



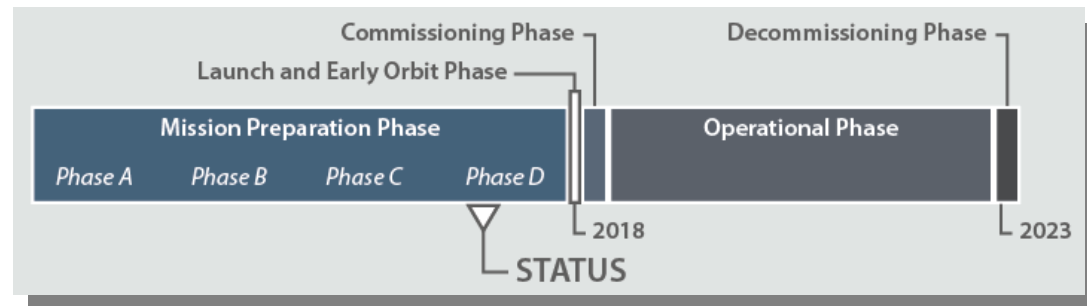
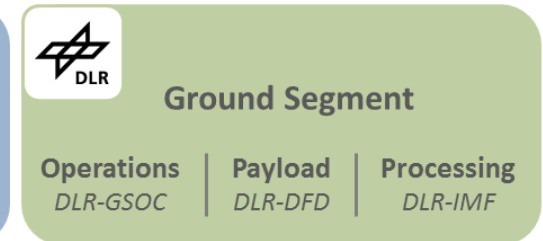
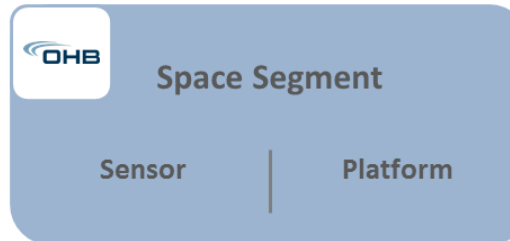
Overview of the EnMAP Imaging Spectroscopy Mission

L. Guanter, H. Kaufmann, K. Segl, S.
Foerster, A. Hollstein, T. Storch, A. Mueller,
U. Heiden, M. Bachmann, G. Rossner, C.
Chlebek, S. Fischer, B. Sang,

the EnMAP Science Advisory Group,
and many others...

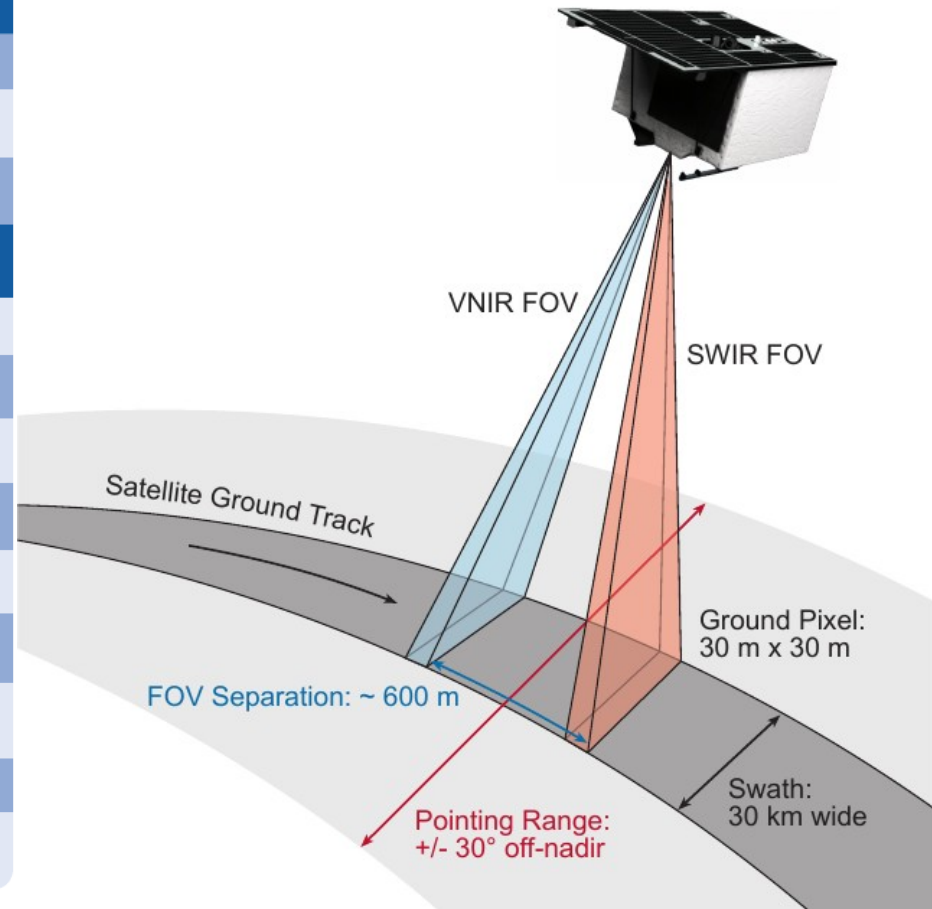


- EnMAP: Environmental Mapping and Analysis Program → www.enmap.org
- German operational imaging spectroscopy mission for Earth Observation
- Focus on good data quality & higher level products
- **Open data policy**
 - **Level1B/C: at sensor radiance**
 - **Level2A: surface reflectance**
- **Launch ~ mid 2018**
- Special Issue "The Environmental Mapping and Analysis Program (EnMAP) Mission: Preparing for Its Scientific Exploitation" in Remote Sensing (ISSN 2072-4292).



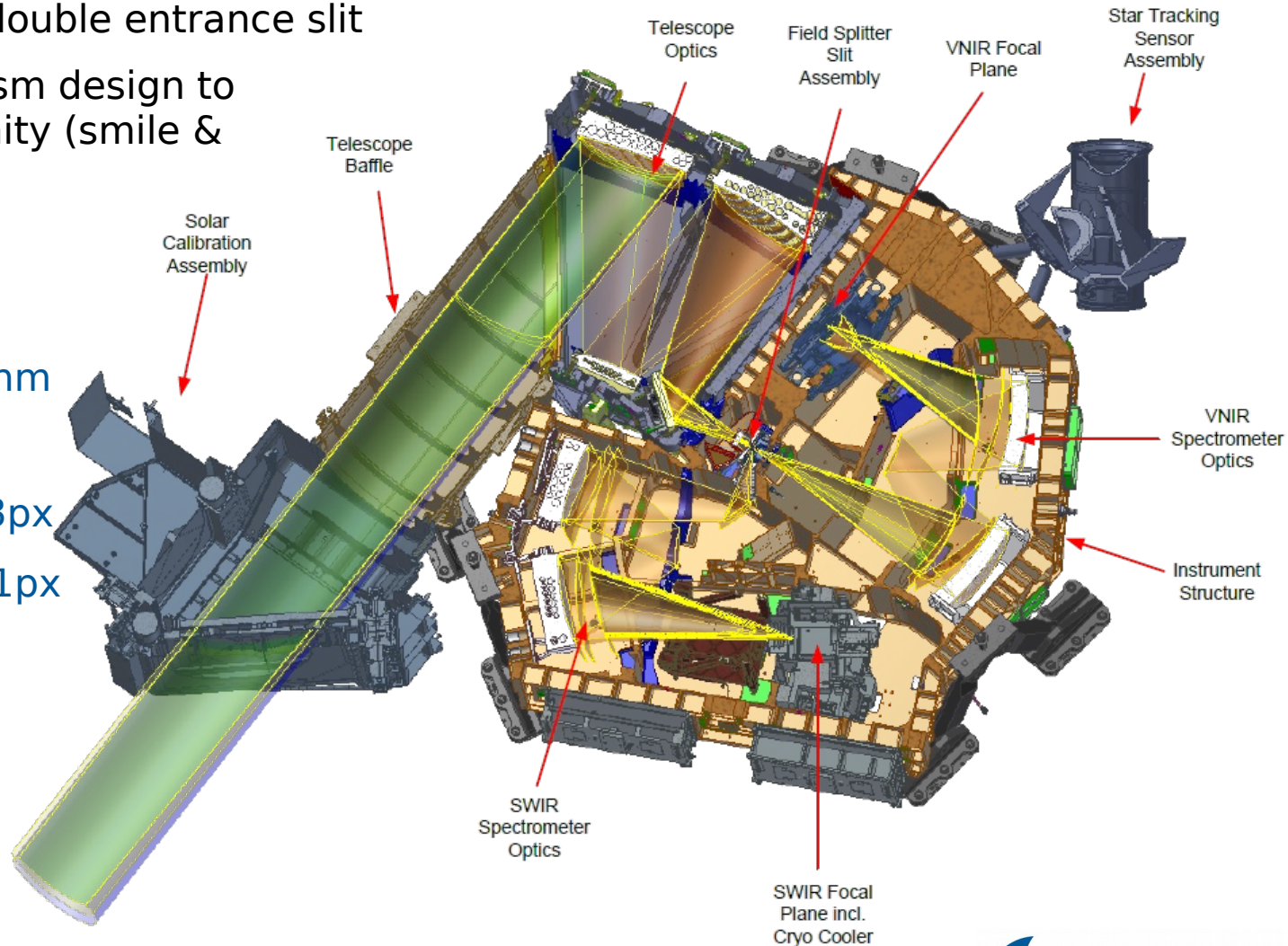
The Environmental Mapping and Analysis Program (EnMAP) – Key Facts

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	SWIR	
Spectral range	420 - 1000 nm	900 - 2450 nm	
Number of bands	89	155	
Spectral sampling interval	6.5 nm	10 nm	
Spectral bandwidth (FWHM)	8.1 ± 1.0 nm	12.5 ± 1.5 nm	
Signal-to-noise ratio (SNR)	> 400:1	> 150:1	
Spectral calibration accuracy	0.5 nm	1 nm	
Ground sampling distance	30 m (at nadir; sea level)		
Swath width	30 km (field-of-view = 2.63° across track)		
Swath length	1000 km/orbit - 5000 km/day		



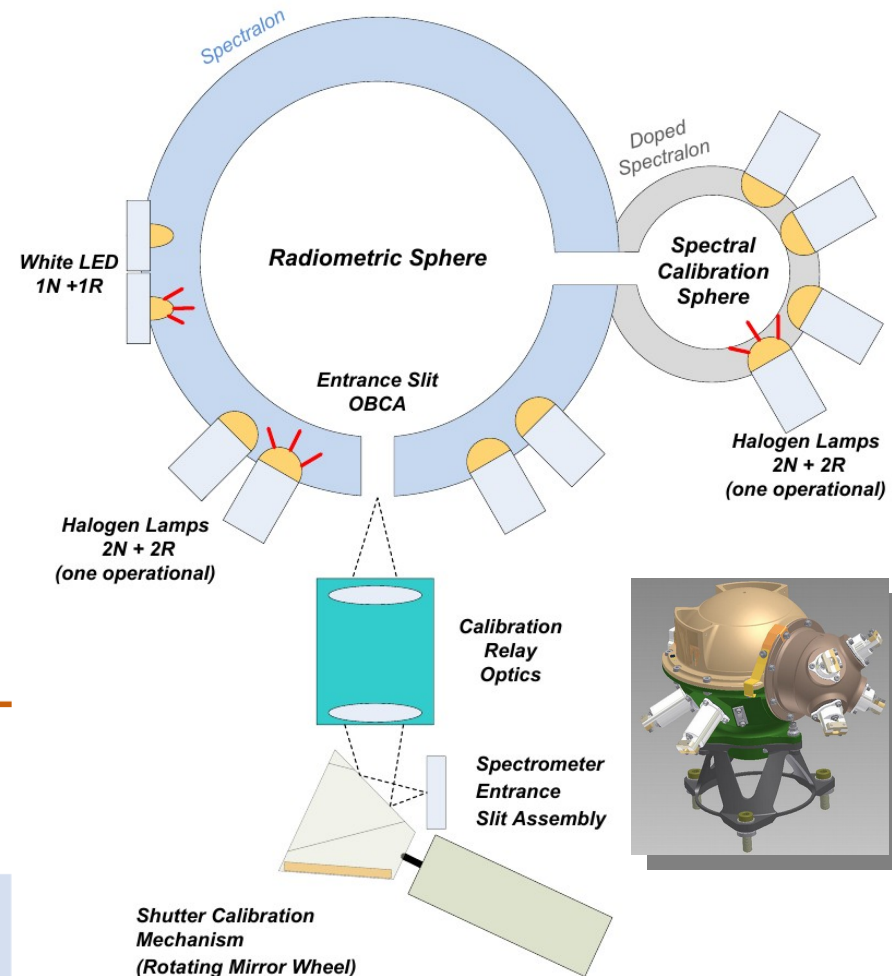
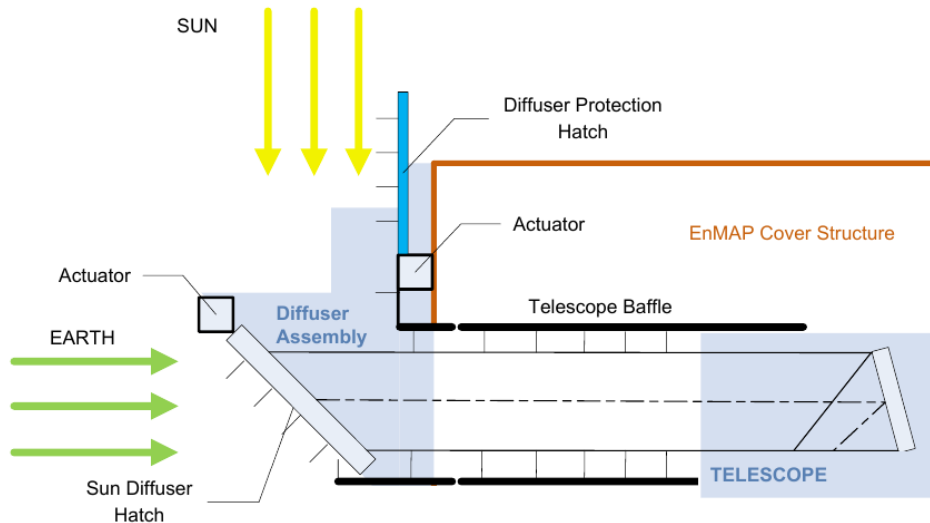
Dual-Spectrometer Instrument Concept

- Independent VNIR and SWIR sensors: field splitter and double entrance slit
- Curved Offner prism design to maximize uniformity (smile & keystone <5%)
- Spectral smile
 - VNIR < 0.5 nm
 - SWIR < +/- 0.5 nm
- Keystone
 - VNIR < +/- 0.03 px
 - SWIR < +/- 0.01 px



On Board Spectral and Radiometric Calibration

- Dark values calibration: using recordings while looking at the closed shutter or into deep space
- Absolute Calibration: Solar calibration using full aperture diffuser assembly, also used for response non-uniformity calibration
- Relative radiometric calibration: monitoring of temporal changes using the large integrating sphere
- Spectral calibration: small integrating sphere with doped Spectralon and dedicated lamps for spectral calibration
- Response non-linearity: focal plane assembly LED's



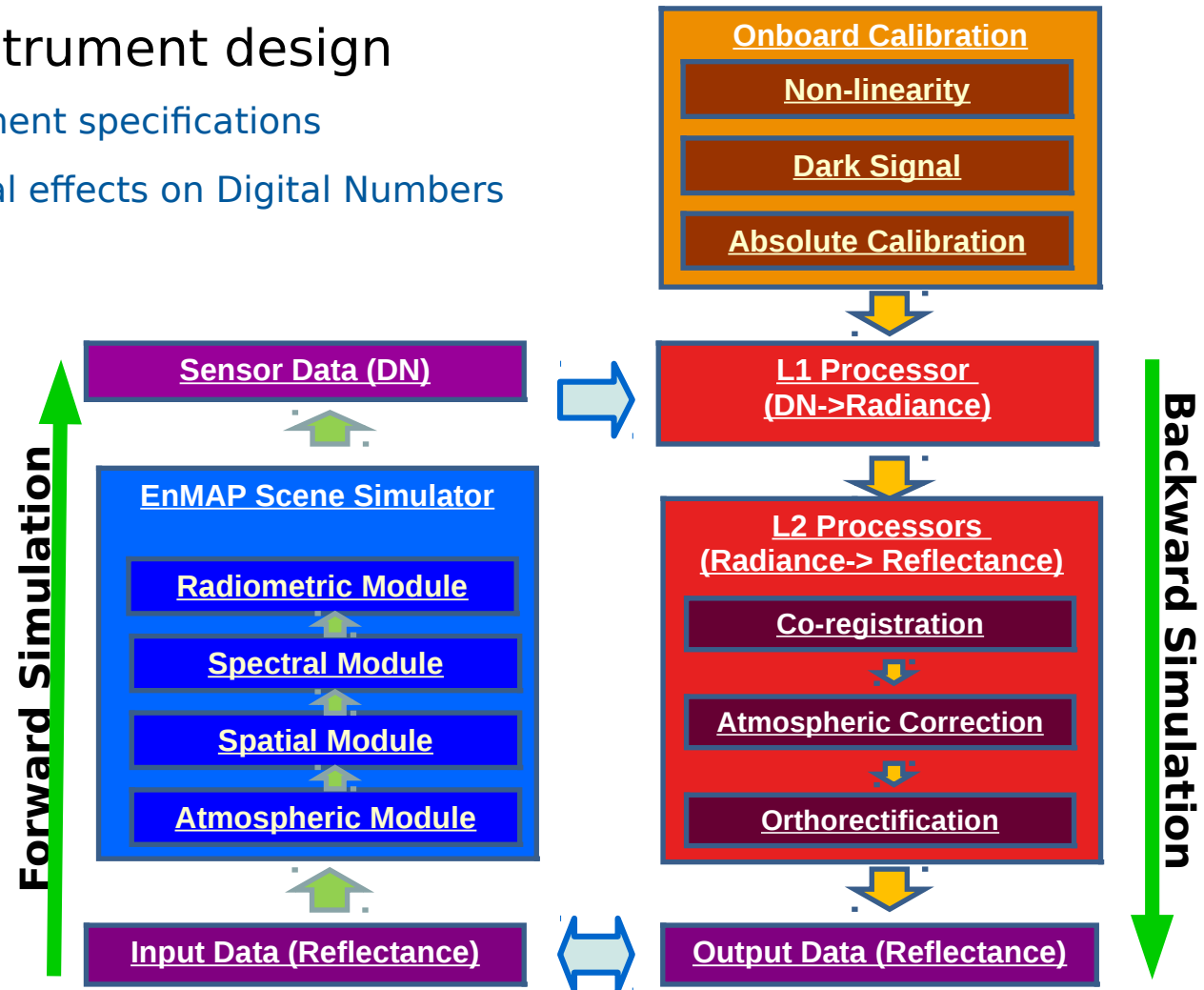
EnMAP Science Plan: <http://www.enmap.org/>

- Content:
 - General mission framework
 - EnMAP perspectives and impact
 - Scientific exploitation strategy
- Current focus of EnMAP Science Advisory Group:
 - Agriculture
 - Forest
 - Ecosystems
 - Soils & Geology
 - Coastal and inland water
 - Urban



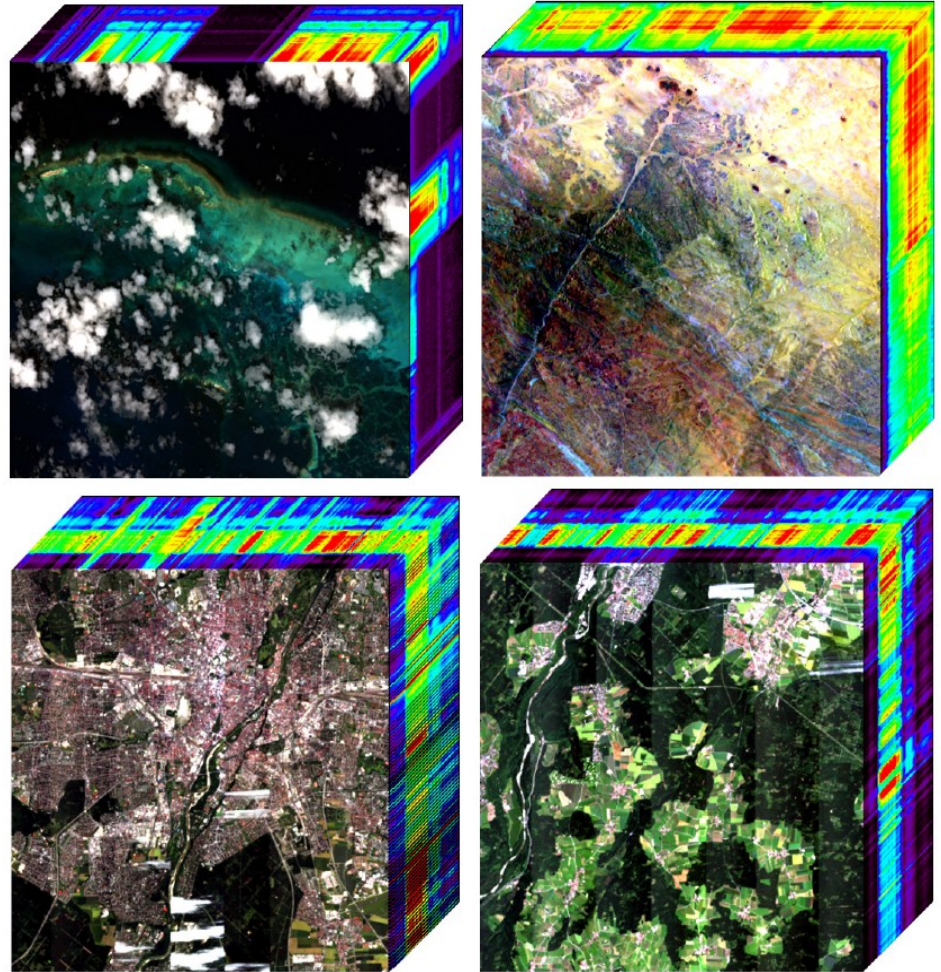
EnMAP End-To-End Scene Simulations

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



EnMAP End-To-End Scene Simulations

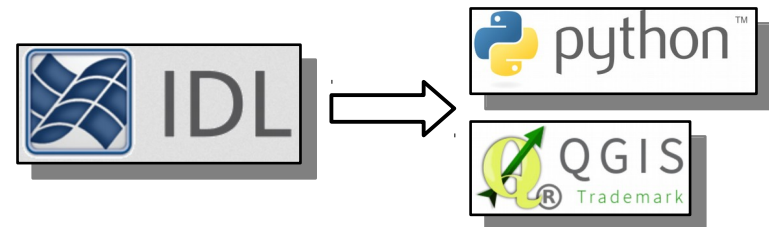
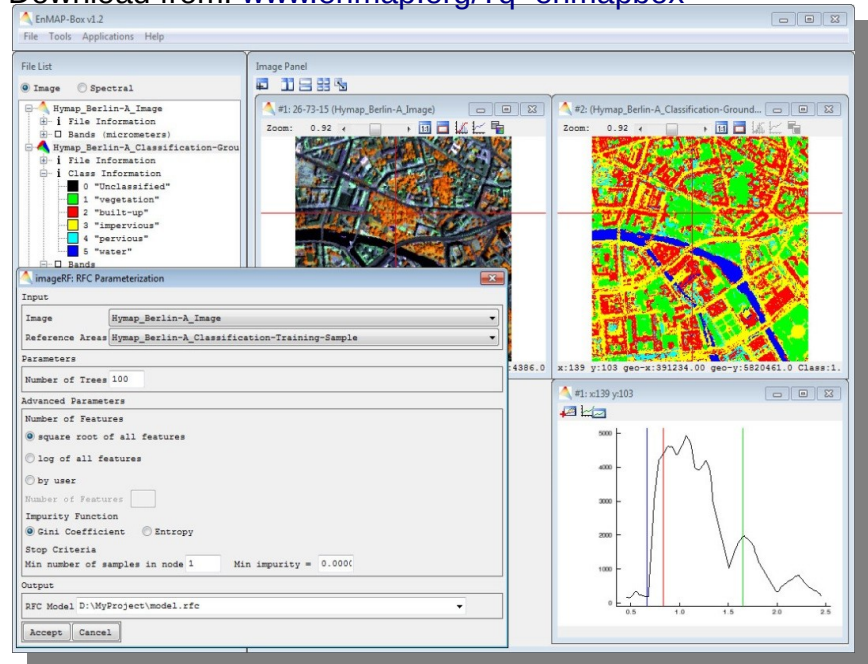
- Simulation of:
 - Level-1C: EnMAP-like top of atmosphere radiance images
 - Level-2A: surface reflectance after atmospheric correction
- Many (>100) simulated EnMAP data sets already available
- Contact Karl Segl at GFZ if you need simulations for your study site! (have surface reflectance maps with high spatial resolution ready)



EnMAP-BOX

- Software for the scientific exploitation of EnMAP data
- Now, based on IDL virtual machine, but undergoing work will change this to Python/QGIS before launch
- Open source software
- Includes algorithms for various applications being developed by EnSAG partners
- Among others, GFZ will provide:
 - Cloud and Cirrus detection
 - Independent Atmospheric Correction
 - Image- fusion with Sentinel-2
 -

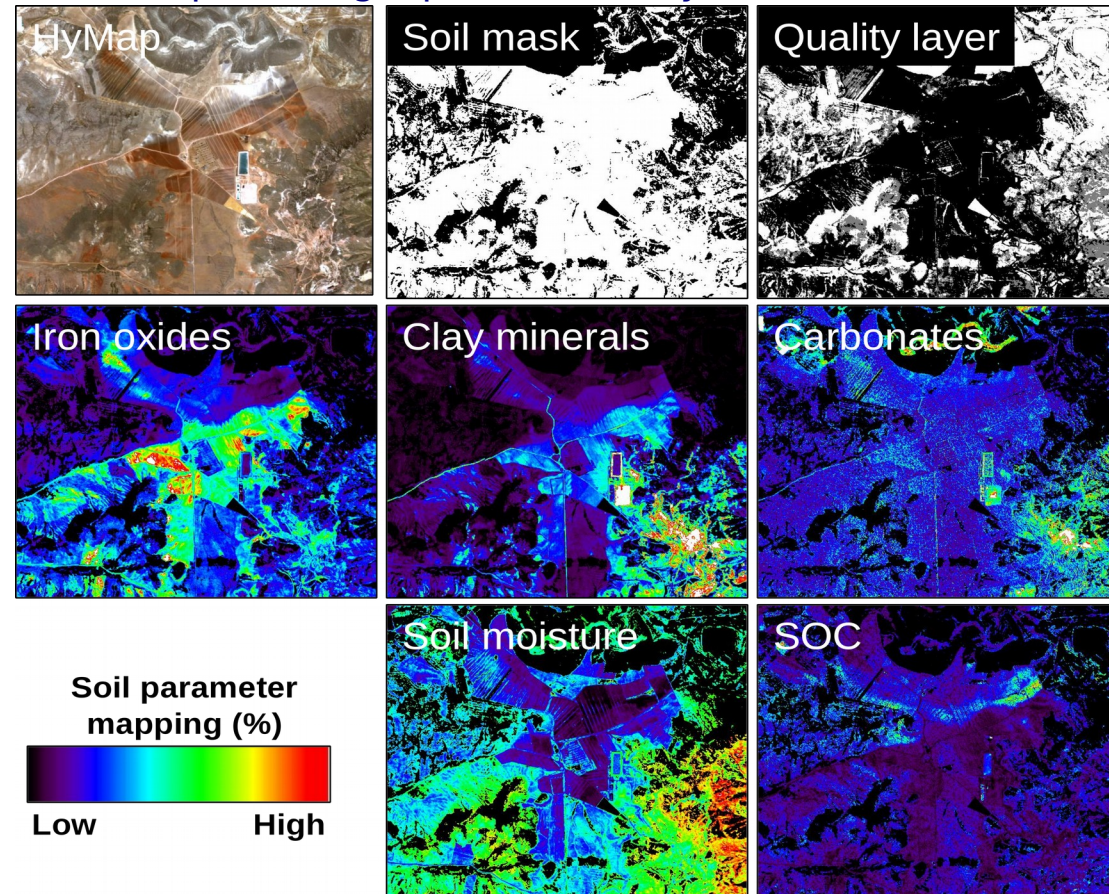
Rabe, van der Linden et al. (HU Berlin)
Download from: www.enmap.org/?q=enmapbox



EnSoMAP: Digital Soil Mapping

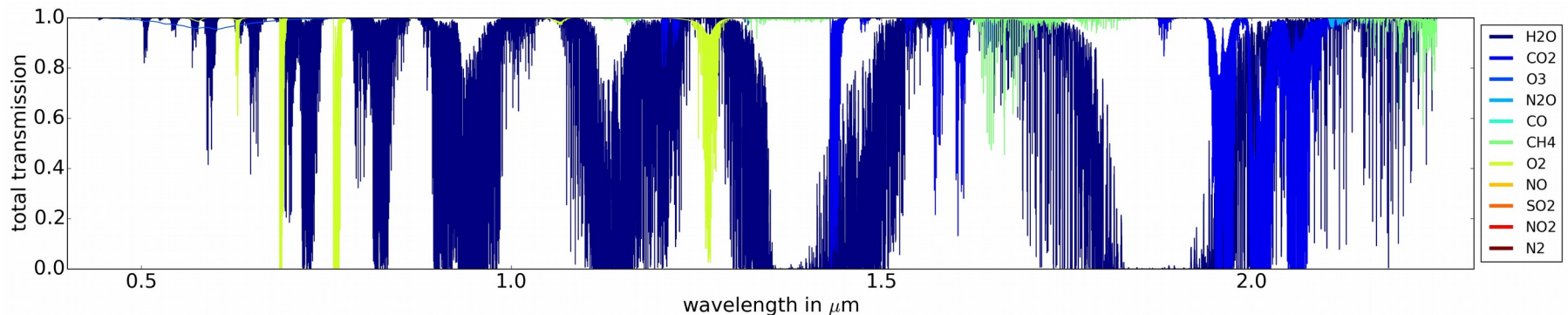
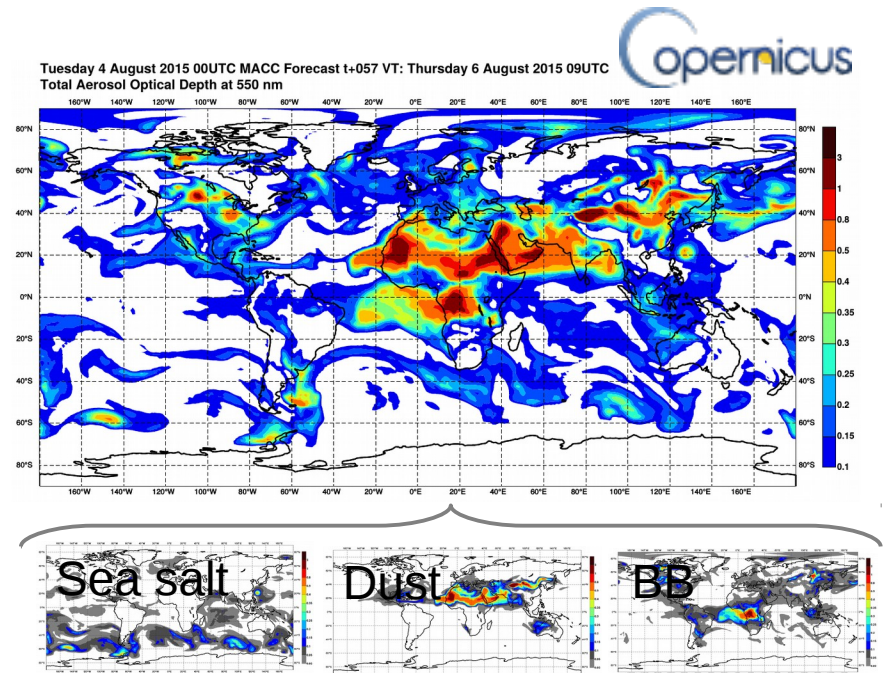
<http://www.gfz-potsdam.de/hysoma>, Chabrillat et al.

- Expert system for soil mapping
- Automatic generation of semi-quantitative soil maps
- (soil moisture content, organic carbon, iron oxides, clays, carbonates content) + quality layer map
- User custom option for fully quantitative soil mapping
- Currently distributed for airborne users



Atmospheric Correction (Under Development)

- Within EnMAP-BOX → will allow user interaction
- Radiative transfer using the MOMO model
- Atmospheric absorption based on latest HITRAN and accurate treatment of water vapor
- Include external operational products from Copernicus, e.g. Ozone and total aerosol optical thickness with 3 hourly AOD at ~120km scale



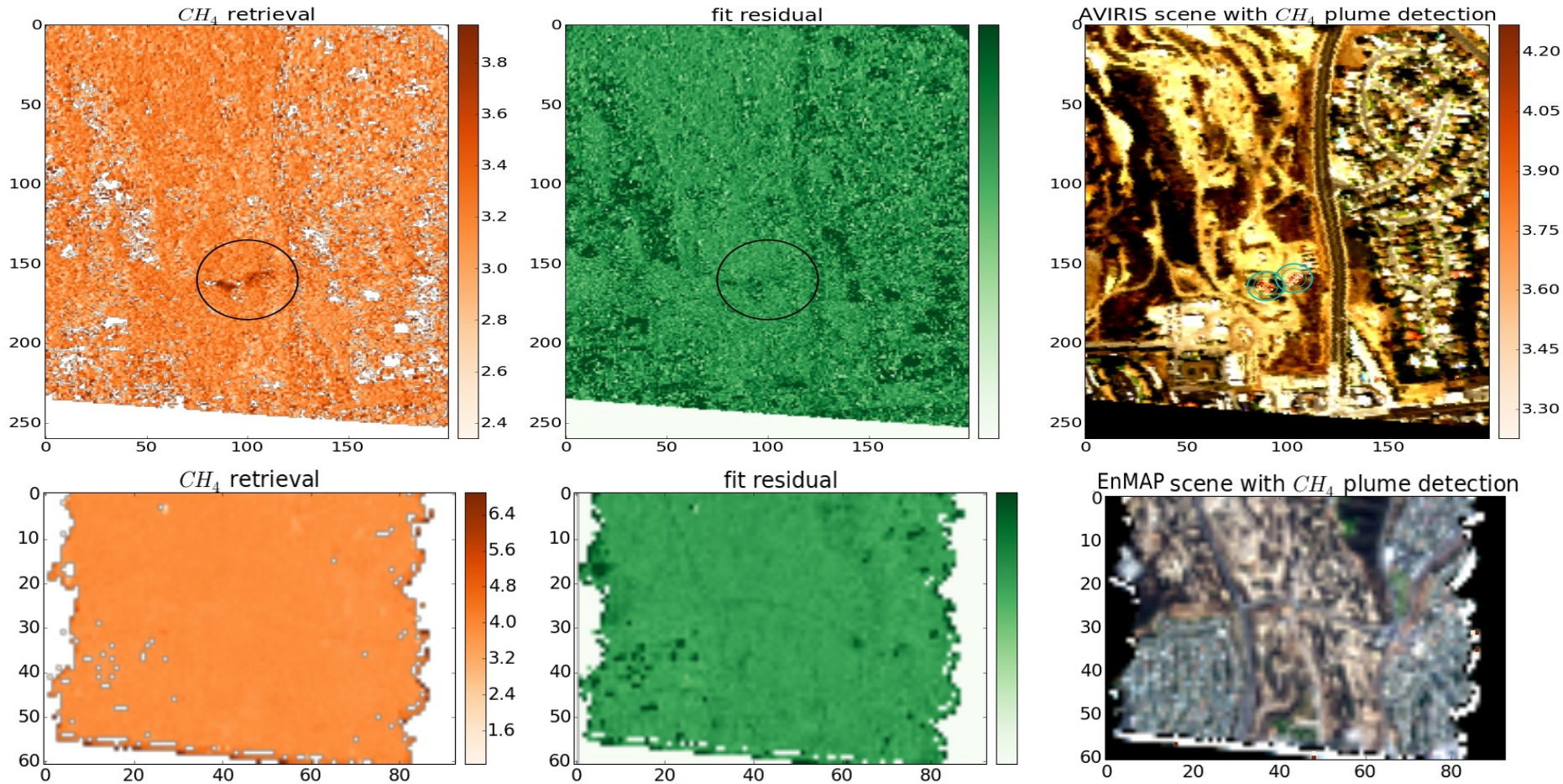
1) http://www.gmes-atmosphere.eu/d/services/gac/nrt/nrt_opticaldepth/

2) Rothman, L. S., et al. "The HITRAN database: 2012 edition." J Quant Spectrosc Radiat Transfer (2013).

3) Hollstein et al. "Radiative transfer solutions for coupled atmosphere ocean systems using the matrix operator technique.", JQSRT, 2012

Assessing Feasibility of Methane Retrievals

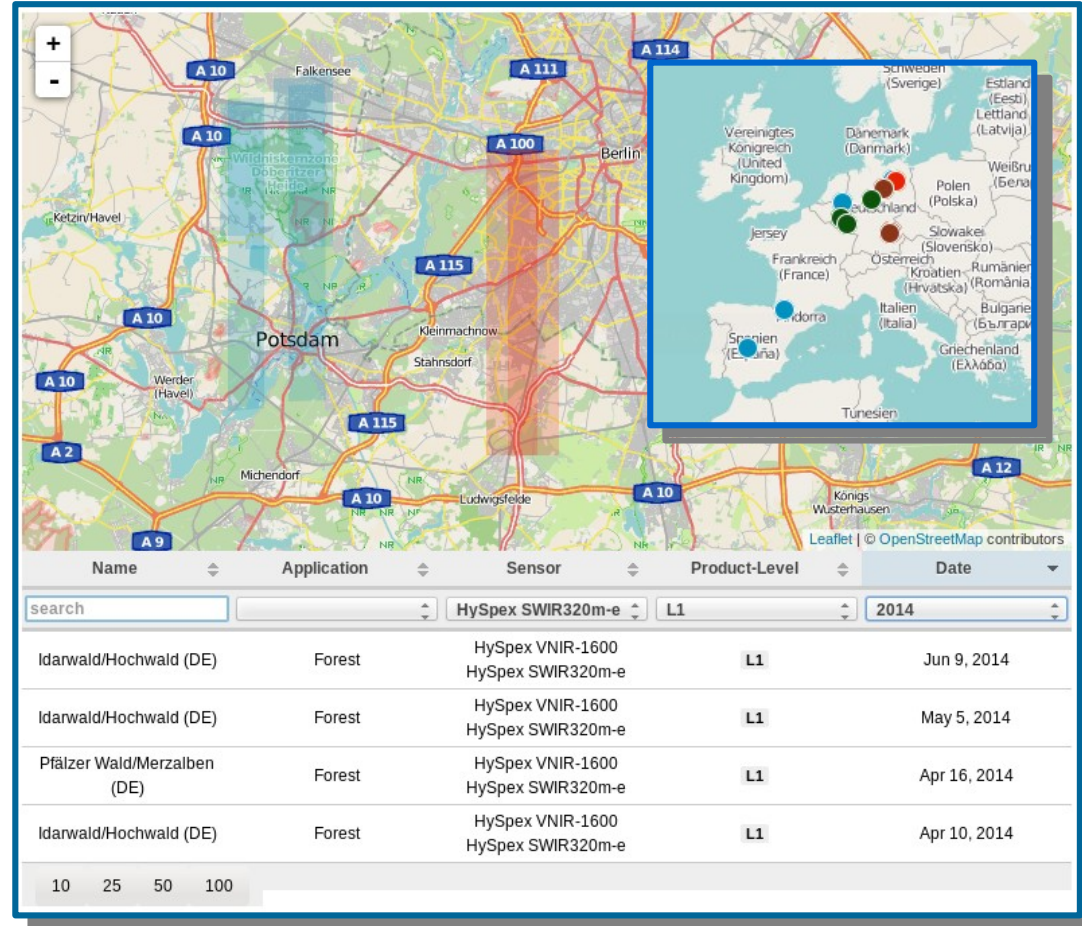
- Although there is the end-to-end simulator → good to use actual measurements to test algorithms
- AVIRIS-Classic → EnMAP (30m ground sampling distance) as a proxy for EnMAP → **early results**



EnMAP-Flight Campaigns

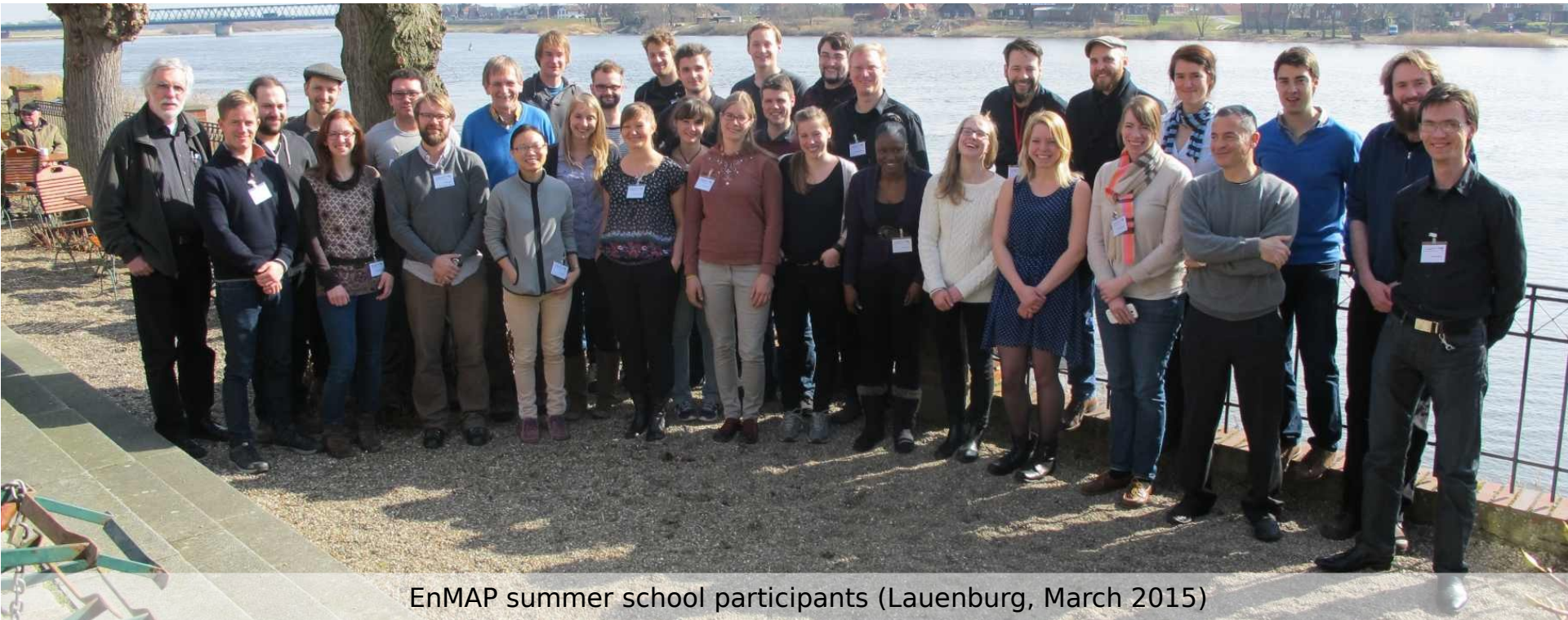
- Airborne hyper-spectral images and associated in-situ data
- Provided free of charge to science community under CC BY-SA license
- Metadata portal at www.enmap.org
- Datasets published as data publications (with DOI)
- Contact campaign PI to get data
- Technical report will be provided with each dataset (documentation of data acquisition, processing, quality etc.)

<http://www.enmap.org/?q=flightbeta>



Support to Young Researchers

- PhD Programme: 15 PhD projects currently ongoing on different research areas and groups in Germany
- YoungEnMAP: International Summer Schools organized every year



EnMAP summer school participants (Lauenburg, March 2015)

Conclusions / Outlook

- EnMAP

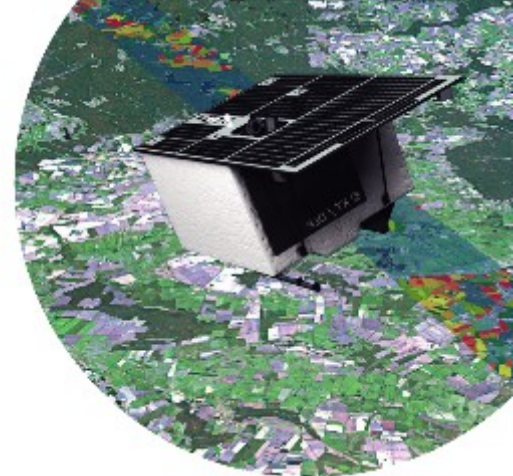
- **Launch: mid 2018**
- Free and Open data policy
- High Data Quality

- Provided data products

- Level-1B/C (TOA radiance)
- Level-2A (Land and Water)

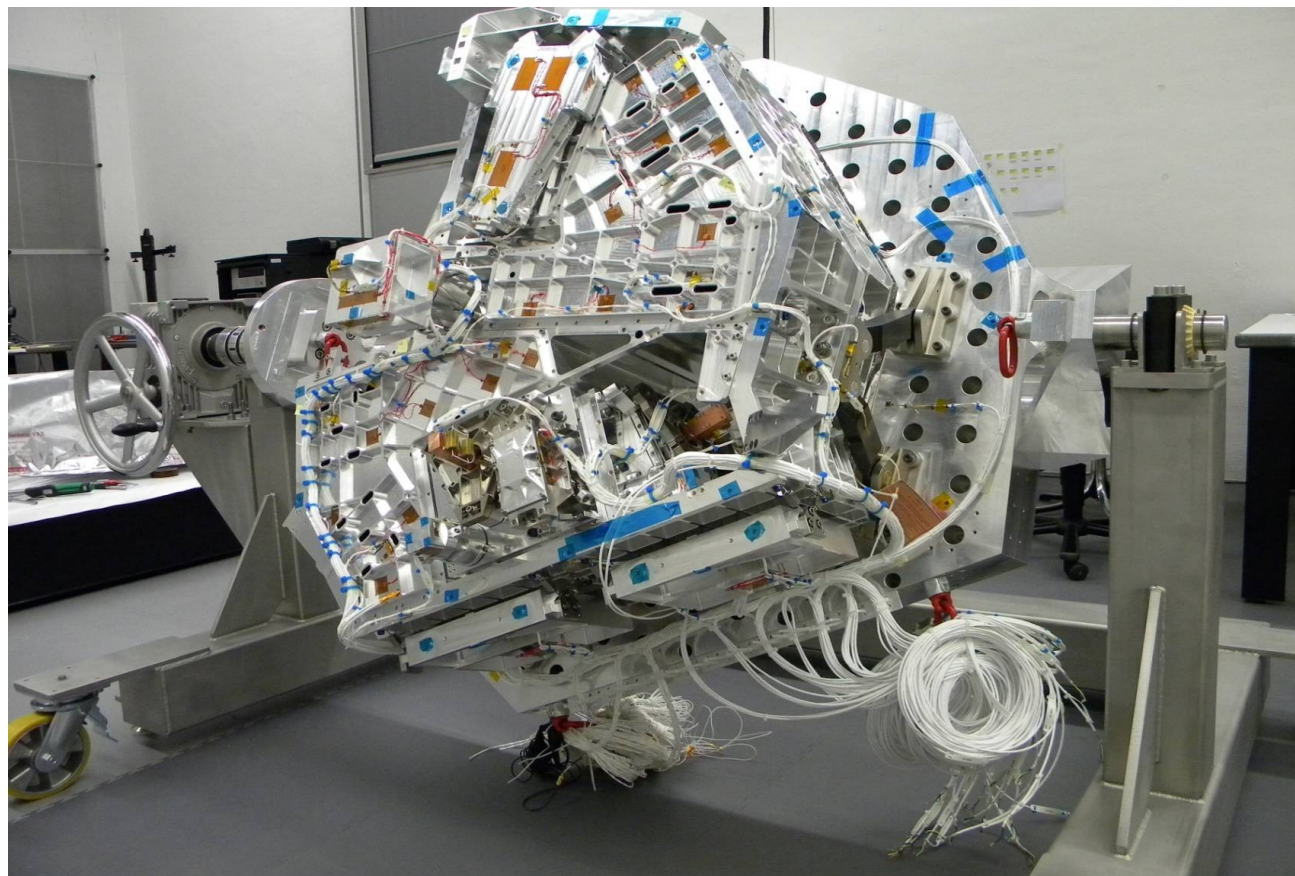
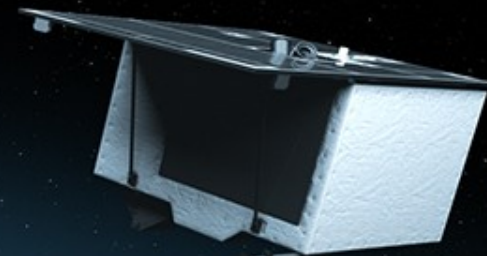
- EnMAP-BOX

- Open source
- Various Algorithms included
- Custom atmospheric correction
- Cloud detection
- Additional algorithms: Methane, ...



EnMAP

Hyperspectral Imager



**Thank you for
your attention!**

www.enmap.org

EnMAP

Hyperspectral Imager



Supported by:



Federal Ministry
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on the basis of a decision
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GFZ

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