EnMAP Research, Mission Synergies & Future Perspectives

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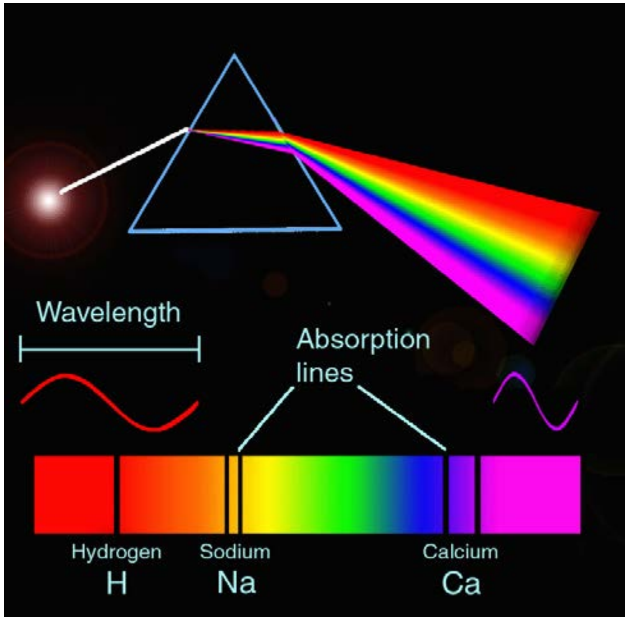
Section 1.4: Remote Sensing

Imaging Spectroscopy (aka Hyperspectral Remote Sensing)

- **Spectroscopy →** study of the interaction between matter and radiated energy specifically looking at what wavelengths of light are emitted or absorbed by an object in order to characterize materials.
- **Remote sensing & imaging spectroscopy:** airborne or spaceborne imaging spectrometers measuring the spectrum of solar radiation reflected by Earth materials.



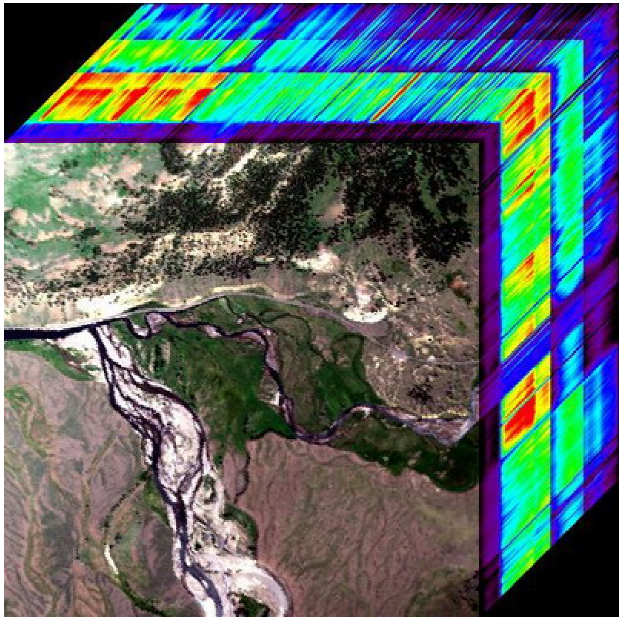
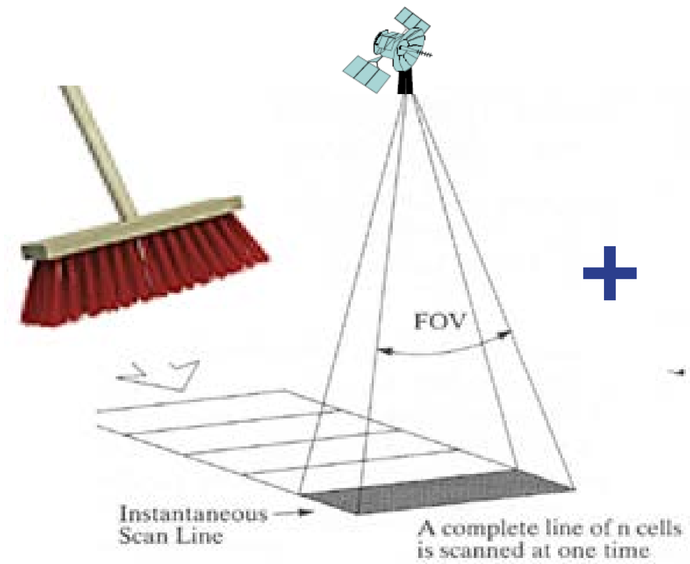


Image Formation in Hyperspectral Remote Sensing

Pushbroom Imaging Principle



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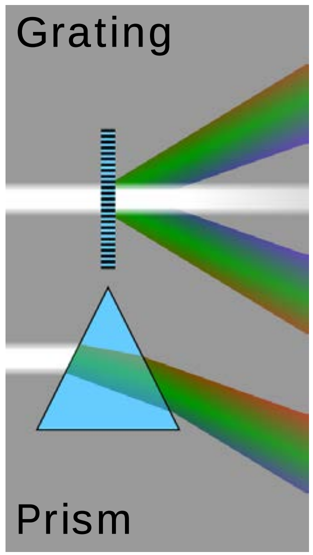
Dispersive element



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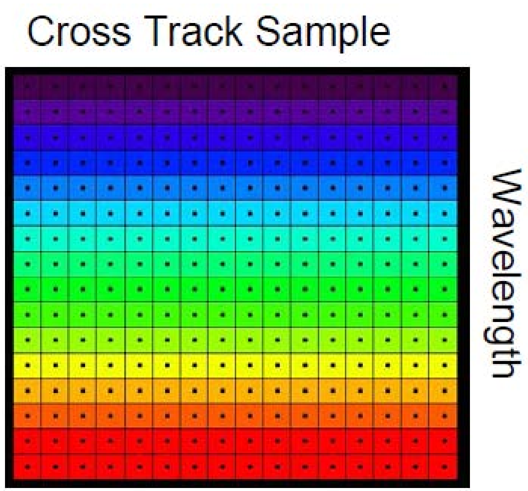
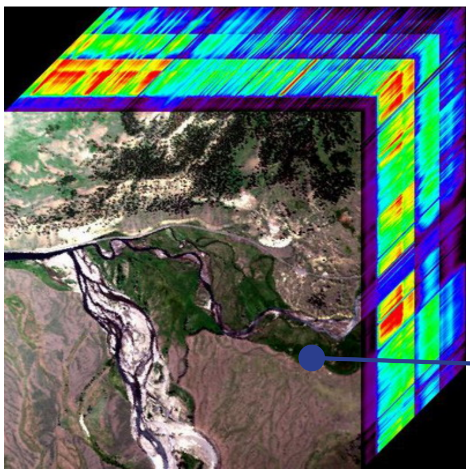
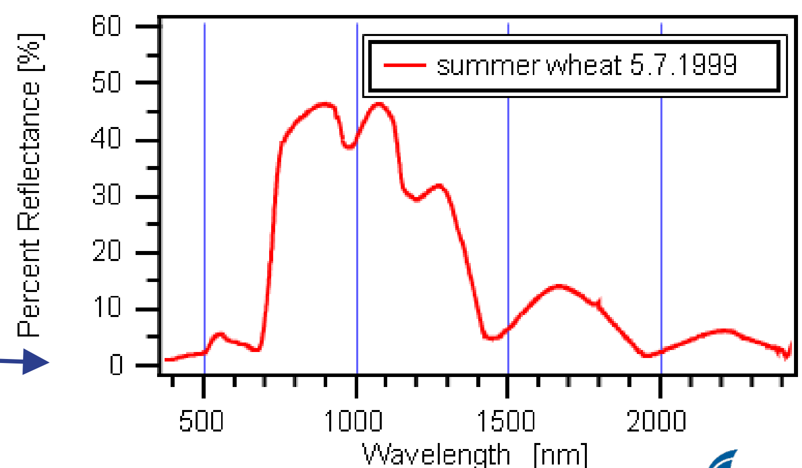
2-D Detector Array



Hyperspectral 3-D Cube



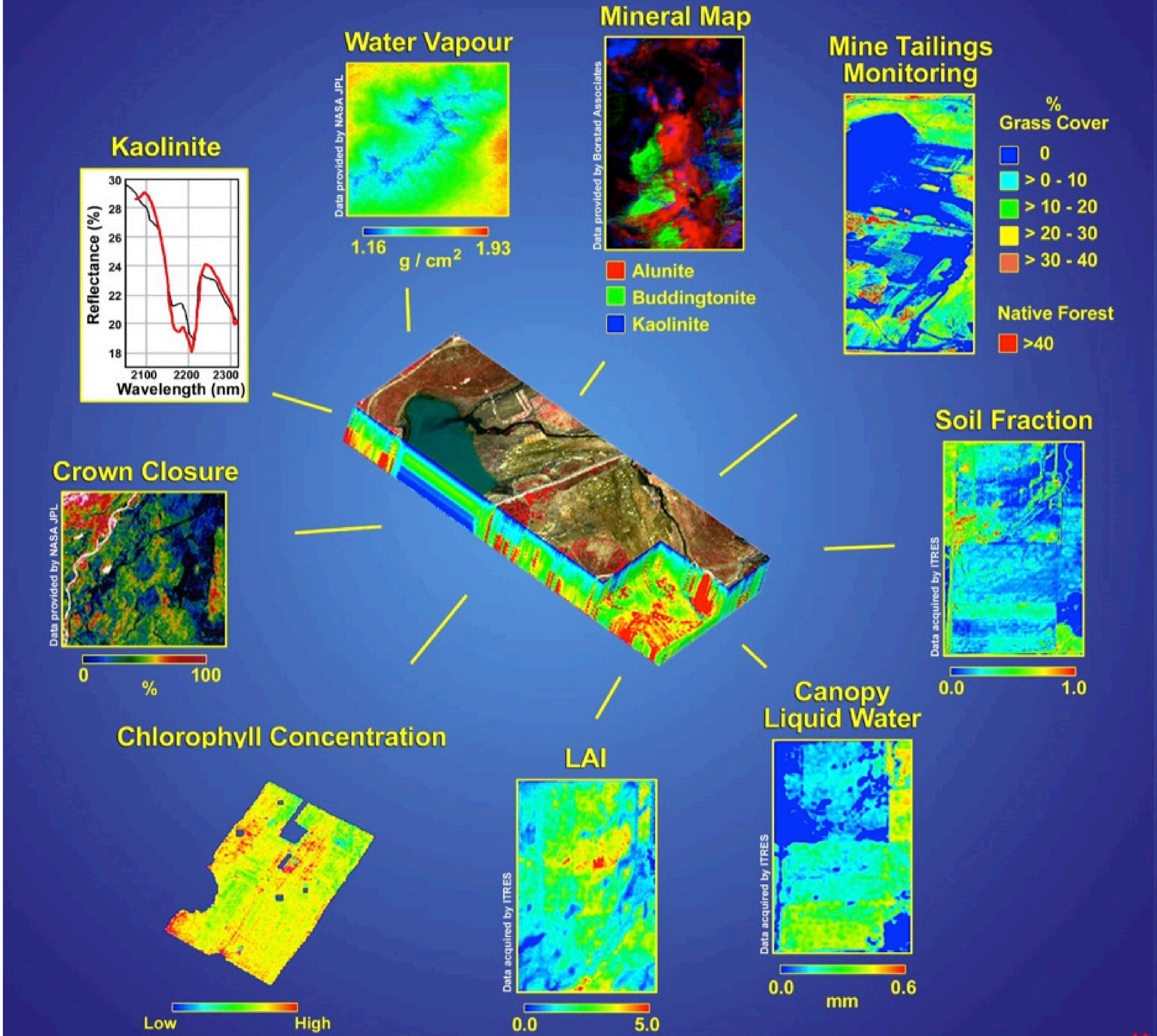
Pre-processing



Imaging Spectroscopy & Science

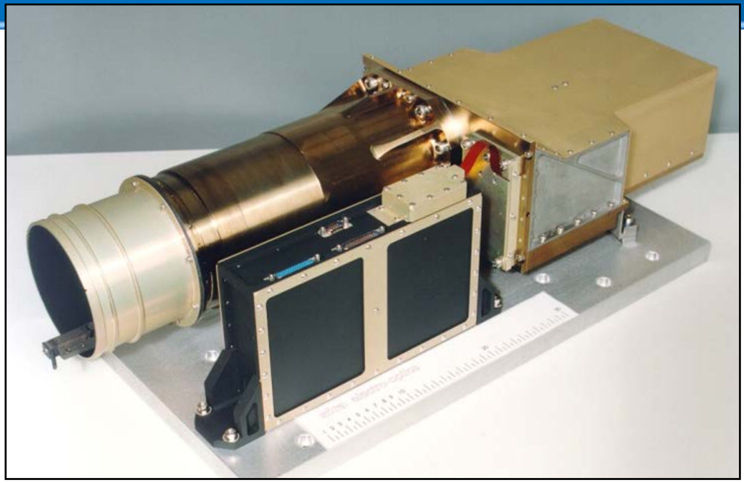
→Quantitative mapping for a wide range of research fields

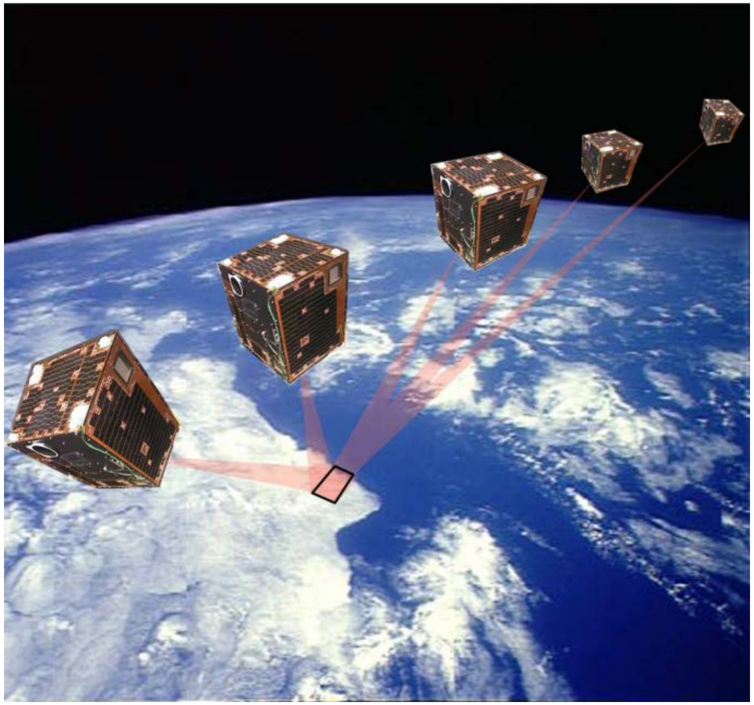
→Great potential for new (and unexpected!) applications



- **The not-so-happy story of spaceborne imaging spectroscopy for Earth observation:**
  - Current missions → So-called "technology demonstrators"
    - Low data quality and limited acquisition capability
    - Examples: EO-1 Hyperion (USA NASA, 2000) & CHRIS/PROBA (UK/ESA, 2001), designed for a 1-year lifetime!

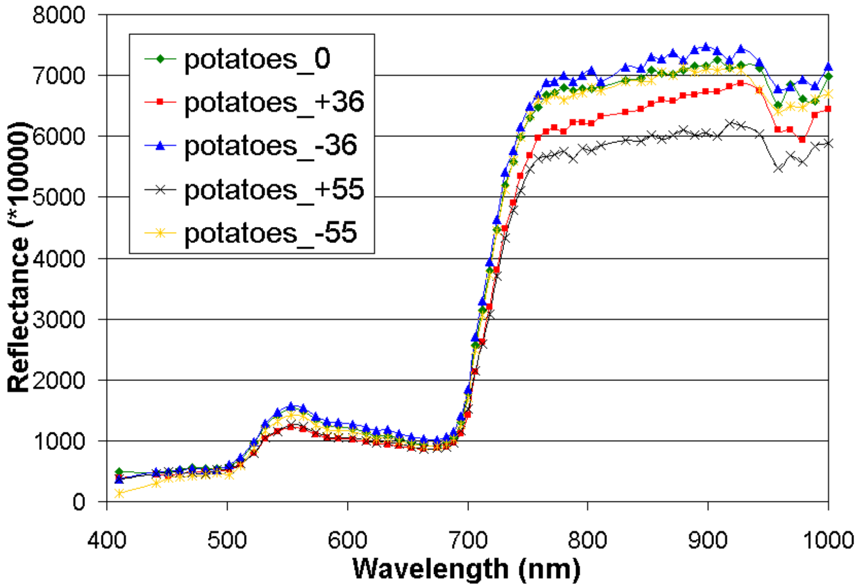
Space-based imaging spectroscopy – CHRIS-PROBA





The CHRIS/PROBA system (UK/ESA):

- Launched in 2001, still operating
- Conceived as a Technology Demonstrator
- Hyperspectral/multiangular system
  - VNIR: 412-1050 nm, up to 62 bands
  - 5 Observation angles (0°, ±36°, ±55°) per acquisition
  - 13 km swath, up to 17 m per pixel

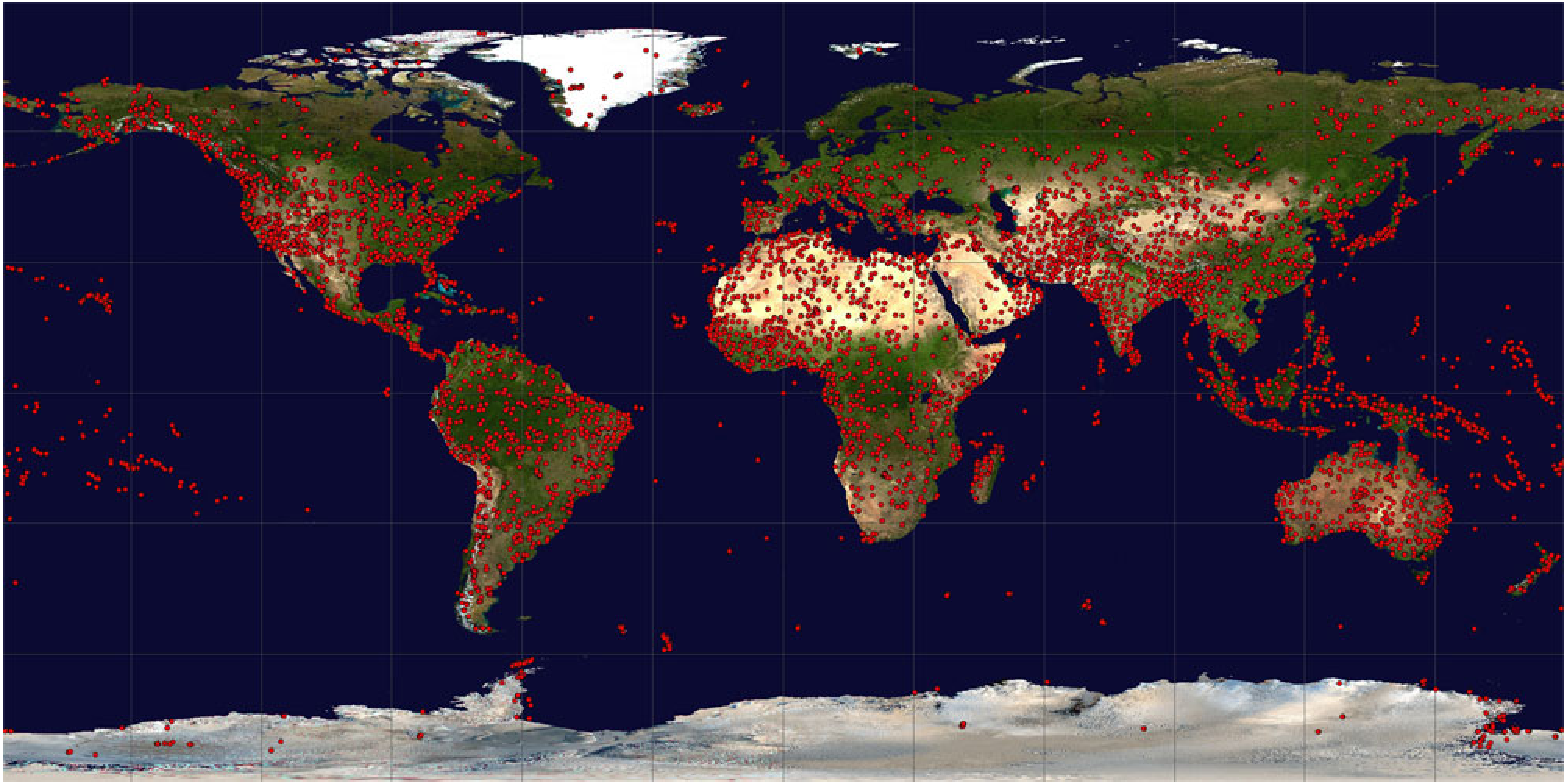


EO-1 Hyperion

- **Technology demonstration project** operated by NASA-GSFC and USGS.
- Launched in 2000, still operating. Operations are likely to be stopped in 2016.
- **Specifications:**
  - Swath = 7.5 km
  - Ground sampling distance = 30m
  - Spectral sampling ~10nm
  - Spectral coverage - 220 bands
    - 70 VNIR 356 - 1058 nm
    - 172 SWIR 852 - 2577 nm
  - Nominal SNR: 160 VNIR, 40 SWIR

→ Only spaceborne imaging spectrometer ever providing VNIR-SWIR data!!

EO-1 Hyperion, Acquisitions



Hyperion Imagery in the USGS EDC Archive Jan 1, 2001 through April 21, 2005

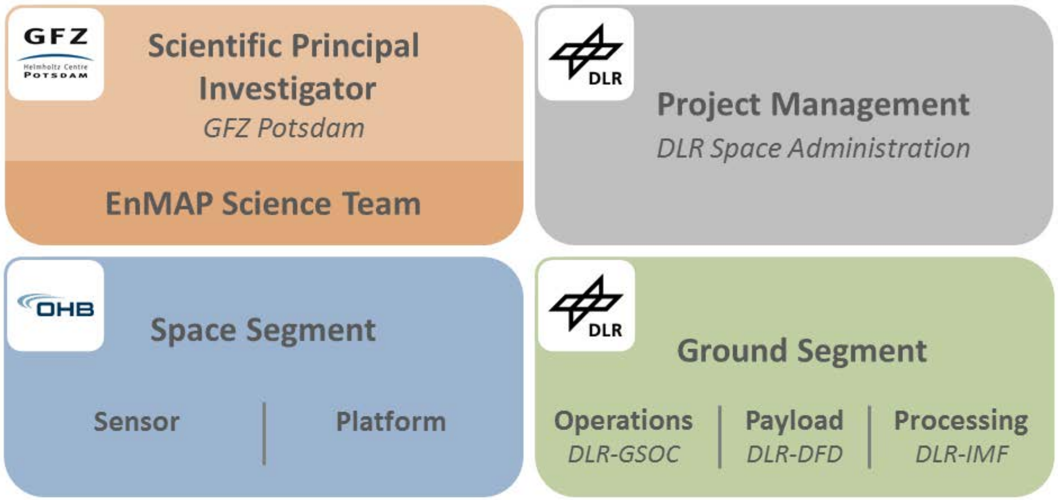
Since June 2009 → Open data policy, acquisitions on-demand at no-cost

International Scenario of Spaceborne Imaging Spectroscopy

- **The not-so-happy story of spaceborne imaging spectroscopy for Earth observation:**

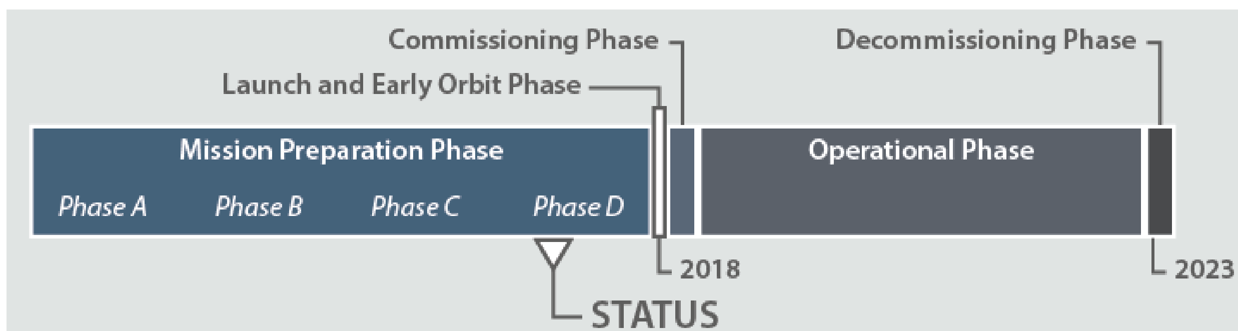
  - Most of imaging spectroscopy applications rely on airborne spectrometers → heritage from AVIRIS (NASA-JPL, since 1987)
  - There are more imaging spectrometers for planetary observation than for Earth observation!

→ **EnMAP (launch 2018) expected to fill this gap in "operational" spaceborne imaging spectroscopy**

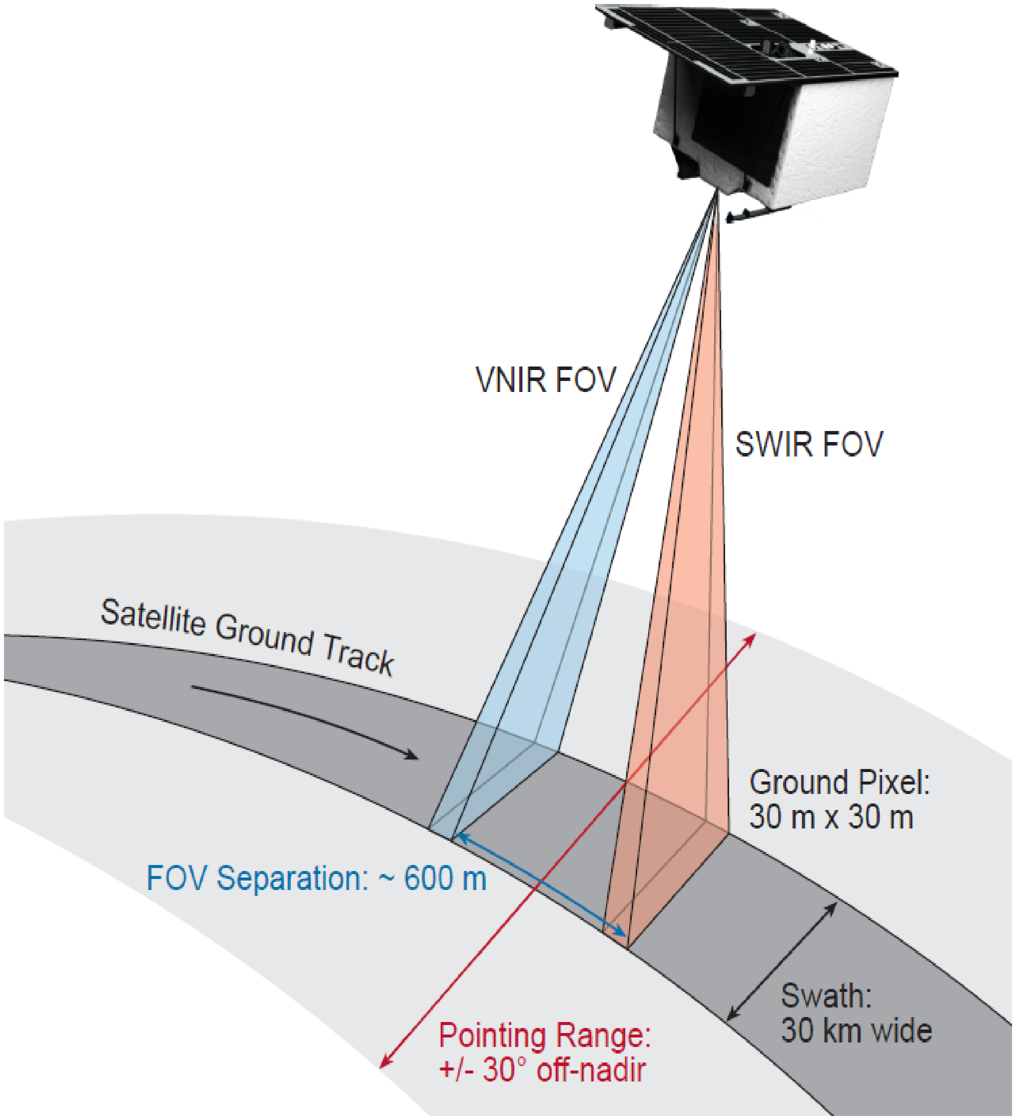


- EnMAP: Environmental Mapping and Analysis Program
- Spaceborne mission aimed at reducing current limitations in global imaging spectroscopy data
- Open data policy

- Core funding from the German Federal Ministry of Economics and Technology
- Currently under construction phase, launch end 2018



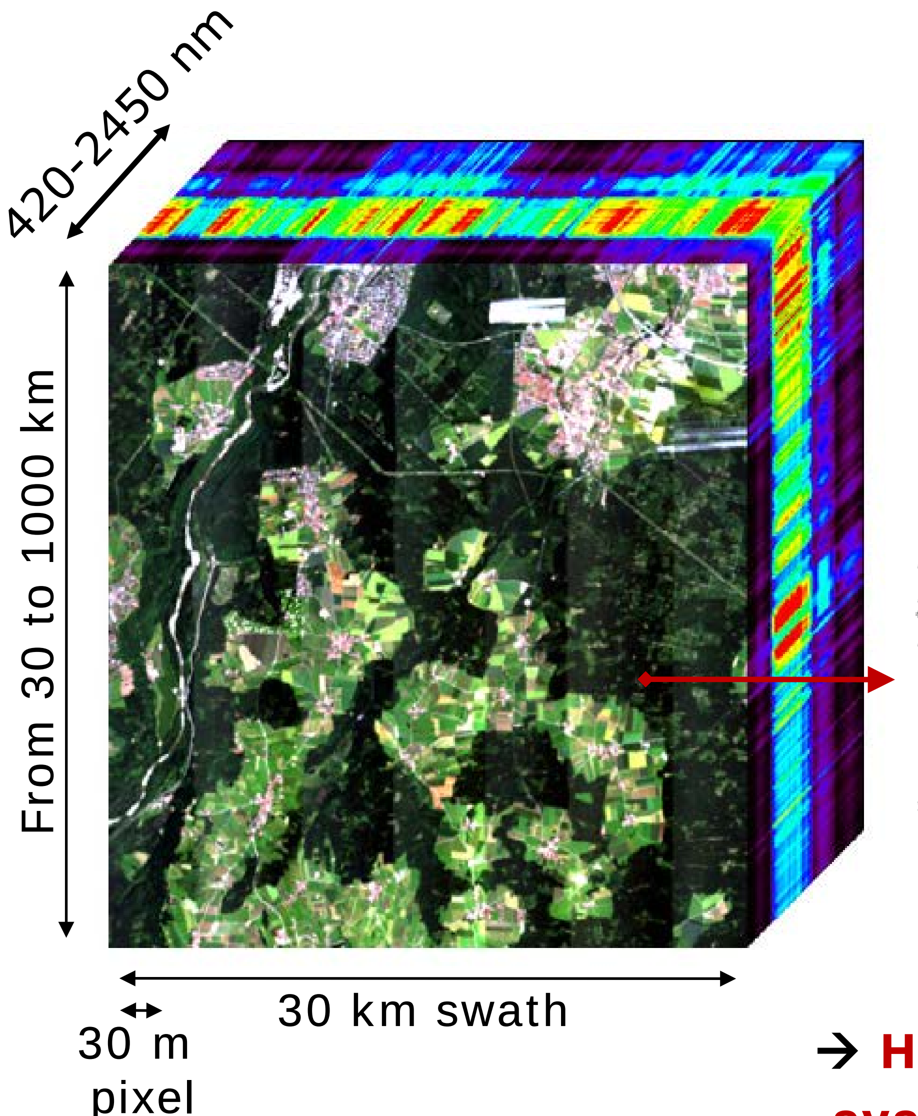
EnMAP – Main Mission Parameters



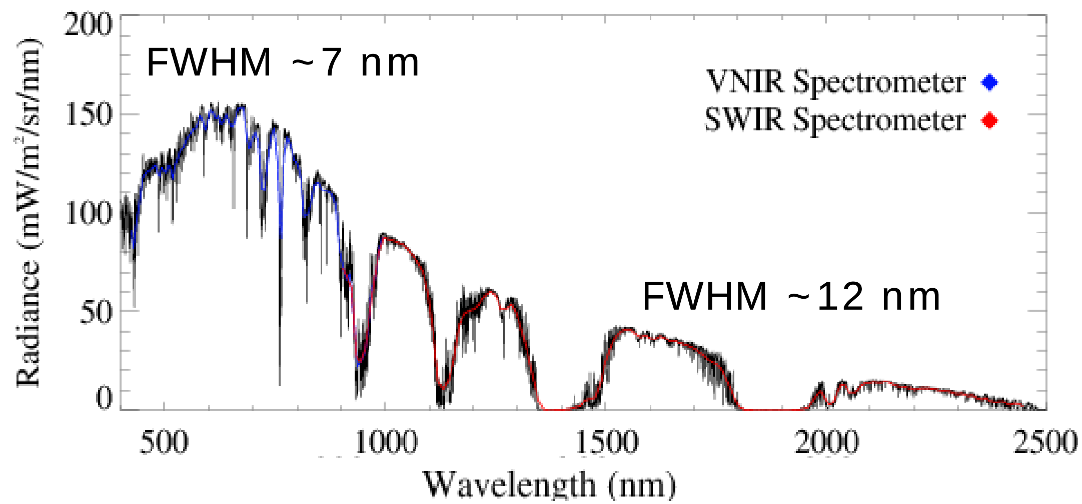
- Push-broom imaging spectrometer
- Sun-synchronous orbit, 11h LTDN
- Spectral range
  - VNIR: 420 nm to 1000 nm
  - SWIR: 900 nm to 2450 nm
- Spectral sampling distance
  - VNIR ~6.5 nm
  - SWIR ~10 nm
- Ground sampling distance 30 m
- Data acquisition
  - Swath width 30 km
  - 1000 km/orbit
  - 5000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

Guanter et al., *Remote Sensing*, 2015

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



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

EnMAP Data Products

User products

- **Level 0 data - digital number data**

→ Radiometric correction

- **Level 1B data - radiometrically calibrated radiance data**

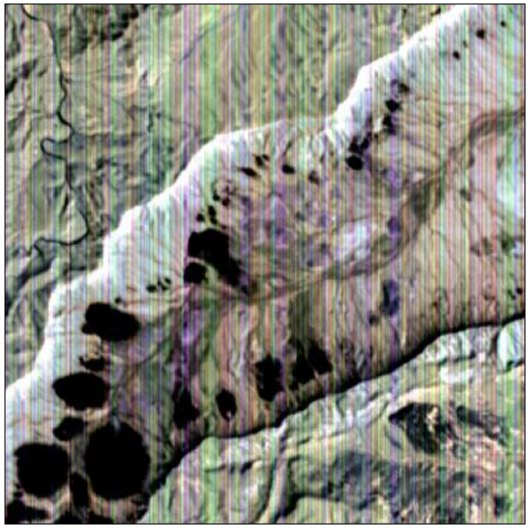
→ Geometric correction

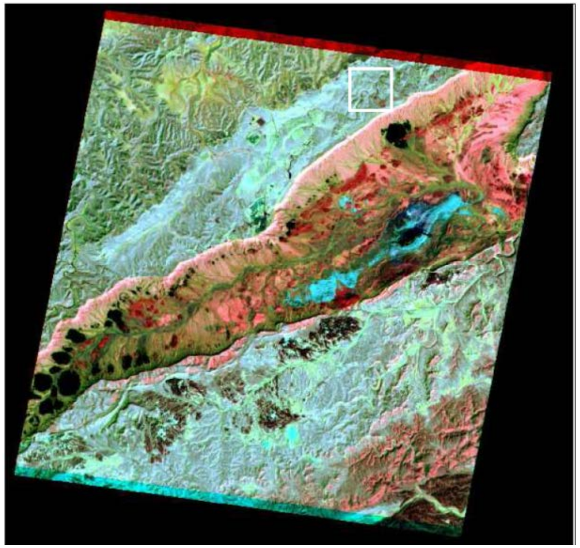
- **Level 1C data - radiometrically calibrated radiance data in a map projection**

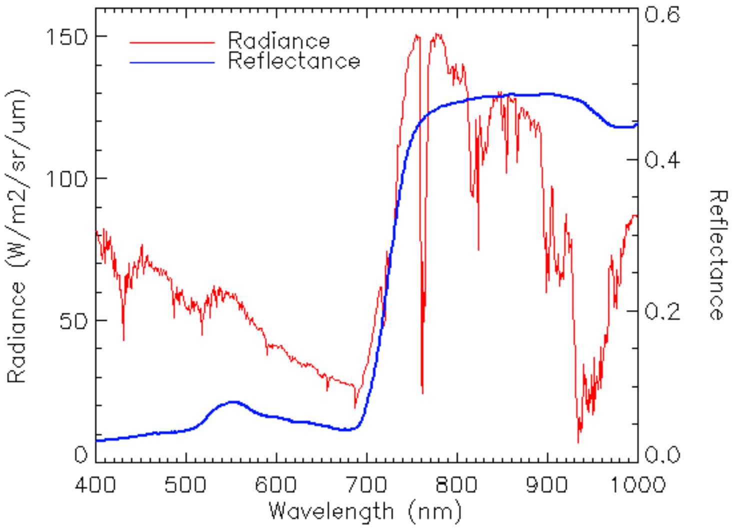
→ Atmospheric correction

- **Level 2 data – Surface reflectance data in a map projection**

"Raw data" (digital numbers) → Calibrated Radiance → Geographical projection → Surface reflectance







EnMAP acquisition plan

EnMAP Acquisitions:

- Restricted to 1000 km/orbit and 5000 km/day
- Based on user requests
- Daily acquisition plan driven by priorities and cloud probability

Priority	Request
1	Internal user
2	Support for catastrophic events
3	Registered users (Cat.1) excellent proposals
4	Registered users (Cat.1)
5	Non-registered users (Cat.2)
6	Requests beyond fulfilled contingents
7	Background mission

EnMAP Science Advisory Group (EnSAG)

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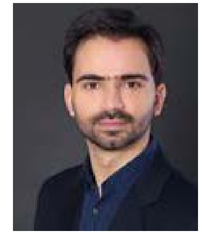
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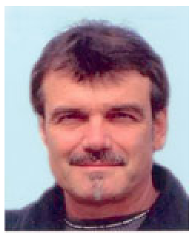
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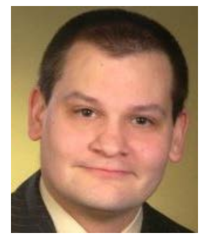
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Jose Moreno (U. Valencia)

EnMAP Science Plan

Content

- Research context and significance
- General mission framework
- EnMAP perspectives and impact
- Scientific exploitation strategy

www.enmap.org

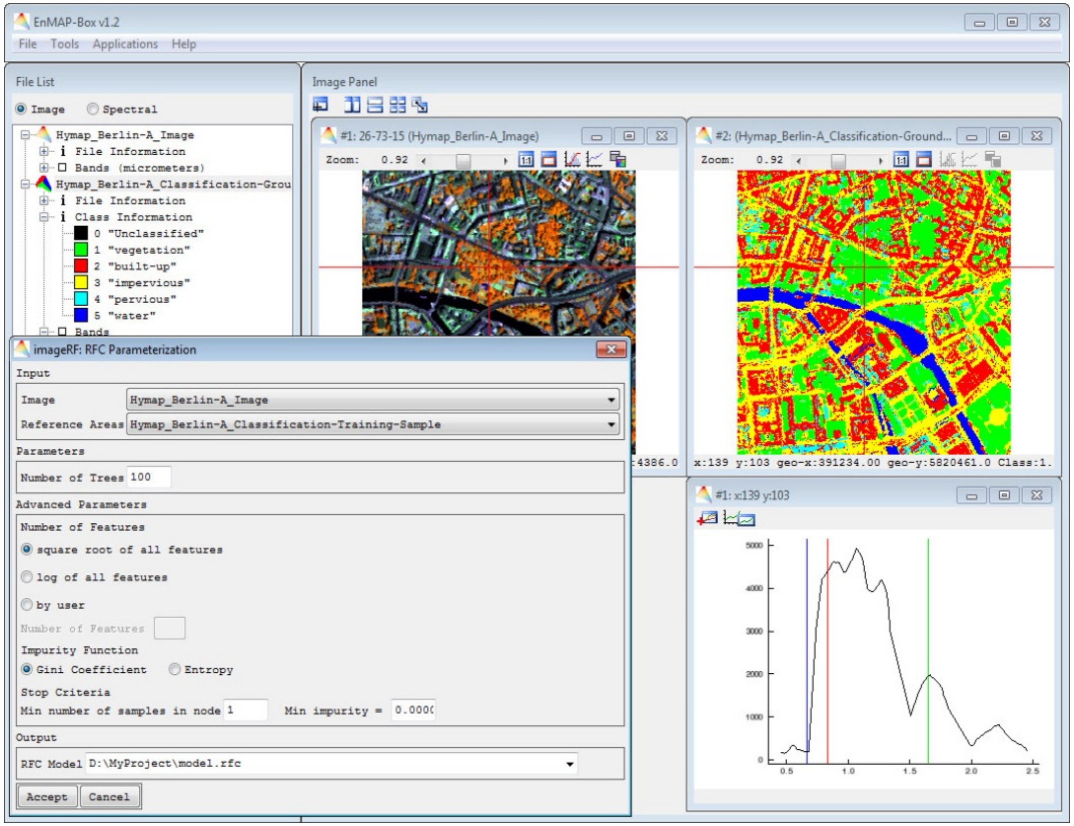
EnMAP preparatory activities

Main research lines (EnSAG):

- Agriculture
- Forest
- Ecosystems
- Soils & Geology
- Coastal and inland waters

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

- Software for the pre-processing and scientific exploitation of EnMAP data
- Free, open source and platform independent

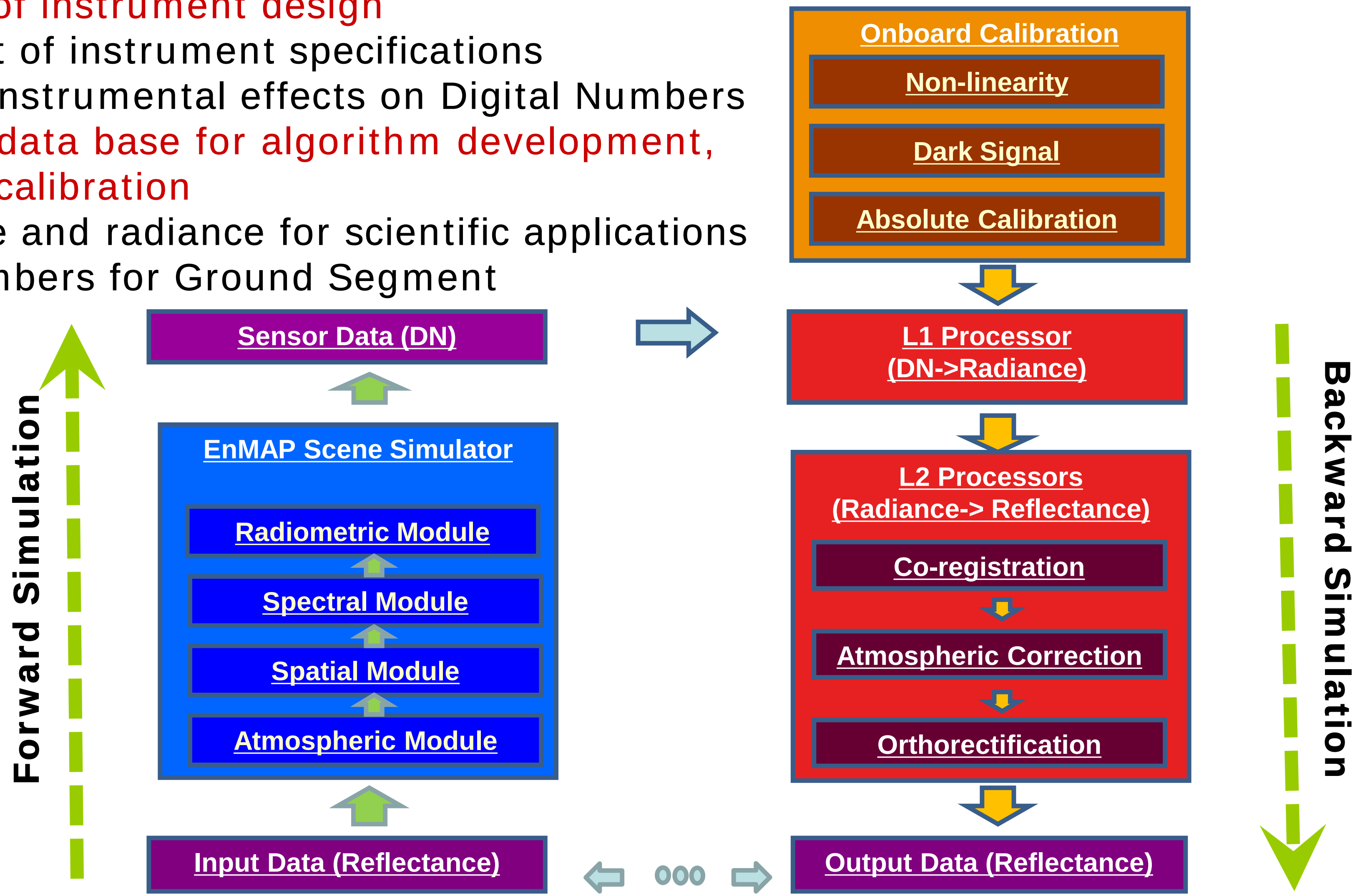


Download from
www.enmap.org/?q=enmapbox

EnMAP end-to-end scene simulations

Objectives:

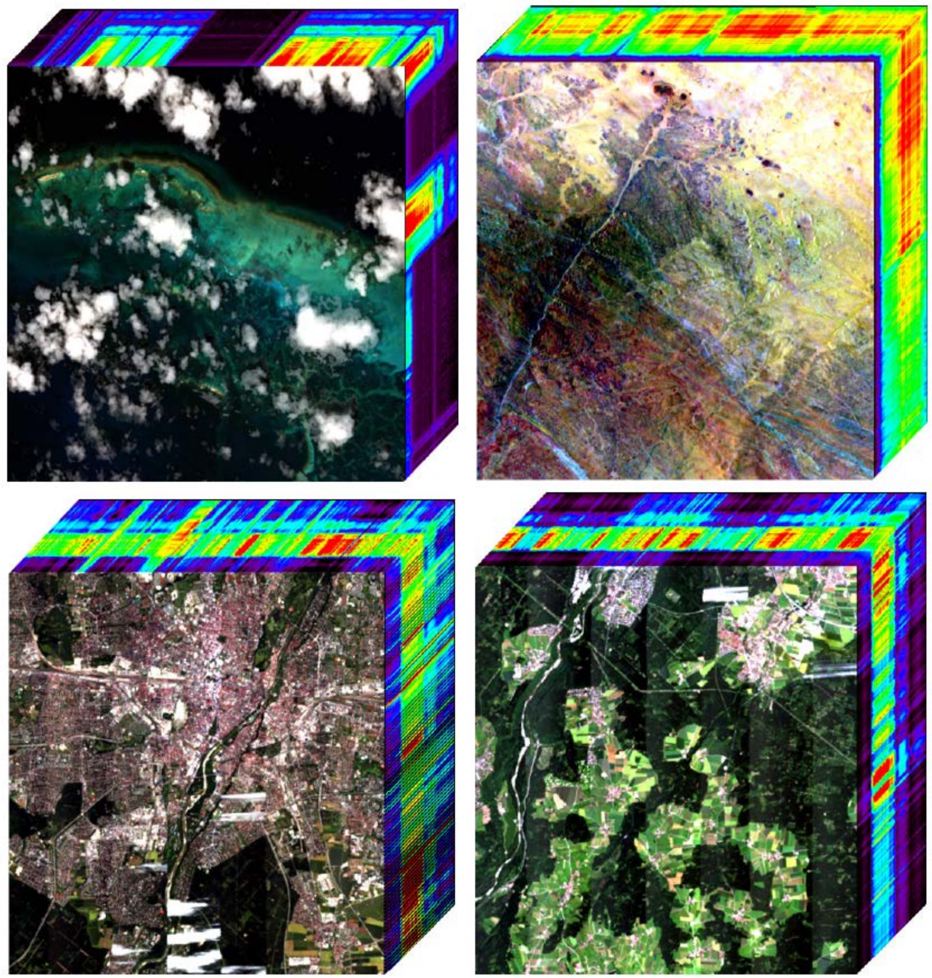
1) Optimization of instrument design
   - Refinement of instrument specifications
   - Impact of instrumental effects on Digital Numbers
2) Generating a data base for algorithm development, validation and calibration
   - Reflectance and radiance for scientific applications
   - Digital Numbers for Ground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



Segl et al., IEEE JSTARS, 2012

EnMAP end-to-end scene simulations

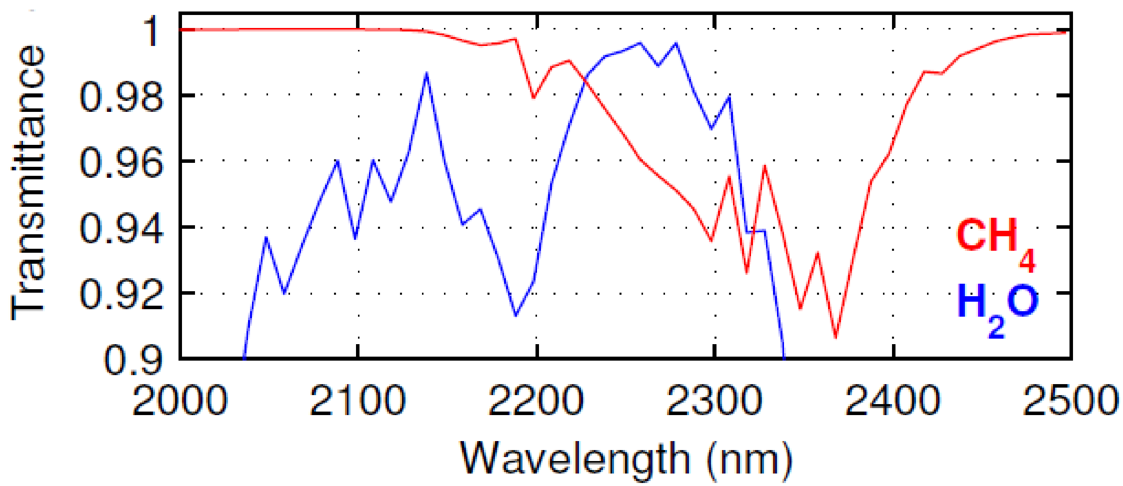
Simulation of (i) EnMAP-like TOA radiance images and (ii) L2 surface reflectance after pre-processing

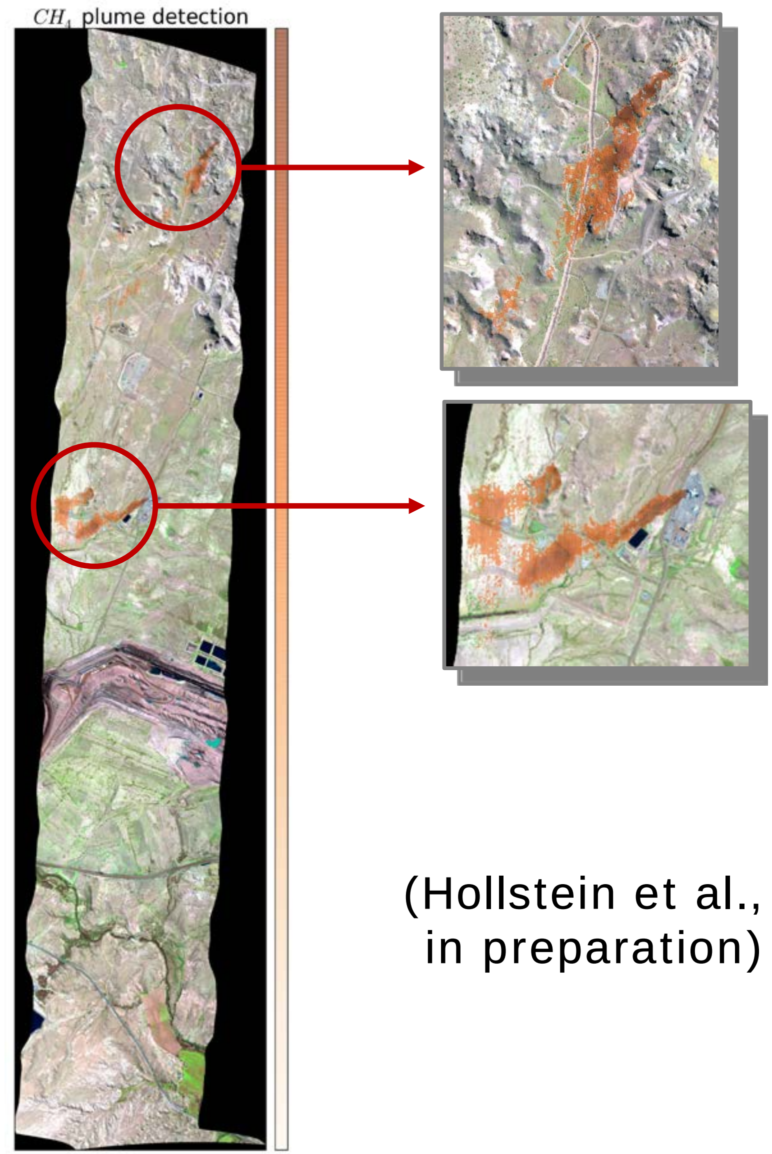


Many simulated EnMAP data sets already available

EnMAP retrievals and simulations: methane point sources

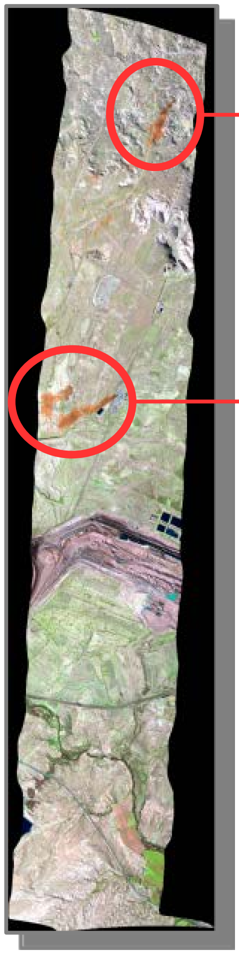
- **Plume detection** algorithm based on fitting of CH4 and H2O absorption features around 2300 nm
- **AVIRIS-NG airborne spectroscopic measurements** from the US Four-Corners campaign used as a test bench for potential satellite-based CH4 retrievals

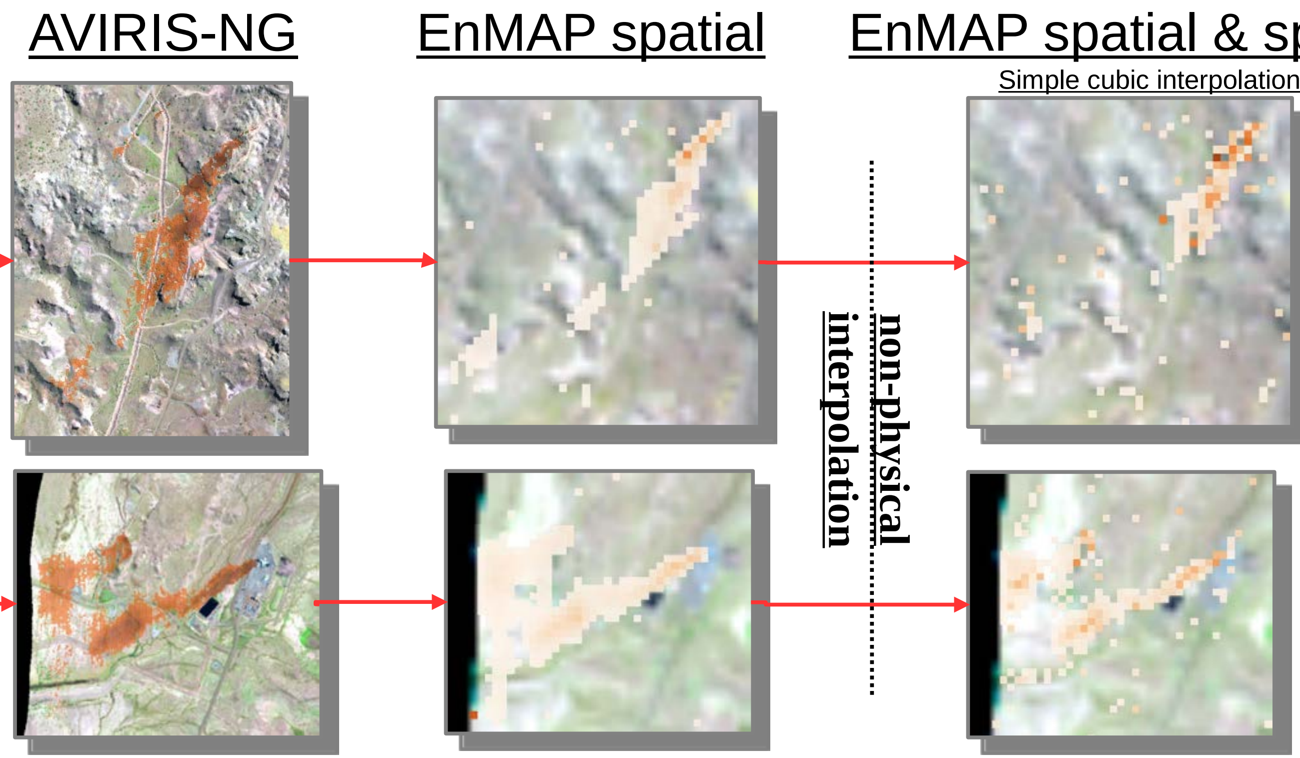




(Hollstein et al., in preparation)

AVIRIS & EnMAP: CH4 Retrieval





- **Spatial and spectral resolution of EnMAP seems to be sufficient for the detection of large anthropogenic plumes**
- Spectral resampling from AVIRIS NG to EnMAP was performed through cubic interpolation, which inevitably leads to spectral artifacts
- Simulation of SNR and radiometric accuracy needs to be further investigated

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)

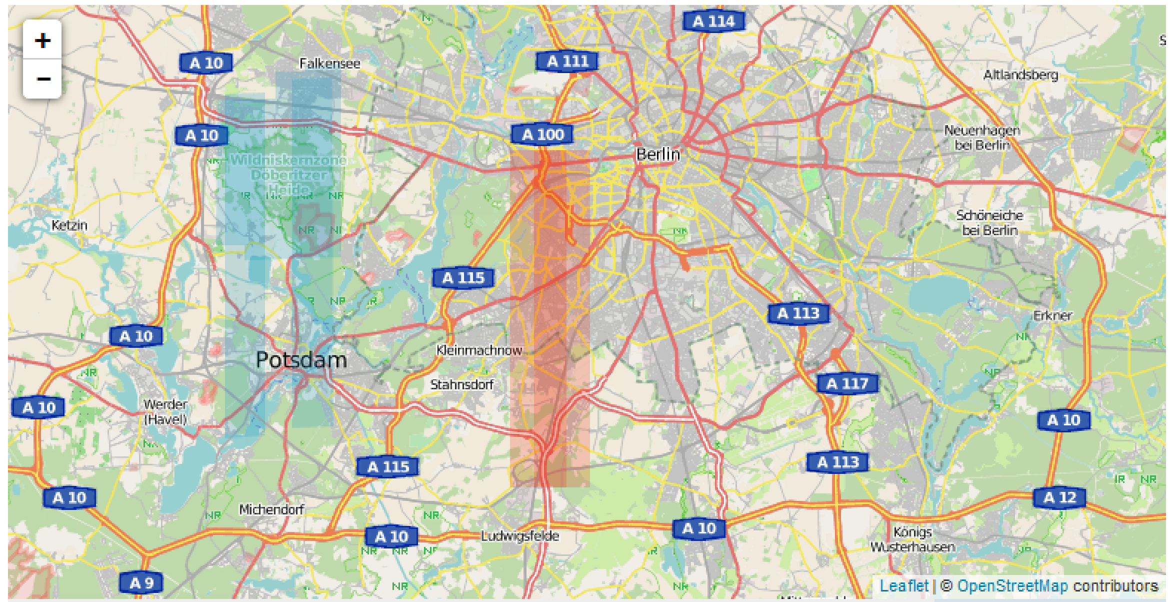
Technical Report will be provided with each dataset (documentation of data acquisition, processing, quality etc.)

Home | Mission | Science | Applications | EnMAP Box | Data

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

EnMAP - Flight campaigns

Several hyperspectral airborne flight surveys have been carried out in the frame of the EnMAP preparatory program to support method and application development in the prelaunch phase. The metadata base below provides details about the campaigns, information about recorded airborne hyperspectral data sets and other data associated to the respective campaigns like field and laboratory measurements. Further, it informs about the availability of simulated EnMAP and Sentinel-2 data. Contact details of the data owners are given for interested researchers regarding data exchange. The data listed in this metadata base is freely available for scientific purposes.



Name	Application	Sensor	Product-Level	Date
search				
Idarwald/Hochwald (DE)	Forest	HySpex VNIR-1600 HySpex SWIR320m-e	L1	Jun 9, 2014
Idarwald/Hochwald (DE)	Forest	HySpex VNIR-1600 HySpex SWIR320m-e	L1	May 5, 2014
Pfälzer Wald/Merzalben (DE)	Forest	HySpex VNIR-1600 HySpex SWIR320m-e	L1	Apr 16, 2014
Idarwald/Hochwald (DE)	Forest	HySpex VNIR-1600	L1	Apr 10, 2014

Schools & Young EnMAP

Trier (September 2010)

Munich (April 2011)

Berlin (September 2012)

Lauenburg (March 2015)

GFZ
Helmholtz Centre
POTSDAM

Schools & Young EnMAP

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- Projects
- Community
- Young EnMAP
- Publications
- Events
- Jobs
- Mailing list

Young EnMAP

published on Thu, 2011-11-03 00:00

Young EnMAP is a group of young researchers interested in sharing ideas and experiences in the field of imaging spectroscopy. The group was founded during the first EnMAP summer school in Trier, Germany in September 2010.

The members of YoungEnMAP are PhD students, early PostDocs and undergraduate students based at various universities and research institutes in Germany. The YoungEnMAP activities include workshops, summer schools, exchange of young researchers between institutions, information exchange via the website and email correspondence. The main objectives of YoungEnMAP are:

- To enhance the communication between different research groups working in research projects funded in the EnMAP mission and other research groups with similar research focus
- To exchange methods, experiences, knowledge and best practices
- To boost interdisciplinary research approaches
- To support the development of a strong scientific offspring in the field of imaging spectroscopy

Related Documents

- Science Plan

For posting an email to the YoungEnMAP list, use the address **enmap_young@gfz-potsdam.de**

Potential EnMAP synergies

- Potential synergetic use of EnMAP and other EO missions with emphasis on land monitoring:

1. **Other spaceborne imaging spectroscopy missions**
2. **Optical multispectral missions: Sentinel-2 & Landsat**
3. **ESA's Fluorescence Explorer (FLEX)**

Potential EnMAP synergies

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Planned spaceborne imaging spectroscopy missions

- **DESIS (DLR Germany & Teledyne USA)**
  - 400-1000 nm, 3.3 nm resolution
  - ~30m GSD & ~30 km swath
  - Expected launch 2017 (Onboard ISS)
- **Prisma (Italian Space Agency)**
  - 400-1010 nm & 920-2500 nm, 10 nm res. + PAN 400-700 nm
  - 30 m GSD & 30 km swath (HSI)
  - Expected launch 2018 (???)
- **HISUI (JAXA Japan)**
  - 440-970 nm & 900-2500 nm, 10 nm & 12.5 nm resolution
  - 30 m GSD & 30 km swath
  - Expected launch 2018 (Onboard ISS)
- **SHALOM (Italy / Israel)**
  - 400-1010 nm & 920-2500 nm, 10 nm res. + PAN 400-700 nm
  - 10 m GSD & 10 km swath (HSI)
  - Two comercial hyperspectral satellites, no launch date set yet
- **HyspIRI (NASA JPL / GSFC USA)**
  - 380-2500 nm, <10 nm resolution + TIR bands
  - 185 km swath
  - Extremely high uniformity, one single detector array
  - Expected launch ???

Potential EnMAP synergies

- Potential synergetic use of EnMAP and other EO missions with emphasis on land monitoring:

    1. **Other spaceborne imaging spectroscopy missions**
    2. **Optical multispectral missions: Sentinel-2 & Landsat**
    3. **ESA's Fluorescence Explorer (FLEX)**

Europe‘s Sentinel-2A multispectral mission launched in June 2015

sentinel-2

esa

ESA | OBSERVING THE EARTH | COPERNICUS | SENTINEL-2

Colour vision
· Introducing Sentinel-2

Applications
· Plant health
· Changing lands
· Water bodies
· Disaster mapping

About the mission
· Facts and figures
· Satellite constellation
· Instrument

About the launch
· Launcher
· Launch site

+ Meet the team

Operations and data
· Data flow
· Data products

ESA > Our Activities > Observing the Earth > Copernicus > Sentinel-2

SENTINEL-2 DELIVERS FIRST IMAGES

First image from Sentinel-2A

29 June 2015 Just four days after being lofted into orbit, Europe's Sentinel-2A satellite delivered its first images of Earth, offering a glimpse of the 'colour vision' that it will provide for the Copernicus environmental monitoring programme.

With a swath width of 290 km, the satellite's first acquisition began in Sweden and made a strip-like observation through central Europe and the Mediterranean, ending in Algeria.

The data were relayed in real time to Italy's Matera ground station, where teams eagerly awaited their arrival for processing.

While northern and central Europe were mostly cloudy, Italy's typical sunny weather allowed the teams to get their first glimpse of the multispectral instrument's capabilities over the northwestern part of the country and the French Riviera – and they were excited by what they saw. With a ground resolution of 10 m per pixel, the images show individual buildings in Milan, agricultural plots along the Po River, and ports along the southern French coast.

Search here

Copernicus

Sentinel-2

Sentinel data access & technical information

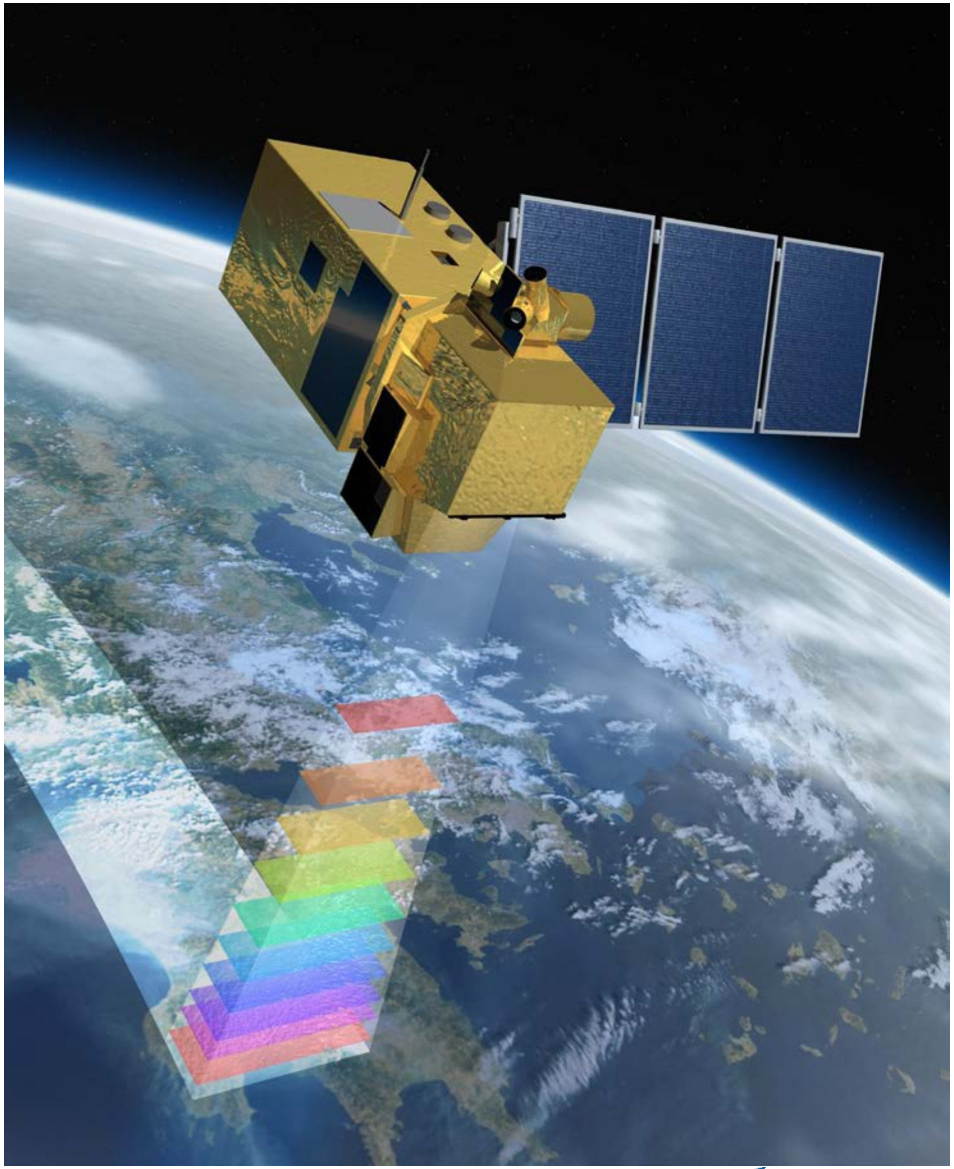
Related links
· European Commission Copernicus site
· Airbus Defence and Space

Follow us
· #Sentinel2

Series of two satellites: European‘s Landsat – high expectation because of better spatio-temporal resolution and spectral coverage than Landsat

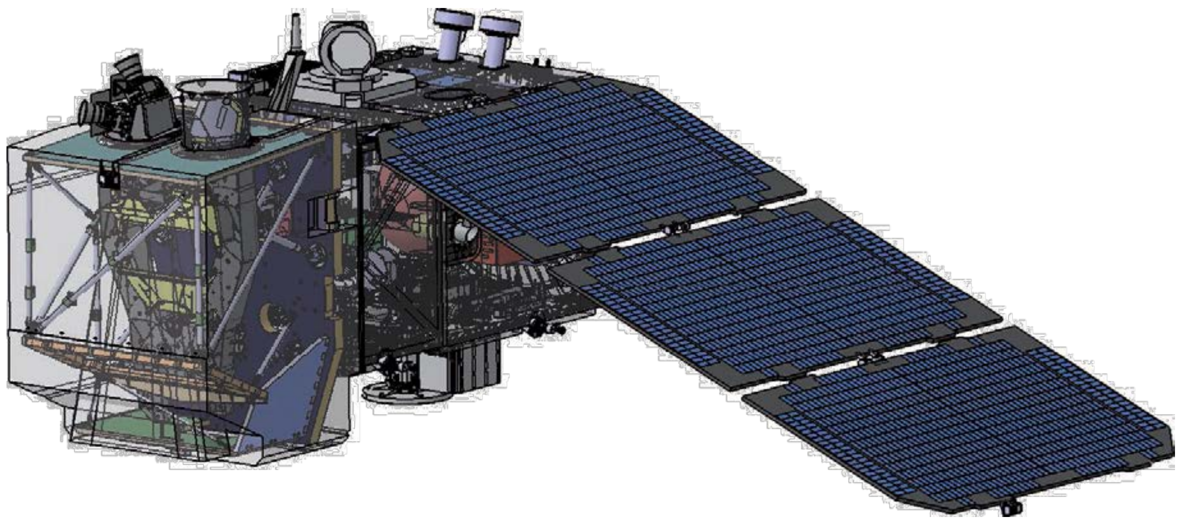
Sentinel-2 Main Applications

- Part of the EU Copernicus programme (6 different „Sentinel“ systems)
- S-2 focused on high resolution **land monitoring**:
  - land cover maps
  - maps of biogeophysical variables such as leaf chlorophyll content
  - acquisition and rapid delivery of images to support disaster relief efforts (flood, volcanoes, earthquakes,…)
- A huge amount of data with high spatial, and temporal resolution and a good spectral coverage (VIS-NIR-SWIR)



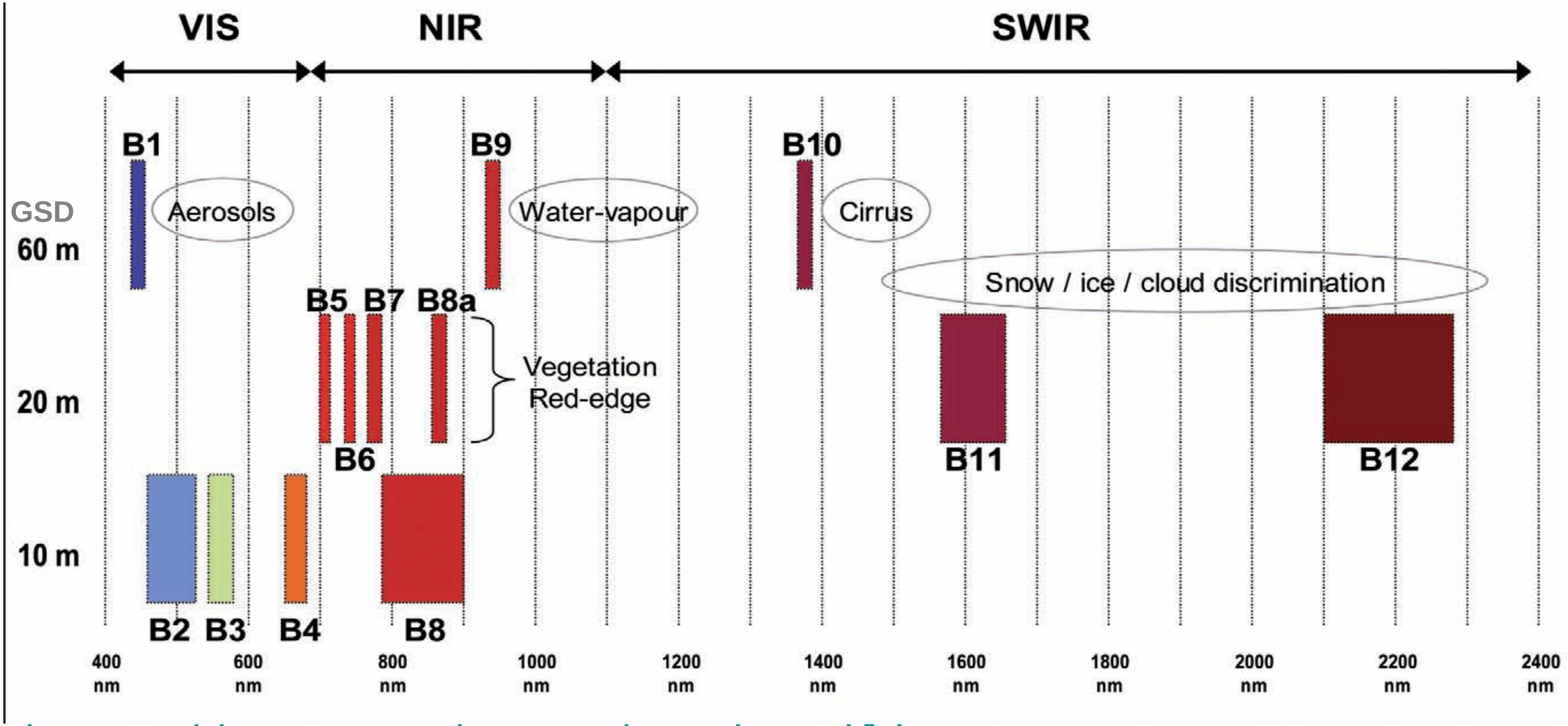
Sentinel-2 Flight Segment – Orbit Parameters

Orbit mean altitude / Type	**786 km / sun-synchronous**
Equator crossing time	**10.30 LTDN**
Coverage	**84º N / 56º S**
Swath width	**290 km**
Repeat period	**5 days based on two satellites**
Mission life time	**7 years**



Sentinel-2 Band setting

Ground sampling distance of 10, 20 or 60 m depending on spectral channel: atmospheric correction, vegetation studies and Landsat/SPOT continuity, resp.



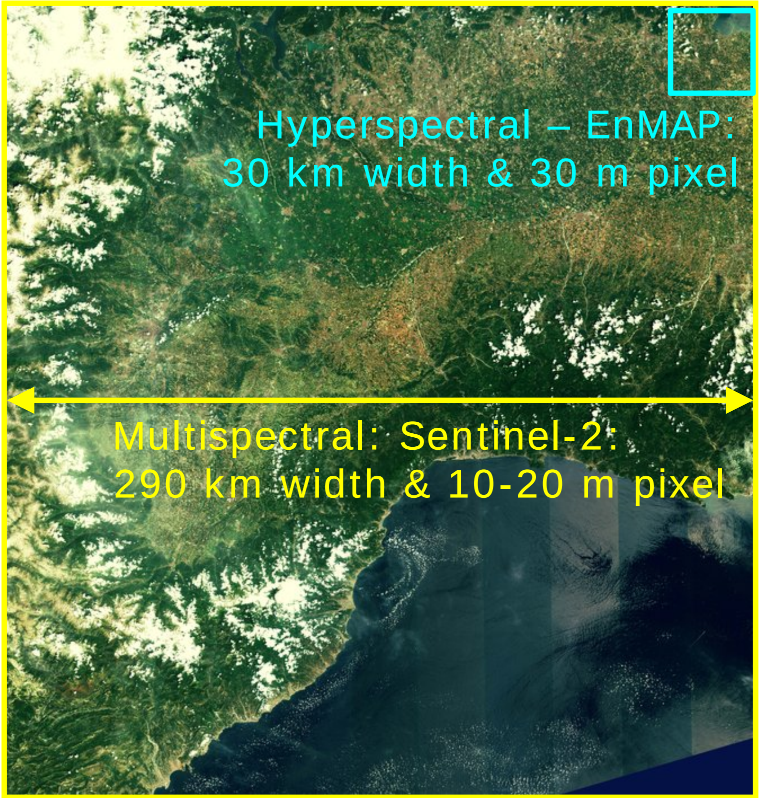
https://www.youtube.com/watch?v=jljN8_7Tz1E

EnMAP & Sentinel-2

- **Sentinel-2:**
  - (+) wide spatial coverage, high spatial and temporal resolution
  - (-) limited spectral information
- **EnMAP:**
  - (+) spectral information
  - (-) medium spatial resolution, poor spatial coverage and temporal resolution

→ Calls for **synergetic use** of both missions:

1. Data fusion to produce high spatial resolution hyperspectral data through "sharpening-like" methods
2. Hyperspectral data as a "microscope" for enhanced information over overlap areas in the multispectral images

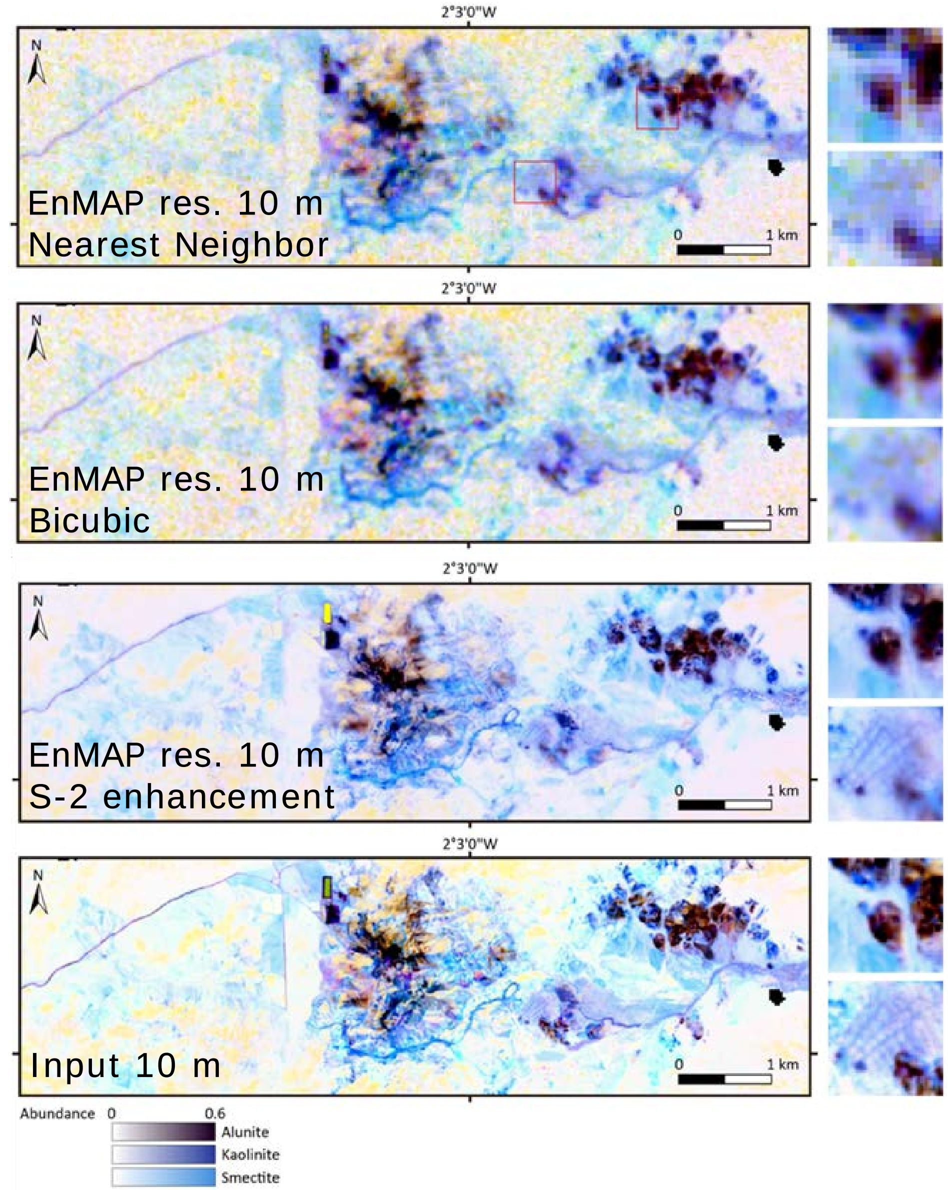


Potential synergies of EnMAP with other EO missions

- Advanced methods for data fusion needed!

- Example: Yokoya et al., RS, 2016: "*Potential of Resolution-Enhanced Hyperspectral Data for Mineral Mapping Using Simulated EnMAP and Sentinel-2 Images*"

→ Sharpening of EnMAP data to 10 m through S-2 for mineral mapping



Color composite images of continuum-removed data using spectral channels potential affected by mineral absorptions (R: 2201 nm, G: 2159 nm, B: 2115 nm)

Potential EnMAP synergies

- Potential synergetic use of EnMAP and other EO missions with emphasis on land monitoring:

1. **Other spaceborne imaging spectroscopy missions**
2. **Optical multispectral missions: Sentinel-2 & Landsat**
3. **ESA’s Fluorescence Explorer (FLEX)**

FLEX selected as ESA's Earth Explorer 8 in November 2015

observing the earth

esa

ESA | OBSERVING THE EARTH | UNDERSTANDING OUR PLANET | SECURING OUR ENVIRONMENT | BENEFITING OUR ECONOMY

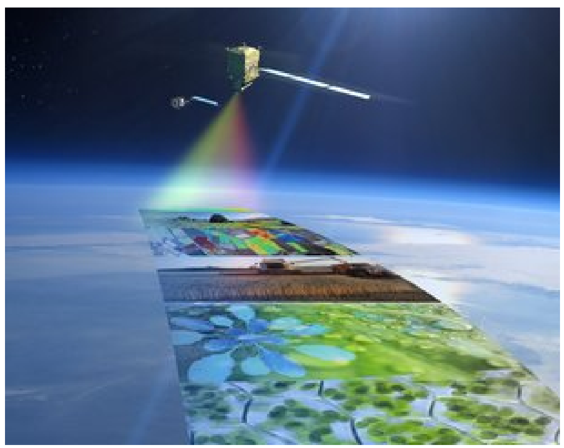
+ About Observing the Earth

EO programmes
- The Living Planet
- Copernicus

ESA's Earth Observing missions
- Envisat
- ERS overview
- Earth Explorers
- Sentinels overview
- Proba-V
- Proba-1 overview
- Third Party Missions overview

ESA > Our Activities > Observing the Earth

NEW SATELLITE TO MEASURE PLANT HEALTH



FLEX concept

19 November 2015 ESA plans to track the health of the world's vegetation by detecting and measuring the faint glow that plants give off as they convert sunlight and the atmosphere's carbon dioxide into energy.

Yielding information about the health and stress of the planet's vegetation is important as the growing global population places increasing demands on the production of food and animal feed.

Following a rigorous selection process, the satellite will be ESA's eighth Earth Explorer, planned for launch by 2022.

Search here

Earth Explorers

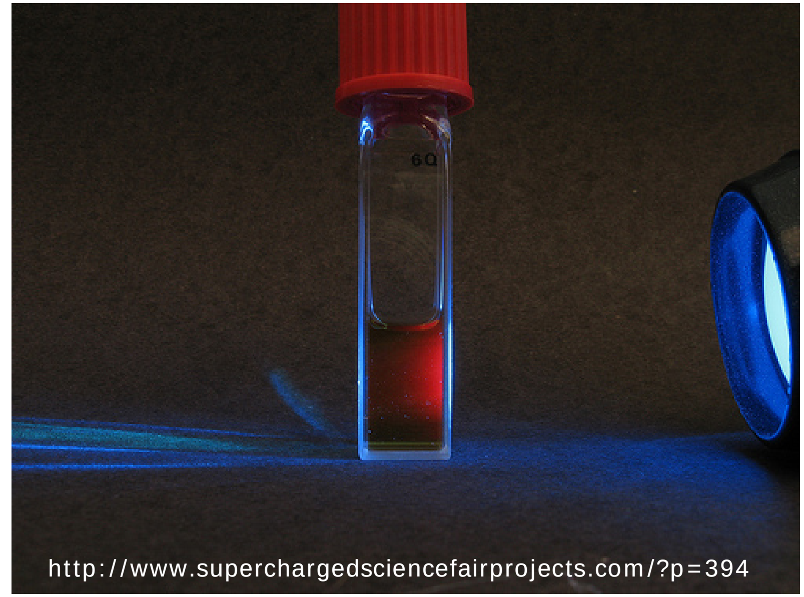
Press release
- FLEX mission to be next ESA Earth Explorer

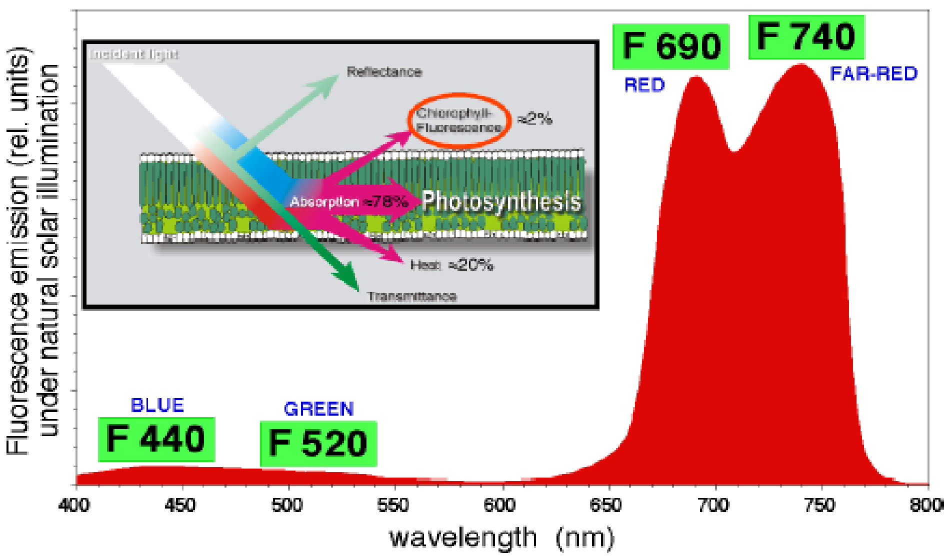
More information
- FLEX report for mission selection SP-1330
- Replay: User Consultation Meeting

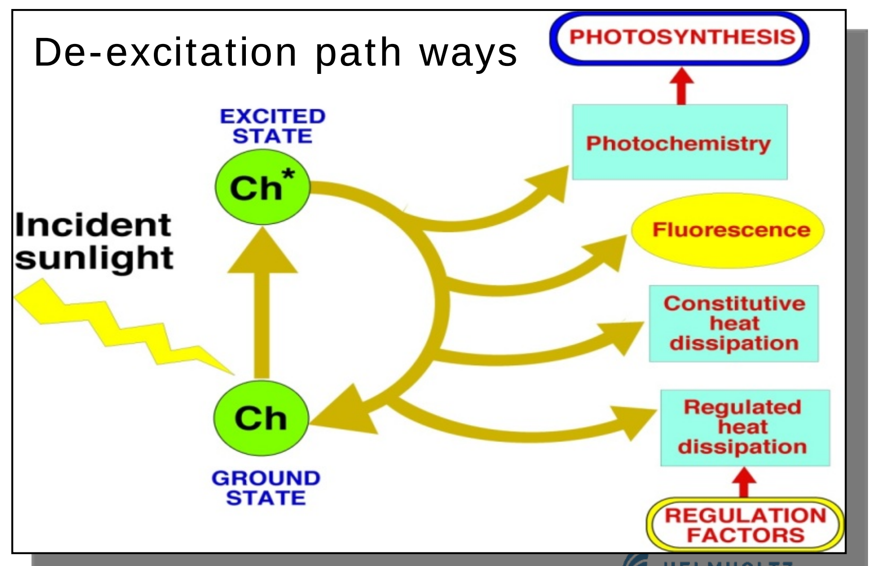
Related links
- University of Valencia-FLEX
- Forschungszentrum Jülich

Sun-induced chlorophyll fluorescence (SIF)

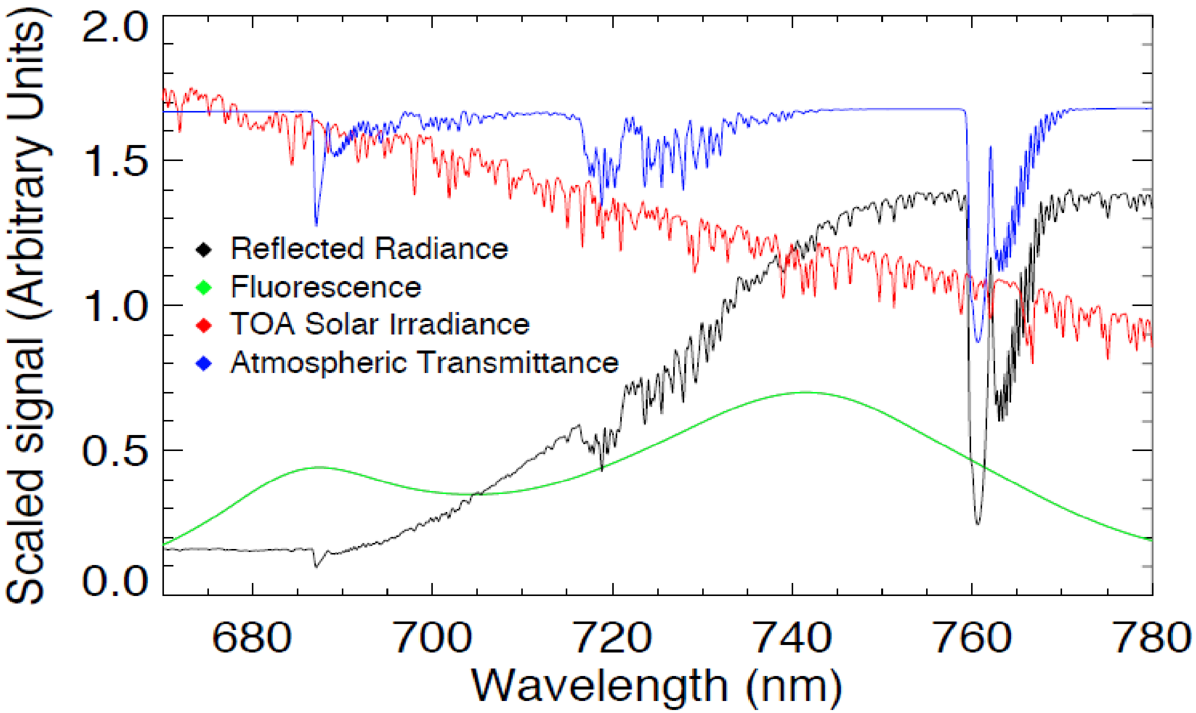
- **Sun-induced chlorophyll fluorescence (SIF)** is an electromagnetic signal emitted by the photosynthetic machinery of green plants that **can be linked to instantaneous photosynthesis**.
- **+10 year of SIF measurements from in-situ and airborne spectrometers;** first global measurements from satellites available since 2011.

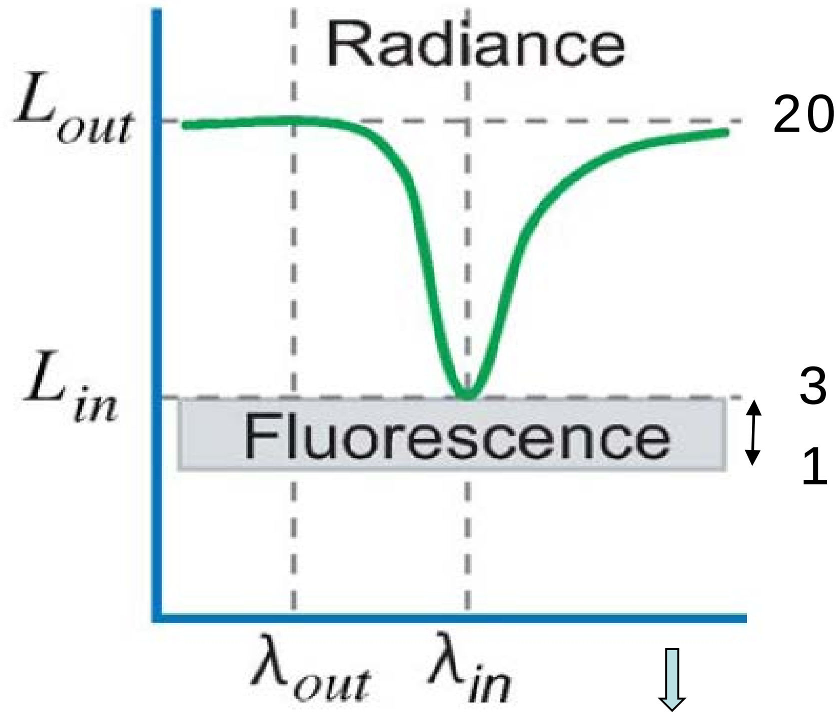






SIF retrieval: in-filling of solar and atmospheric lines





Absorption features shorten with an additive signal (e.g. SIF) → band in-filling due to SIF

High spectral resolution (ideally <0.3 nm) needed to resolve solar and atmospheric lines for SIF retrieval

Example

FD: Fractional depth, =ratio bottom/continuum

FD (SIF=0)= Li/Lo =3/20= 0.15

FD (SIF=1)=(Li+SIF)/(Lo+SIF) =4/21= 0.19

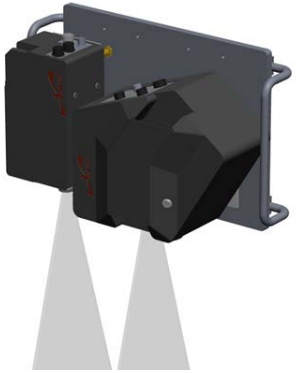
→ SIF modifies FD of absorption features

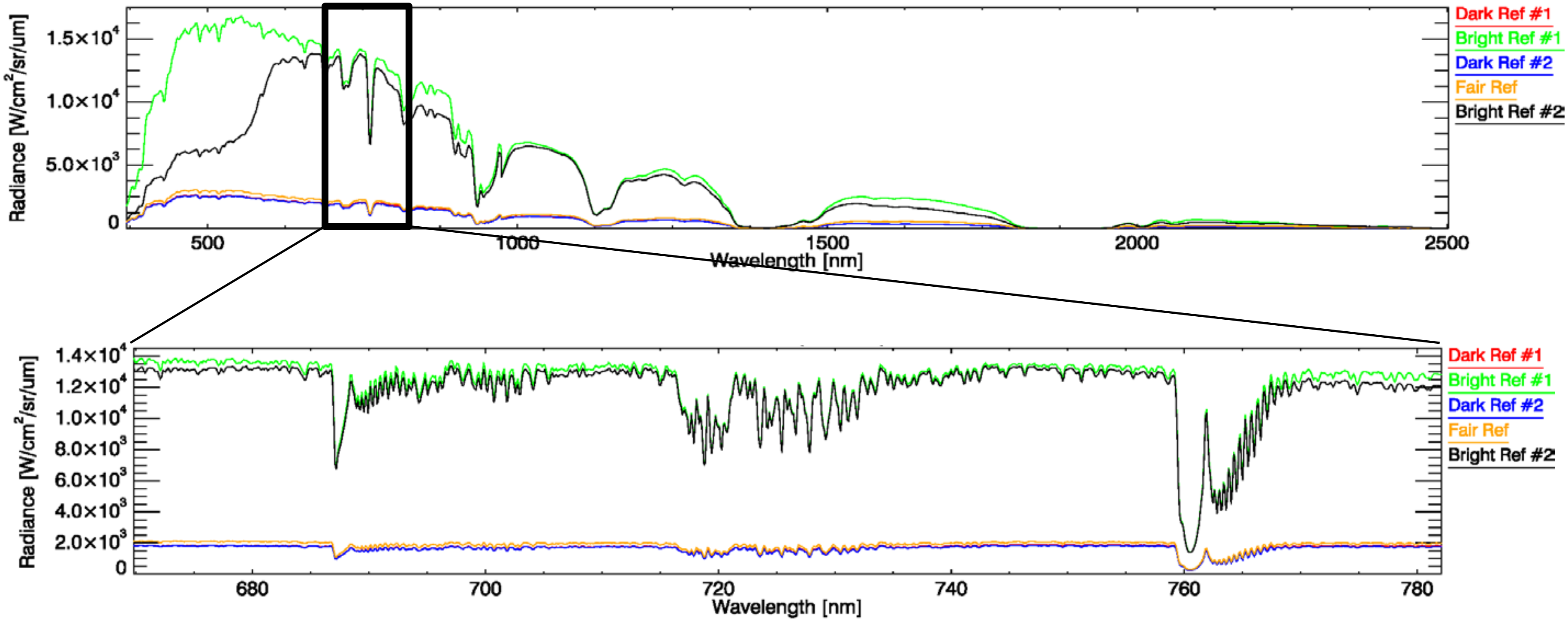
HyPlant: a high performance airborne spectrometer for SIF monitoring

Module 1: Imaging spectrometer (380 – 2500 nm) with 3 nm (VIS) and 10nm (SWIR) spectral resolution; 1-3 meters spatial resolution

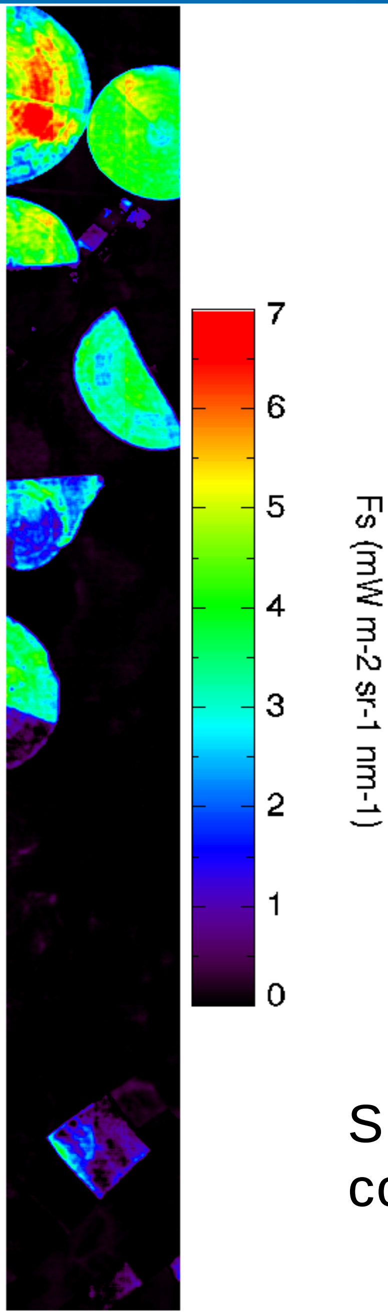
Module 2: Fluorescence module (670 – 780 nm) with 0.25 nm (FWHM) and 0.11 nm (SSI)

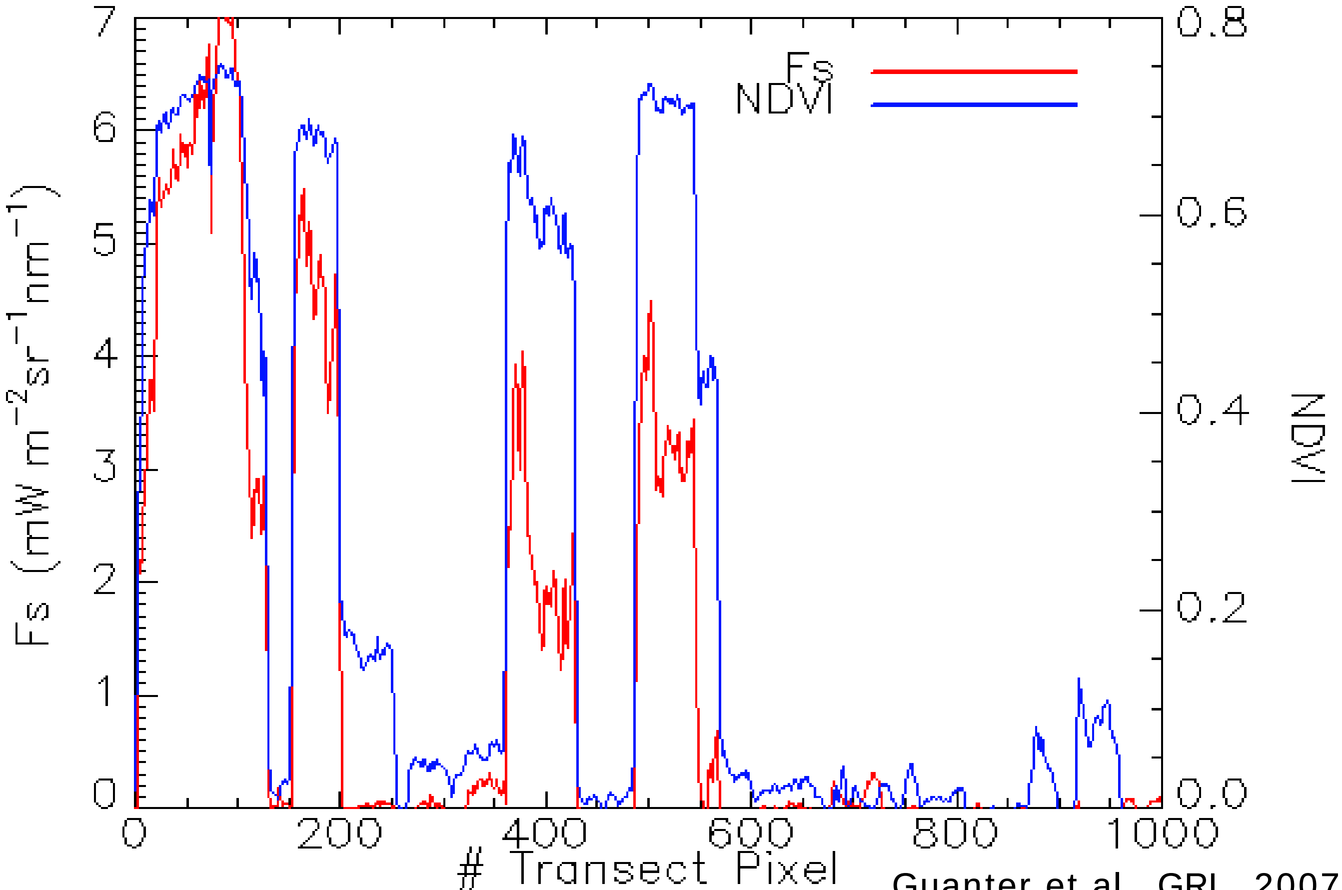
Owned and operated by FZ Jülich





Rascher et al., GCB, 2015





Guanter et al., GRL, 2007

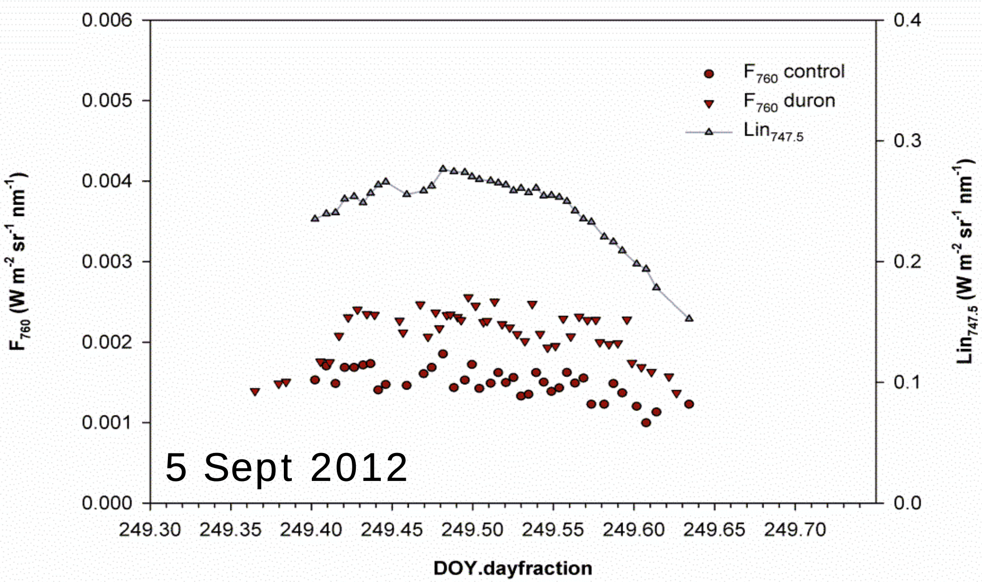
SIF and Greenness both driven by canopy chlorophyll content and structure, but not redundant

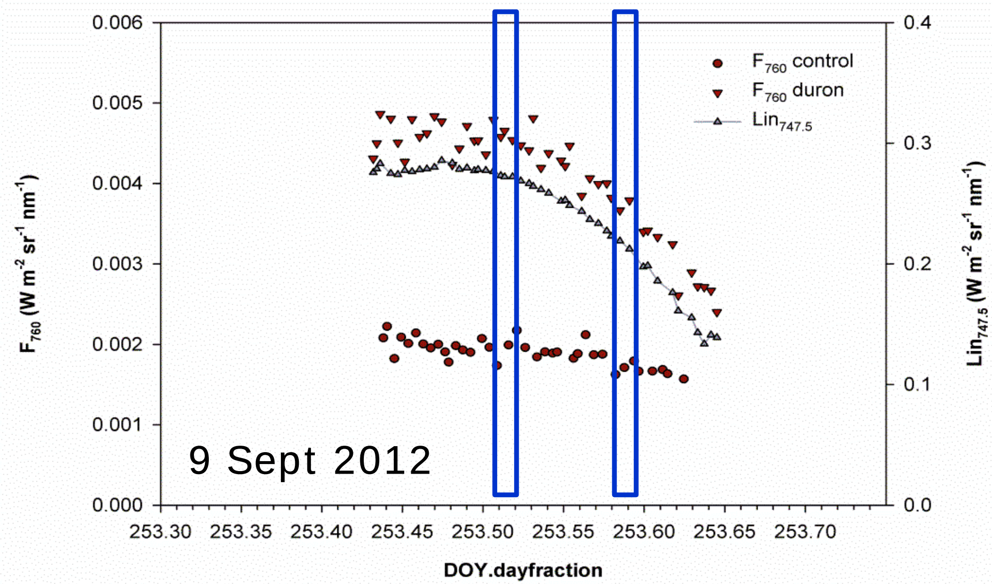
“Validation”: are we really measuring SIF? HyFLEX airborne campaign – Grassland experiment

The application of Duron treatment on 9th Sept. caused an increase of **SIF** at 760nm up to **5** mW m^{-2} sr^{-1} nm^{-1}, **more than** the **double** of “natural” SIF values

Duron blocks energy transfer in photosysnthesis without changing the pigments. Excess energy dissipated as fluorescence

Rossini et al., GRL, 2015



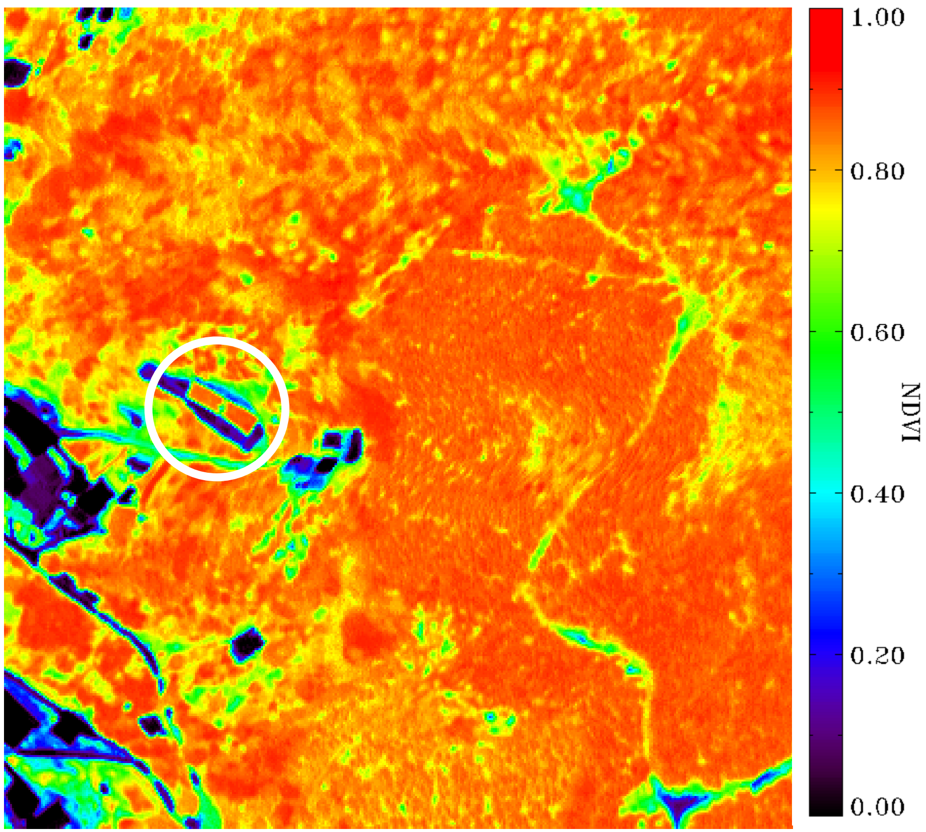


Chlorophyll fluorescence as an indicator of plant biochemistry

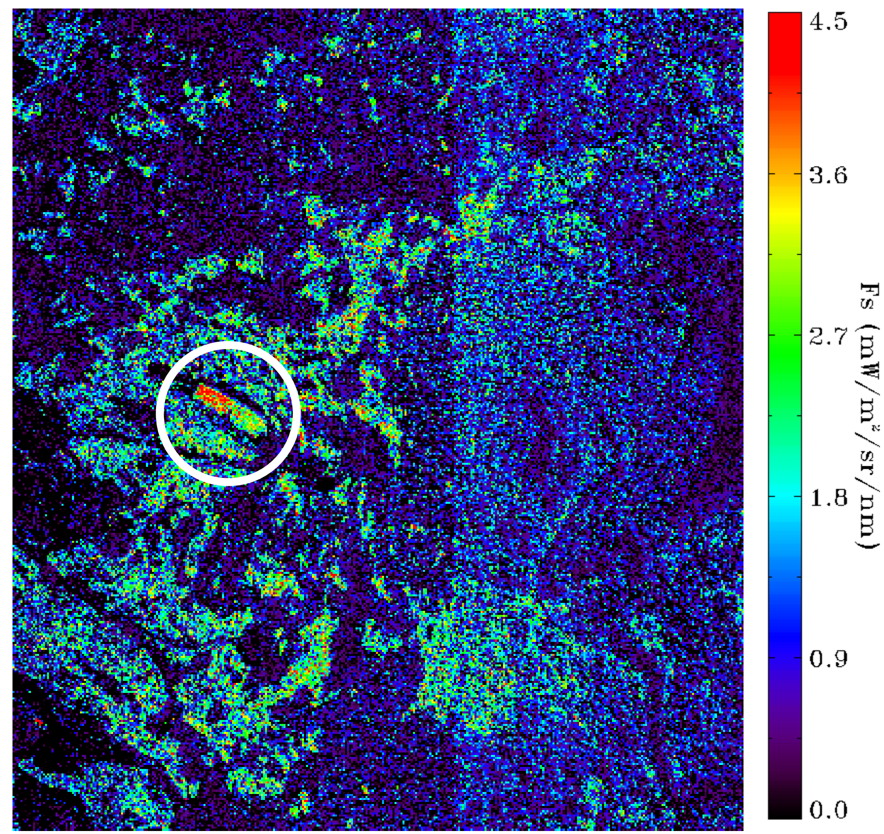
- Example: *Duron* herbicide applied to a grassland carpet → blocks energy transfer in photosynthesis without changing the pigments; excess energy dissipated as fluorescence

→ Fluorescence provides information on plant biochemical processes

"Greenness"



Fluorescence



First global maps of sun-induced fluorescence (SIF) in 2011

nature climate change

Home | Opinion & Analysis | Research | Curr

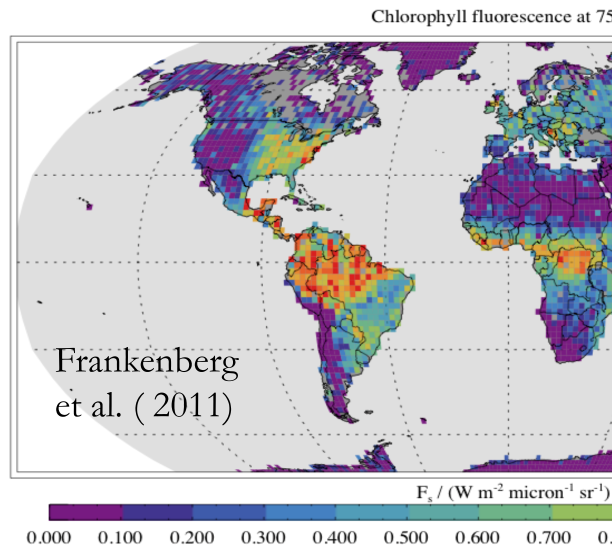
Archive > 2011 > September > Snapshot

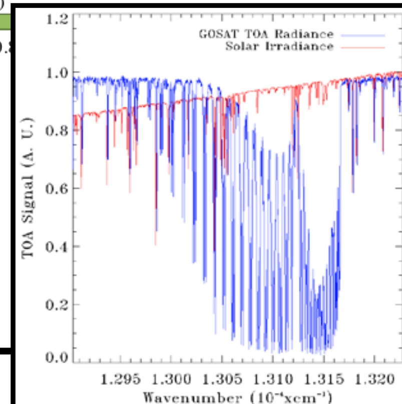
NATURE CLIMATE CHANGE | SNAPSHOT

Mapping photosynthesis

Sid Perkins

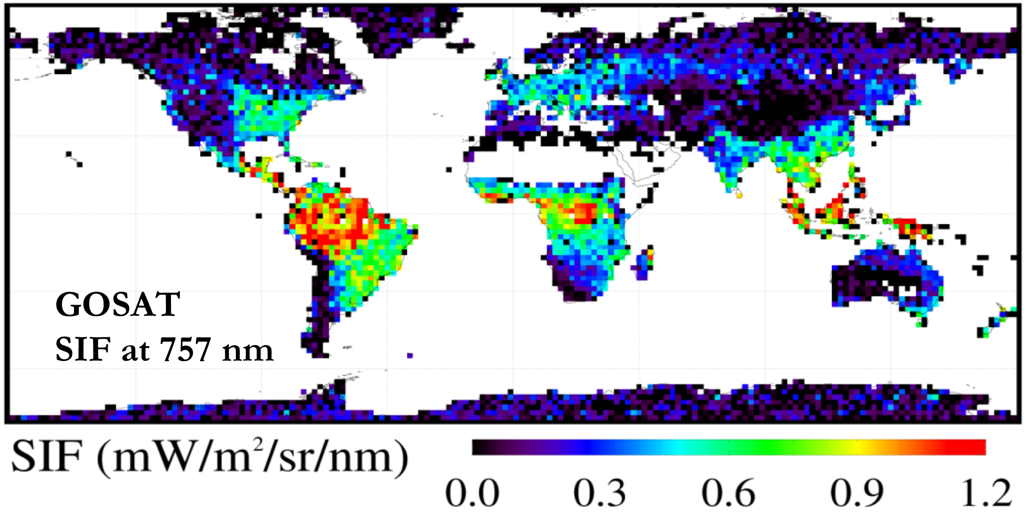
Nature Climate Change **1**, 282 (2011) | doi:10.1038/nclimate1208
Published online 26 August 2011

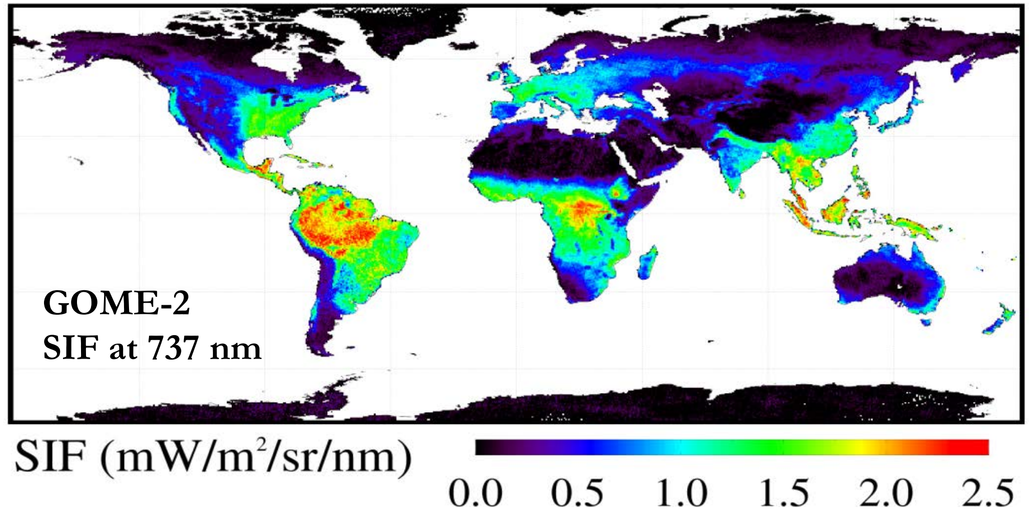


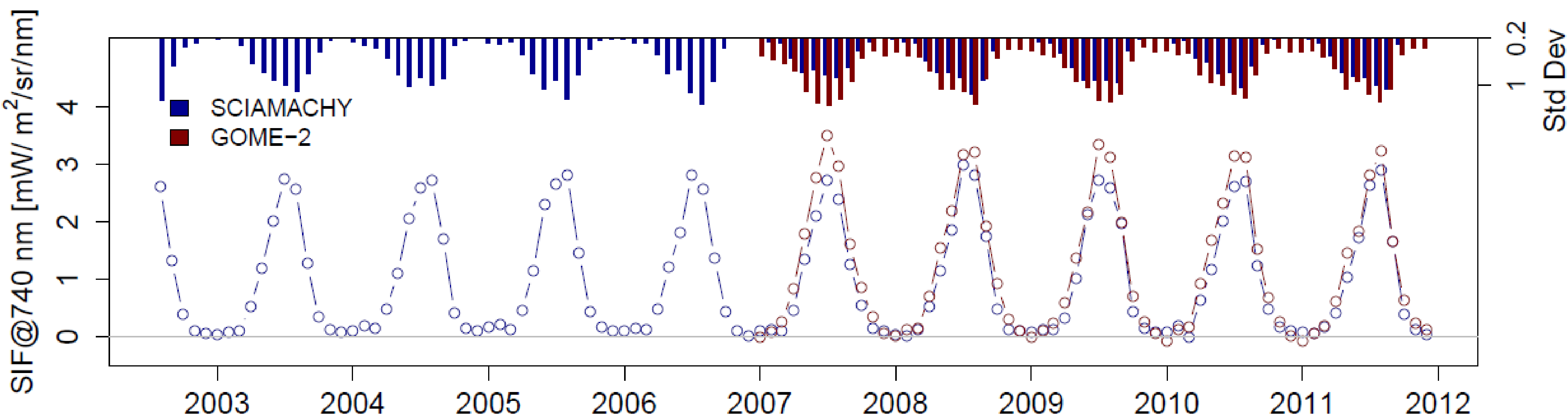


Researchers have created a global map of the fluorescence emitted by land-based plants during photosynthesis. This subtle glow at certain wavelengths could serve as an early warning system for plant stress and help scientists better understand Earth's carbon cycle.

Global SIF data sets





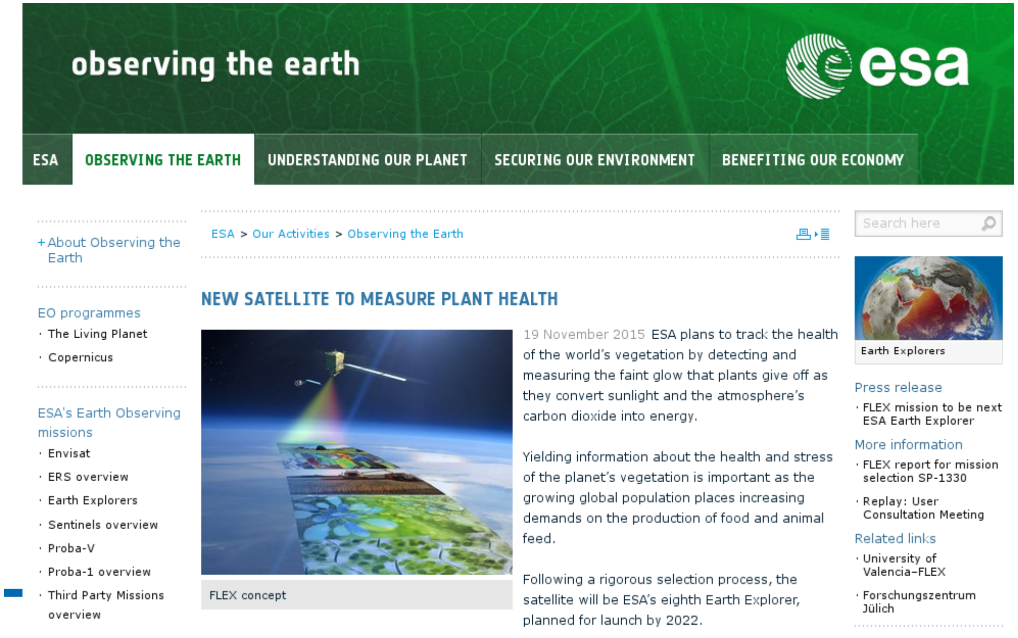


croplands between 100-80 W, 35-50 N

Upcoming missions with potential for SIF retrieval

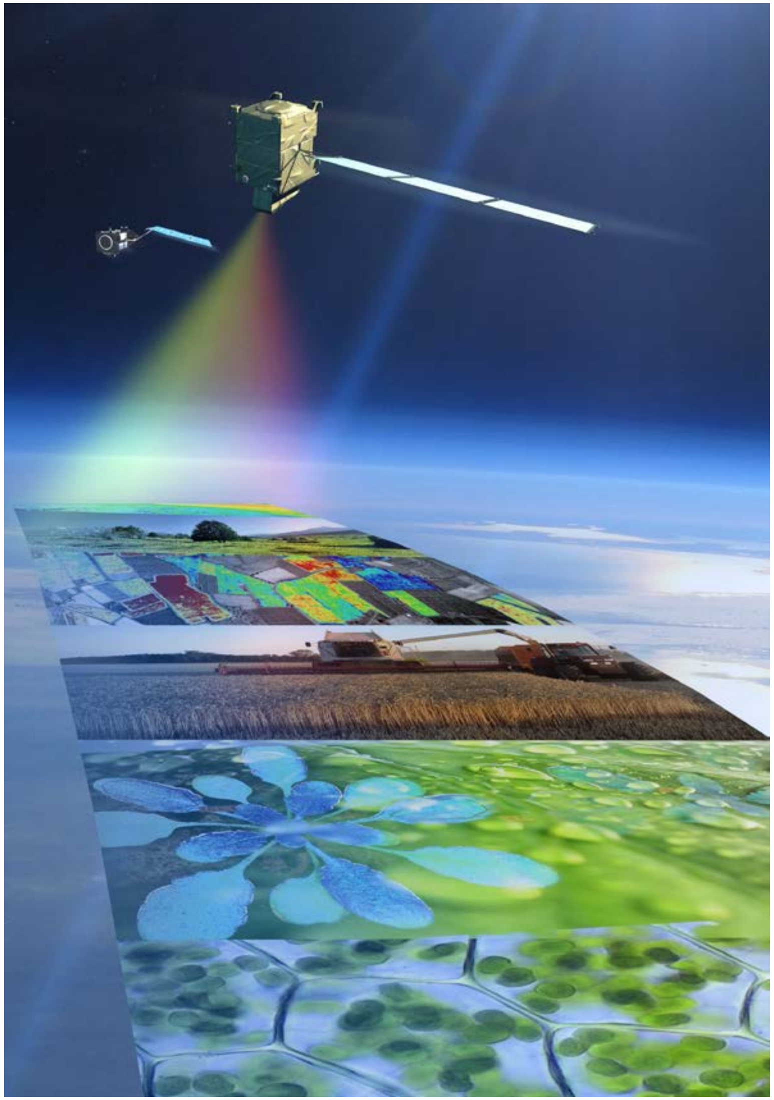
- **Bottleneck so far:** coarse spatial resolution of global composites; best: MetOp/GOME-2, 0.5º~50km/pixel.
- **Promising scenario for fluorescence monitoring in the near future:**
  - Sentinel-5 Precursor (ESA/Copernicus/KNMI/SRON), ~end 2016
  - ESA Earth Explorer 8th FLEX, launch >2022

	GOME-2	S5P/TROPOMI
Data since/from	Jan 2007	End 2014
Overpass time	Morning	Midday
Spectral coverage	650–790 nm	675–775 nm
Spatial sampling	Continuous	Continuous
Spatial resolution of single measurements	40×80 km^2	**7×7 km^2**
Spatial resolution of global composites	0.5°	**0.1°**
Sensitivity of SIF retrieval to cloud contamination	High	Medium
Approx. number of clear-sky observations per day	3,500	**~400,000**



FLEX: ESA's Fluorescence Explorer

- First EO mission **designed to measure and exploit fluorescence data**.
- **Goal:** full characterization of terrestrial photosynthetic processes through SIF and ancillary measurements (PRI, pigments, temperature, ...).
- **Features:**
  - High spectral resolution spectrometer (FWHM~0.3-3 nm) in 500-800 nm
  - 300 m pixel & 100 km swath
  - Expected launch ~2022
- *(if co-existing!)* **A fusion of FLEX and EnMAP data** could be used for
  - sub-pixel analysis of vegetation biochemical parameters
  - Potential for down-scaling of products from 300 to 30 m.



A look into the future of imaging spectroscopy:

Contribution to operational EO programmes and topics of direct societal impact

Copernicus

Europe's eyes on Earth

Potential contribution of imaging spectroscopy to operational EO programmes

Added-value HSI wrt MSI

- Land-cover/Land-use mapping
- Vegetation
  - Productivity & photosynthetic
  - Plant functional types & ecosystem composition
  - Plant biochemistry (pigments, liquid water content)
- Geology and soils
  - Mineral composition and abundance
  - Organic content in soils
- Inland and coastal waters
  - Chlorophyll and secondary pigments
  - Phytoplankton composition
- Hazards
  - Hydrocarbon content (plastic debris, oil spills)
  - Industrial CH4 emissions
  - Pollutants (e.g. acid mine waste)
  - Volcanic lava flow
- Cryosphere – snow composition
- Urban – materials & energy

Current Copernicus Land & Emergency Management Services

Global Copernicus Monitoring Services	
Vegetation	Biochemical composition, structural parameters
Water	Water quality parameters
Energy	Directional albedo, TOC-R
Pan-European Copernicus Monitoring Services	
CORINE Land Cover	Land cover information at fine classification level (down to level of plant compositions, materials)
Local Copernicus Monitoring Services	
Urban Atlas	Urban land cover classes (down to material level), imperviousness
Riparian Zones	Riparian ecosystem composition
Natura 2000	Ecosystem composition, biodiversity variables
Copernicus Emergency Management Services	
Natural and man-made disaster response	Mine waste, oil spills, CH4 emission, hydrocarbons

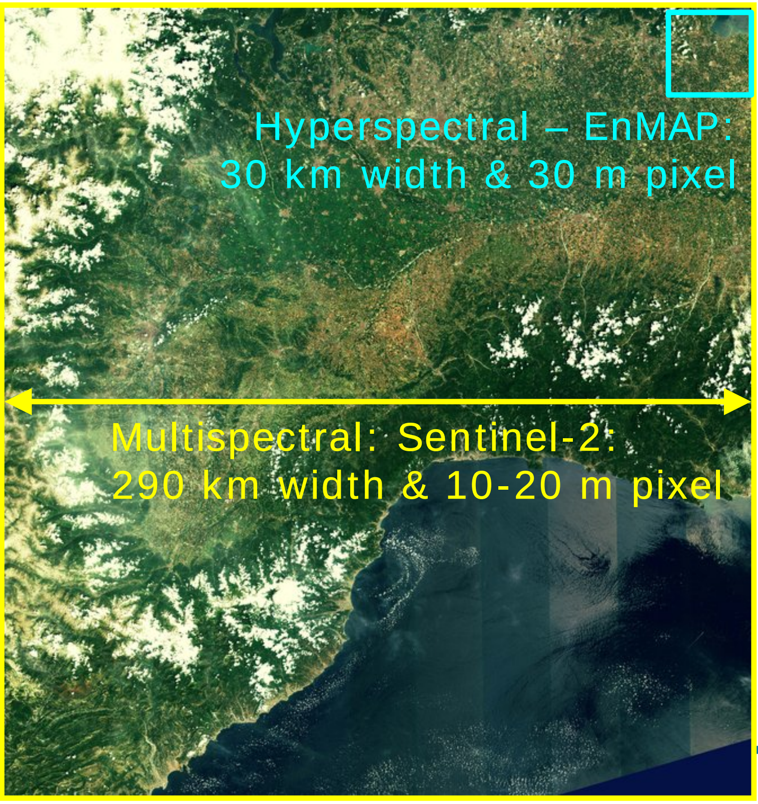
2016-2025 GEOSS Societal Benefit Areas

GEOSS Societal Benefit Areas	
Biodiversity and Ecosystem Sustainability	Plant functional types and ecosystem composition, biodiversity variables
Energy and Mineral Resources Management	Mineral abundances, biomass as energy resource
Food security and Sustainable Agriculture	Crop biochemical composition, photosynthetic functioning, structural parameters Soil mineralogy, texture, organic carbon, soil moisture
Water Resource Management	Water quality, snow properties
Sustainable urban development	Urban land cover classes (down to material level), imperviousness
Disaster resilience	Mine waste, oil spills, CH4 emission, hydrocarbons

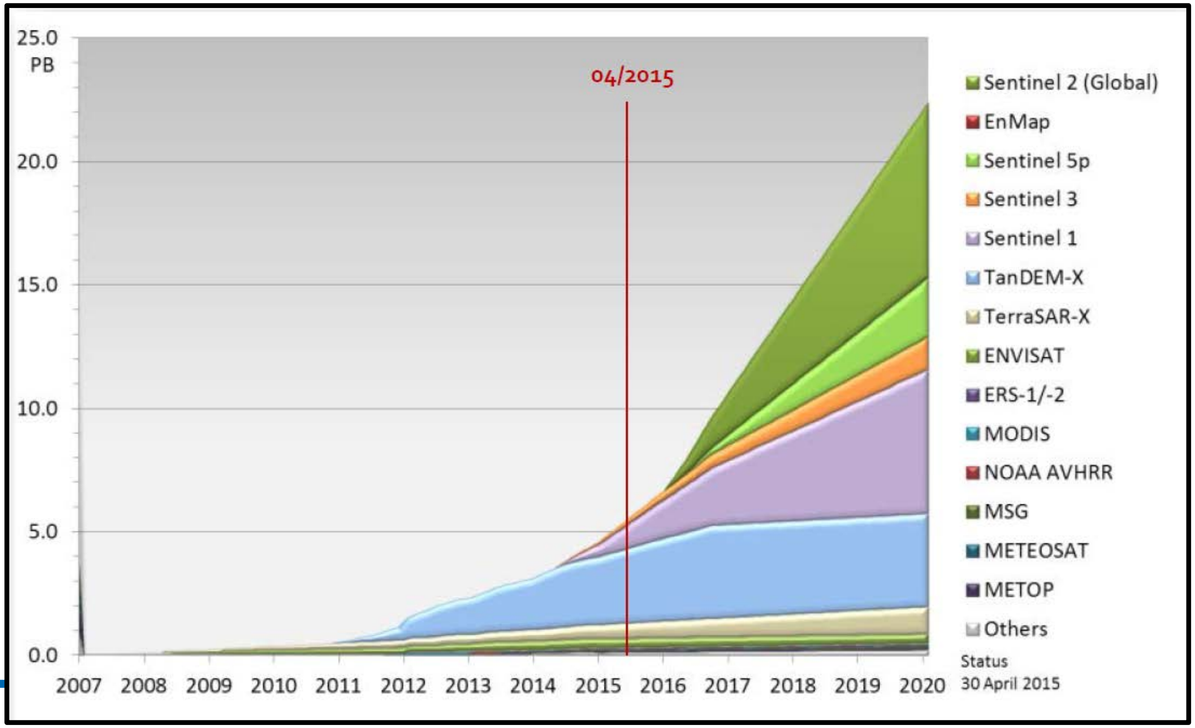
A look into the future of imaging spectroscopy

- **Mid-term objective**: hyperspectral remote sensing to replace/complement multispectral systems for operational monitoring services.
- **Operational monitoring services** (e.g. EC Copernicus Earth Observation programme): Earth observation data products providing key information for a number of society-relevant areas.
- High spatial and temporal resolution measurements required (and hence enormous amount of data): bottleneck for hyperspectral technology → **First steps to investigate technical feasibility started in Germany and Europe.**

Copernicus' Sentinel-2 first image, 29 June 2015



Projection of expected amount of data from existing and future EO missions



Summary

- **Imaging spectroscopy:** state-of-the-art technology for the monitoring of the Earth's land surface.
- Enables **"mapping" of key bio-geophysical and geochemical parameters** in a wide range of disciplines including geology, water, vegetation and hazards.
- **EnMAP** has become the most promising mission for the international community.
- Large potential for **synergies with Sentinel-2 and FLEX** missions.
- Big expectations for imaging spectroscopy to contribute to **operational Copernicus services** in the near future.

Summary

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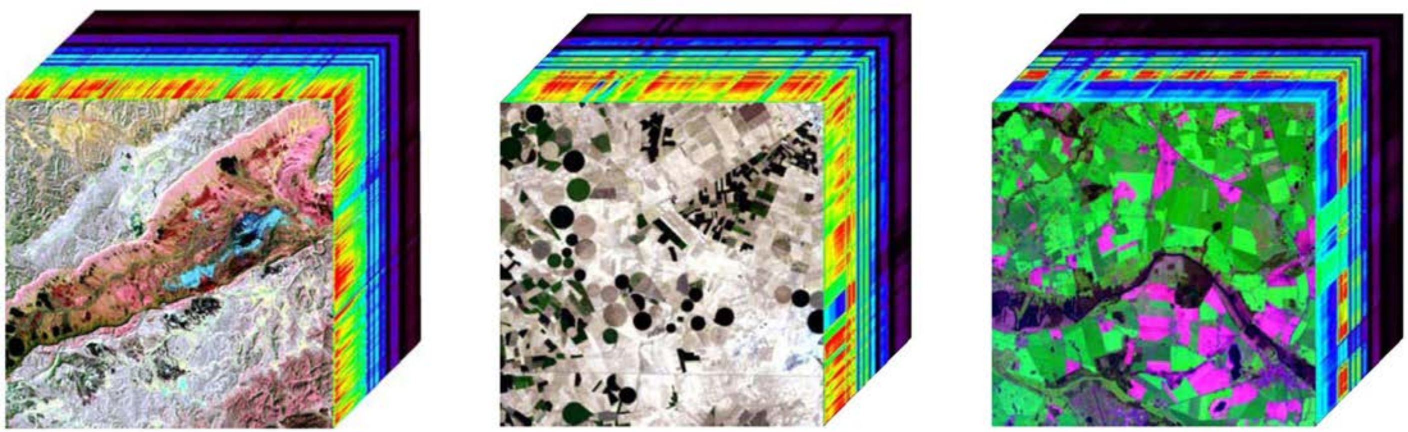

Thank you for your attention!!

GFZ Helmholtz Centre Potsdam

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