Overview of the EnMAP imaging spectroscopy mission

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on behalf of the EnMAP team

EnMAP Hyperspectral Imager

Scientific Principal Investigator
GFZ Potsdam

EnMAP Science Team

Project Management
DLR Space Administration

Space Segment

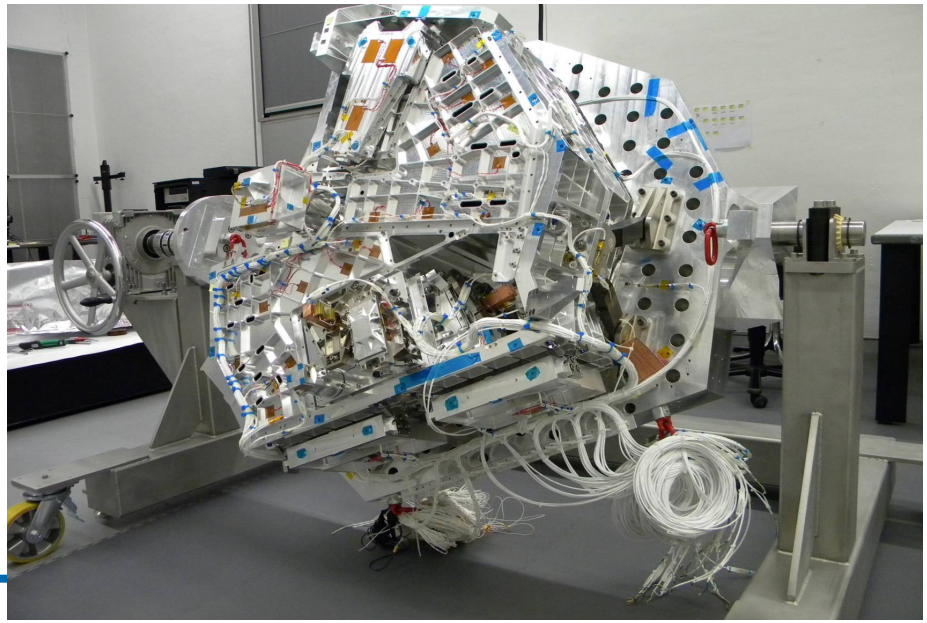
Sensor | Platform

Ground Segment

Operations *DLR-GSOC* | Payload *DLR-DFD* | Processing *DLR-IMF*

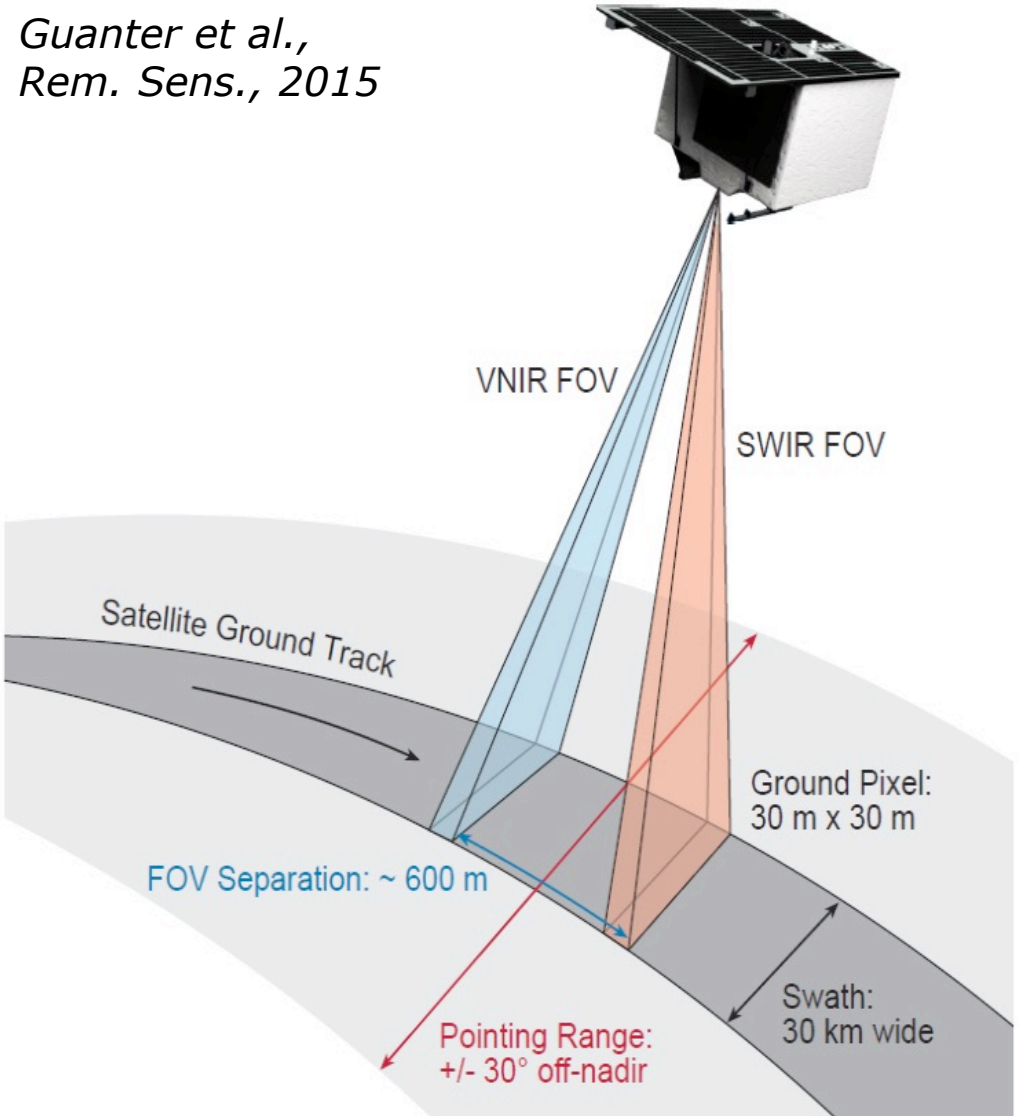
- Core funding from the German Federal Ministry of Economics and Technology
- Currently under construction phase (D)

- EnMAP: Environmental Mapping and Analysis Program
- High performance scientific mission covering up to L2 product
- Open data policy



EnMAP – Main Mission Parameters

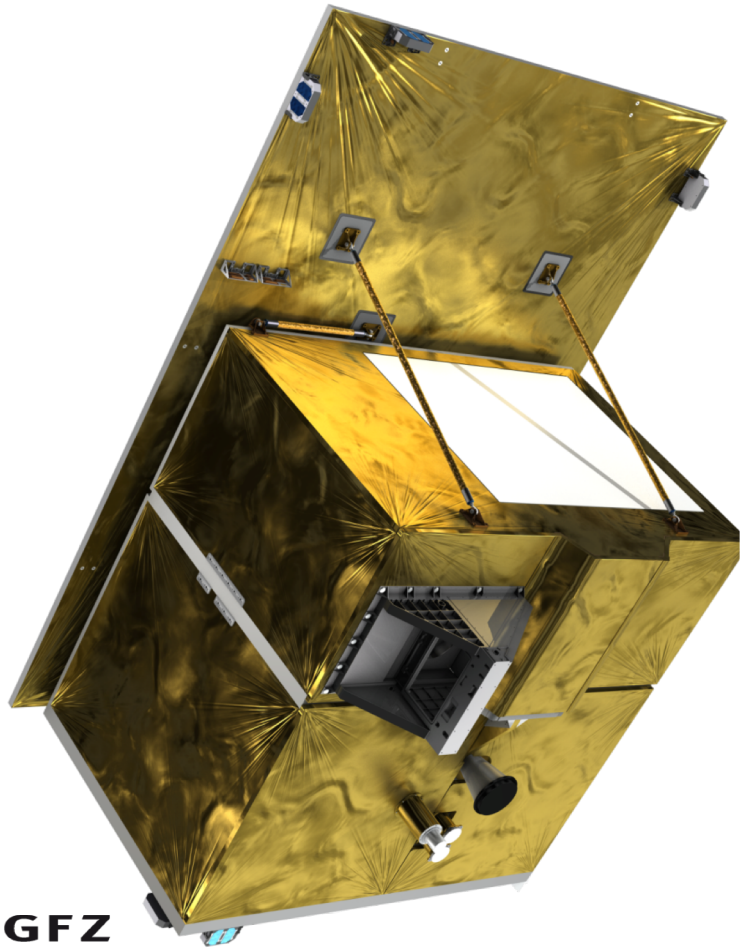
Guanter et al., Rem. Sens., 2015

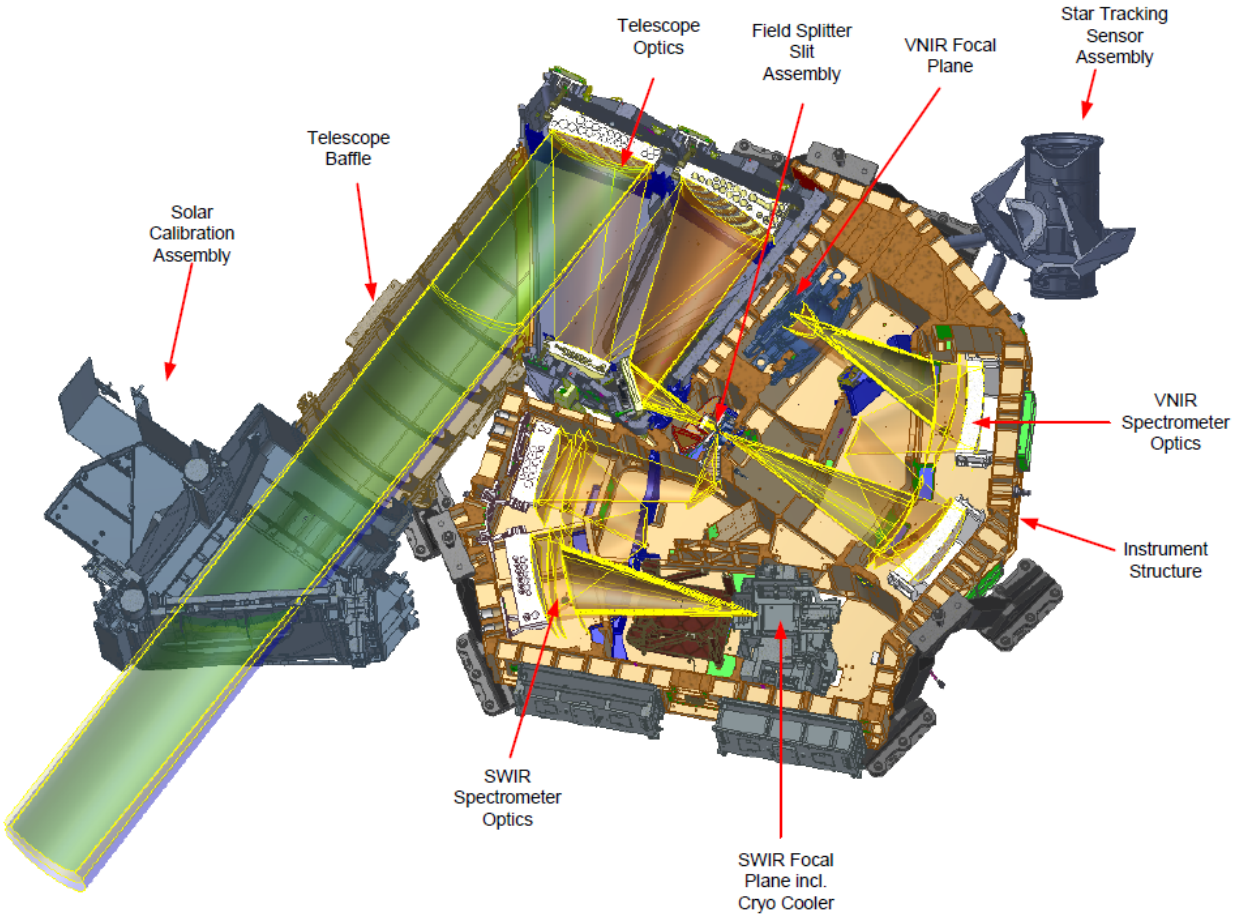


- Sun-synchronous orbit, 11h LTDN
- Push-broom imaging spectrometer
- Spectral range (spectral sampling)
  - VNIR: 420 nm to 1000 nm (~6.5 nm)
  - SWIR: 900 nm to 2450 nm (~10 nm)
- Swath width 30 km
- Ground sampling distance 30 m
- Revisit time
  - 27 d nadir
  - 4 d with 30º across-track pointing
- Mission lifetime ≥ 5 years
- Data acquisition
  - 1000 km/orbit
  - 5000 km/day

EnMAP space segment

- Instrument: Independent VNIR & SWIR spectrometers
- Curved prism design to maximize spectral and spatial uniformity





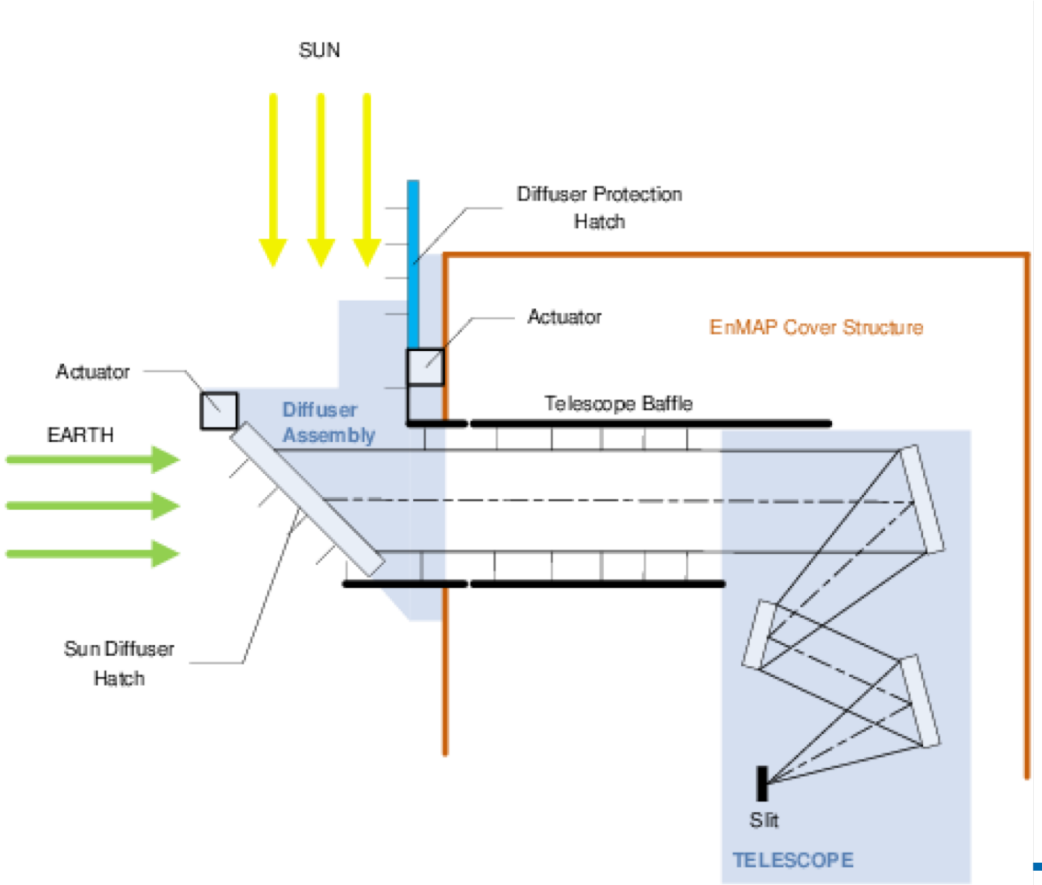
Onboard calibration units

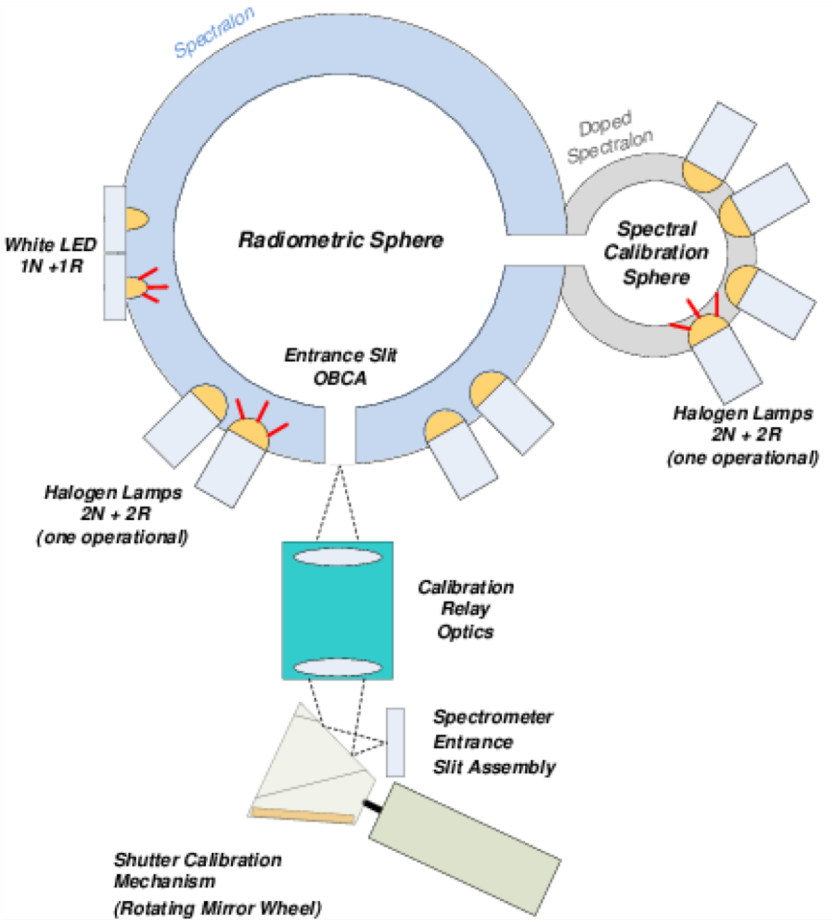
Radiometric sphere + LEDs: detector linearity and pixel mapping

Spectral sphere + doped spectralon: spectral calibration

Sun diffuser: absolute radiometric calibration

Shutter mechanism: dark signal calibration



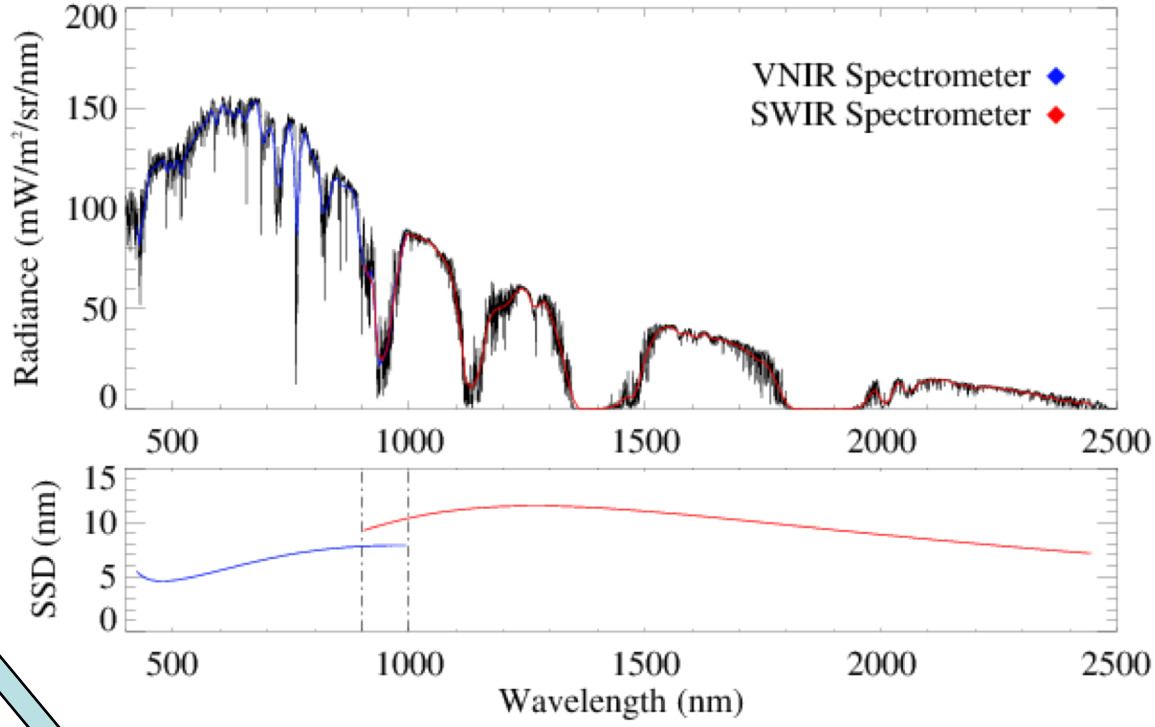


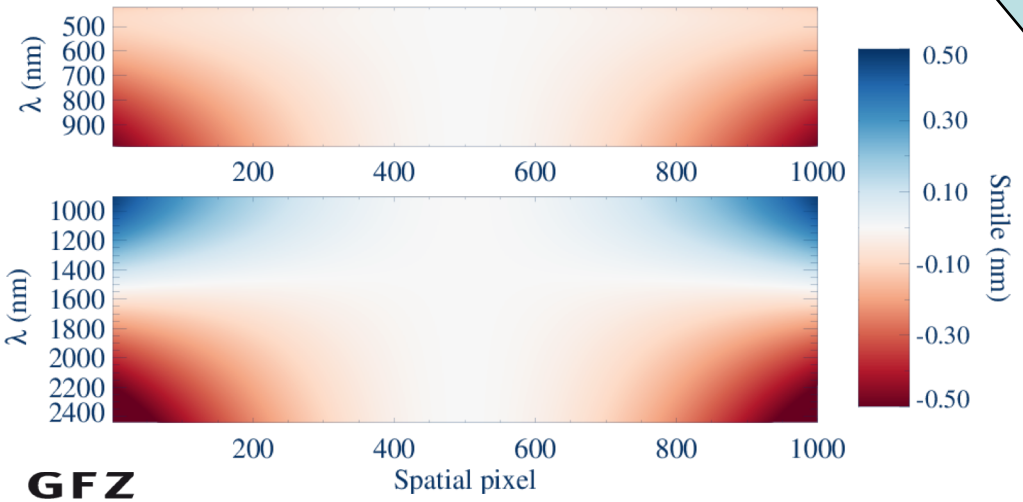
Spectral & radiometric performance

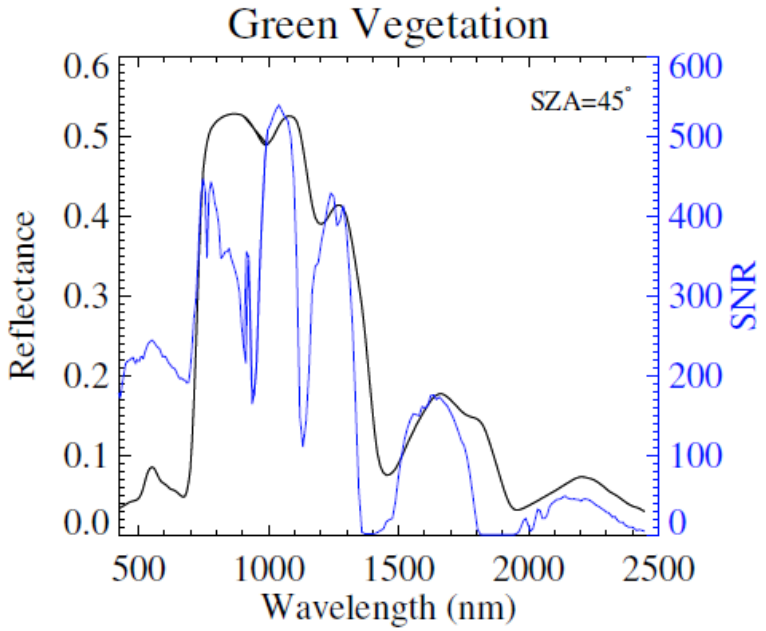
Mean spectral sampling distance (SSD) of 6.5 nm in VNIR and 10 nm in SWIR

Reference SNR of 400:1 in VNIR and 150:1 in SWIR

Uniformity: smile and keystone <5% pixel

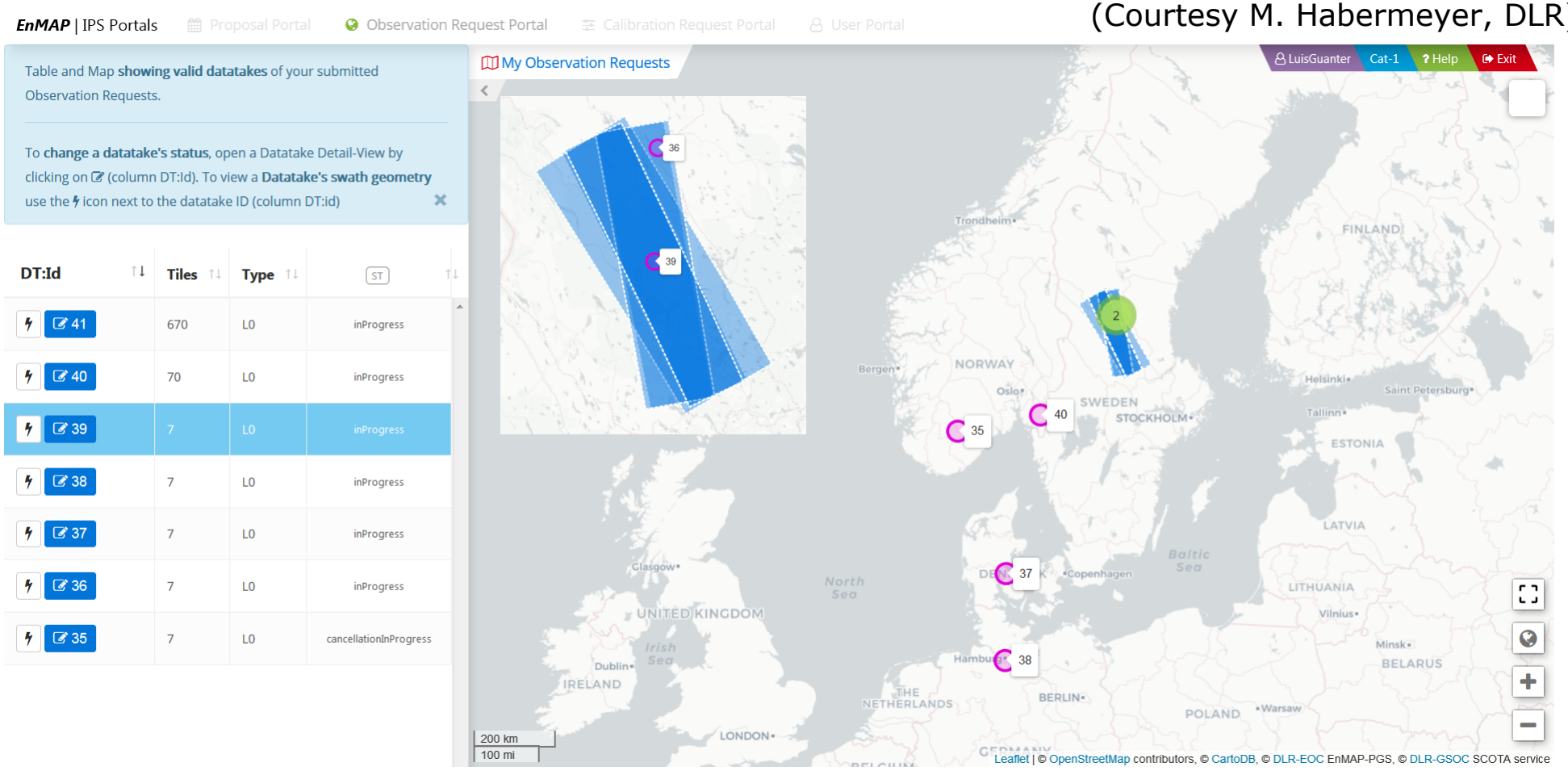






Data acquisition

(Courtesy M. Habermeyer, DLR)

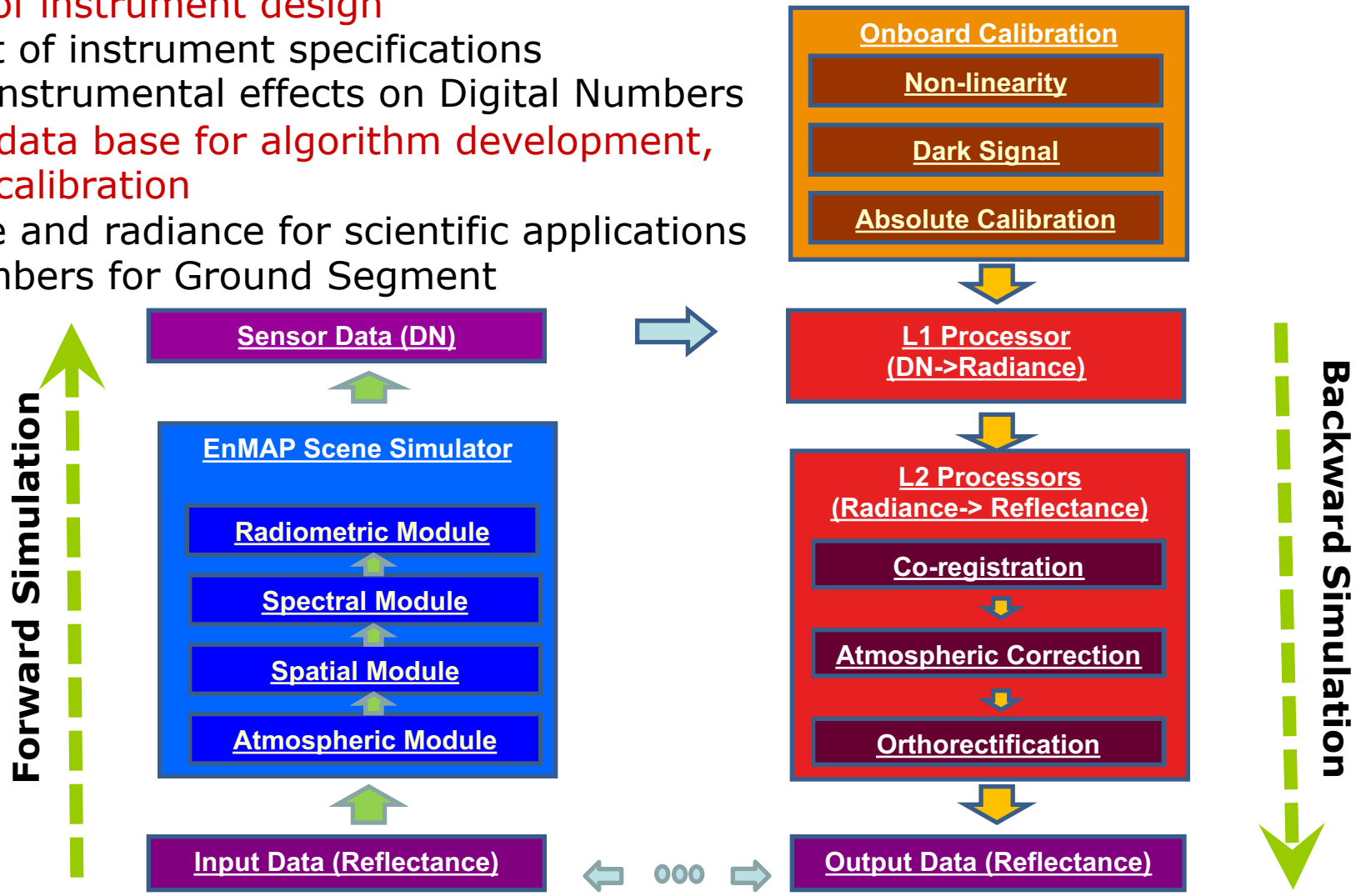


- Daily acquisition plan driven by user requests and cloud forecast
- Restricted to 1000 km/orbit and 5000 km/day

EnMAP end-to-end scene simulations

Objectives:

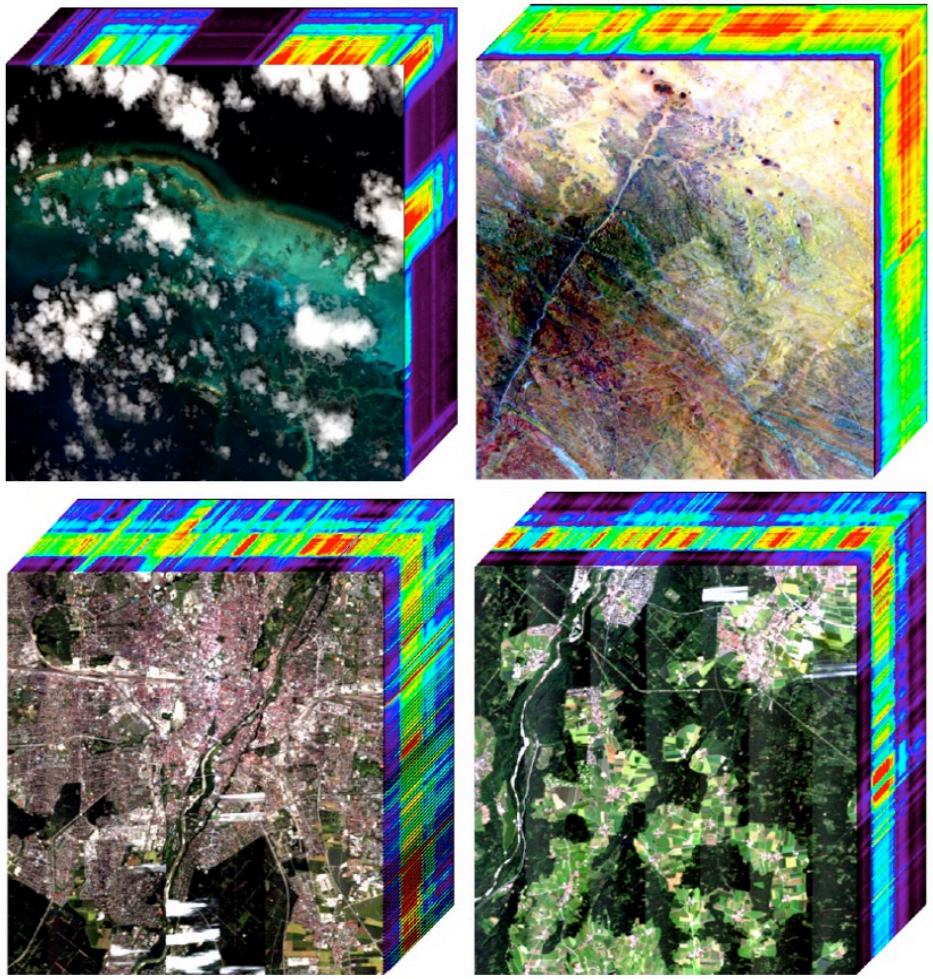
1) Optimization of instrument design
   - Refinement of instrument specifications
   - Impact of instrumental effects on Digital Numbers
2) Generating a data base for algorithm development, validation and calibration
   - Reflectance and radiance for scientific applications
   - Digital Numbers for Ground Segment



Segl et al., IEEE JSTARS, 2012

EnMAP end-to-end scene simulations

Simulation of EnMAP-like L1b and L2 products for development and testing of data pre-processing and scientific product retrieval algorithms



Many (>100) simulated EnMAP data sets already available

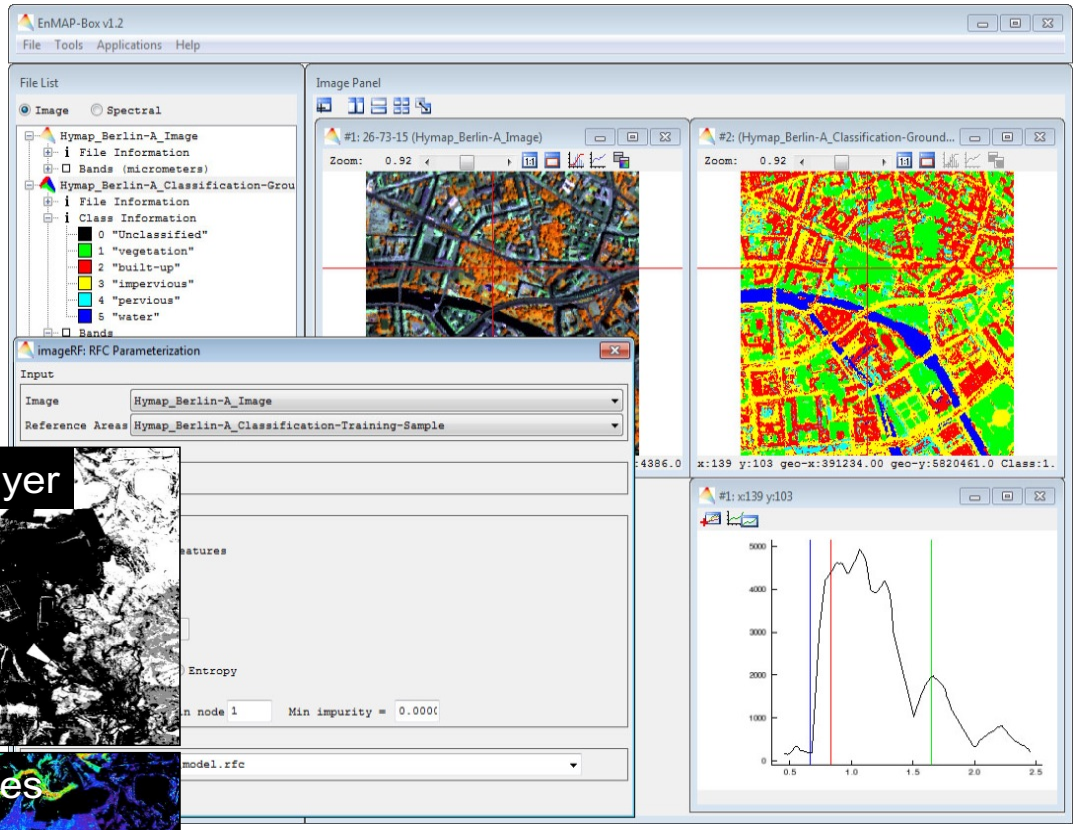
Contact Karl Segl at GFZ if you need simulations for your study site!

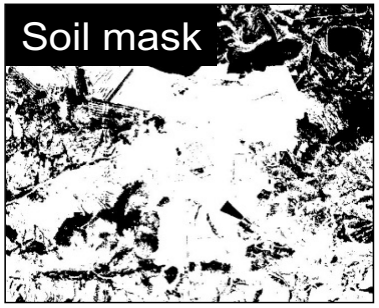
EnMAP-Box

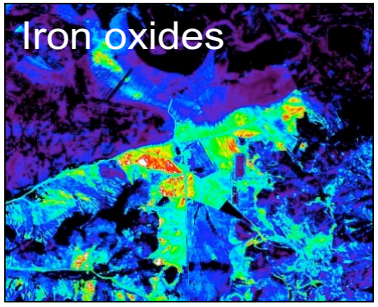
Rabe, van der Linden et al. (HU Berlin)

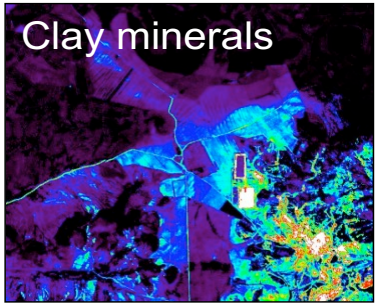
Focus on the development of algorithms for the **EnMAP-Box:**

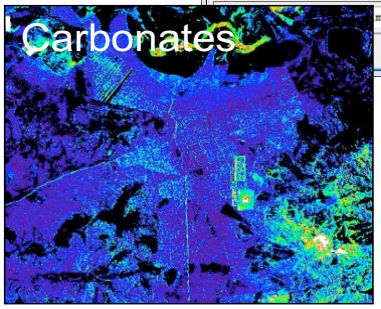
- Open software for the scientific exploitation of EnMAP data
- Extends ground segment beyond L2











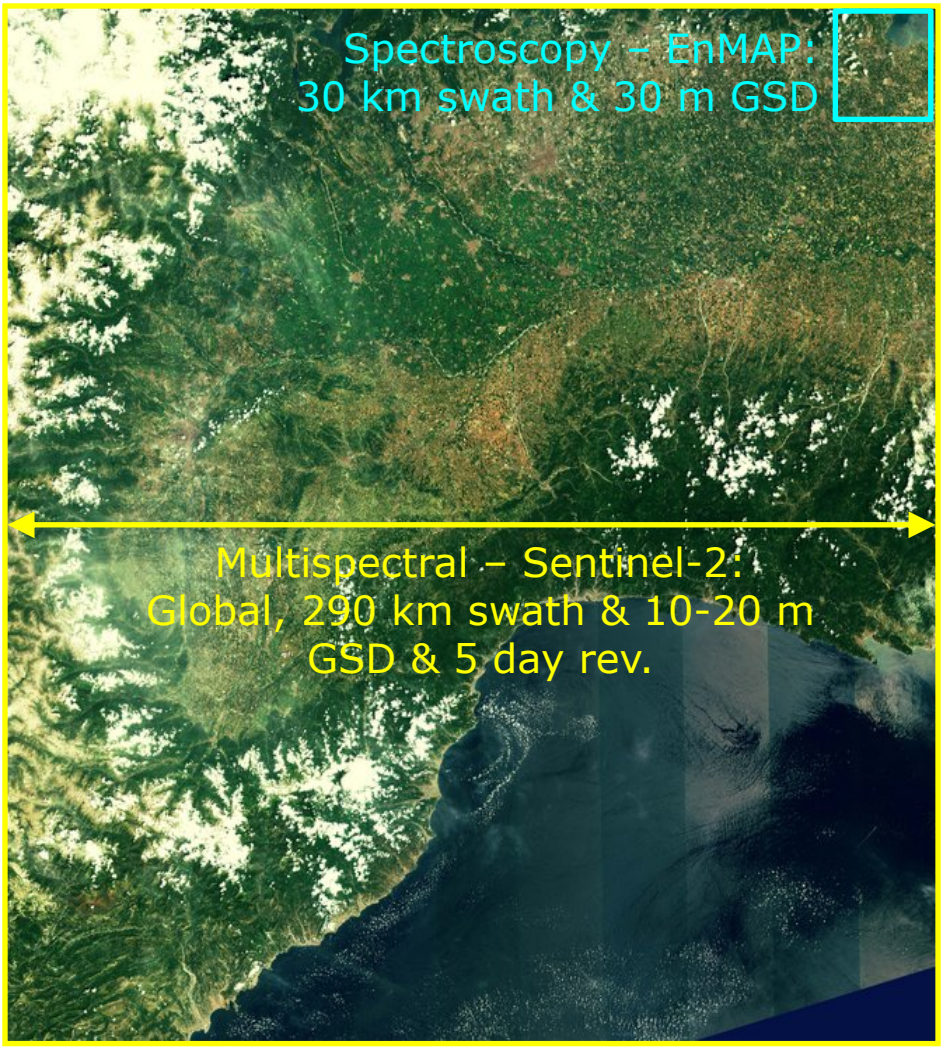
Download from
www.enmap.org/?q=enmapbox

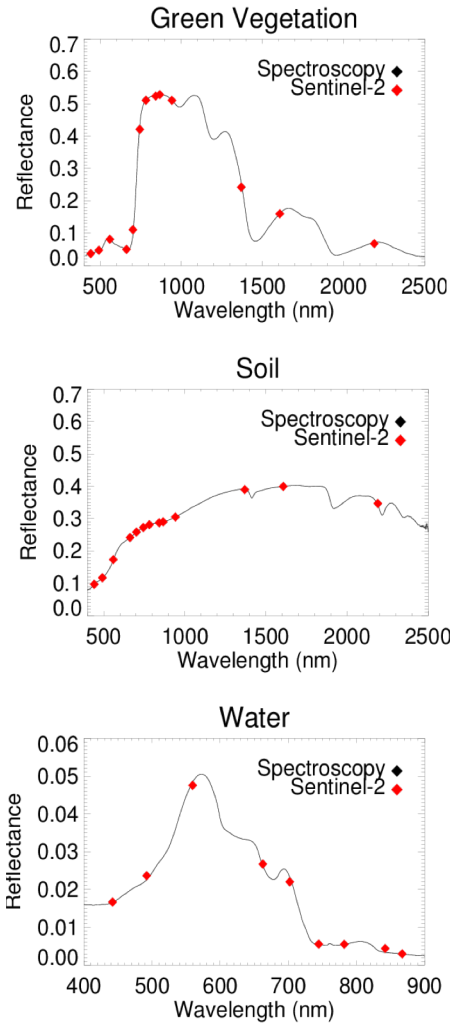
Chabrillat et al.: EnSoMAP processor for digital soil mapping with EnMAP

Synergies EnMAP & optical multispectral missions

Sentinel-2 & EnMAP, potential synergies**:**

1. Downscaling of EnMAP data to 10 m with sharpening techniques
2. Exploitation of spectroscopic information for improved spatio-temporal monitoring with S-2





Guanter et al., Synergies of Spaceborne Imaging Spectroscopy with other Remote Sensing Techniques, Surv. Geophysics (2018)

EnMAP-flight campaigns

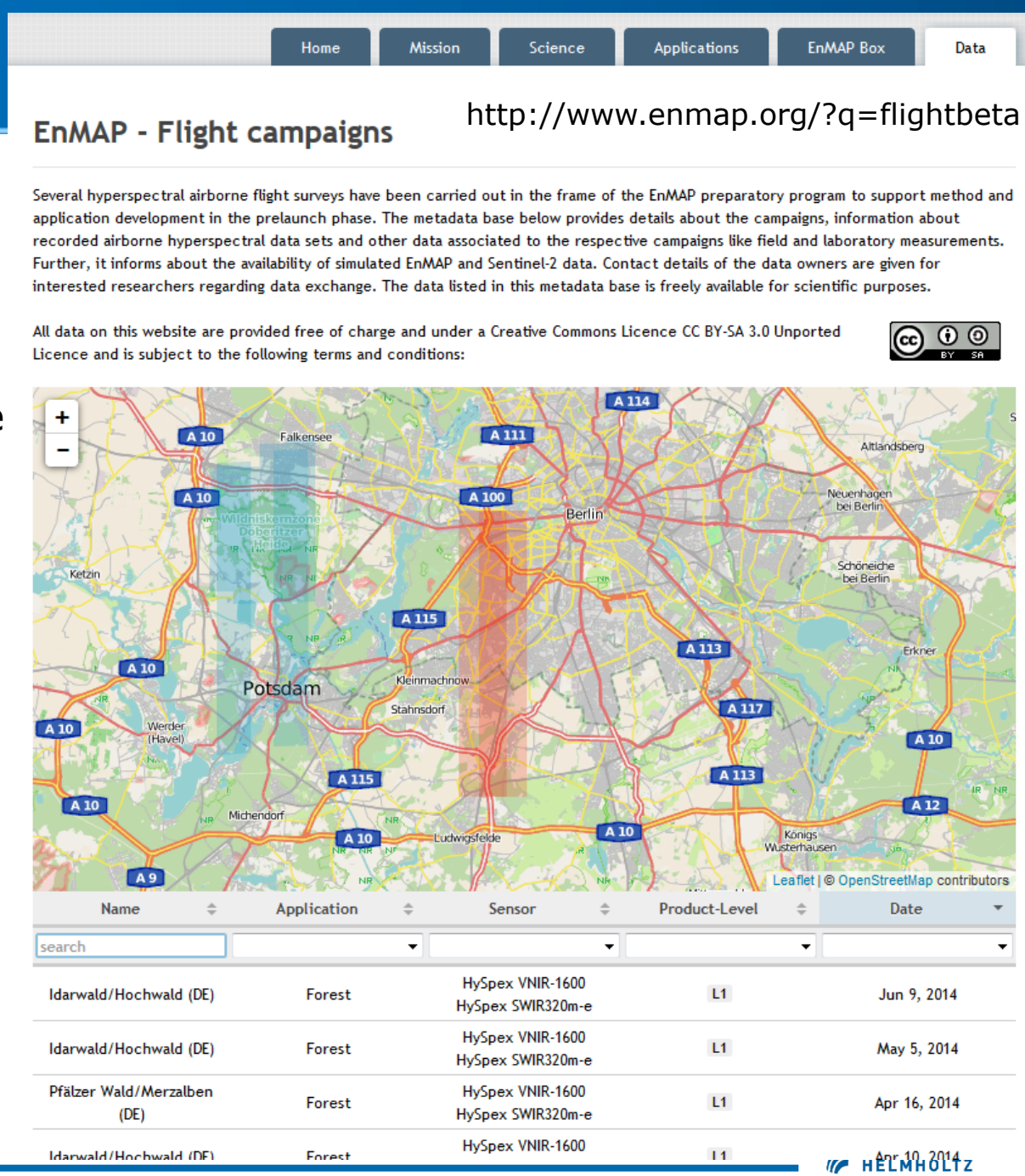
Airborne hyperspectral images and associated in-situ data

provided free of charge to science community under CC BY-SA Licence

Search **metadata portal** at www.enmap.org → data

Datasets published as **data publications** (with DOI)

Technical Report will be provided with each dataset (documentation of data acquisition, processing, quality etc.)



Support to young researchers

PhD Programme: many PhD projects dealing with imaging spectroscopy in Germany

YoungEnMAP: international summer schools and workshops held every year

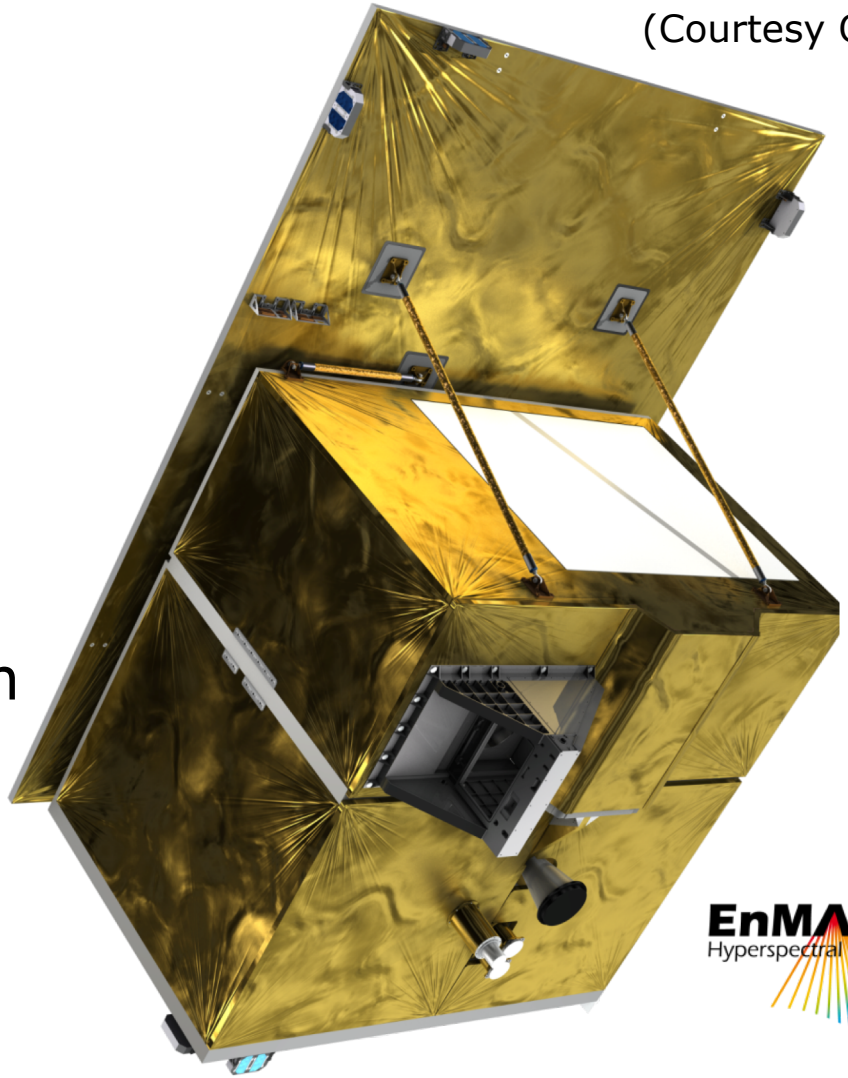
Upcoming: **EnMAP Box workshop** organised by HU Berlin in Feb-Mar 2019

EnMAP Workshop 2017 (Munich, September 2017)

EnMAP Mission status

- Platform and instrument are being integrated at OHB
- After solving a major design problem, the manufacturing of the flight model SWIR cameras has started
- Ground segment in implementation phase at DLR
- Launch: end 2020 → bridge between Hyperion and SBG (and CHIME?)

(Courtesy OHB)



EnMAP Hyperspectral Imager

Thank you for your attention!

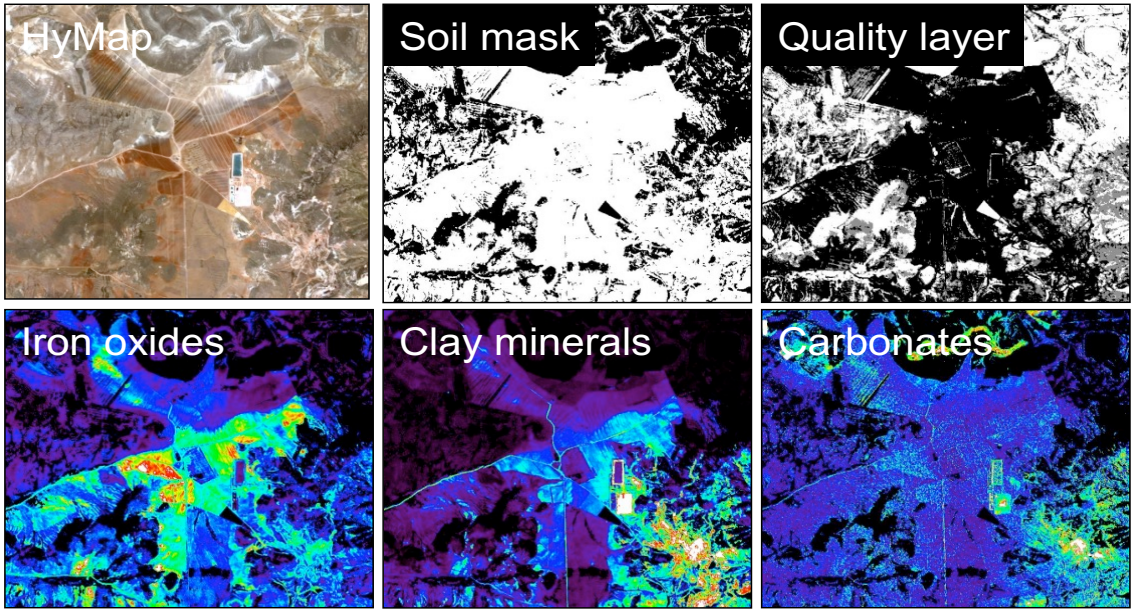
GFZ Helmholtz Centre Potsdam

DLR

Federal Ministry of Economics and Technology

EnMAP at GFZ: developments for geology & soil mapping

EnGeoMAP and EnSoMAP processors for mineral and soil mapping to be implemented in the EnMAP-Box software



Chabrillat et al.: EnSoMAP processor for digital soil mapping with EnMAP

Preprocessing Module

Input: Data Cube Reference Library Color Table

Resampling Library to Target Sensor

Geometric Hull Continuum Removal

Automatic Absorption Feature Extraction

Spectral Module

Sensor or User Specific SNR Thresholding
Weighted Fitting Between Reference Library and Image Spectrum

Spectral Unmixing Using Bound Value Least Squares Unmixing Per Pixel With Detected Spectral Endmembers

Spatial Module

Creation of Best Fit Material Map Using User Defined Color Scheme

Calculation of Spatio-Spectral Gradients and Corresponding Hyperspectral Edges

Mineral Exploration Module

Automated Detection of Mineral Exploration Anomalies (e.g. Gossans, Alteration Zones)

Output

Material Map, Spatio-Spectral Gradients and Hyperspectral Edges
Mineral Exploration Anomaly Map

Mielke et al.: EnGeoMAP processor for geological mapping with EnMAP

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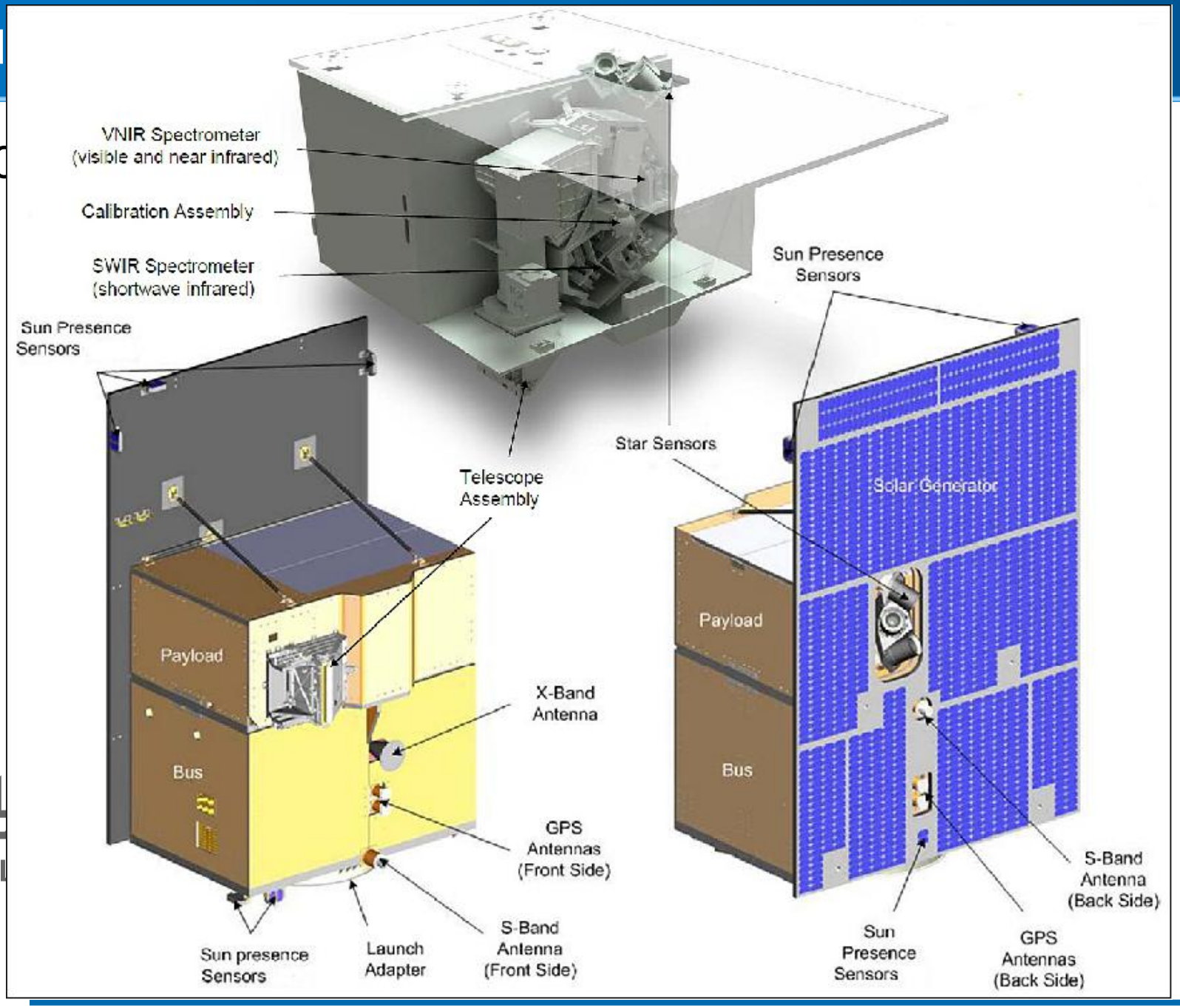
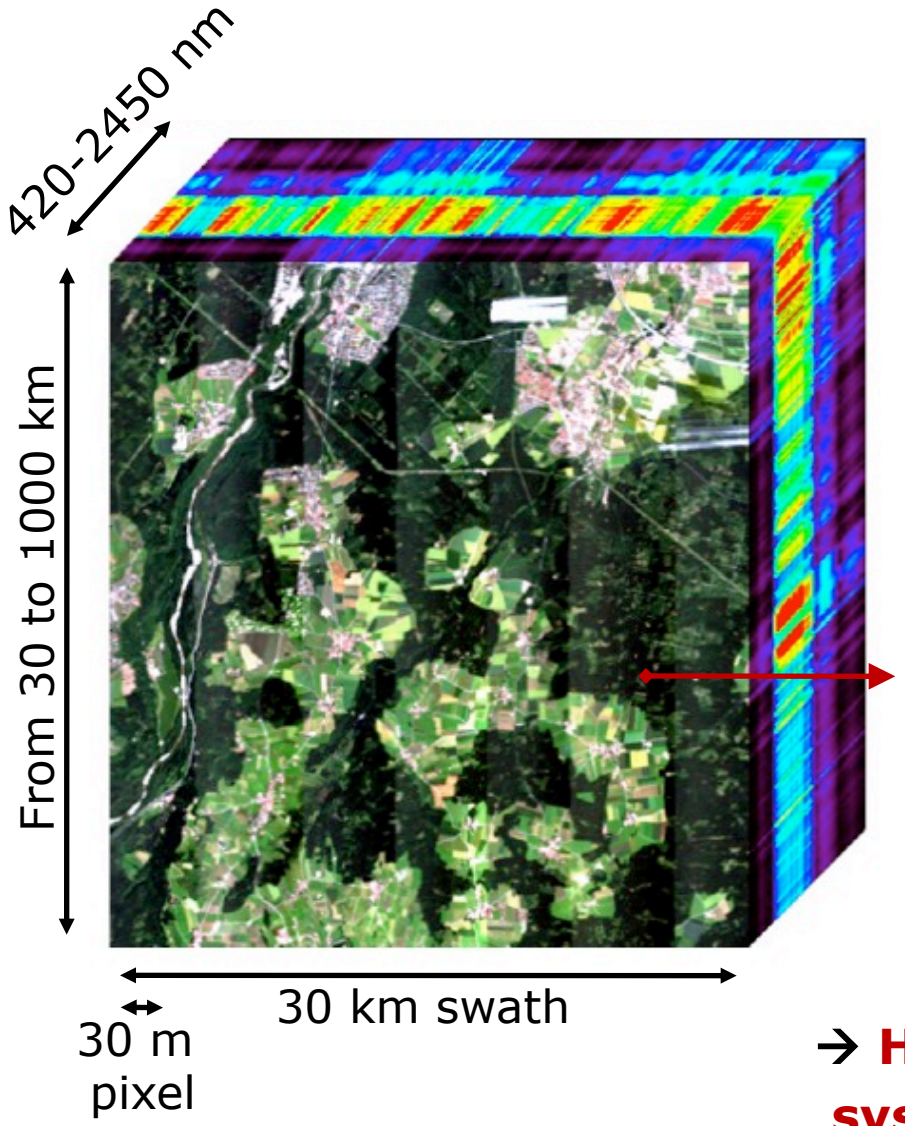
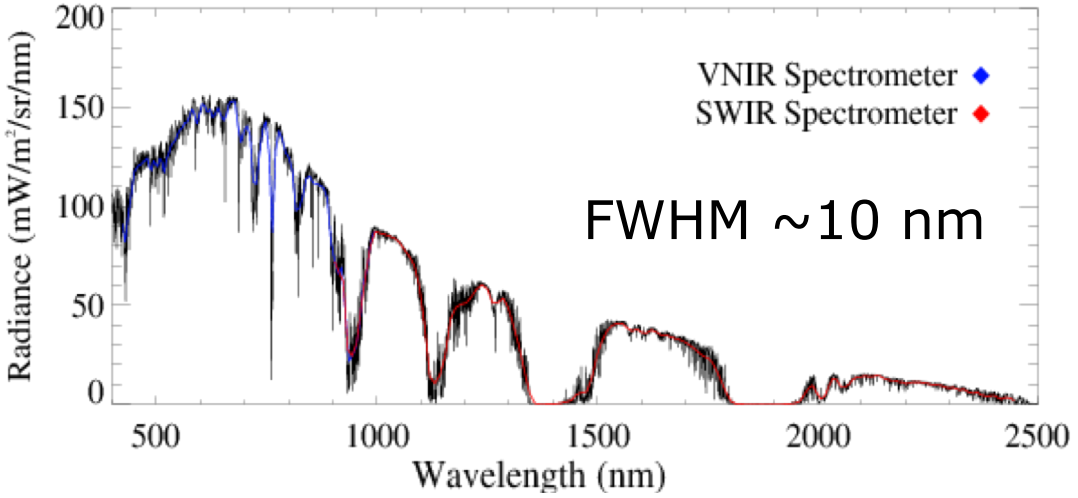

VNIR Spectrometer
(visible and near infrared)
Calibration Assembly
SWIR Spectrometer
(shortwave infrared)
Sun Presence
Sensors
Sun Presence
Sensors
Star Sensors
Telescope
Assembly
Solar Generator
Payload
Payload
Bus
Bus
X-Band
Antenna
GPS
Antennas
(Front Side)
S-Band
Antenna
(Front Side)
Sun presence
Sensors
Launch
Adapter
Sun
Presence
Sensors
GPS
Antennas
(Back Side)
S-Band
Antenna
(Back Side)

Key mission characteristics for scientific use of EnMAP



- Up to 4 days revisit time with tilted obs.
- Ground segment distributing geometrically-corrected reflectance data
- Co-existence with Sentinel-2 & Landsat-8
- Open data policy for scientific use



→ **High-performance imaging spectroscopy system for Earth observation**