An example of an operational national satellite center in Germany. – What is critical for a successful service?

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Earth Observation Center – EOC
German Aerospace Center – DLR

25 November 2014 in Oslo, Norway

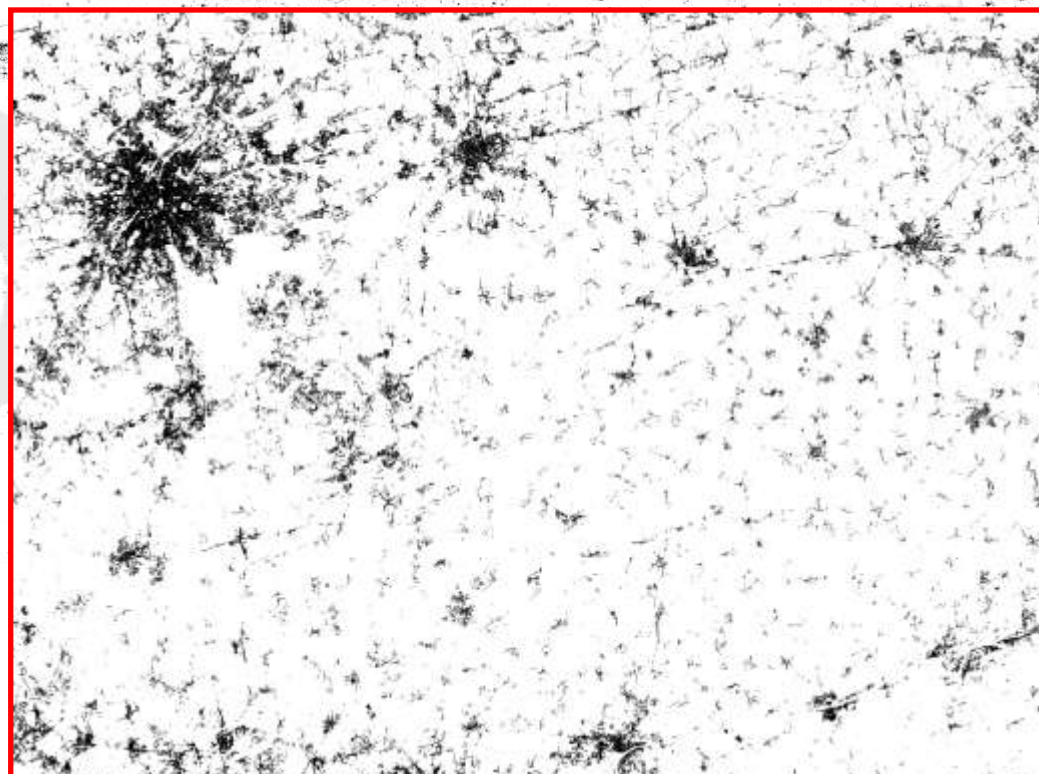
Workshop: Preparations
for Sentinel-2
in Europe

DLR

– Establish Sustainable Systems by Teaming Projects

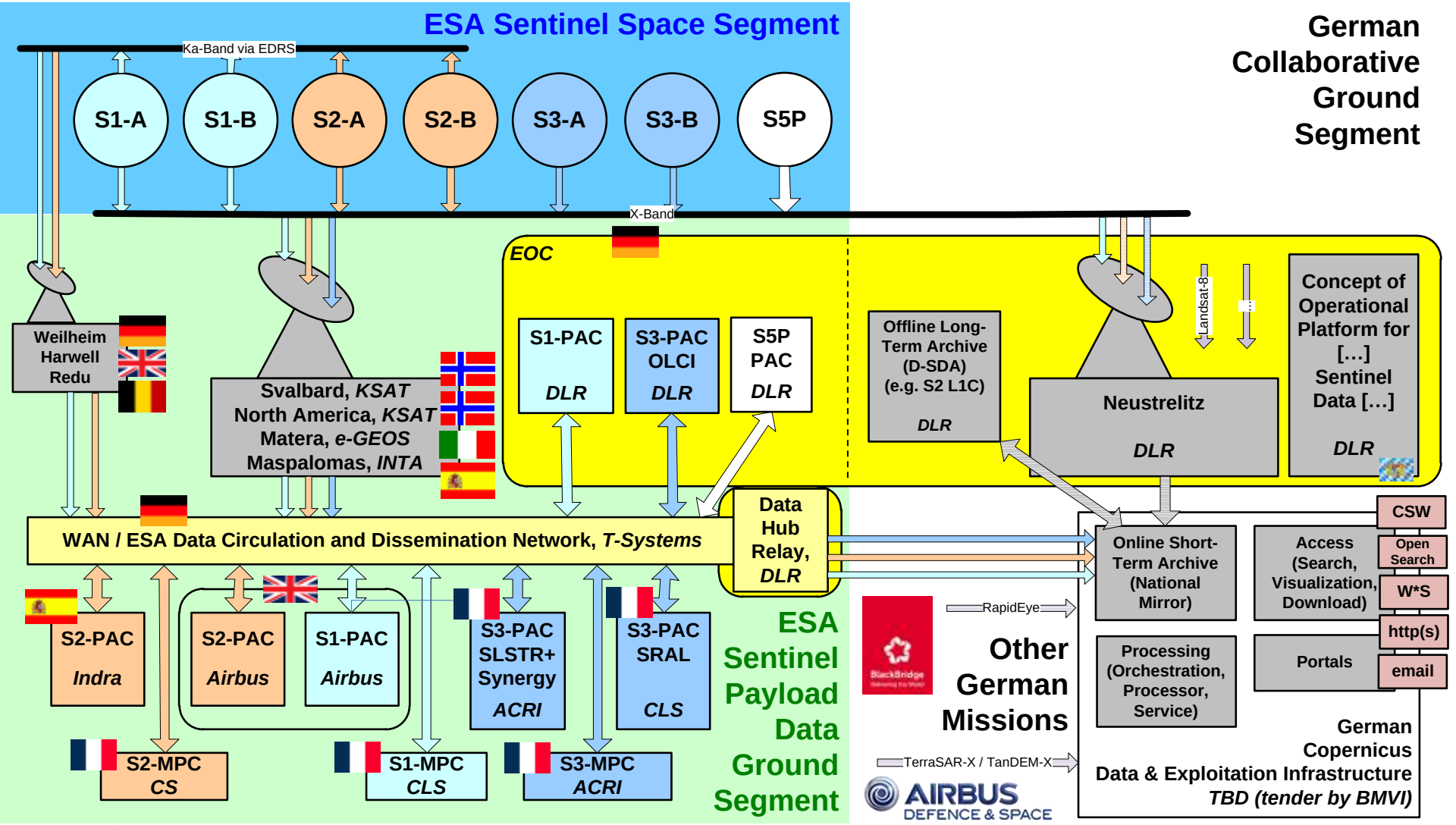
– Big Data with Networks and the Demands

– Automatic Standardized Global Processing Chains



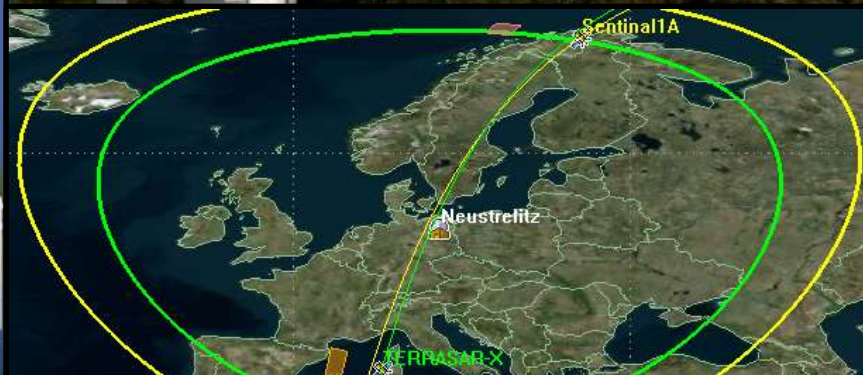
Global Urban Footprint of Europe and Brussels based on TanDEM-X

Core and German Collaborative Ground Segment



Near Real-Time Services from Neustrelitz

- Acquisition of spaceborne SAR data, e.g.
  - TerraSAR-X (& follow-ons)
  - Sentinel-1
  - Radarsat-2
- NRT product generation, e.g. for maritime security
  - SAR images
  - Ship detection (and combination with AIS)



EOC Archive for National and Sentinel Missions Products

- 50 PetaBytes Storage Capacity
- Used for projects, e.g.
  - Sx-PAC
  - Sx-LTA
- 1.5 PetaByte of Products (L0/L1/L2) per Year per Sentinel Mission
- Used for missions, e.g.
  - CCM: TerraSAR-X & TanDEM-X (DLR & Airbus), EnMAP (DLR) (Global) [GS dev & ops]
  - CCM: IRS-1C & IRS-1D & IRS-P3 & IRS-P6 (GAF) (Europe) [GS ops & improvement]
  - NOAA/METOP AVHRR & Terra/Aqua MODIS (Europe)
  - Landsat-4 & Landsat-5 (Germany)
  - Landsat-7 & Landsat-8 (Europe)
  - Airborne, MERIS, SRTM, …
- Technical support and data format services

per year in TeraBytes	Global	European	German
S1 (L1+L2)	860+40	75	3
S2 (L1)	1500	120	5
S3 (L1+L2)	900+600	120	5
Sum	*3300*	*315*	*13*

- Copernicus Contribution Missions (CCM) with EOC support but not with EOC archiving
  - WorldView-2 & Worldview-3 & SkySat (EUSI) [GS ops & improvement]
  - RapidEye (BlackBridge) [science data archive & support]

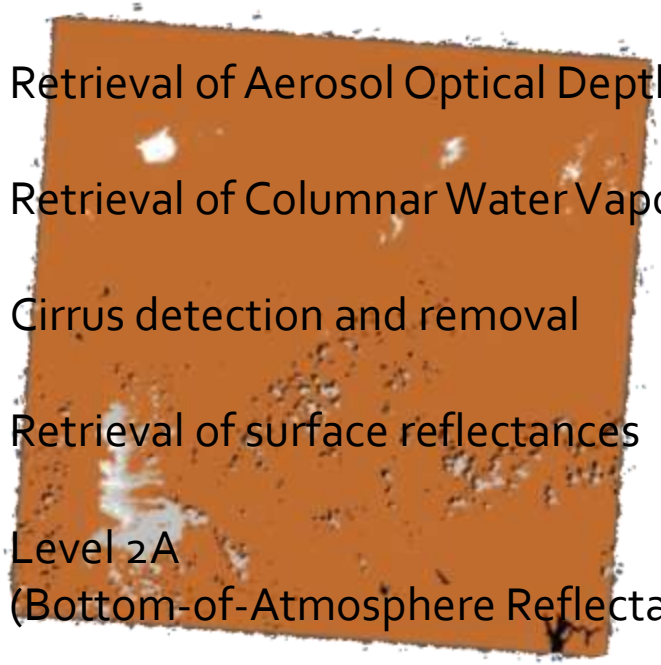
EOC Big Data Computing in 2016

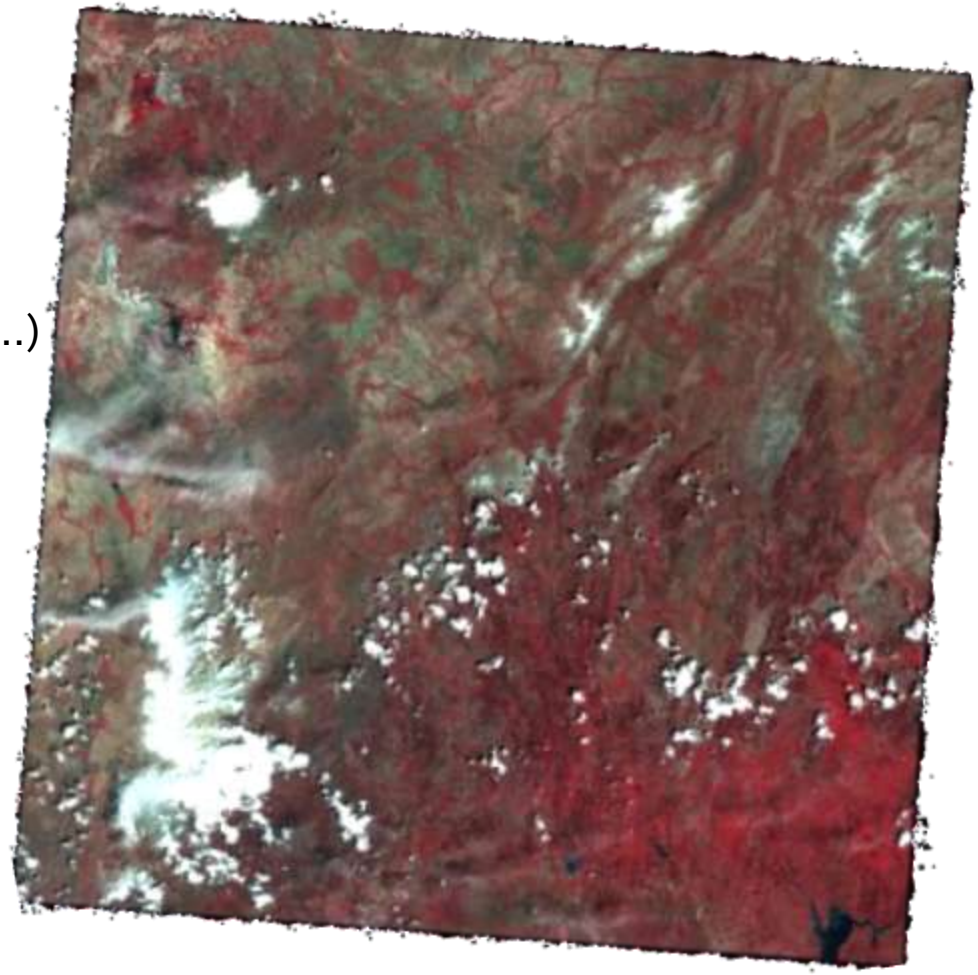
- 2.7 PetaBytes per Year for Sentinel Missions at EOC
- 1.9 PetaBytes Storage (HDD & SSD)
- 33 TeraBytes Memory
- 4300 Cores
- 2 × 10 GigaBit Network Connection

- EOC in-house private cloud for large-scale EO computing, e.g.
  - Consistent reprocessing (multi-sensor algorithms) of time series of 30 years of NOAA/METOP AVHRR for climte models
  - Registration and orthorectification of optical images for mosaics
- Larger installations for an envisaged "German Copernicus Center"

Atmospheric Correction (L2A) for Optical Satellite Images

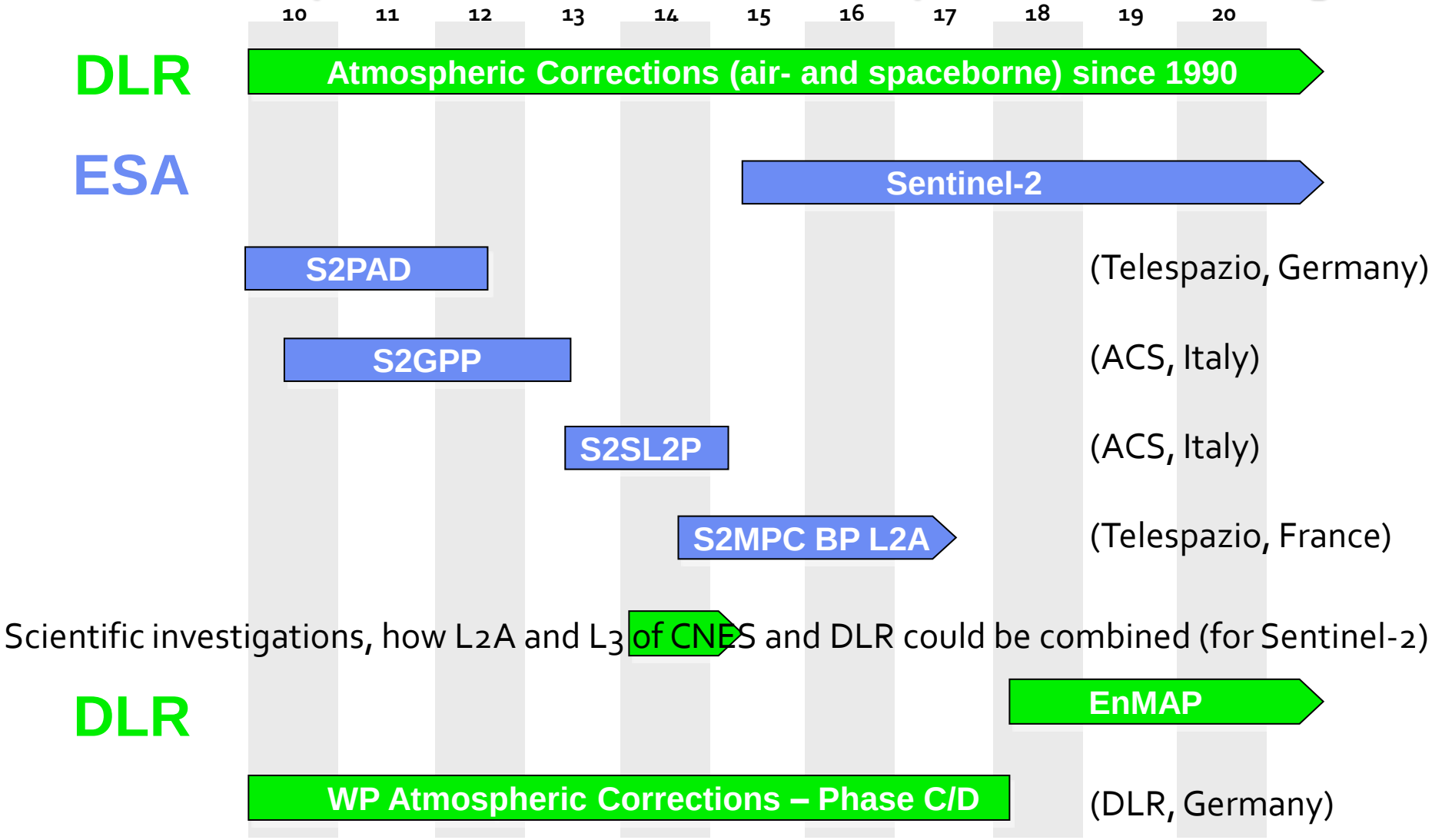
- Level 1C
  (Top-of-Atmosphere Radiance)
- Classification
  (Clouds, Cloud Shadow, Land/Water, …)
- Retrieval of Aerosol Optical Depth
- Retrieval of Columnar Water Vapor
- Cirrus detection and removal
- Retrieval of surface reflectances
- Level 2A
  (Bottom-of-Atmosphere Reflectance)





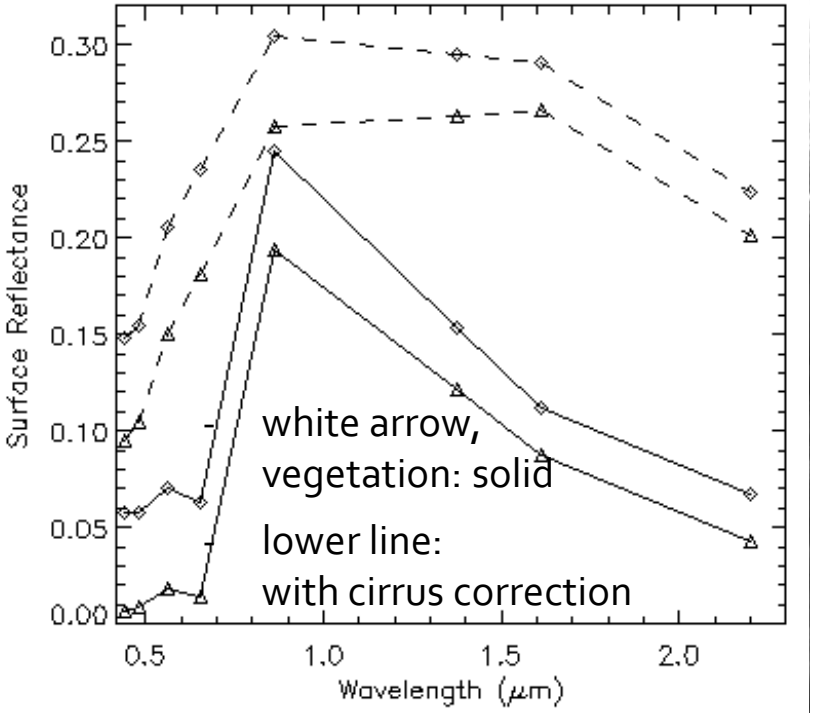
SPOT-5, R=840 nm, G=660 nm, B=550 nm

EOC Atmospheric Correction (L2A) for Optical Satellite Images



Atmospheric Correction (L2A) for Optical Satellite Images

- Without cirrus removal
- With cirrus removal



Landsat-8, 1380 nm (cirrus band)

Landsat-8, R=660 nm, G=550 nm, B=480 nm

Atmospheric Correction (L2A) for Optical Satellite Images

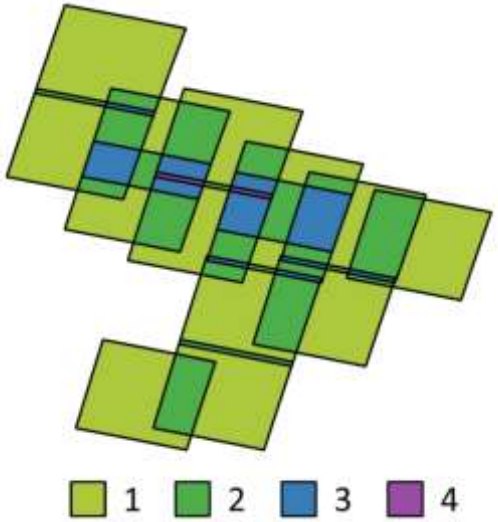
- Retrieval of surface reflectances without topographic correction

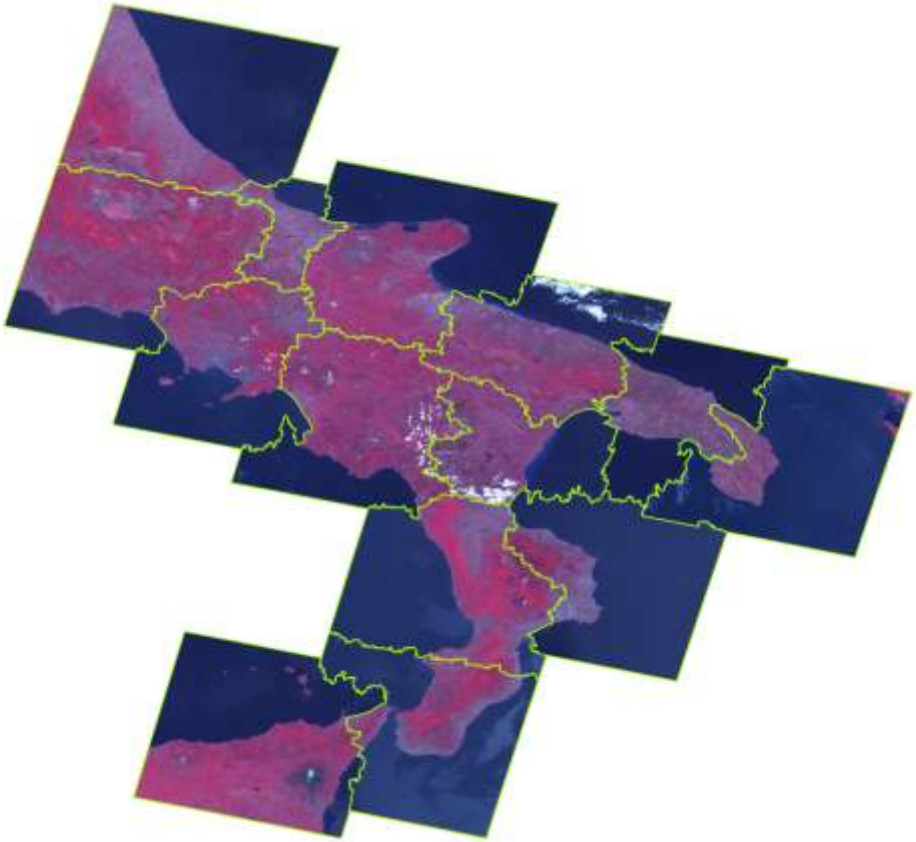
- Retrieval of surface reflectances with topographic correction

SPOT-5, R=1650 nm, G=840 nm, B=660 nm

Mosaicking/Compositing (L3) for Optical Satellite Images

- Seam-line detection based on morphological image compositing
- Regions described by vector data
- Linear runtime complexity



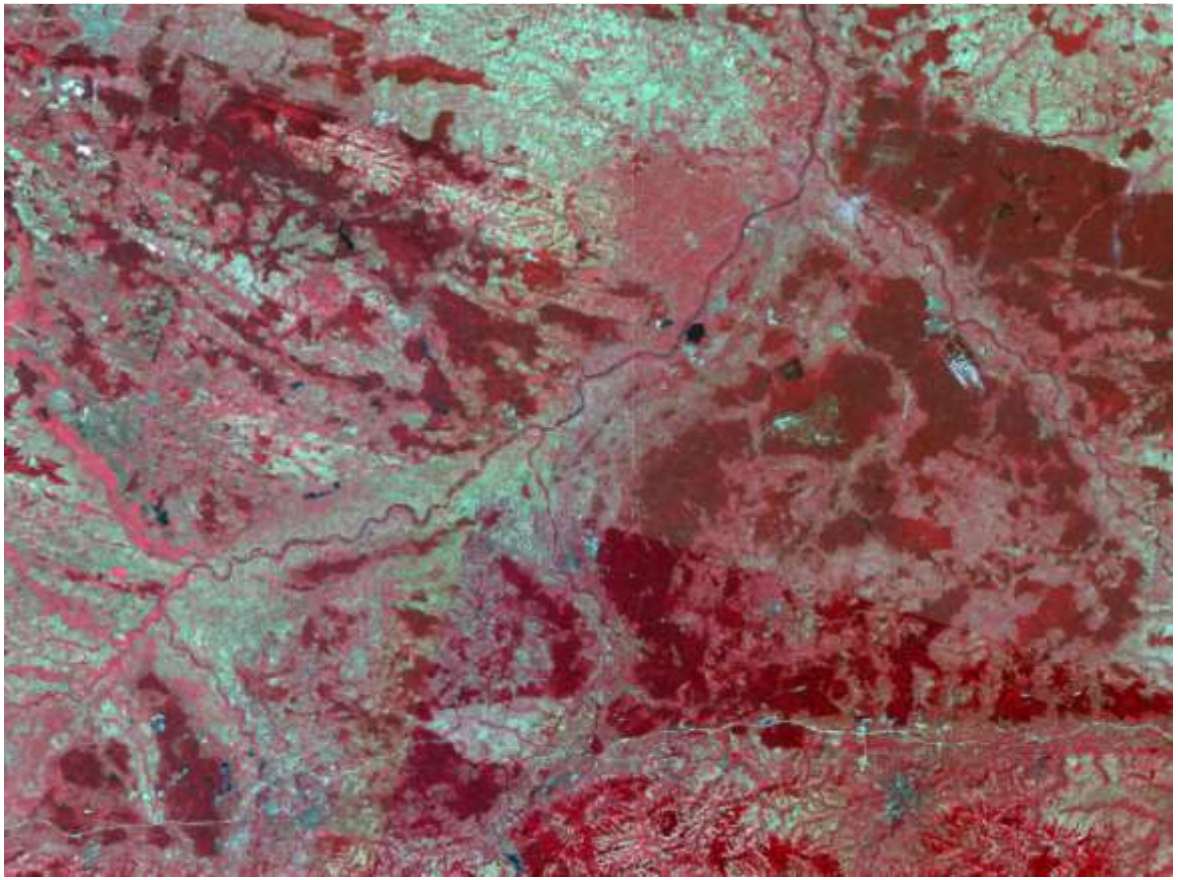


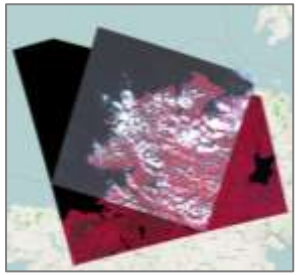
Degree of overlap for | 16 IRS-P6/LISS3, R=820 nm, G=650 nm, B=550 nm

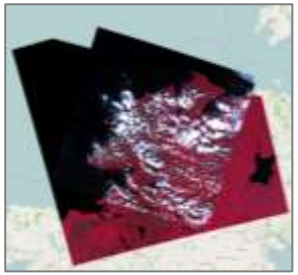
Block Adjusted Radiometry for Optical Satellite Images

- LR reference acquired during same season and with low cloud cover

- Used to adjust by linear adaption the radiometry of 2000 HR IRS-P6/LISS3 & SPOT-4 & SPOT-5

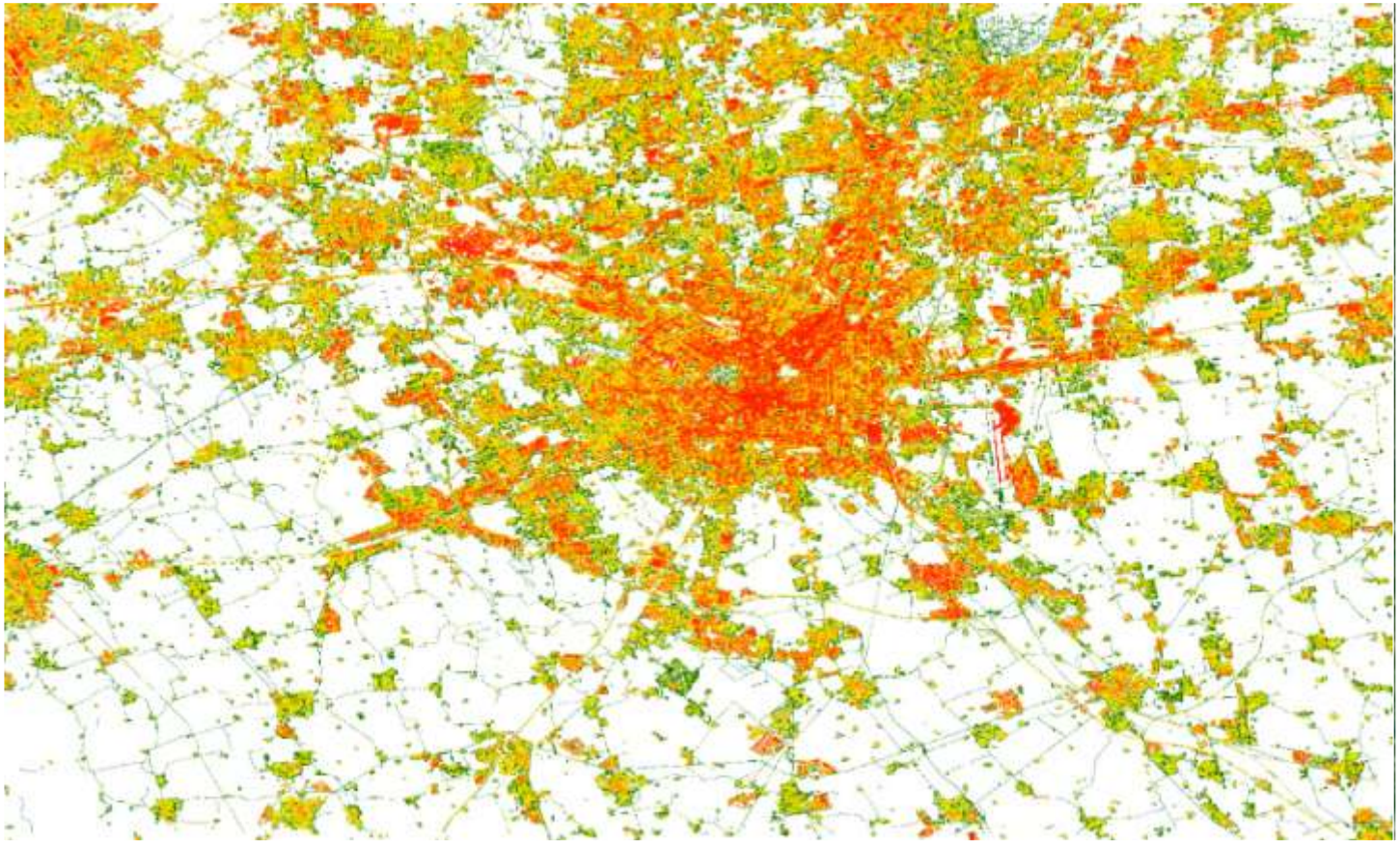


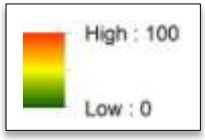




9 IRS-P6/AWiFS, R=820 nm, G=650 nm, B=550 nm

Thematic Processing Chain for Optical Satellite Images





Based on seasonality, Fourier Model, Max NDVI, Mean NDVI

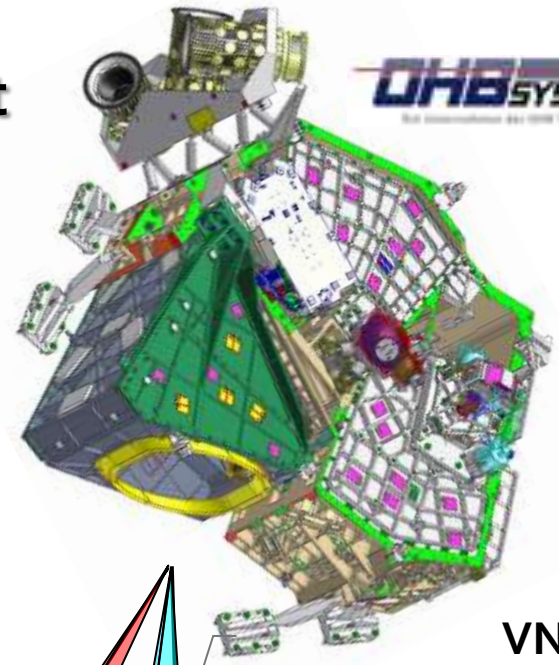
Based on seasonality, Fourier Model, Max NDVI, Mean NDVI

EnMAP = Environmental Mapping and Analysis Program

- Germany's first imaging spectroscopy Earth observing satellite mission
- Scientific path finder mission for later operational services (EnMAP FO, tbd)
- Provide high-quality calibrated image products (including orthorectification & atmospheric corrections) on a frequent basis
- To observe a wide range of ecosystem parameters (including terrestrial, aquatic, natural resources, hazards /risks)
- To extend the scientific and technical know-how
- Funded by BMWi

Instrument Optical Unit

EnMAP Space Segment
[Sentinel-2]

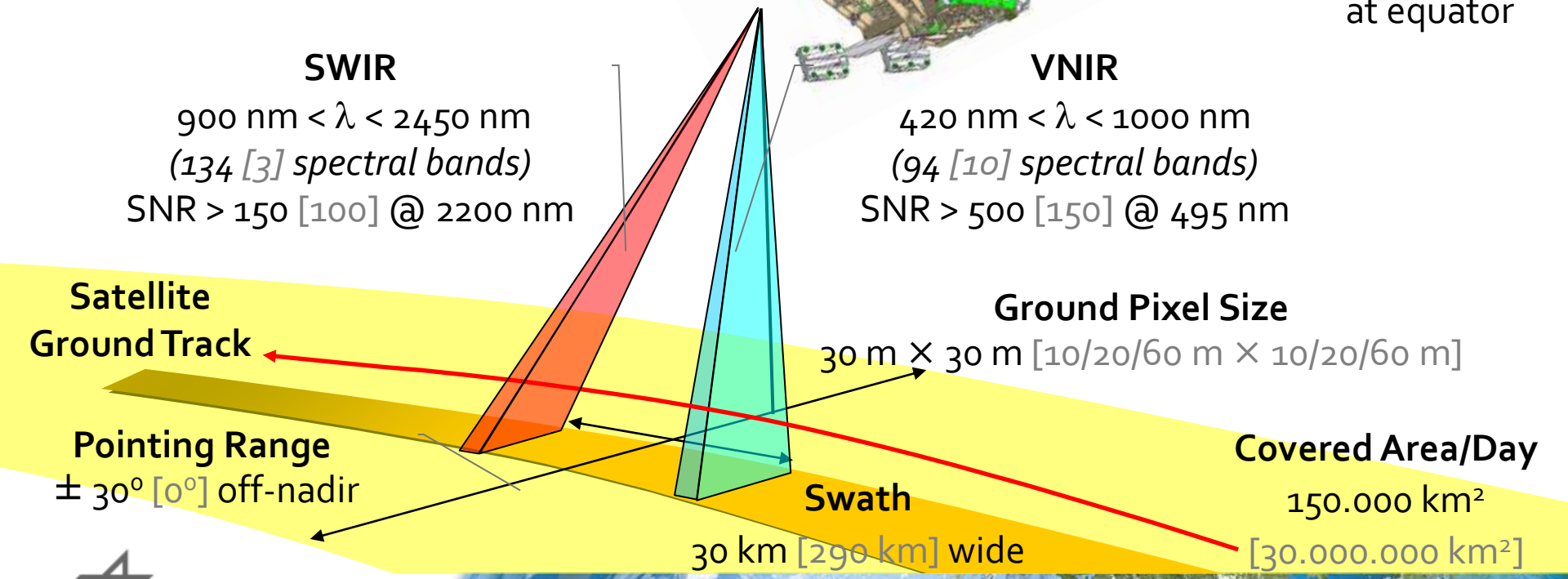


Size of satellite
3.1 m × 2.0 m × 1.7 m
[3.4 m × 2.3 m × 1.8 m]
Launch mass of satellite
1000 kg [1140 kg]

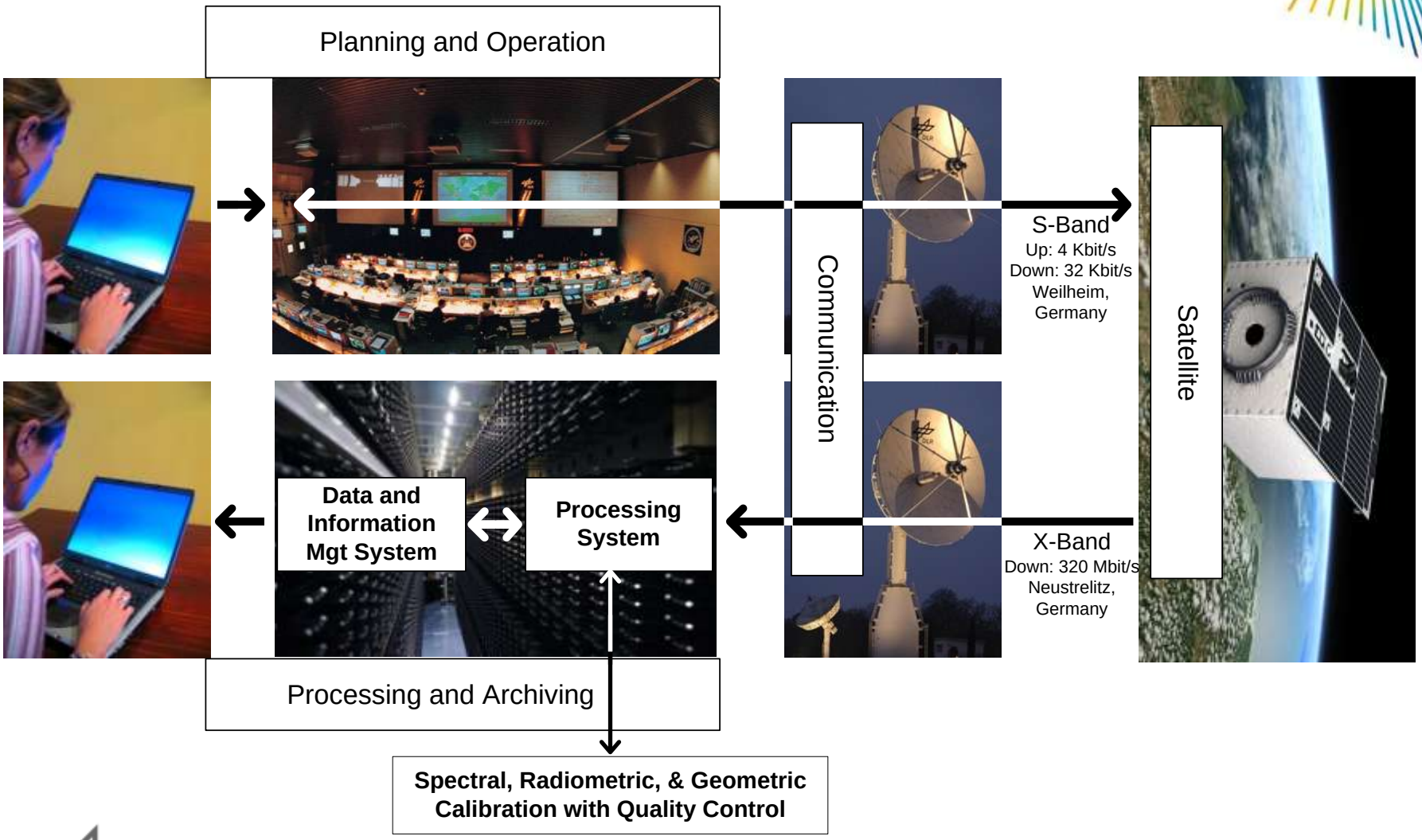
Sun-synchronous polar repeat orbit at
653 km [786 km] altitude,
11:00 [10:30] local time at equator

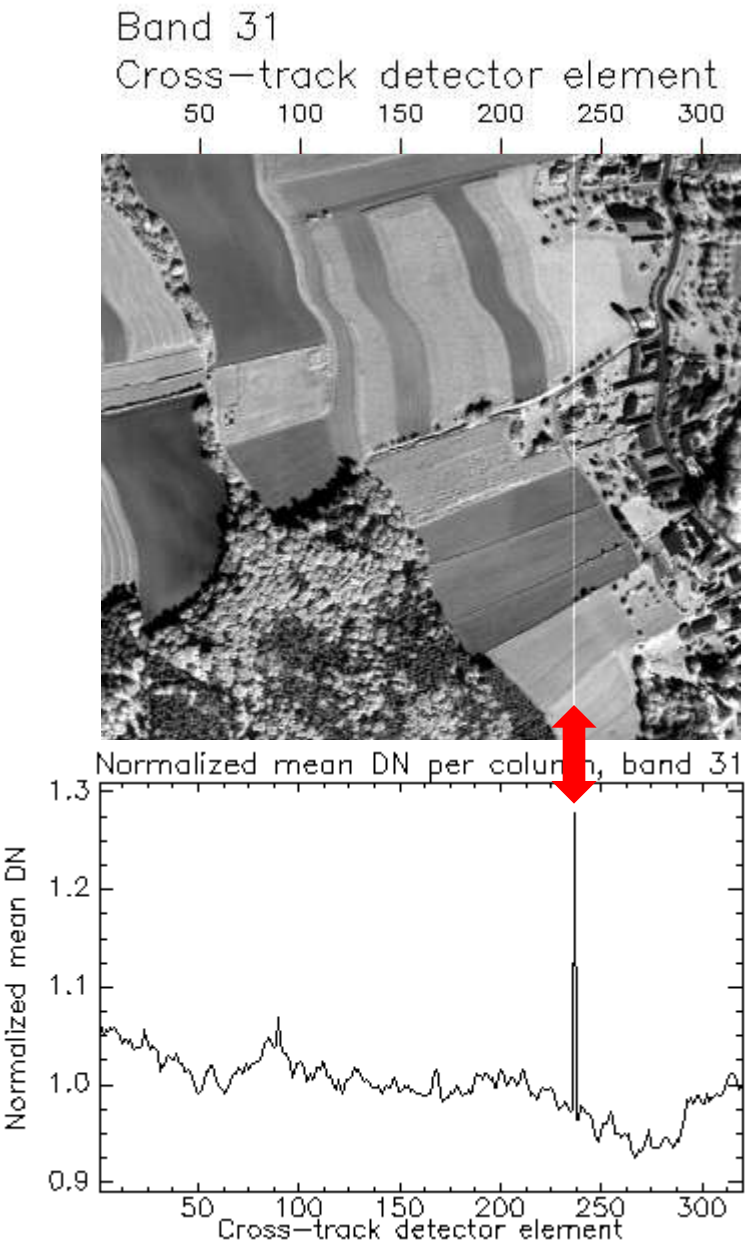
SWIR
900 nm < λ < 2450 nm
(134 [3] spectral bands)
SNR > 150 [100] @ 2200 nm

VNIR
420 nm < λ < 1000 nm
(94 [10] spectral bands)
SNR > 500 [150] @ 495 nm



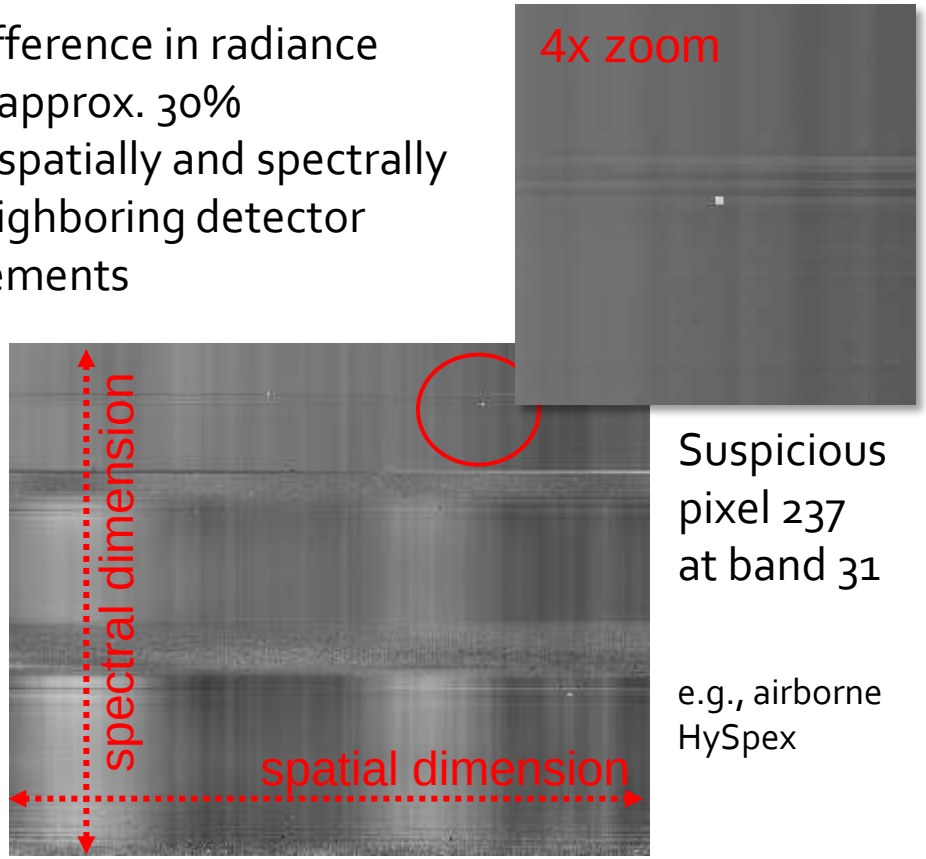
EnMAP Ground Segment





Quality Control

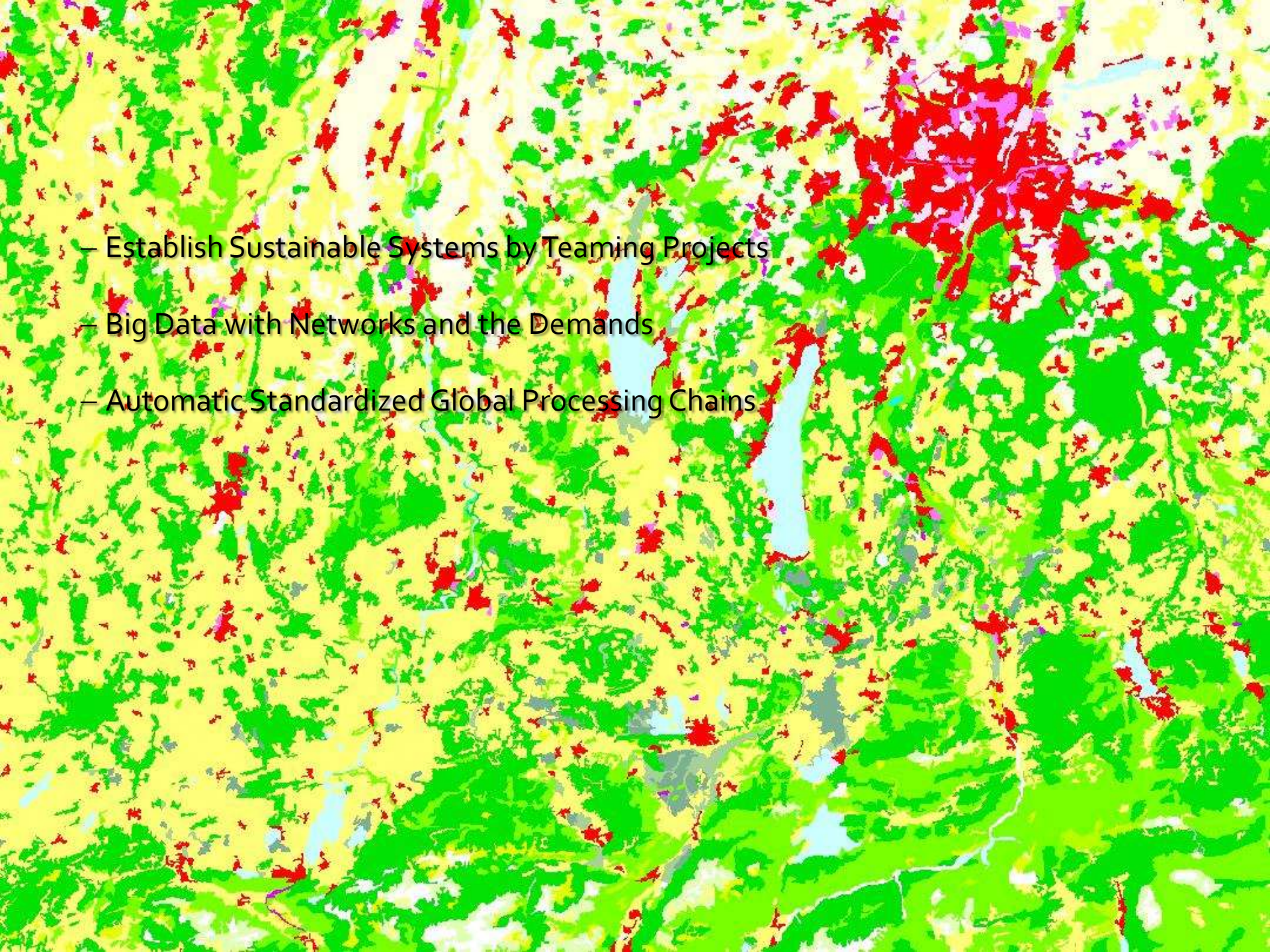
Difference in radiance
of approx. 30%
to spatially and spectrally
neighboring detector
elements



Suspicious
pixel 237
at band 31

e.g., airborne
HySpex

Normalized detector map of one scene,
mean DN for every band and
every across-track detector element



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