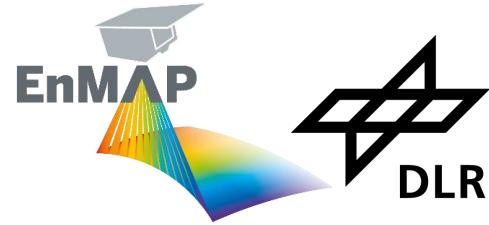
EnMAP Data Access points

Registration obligatory → EU sanction list check



EnMAP Tasking

EnMAP ist als nutzergesteuerte Mission und ist auf Ihren Beitrag angewiesen!



<https://planning.enmap.org/>

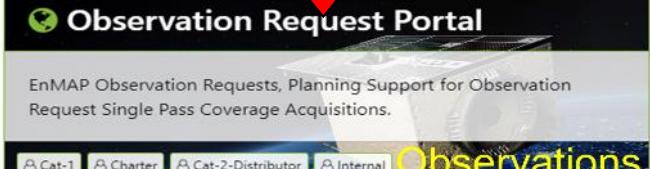
Instrument Planning Portal



Proposal Portal

EnMAP Proposals, Announcement of Opportunity Processes, Reviews, Up and Download of proposal-related Files.

Cat-1 Reviewer



Observation Request Portal

EnMAP Observation Requests, Planning Support for Observation Request Single Pass Coverage Acquisitions.

applicationSupport Cat-1-Distributor

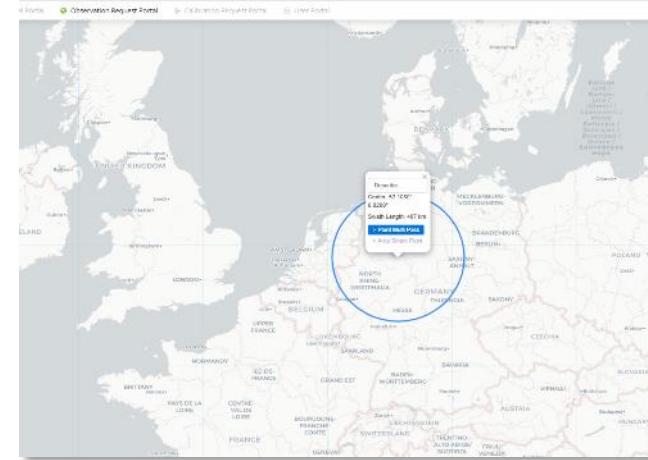
Observations

Source: DLR

Tasking future acquisitions

Accessing archived data

Ins. Planning Portal Observation Request



Source: DLR



Einstiegspunkt ist das **Instrument Planning Portal** (Selbstregistrierung):

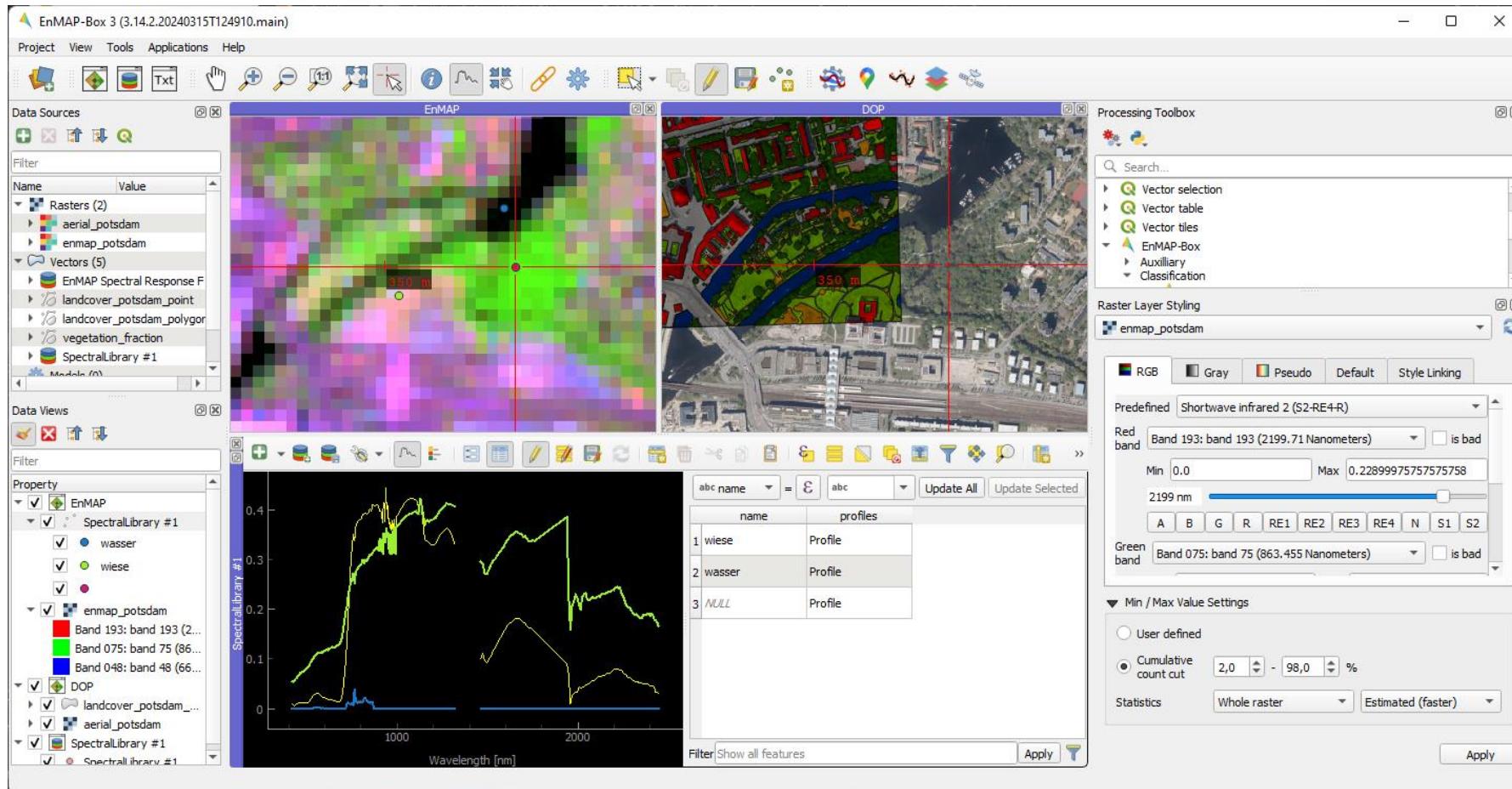
1. Benutzerregistrierung
2. Einreichung von ‚Proposals‘ (Wissenschaft - Cat1/ Firmen - Cat2)
3. Tasken von zukünftigen EnMAP-Aufnahmen



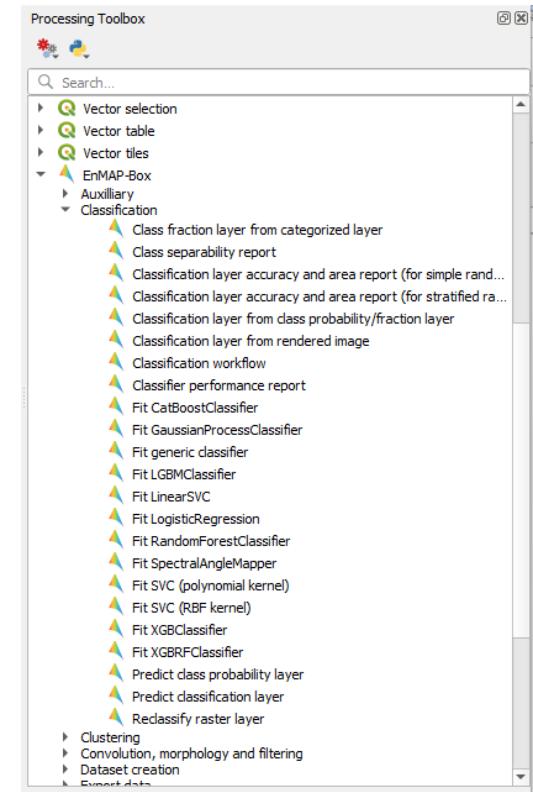
EnMAP-Box



HUMBOLDT
INNOVATION
CONNECTING SCIENCE AND SOCIETY

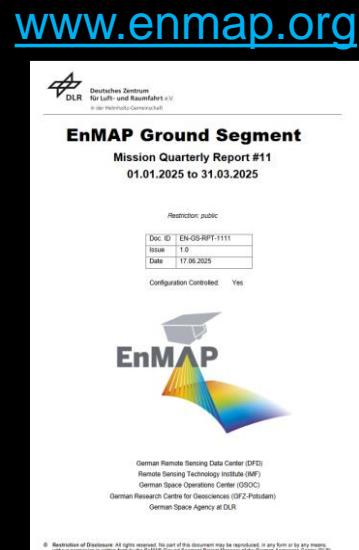


QGIS



<https://enmap-box.readthedocs.io>

Jakimow, Janz, Thiel, Okujeni, Hostert, van der Linden, 2023. EnMAP-Box: Imaging spectroscopy in QGIS. SoftwareX 23, 101507.



Danke für die Aufmerksamkeit



MOOC: Einführung
in die hyperspektral-
Fernerkundung



EnMAP als Wegbereiter für die ESA-CHIME Mission

CHIME - Copernicus Hyperspectral Imaging Mission

- EnMAP entscheidend für die Festlegung der CHIME-Missionsanforderungen in der frühen Phase
- EnMAP grundlegend für die CHIME Level-2 Prototyp Aktivitäten



CHIME Key Specifications

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

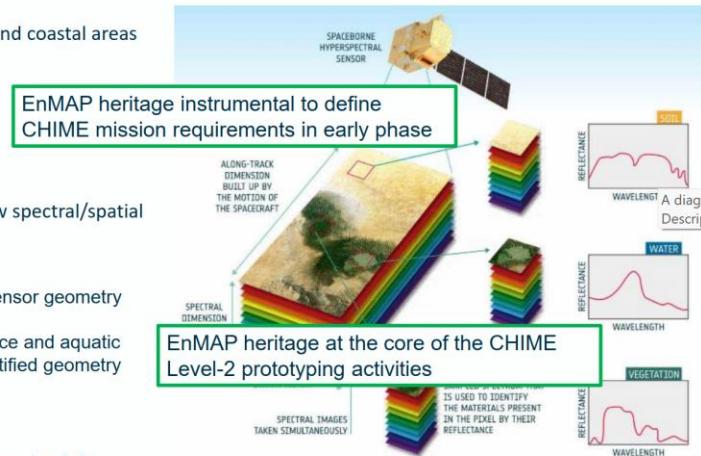
User data products:

- 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

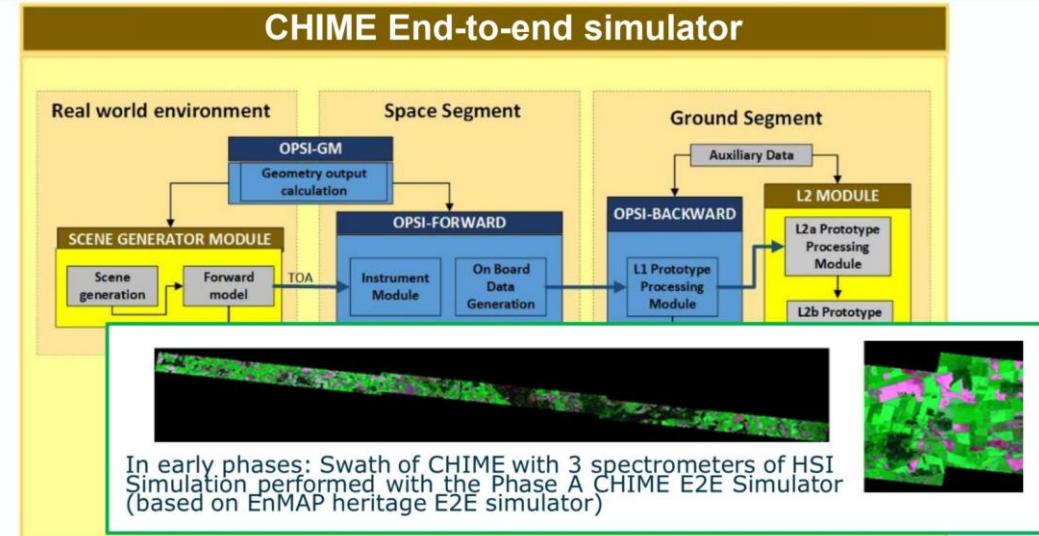
>> with associated uncertainties

Current baseline documentation:

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



CHIME End-to-End Simulator



Slides: Marco Celesti, ESA

International campaign support

ESA Advanced Ocean Training Course 2025

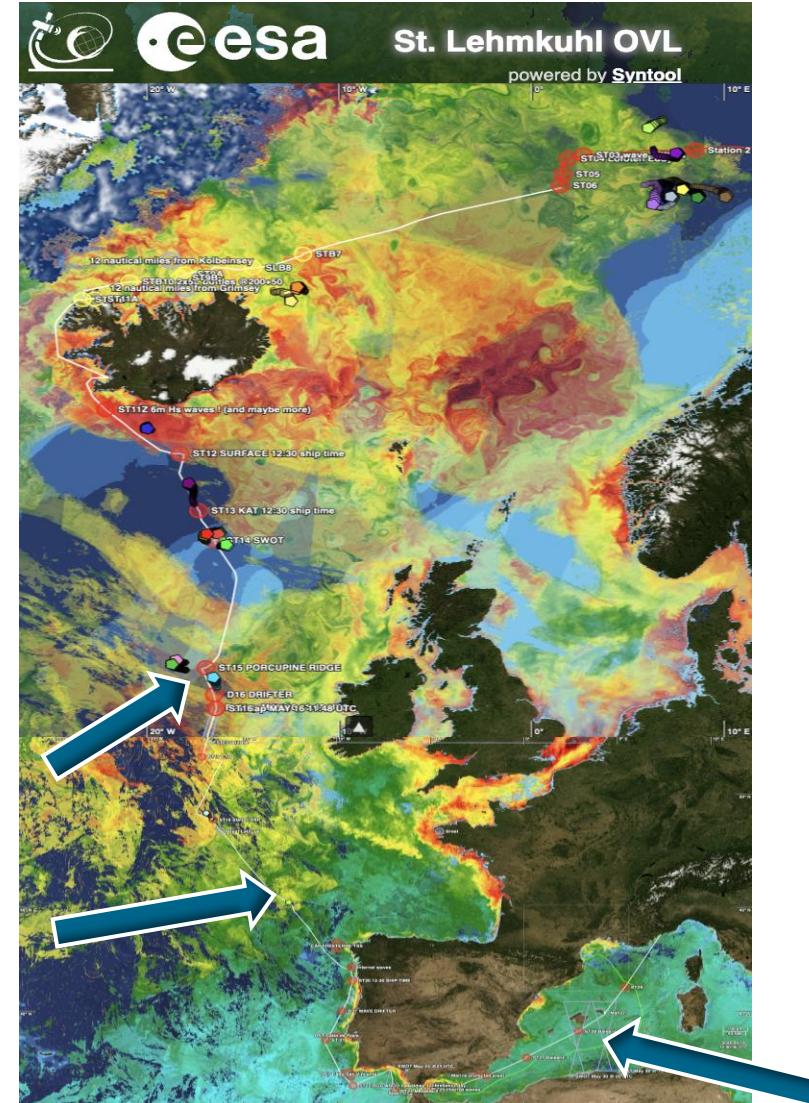
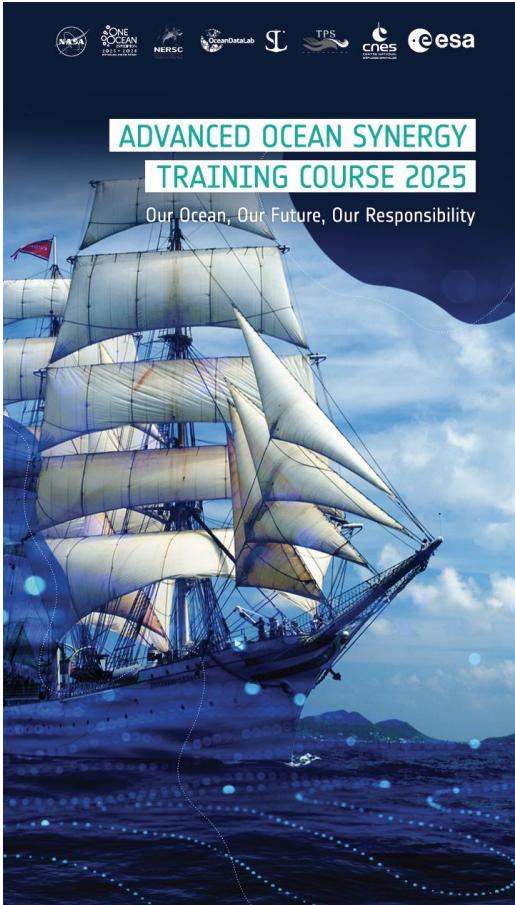
A unique co-located satellite and in situ data set

- 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,

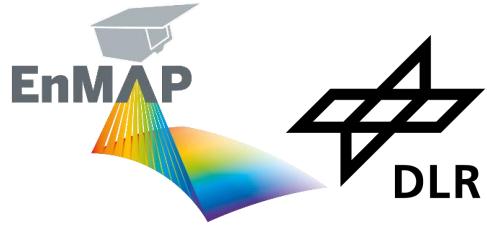
→ EnMAP (16.05., 19.05. and 28.05.2025)

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

Slide courtesy: Craig Donlon and
Vannessa Keuck, ESA

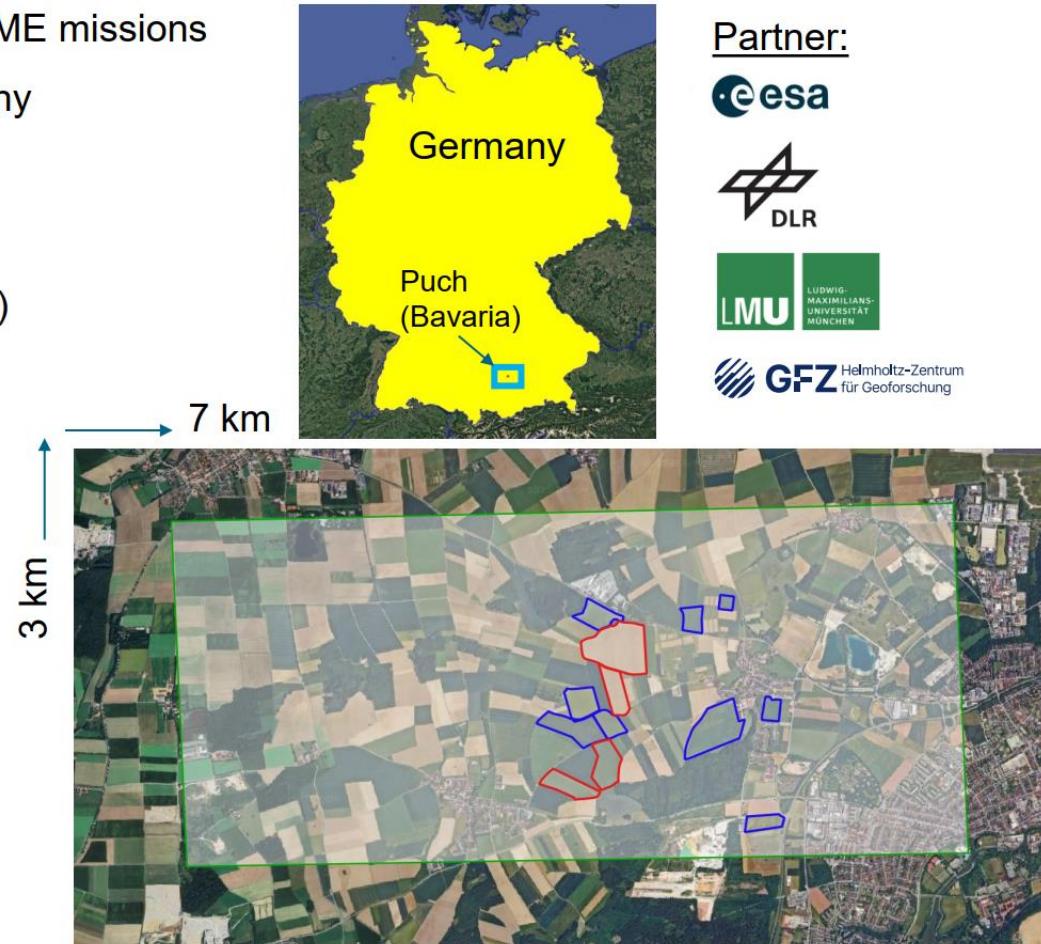


International campaign support



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)

Moon calibrations



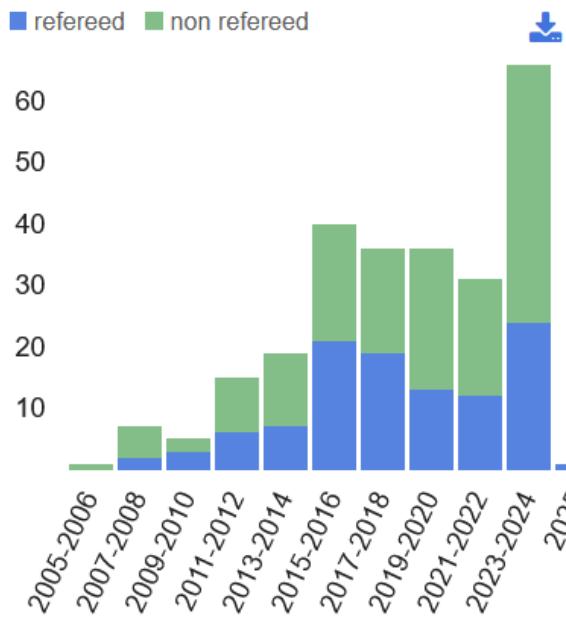
- Moon observations for calibration & cal/val studies
- Along-track scanning strategy
- 10 acquisitions since launch
- 2-monthly acquisitions, close in time to Sun calibrations
- Data not publicly available
- Collaborations with external partners for Moon data exploitation (e.g. CNES)



10.04.2025



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)



nd Field
Spectrometer Measurements on “Sale ‘e Porcus”, a Salty Pond
(Sardinia, Italy)

by Massimo Musacchio 1,* , Malvina Silvestri 1 , Vito Romaniello 1 , Marco Casu 2,3 , Maria Fabrizia Buongiorno 1 and Maria Teresa Melis 2

Detecting methane emissions from palm oil mills with airborne and spaceborne imaging spectrometers
Full mission evaluation of EnMAP reflectance products using three correction processors

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

MARIANA A. SOPPA,¹ MAXIMILIAN BRELL,
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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,*}

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

@EGU24-17168

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

by Ana B. Pascual-Vento^{1,*} , Jose L. Garcia¹ , Katja Berger^{1,2} , José Estévez¹
Jorge Vicent^{1,3} , Adrián Pérez-Suay¹ , Shari Van Wittenbergh¹ and Jochem Verrelst¹

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

by Otto C. A. Gadea and Shuhab D. Khan *

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

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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>