EnMAP – Environmental Mapping and Analysis Program

www.enmap.org

Mathias Schneider

Mission Objectives

- Regular provision of high-quality calibrated hyperspectral data
- Precise measurement of ecosystem parameters (agriculture, forestry, soil and geological environments, coastal zones and inland waters)
- Improved modeling of biospheric and geospheric processes
- Retrieval of presently undetectable diagnostic parameters
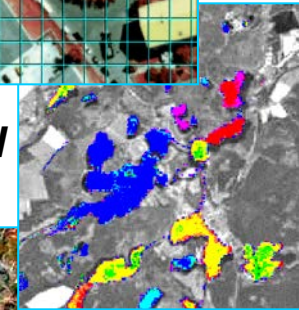
management of agricultural and forest ecosystems
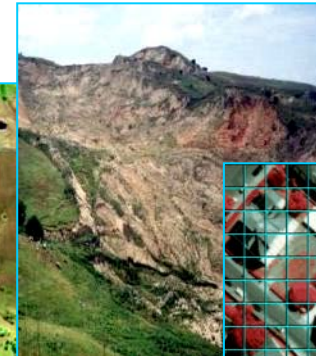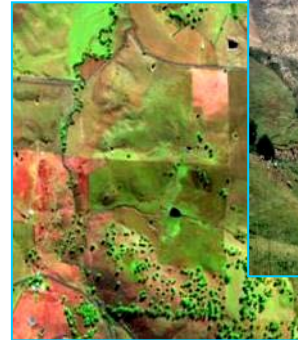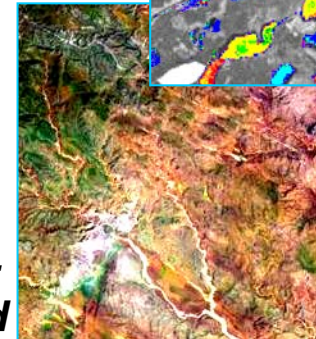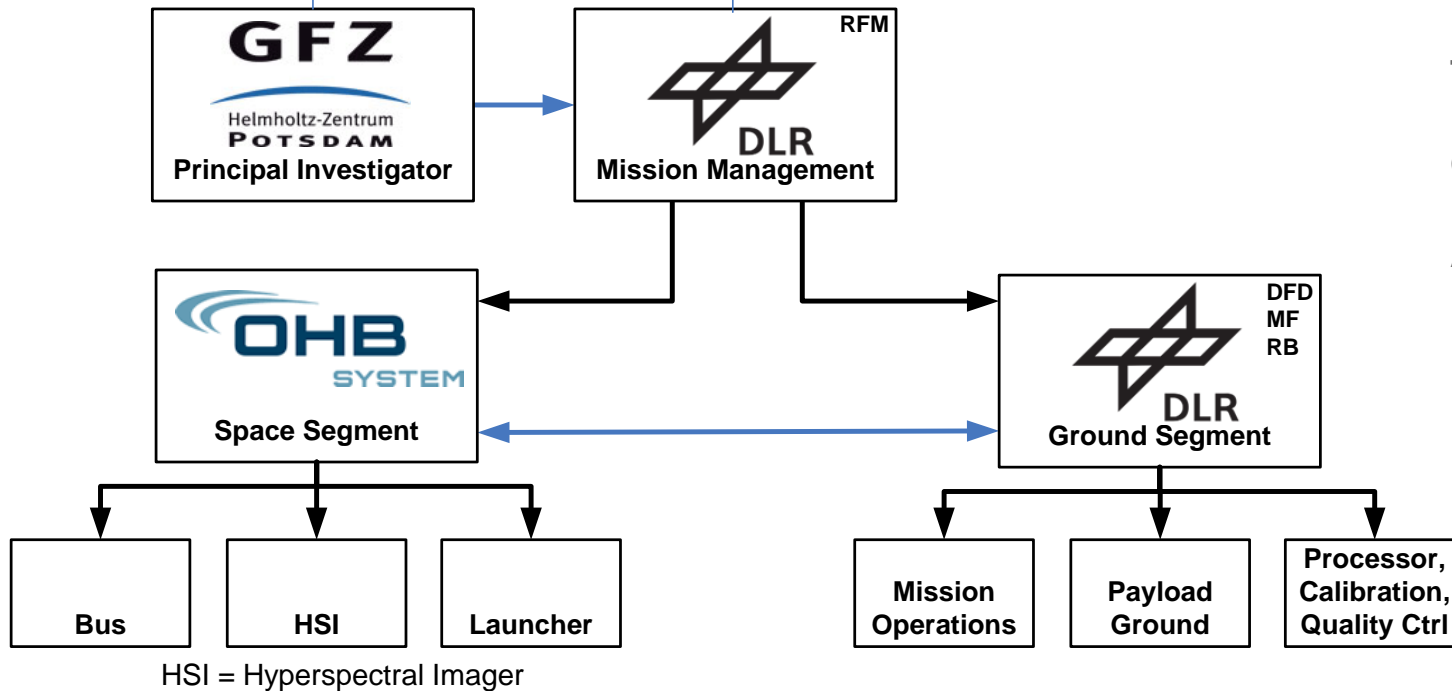
hazard assessment
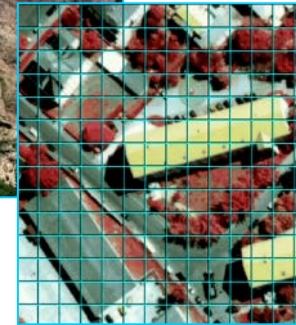
urban develop-ment

inland water

dry-land degradation

Mission Organization and Status

GFZ Helmholtz-Zentrum POTSDAM
Principal Investigator

DLR (RFM)
Mission Management

The EnMAP Program is funded by the German Federal Ministry of Economic Affairs and Technology

OHB SYSTEM
Space Segment

DLR (DFD, MF, RB)
Ground Segment

Bus

HSI

Launcher

Mission Operations

Payload Ground

Processor, Calibration, Quality Ctrl

HSI = Hyperspectral Imager

Indian PSLV (Polar Satellite Launch Vehicle) rocket in Sriharikota, India

Critical Design Reviews
GS   SS   Lab   Launch   Initial   Routine

2010   2012 Pre-F.-Cal.   2019   In-F.-Cal.   2023

Sensor Parameters

SWIR FOV
900 nm< λ < 2450 nm
(155 spectral bands 134 transmitted)

VNIR FOV
420 nm< λ < 1000 nm
(94 spectral bands)

Satellite Ground Track

FOV Separation: 600m

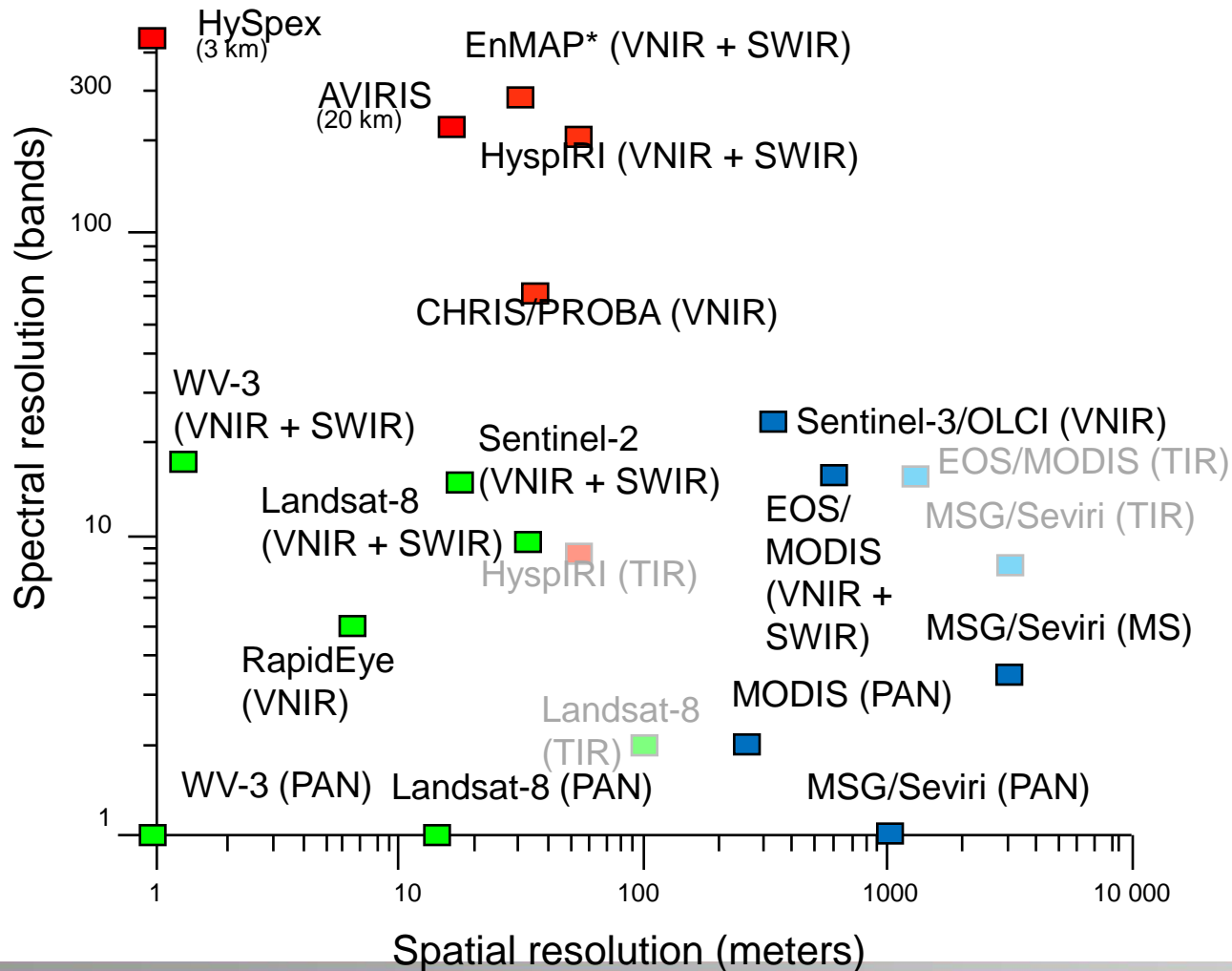**Pointing Range:** +/- 30° off-nadir
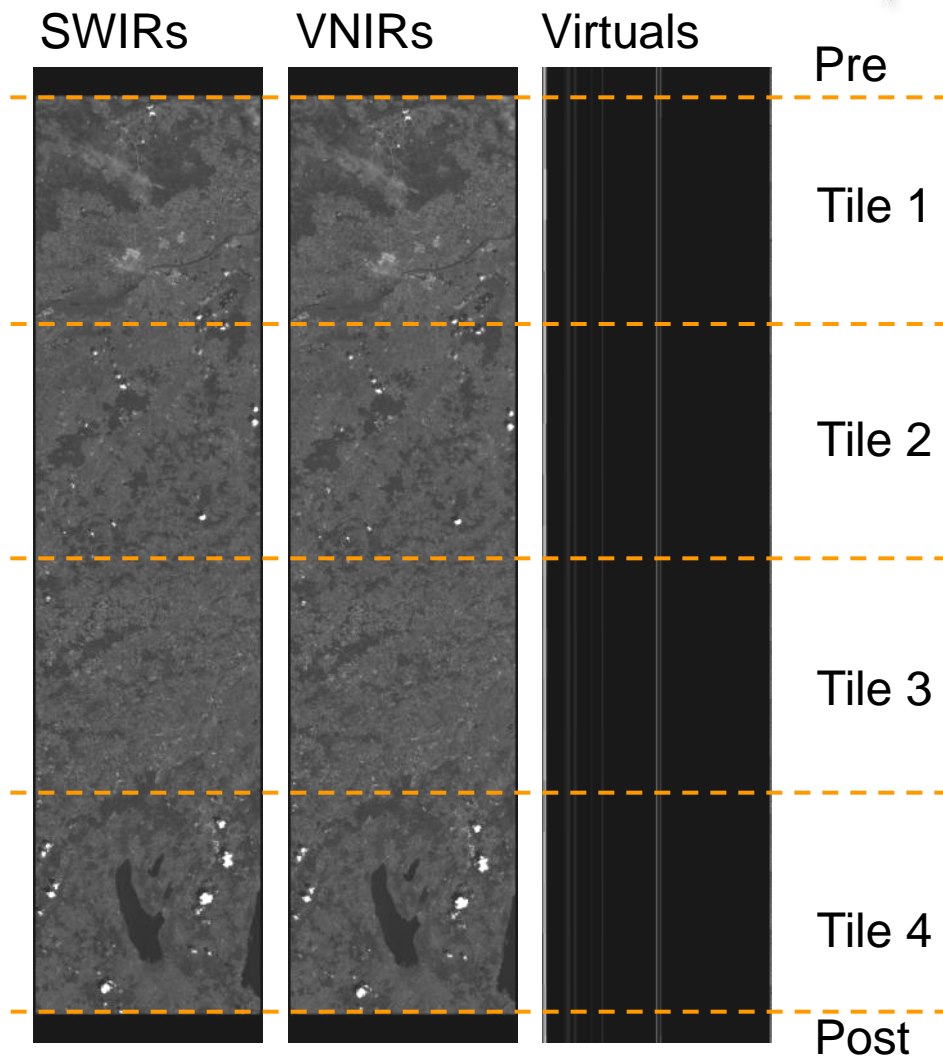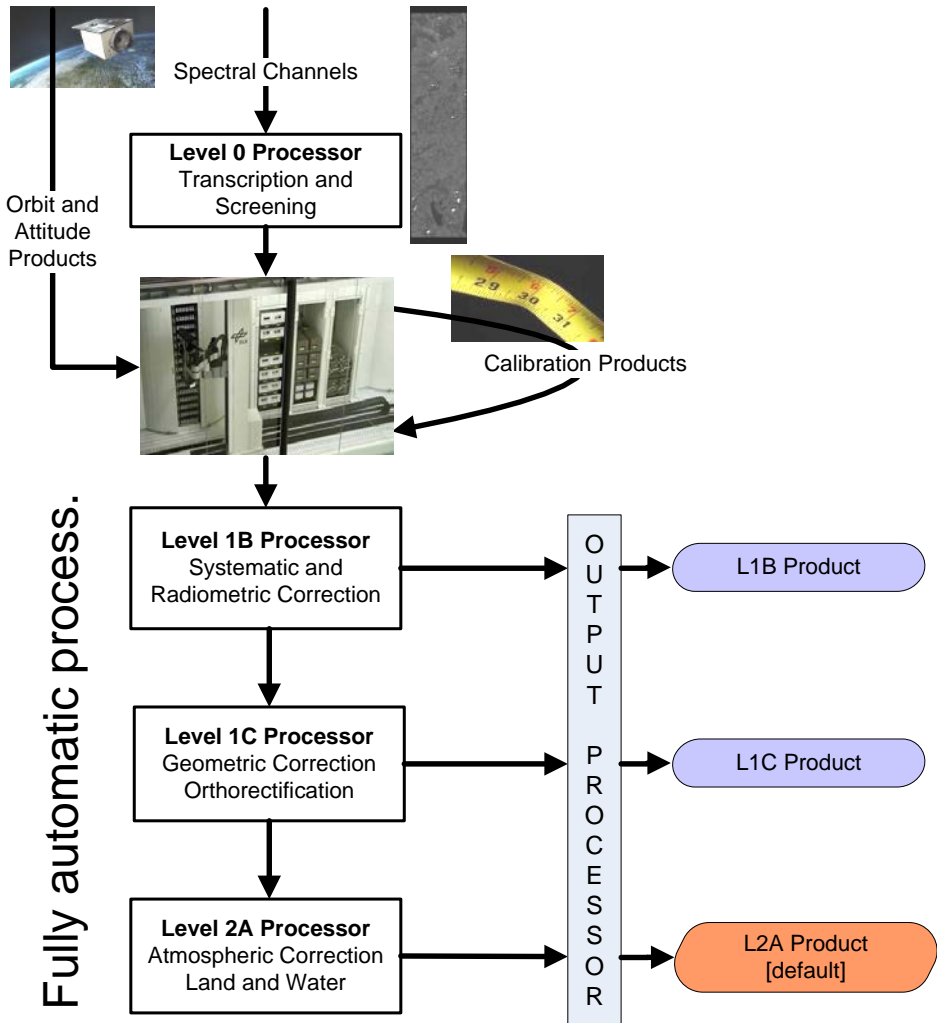
Ground Pixel: 30 m x 30 m

Swath: 30km wide
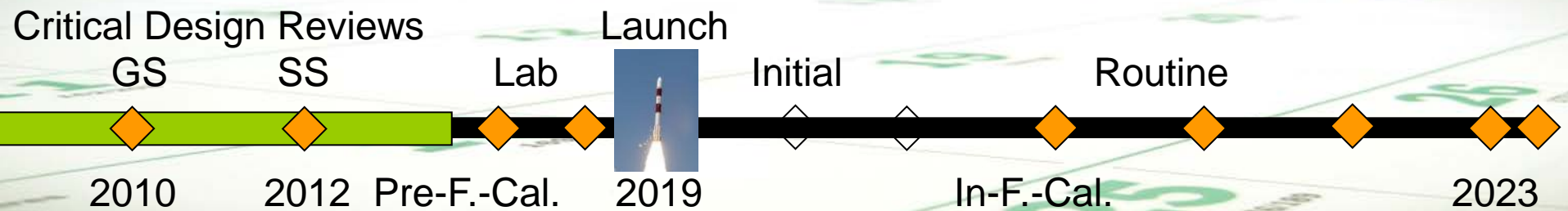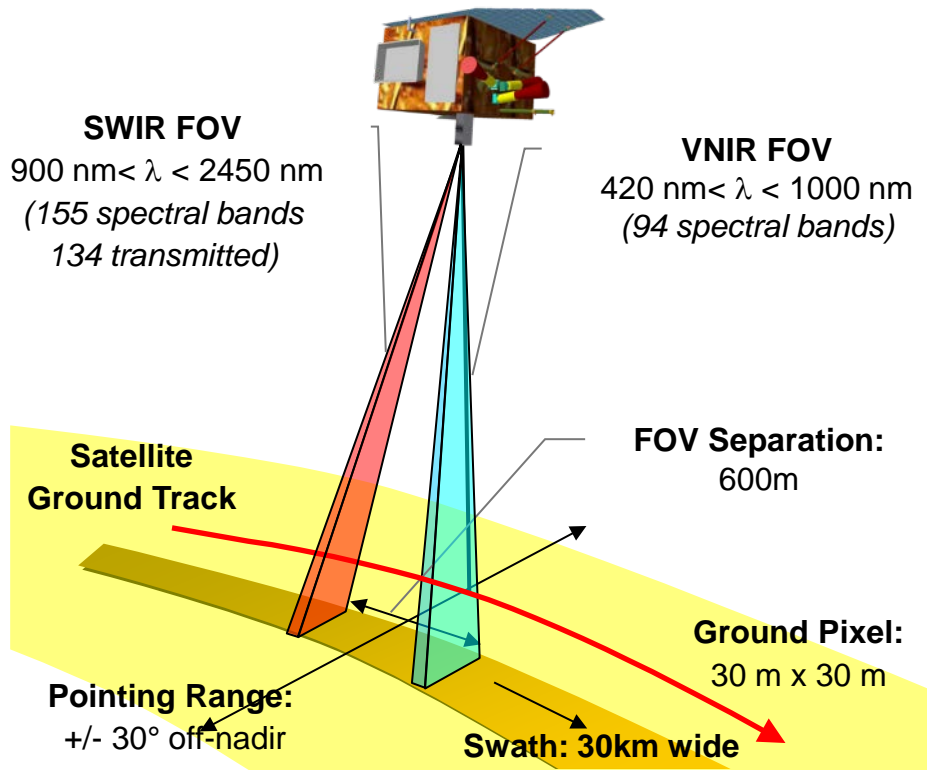
- Pushbroom type hyper spectral imager
- Wavelength 420 - 2450 nm
- 30m GSD, 30 km swath (nadir)
- 228 spectral bands
- VNIR 6.5 nm sampling
  SWIR 10 nm sampling
- SNR VNIR > 500 @ 495 nm,
  SWIR > 150 @ 2200 nm
- Polarization sensitivity < 5%
- Smile and Keystone < 0.2 pix
- Pointing knowledge 100m
- Radiometric accuracy 5%
- Radiometric stability 2.5%
- Response Linearity 0.5%
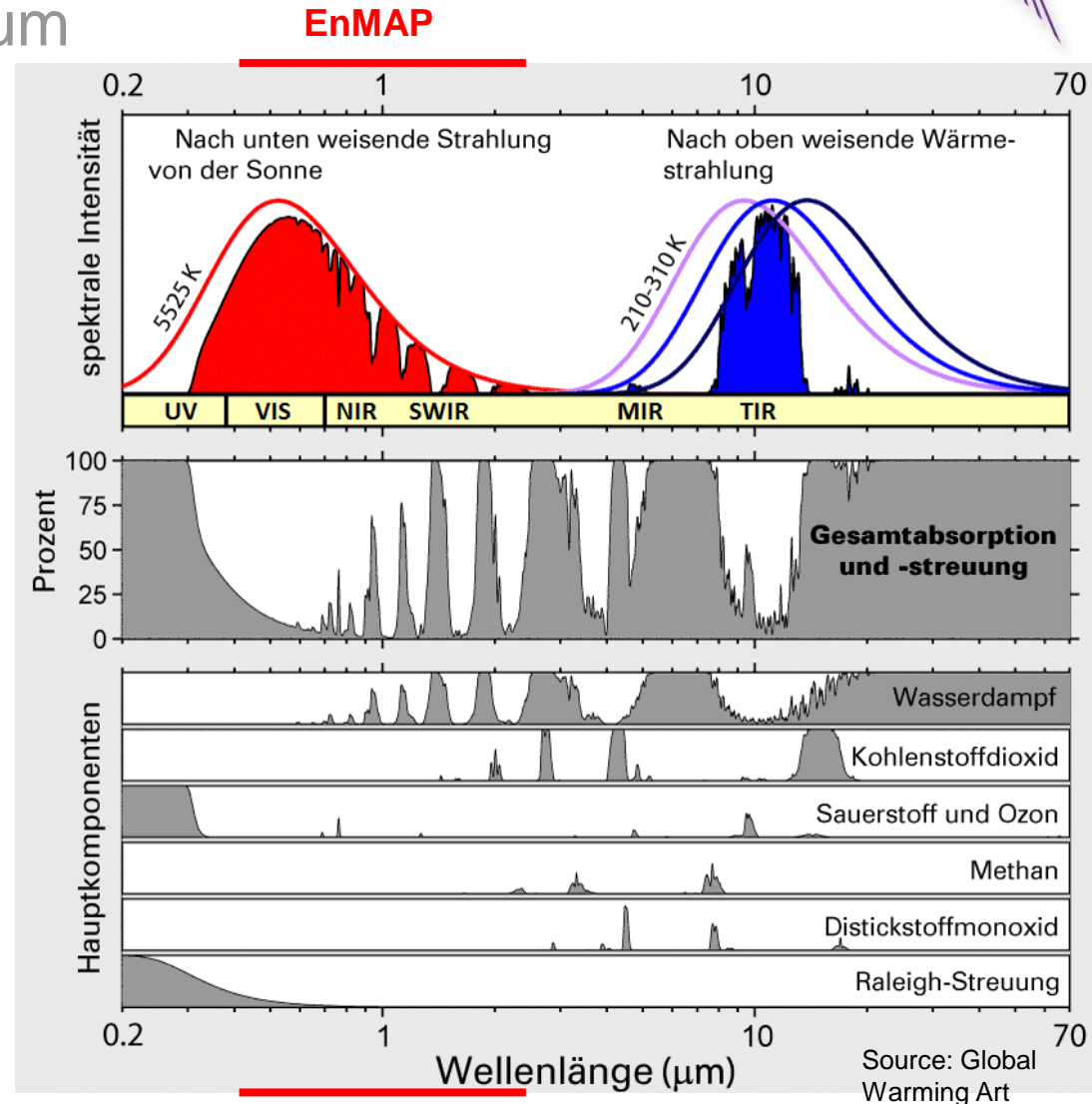- Spectral accuracy 0.5nm / 1nm

EnMAP vs. other Optical EO Missions

Chart: Spectral resolution (bands) vs. Spatial resolution (meters)

Y-axis: Spectral resolution (bands) — 1, 10, 100, 300

X-axis: Spatial resolution (meters) — 1, 10, 100, 1000, 10 000

Data points labeled:
- HySpex (3 km)
- EnMAP* (VNIR + SWIR)
- AVIRIS (20 km)
- HyspIRI (VNIR + SWIR)
- CHRIS/PROBA (VNIR)
- WV-3 (VNIR + SWIR)
- Sentinel-2 (VNIR + SWIR)
- Sentinel-3/OLCI (VNIR)
- EOS/MODIS (TIR)
- MSG/Seviri (TIR)
- Landsat-8 (VNIR + SWIR)
- HyspIRI (TIR)
- EOS/ MODIS (VNIR + SWIR)
- MSG/Seviri (MS)
- RapidEye (VNIR)
- MODIS (PAN)
- Landsat-8 (TIR)
- WV-3 (PAN)
- Landsat-8 (PAN)
- MSG/Seviri (PAN)

* similar: Hyperion/EO-1, PRISMA, HISUI/ALOS-3

DLR

EnMAP Products

SWIRs   VNIRs   Virtuals

Pre

Tile 1

Tile 2

Tile 3

Tile 4

Post

Spectral Channels

Level 0 Processor
Transcription and Screening

Orbit and Attitude Products

Calibration Products

Level 1B Processor
Systematic and Radiometric Correction

O U T P U T   P R O C E S S O R

L1B Product

Level 1C Processor
Geometric Correction Orthorectification

L1C Product

Level 2A Processor
Atmospheric Correction Land and Water

L2A Product [default]

Fully automatic process.

Elektromagnetic Spectrum

- UV (ultraviolet)
  - 100 nm – 380 nm
- VIS (visible)
  - 380 nm – 780 nm
- NIR (near infrared)
  - 780 nm – 1000 nm
- SWIR (short wave infrared)
  - 1000 nm – 3000 nm
- MIR (mid infrared)
  - 3000 nm – 8000 nm
- TIR (thermal infrared)
  - 8000 nm – 15000 nm

- VNIR = VIS + NIR

EnMAP

Source: Global Warming Art

Elektromagnetic Spectra

Legend:
- Soil
- Dry vegetation

Landsat 7 ETM+
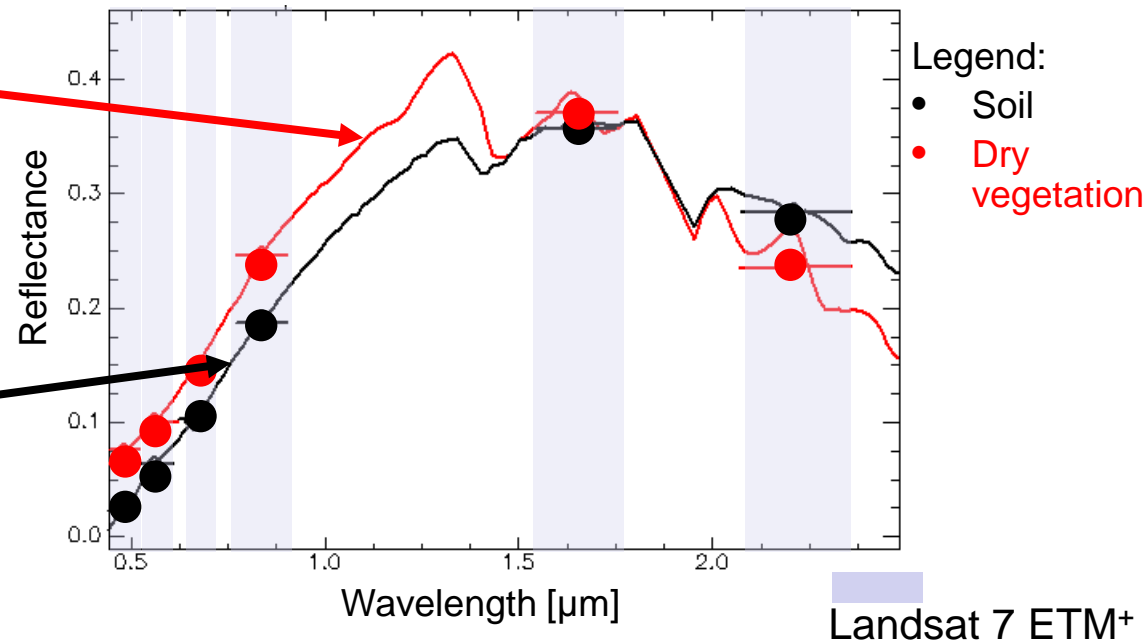
- EO-1/Hyperion, USA. Date: 2000. Height: 700 km. GSD: 30 m.
- 220 Bands:
  400 nm – 2500 nm

Quelle: NASA/USGS

Elektromagnetic Spectra (2)
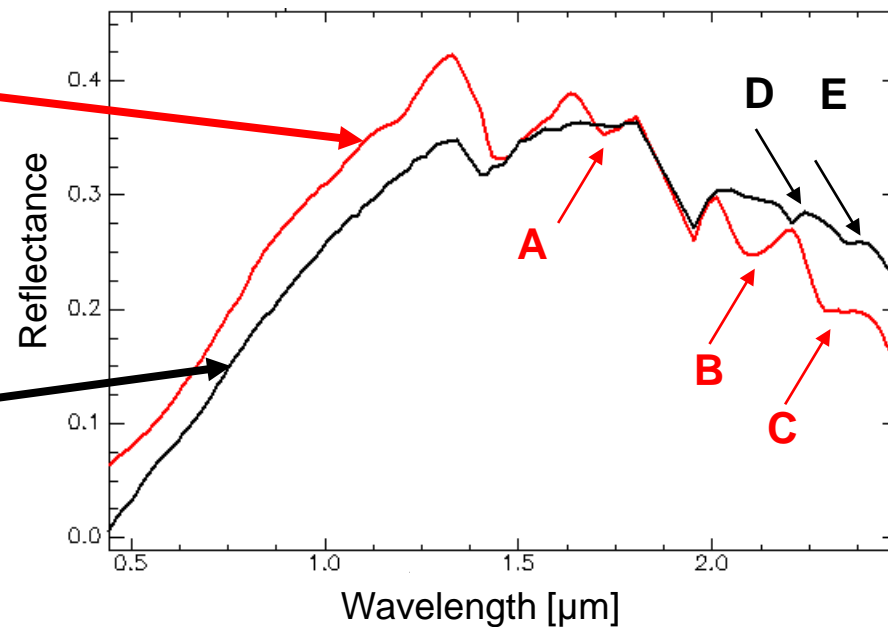
Quelle: NASA/USGS

- Legend:
  - A: Xylan & Cellulose
  - B: Lignin & Cellulose
  - C: Cellulose
  - D: Clay
  - E: Carbonate

Mapping of Geological Ressources

2 km
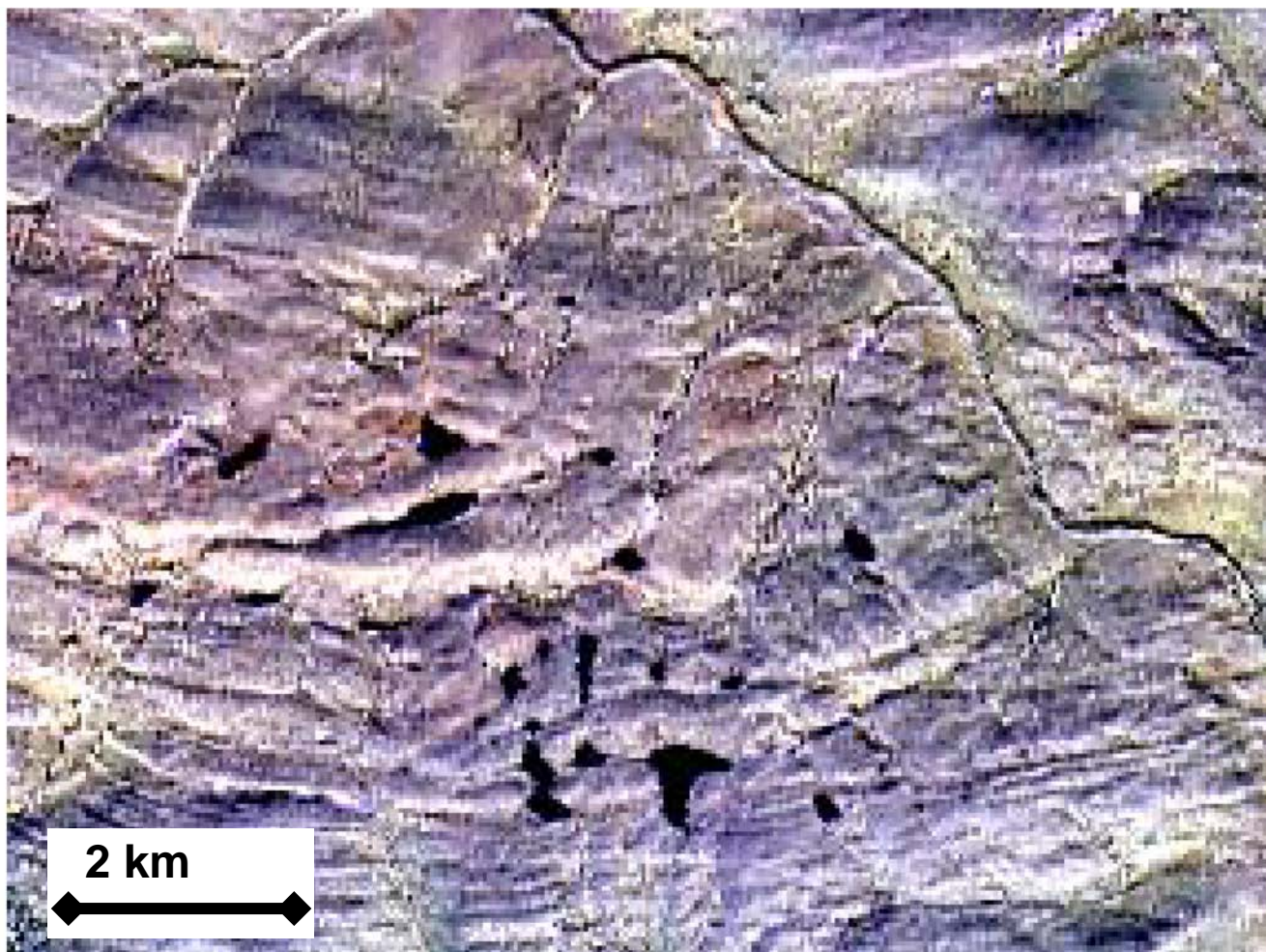
- Canada
- Date: 07/2008

Source: DLR

Mapping of Geological Ressources

2 km
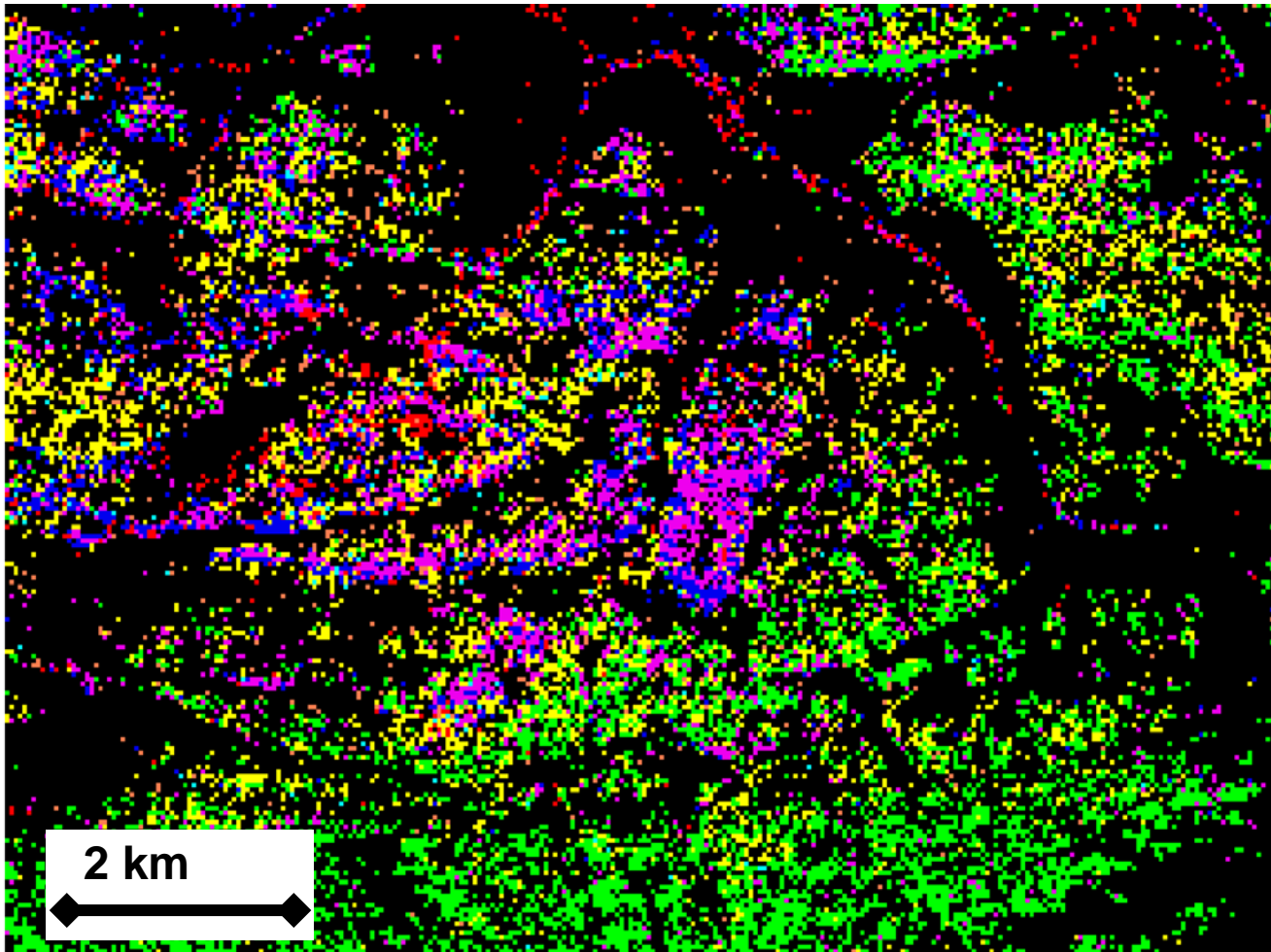
- Canada
- Date:
  07/2008

- Legend:

Ultramafic (Peridotite)
Ultramafic (Pyroxenite)
Mafic (Gabbro)
Mafic (Basalt)
Granodiorite/mafic enclaves
Gossan (plus alluvial rusted surfaces)
Sediments
Alluvial material

Source: DLR

Surface Materials – Urban Area

Trees
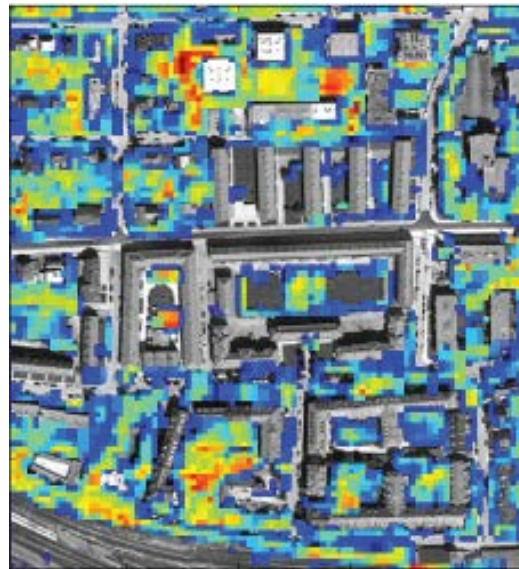
Red Roofs
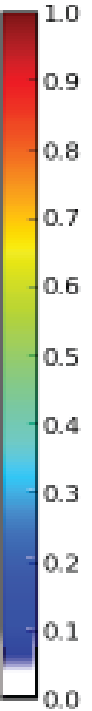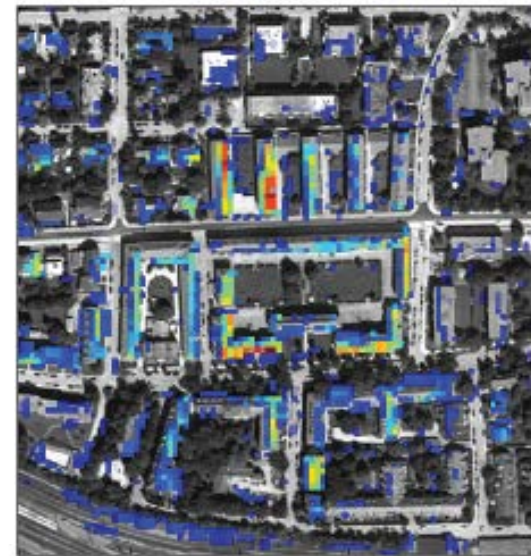
Surface Materials – Urban Area

- Roofing tiles
- Roofing concrete
- Roofing metal
- Roofing bitumen / tar
- Roofing synthetic / glass
- Vegetated roof
- Roofing gravel
- Unknown
- Concrete
- Asphalt
- Tartan/ synthetic turf/polyethylene surfaces
- Loose chippings
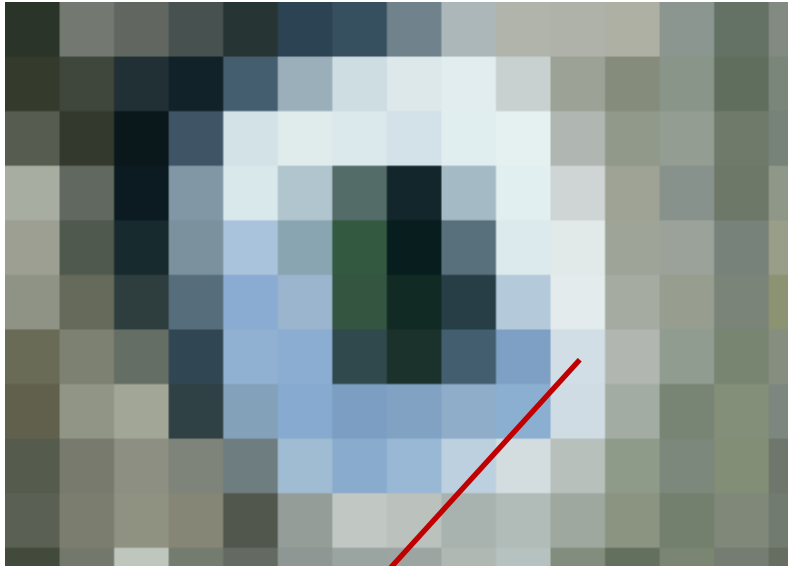- Railway tracks
- Sand/soil
- Trees
- Lawn
- Water
- Shadow
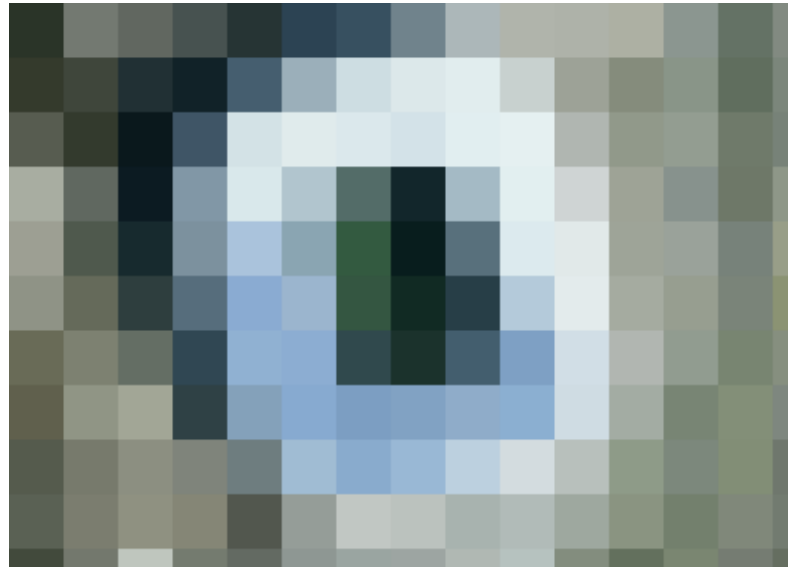
Spectral Unmixing
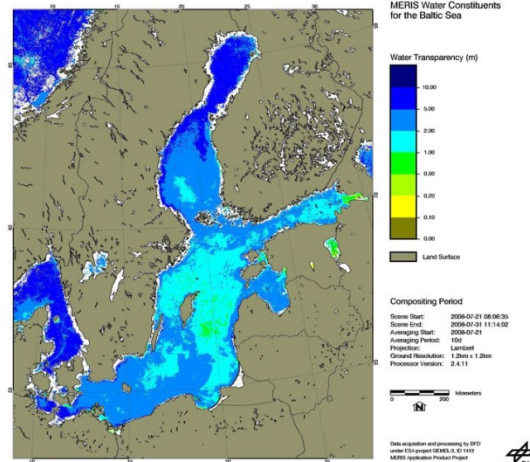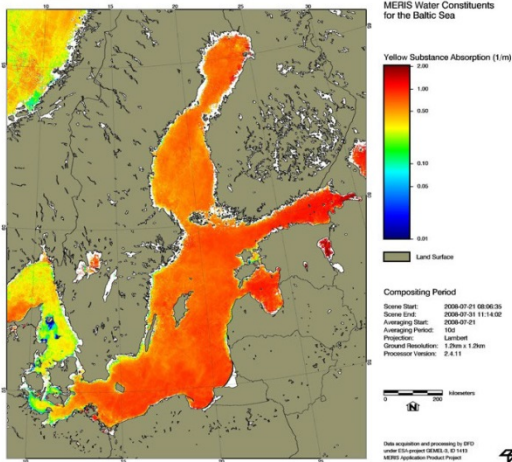

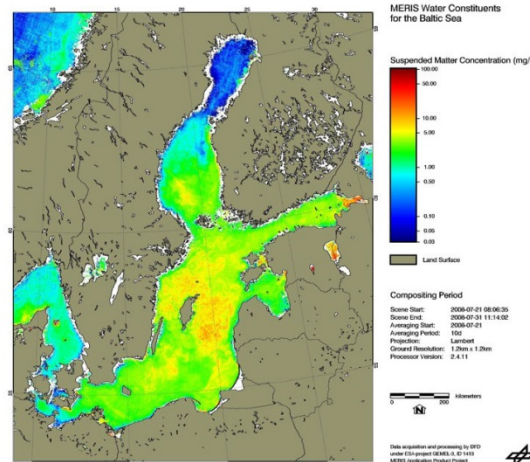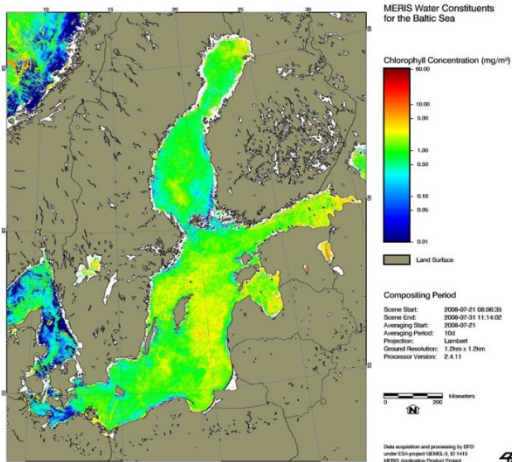- 30 cm spatial resolution

Source: BayernAtlas

Spectral Unmixing

$$\begin{pmatrix} y_1 \\ \vdots \\ y_n \end{pmatrix} = a_1 \cdot \text{Material}_1 + a_2 \cdot \text{Material}_2 + \ldots + a_m \cdot \text{Material}_m$$

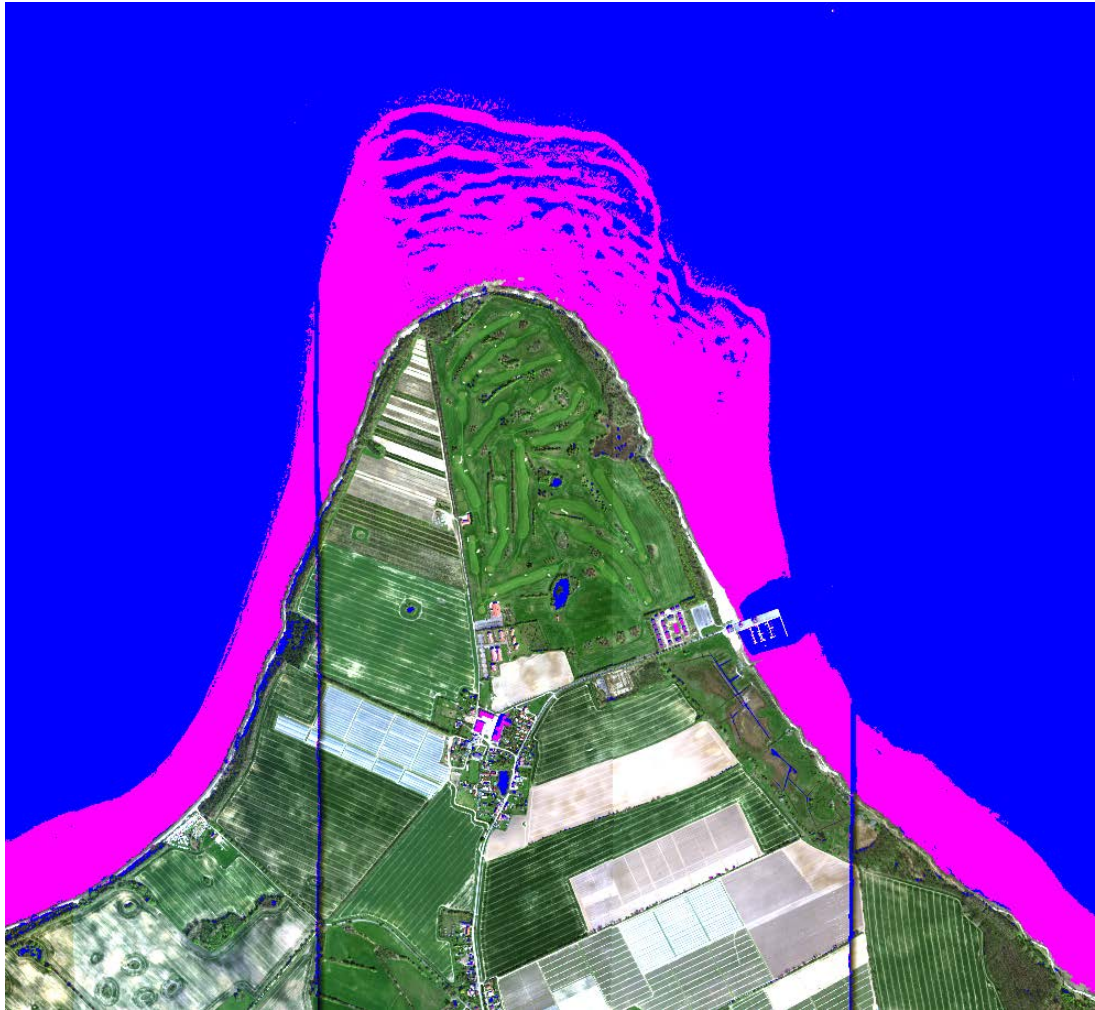(Typical) Task: Determination of percentage (a_i) of materials in one pixel.

Water Applications

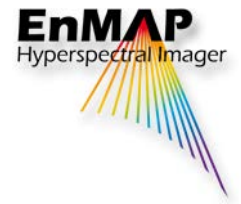- Bio-optical and radiation transport models
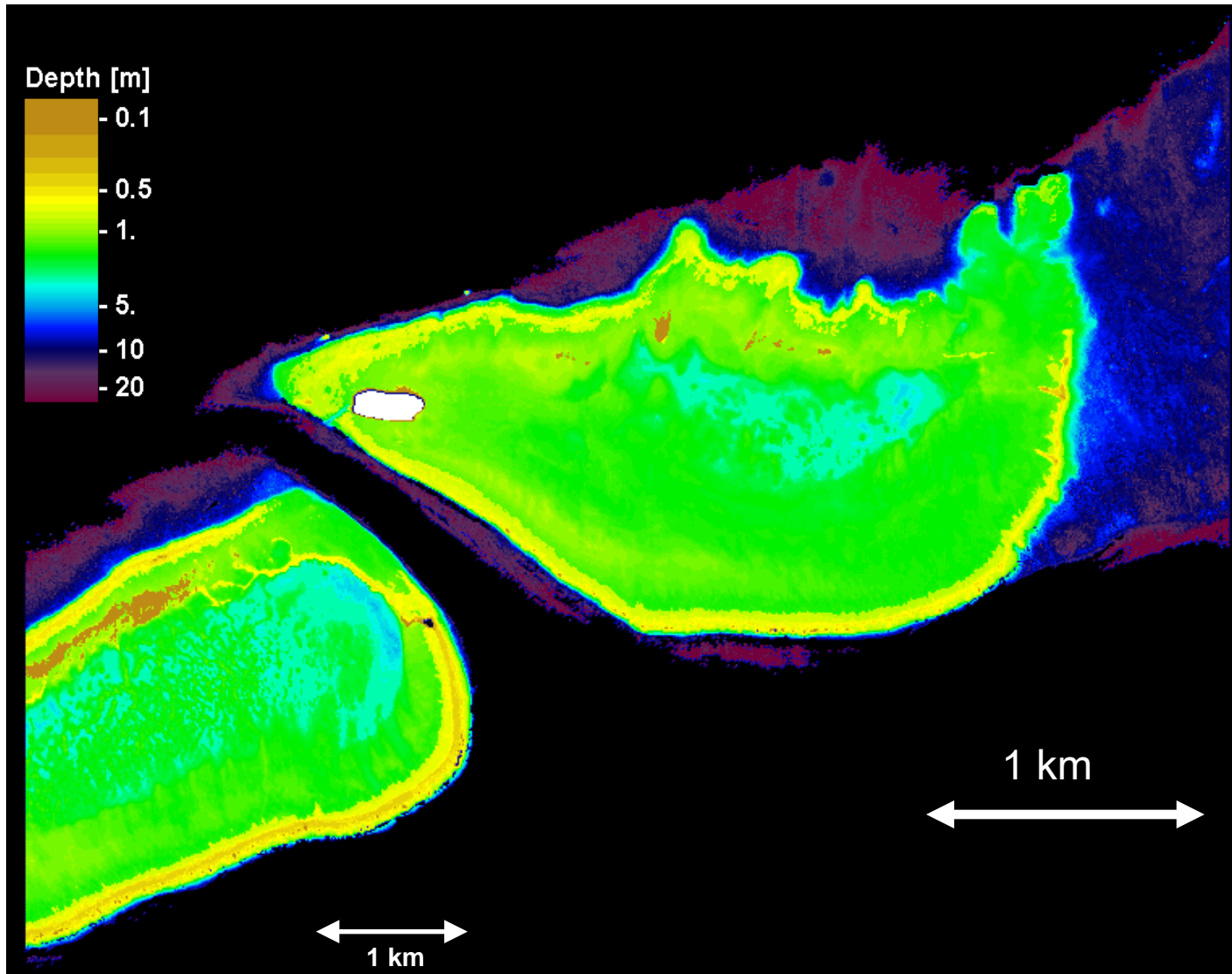- Detect and quantify algae blooms

Shallow water applications

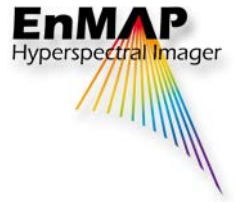- HySpex campaign 2016
- Detection of water / shallow water with sandy bottom
- Simple classification algorithm

Heron Island, Australia

Heron Island, Australia

Quelle: OHB, DLR