International Autumn School
The EGSIEM School for Satellite Gravimetry Applications

11 – 15 September 2017

GFZ Helmholtz Centre, Potsdam, Germany

Hendrik Zwenzner
German Aerospace Center (DLR), Oberpfaffenhofen
hendrik.zwenzner@dlr.de

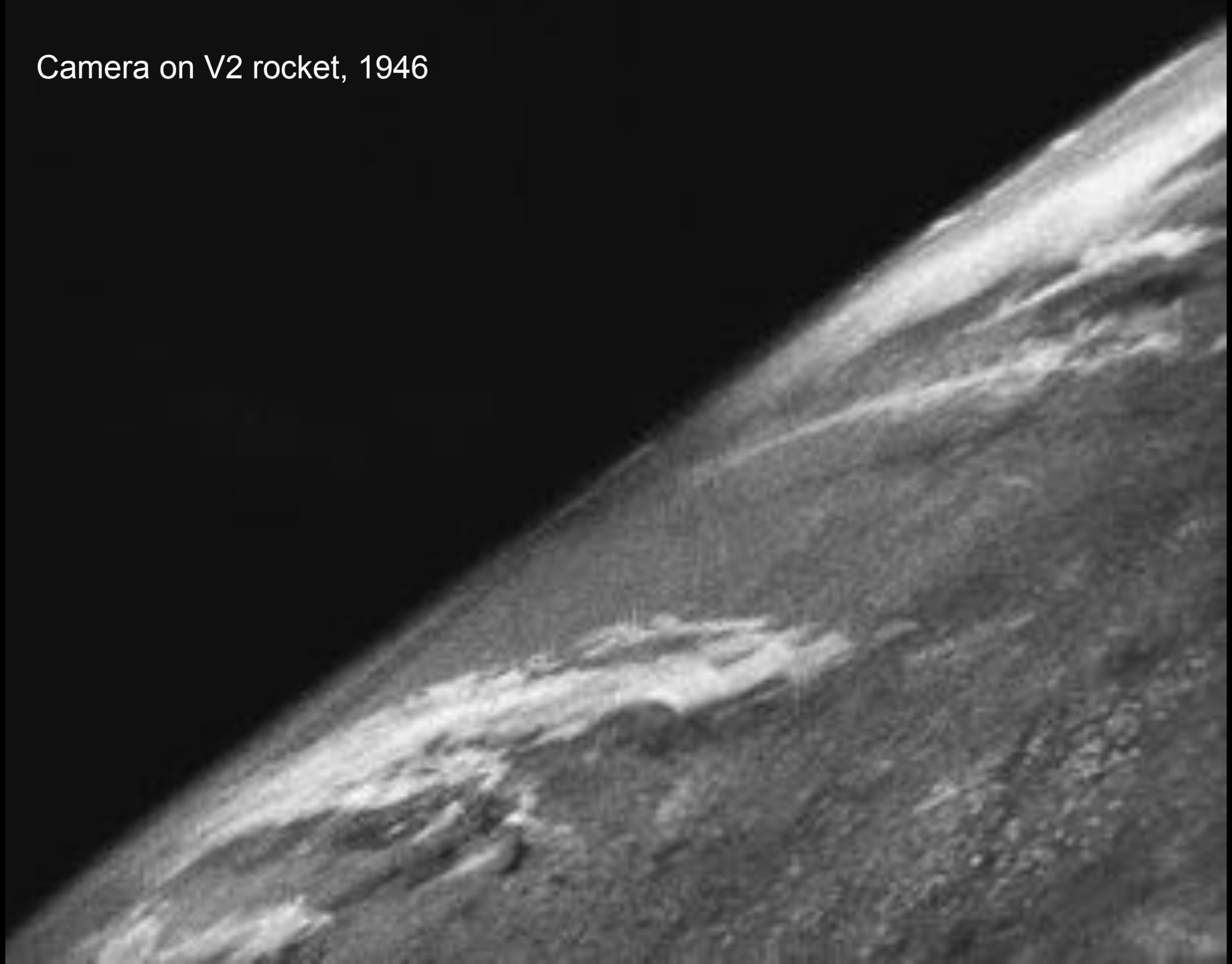
Session: Remote Sensing
Thursday, 14 Sept 2017

Center for Satellite-based Crisis Information (ZKI)

- Operational service of DLR since 2004
- Rapid **provision**, **processing** and **analysis** of remote sensing data in case of
  - natural and environmental disasters
  - humanitarian relief activities
  - civil security issues
- Activities on national/international level
  - Pre-operational Copernicus Emergency Response Service
  - International Charter Space and Major Disasters
  - ZKI Service for Federal Agencies (ZKI-DE)
  - Copernicus Emergency Management Service – Mapping (EMS)

Introduction

Camera on V2 rocket, 1946




1st meteorological satellite (TIROS-1), USA, 1960

Auckland, Port, New Zealand, WorldView-3, 30 cm

Pont-des-Arts bridge,
Paris,
WorldView-3, 30 cm

Pont-des-Arts-Brücke,
Paris,
WorldView-3, 30 cm

Remote Sensing

„… is the acquisition of information about an object or phenomenon without making physical contact with the object and thus in contrast to on-site observation.“

„… is used in numerous fields, including geography, land surveying and most Earth Science disciplines; it also has military, intelligence, commercial, economic, planning, and humanitarian applications.

Wikipedia

<u>Categorization</u>

- active vs. passive remote sensing systems
- optical, radar, thermal, hyperspectral

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MERIS, forest fires, Greece


TerraSAR-X, dam break, Nepal

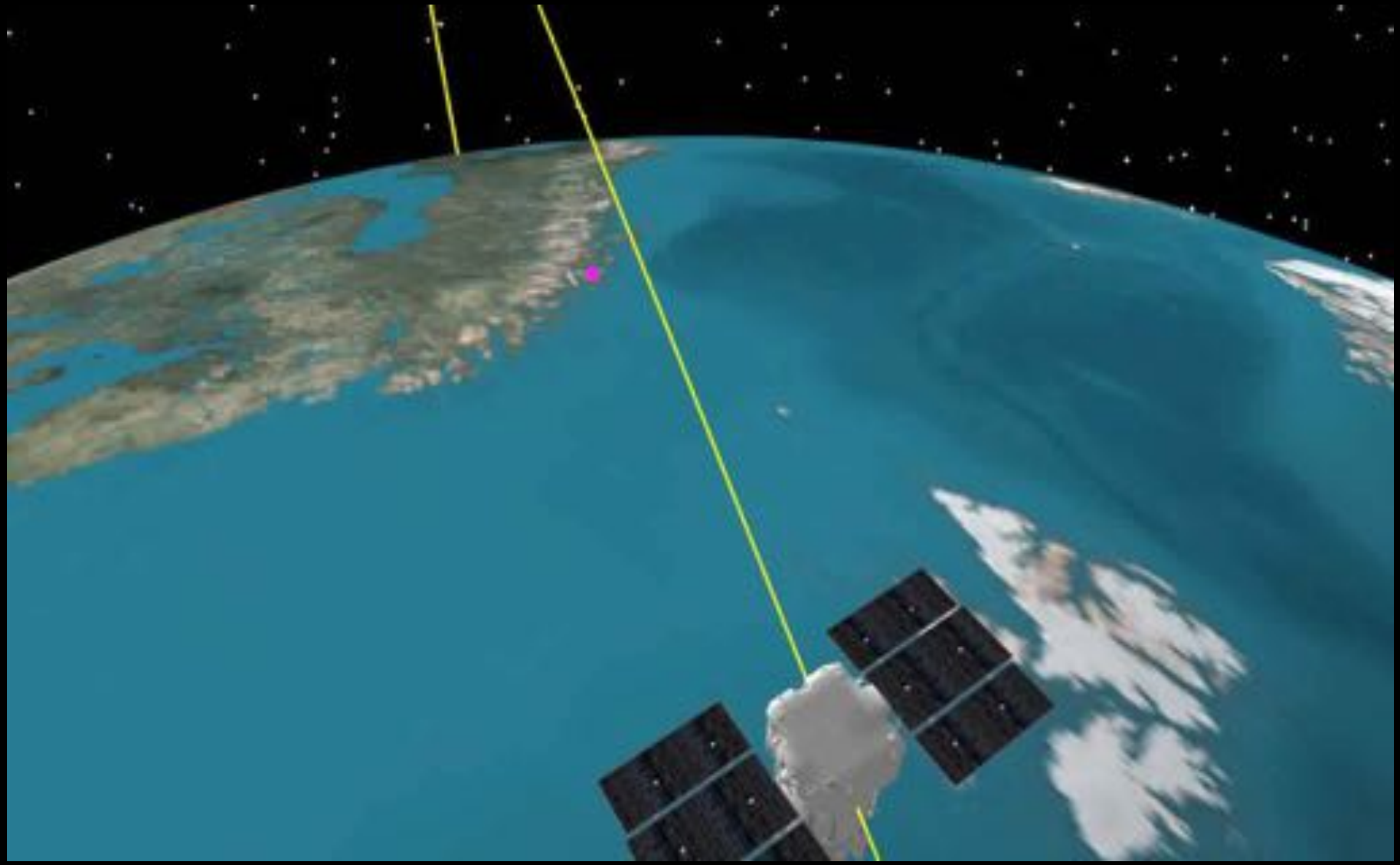
SPOT-5, landslide, Tadjikistan

VHR optical, refugee camp, Ethiopia

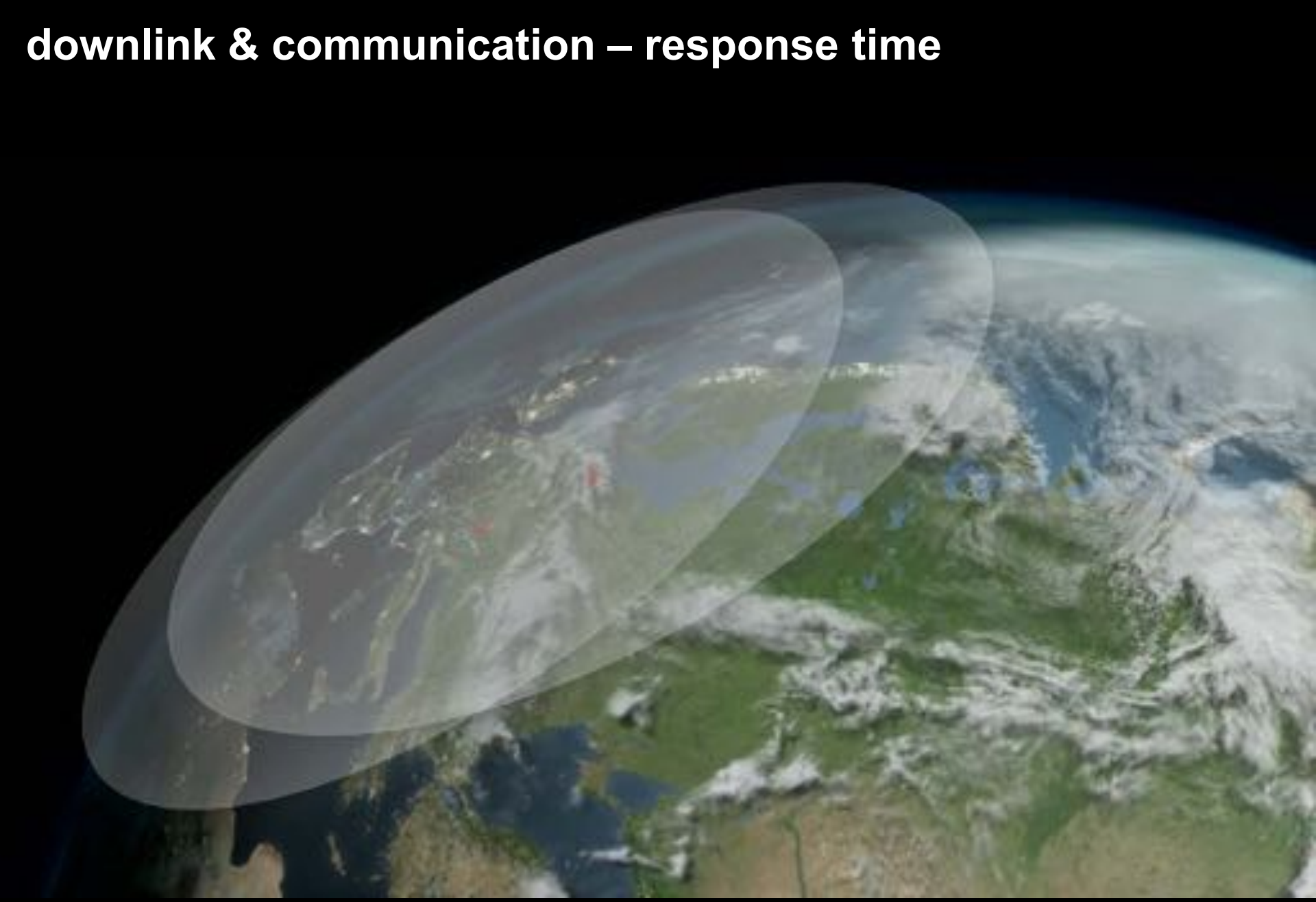
Determining factors of satellite-based Earth observation

1. Orbits & Ground stations

sun-synchronous orbits



downlink & communication – response time



Determining factors of satellite-based Earth observation

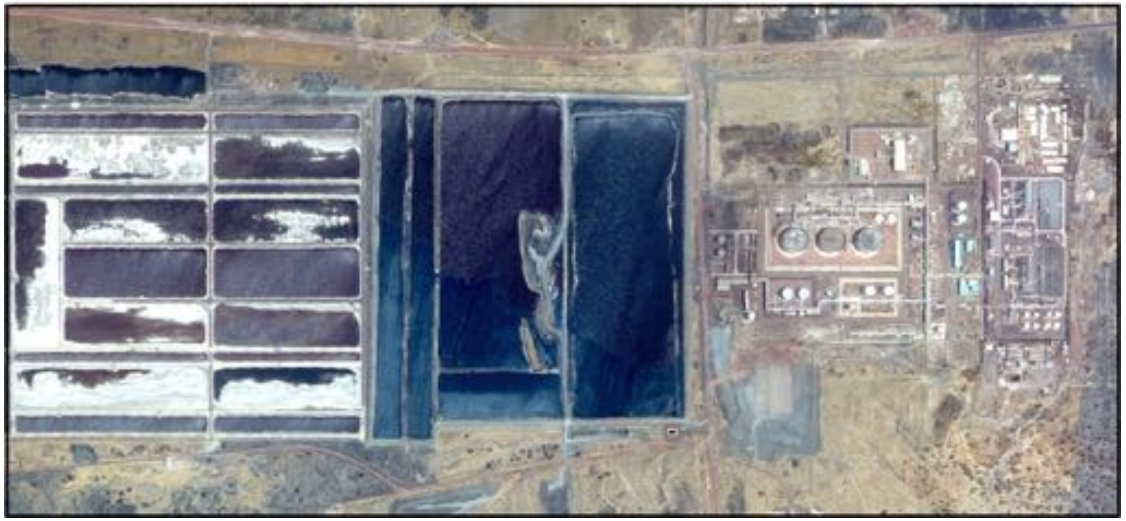
1. Orbits & Ground stations

- field of view
- frequency of overpasses
- data storage
- Downlink time

2. Spatial resolution

LANDSAT-5

30 m



WORLDVIEW-2

0.5 m

South Sudan, Oil refinery

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Spatial resolution vs. coverage

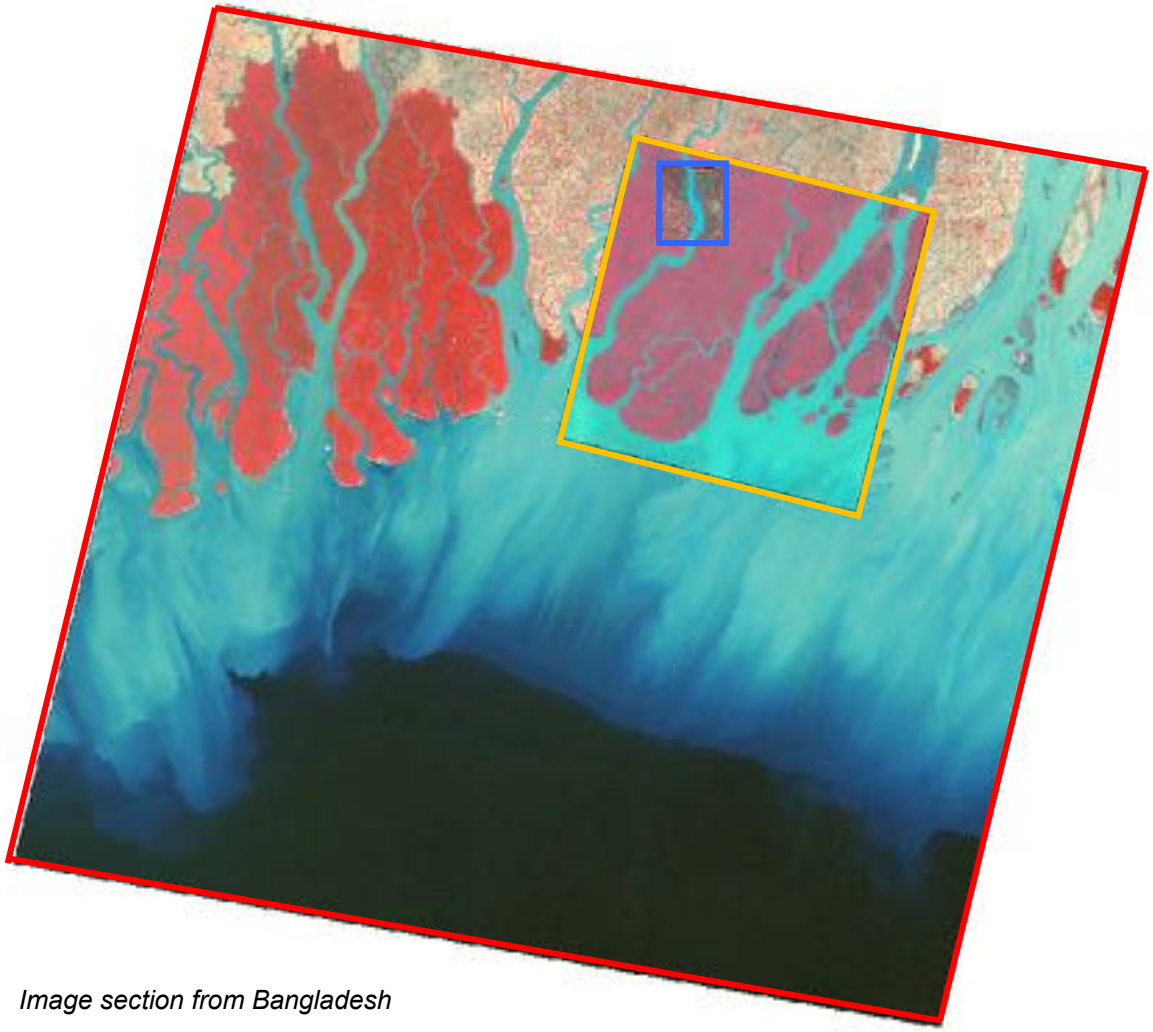

Image section from Bangladesh

IKONOS: 13 x 13 km
Auflösung: 1 m

SPOT: 60 x 60 km
Auflösung: 5 – 10 m

LANDSAT: 170 x 170 km
Auflösung: 30 m

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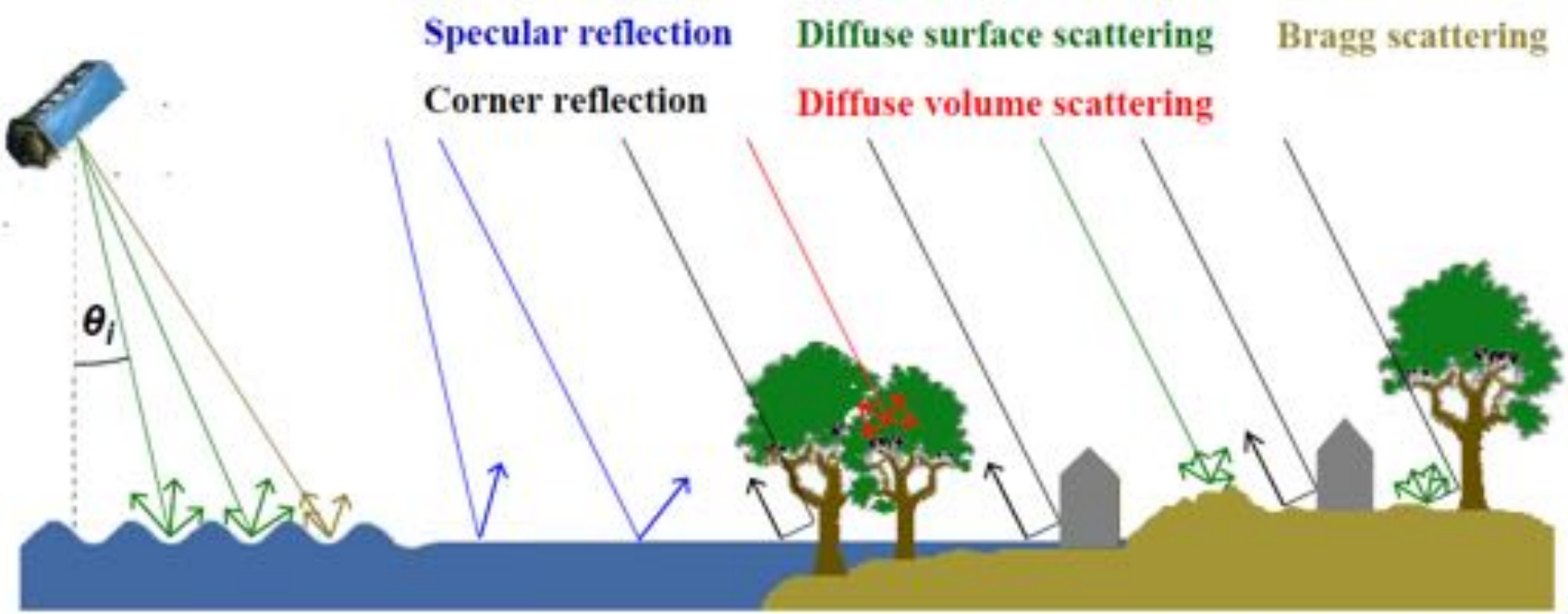
Determining factors of satellite-based Earth observation

3. Synthetic Aperture Radar (SAR) sensors

Magdeburg, TerraSar-X (8,25 m)

Characteristics of remote sensing with SAR systems



Characteristics of remote sensing with SAR systems

- Active microwave remote sensing method
- Measurement of time from sending out the radar pulse until receiving the backscatter signal
- Acquisitions possible at the night time and through clouds (depending on wave length)
- SAR sensor captures surface roughness, geometry and surface wetness
- Data analysis is more complex than with optical data; not „intuitively“ readable
- Sensors: TerraSAR-X/TanDEM-X, Radarsat-2, Sentinel-1, ALOS-PALSAR-2, Risat-1

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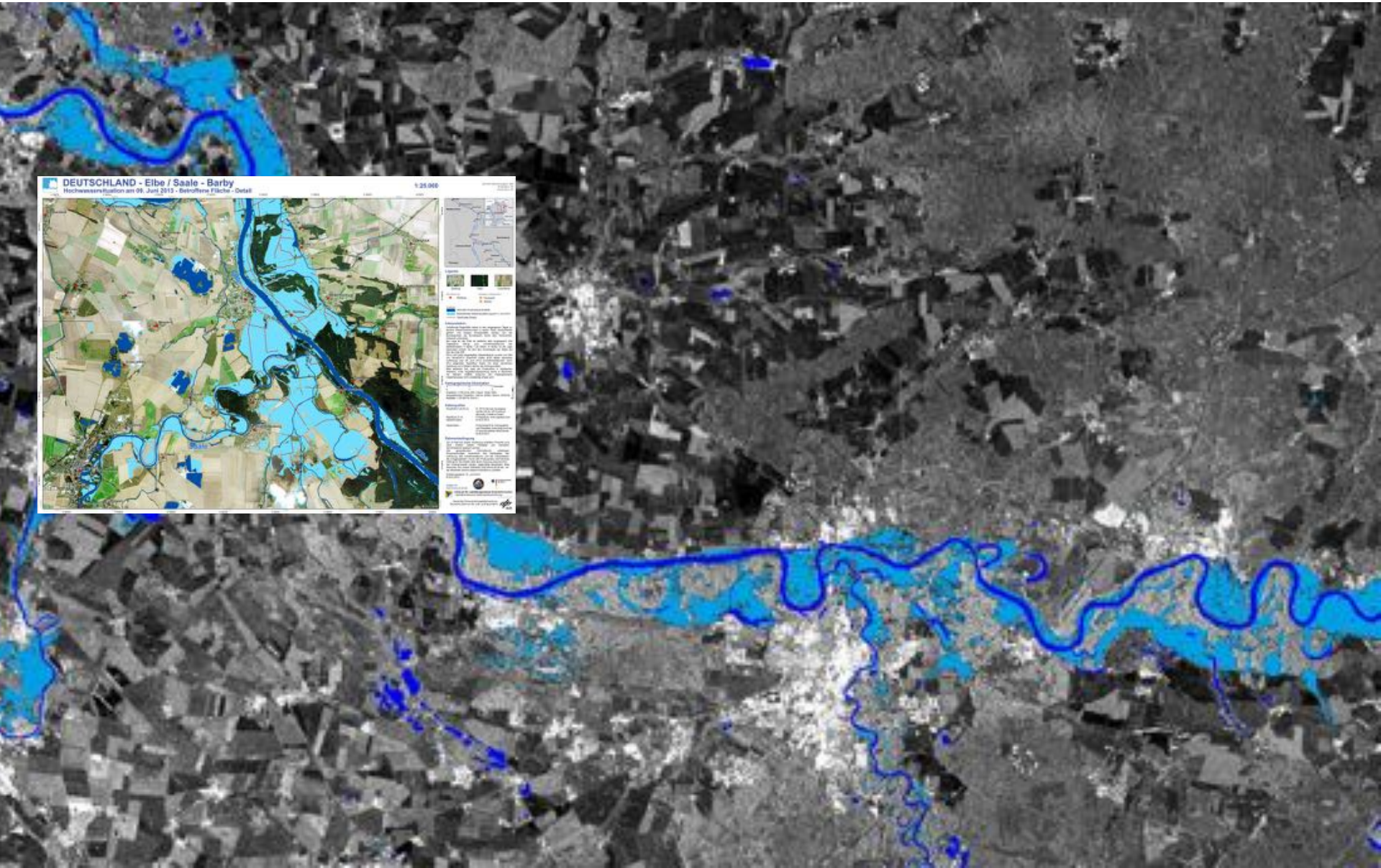
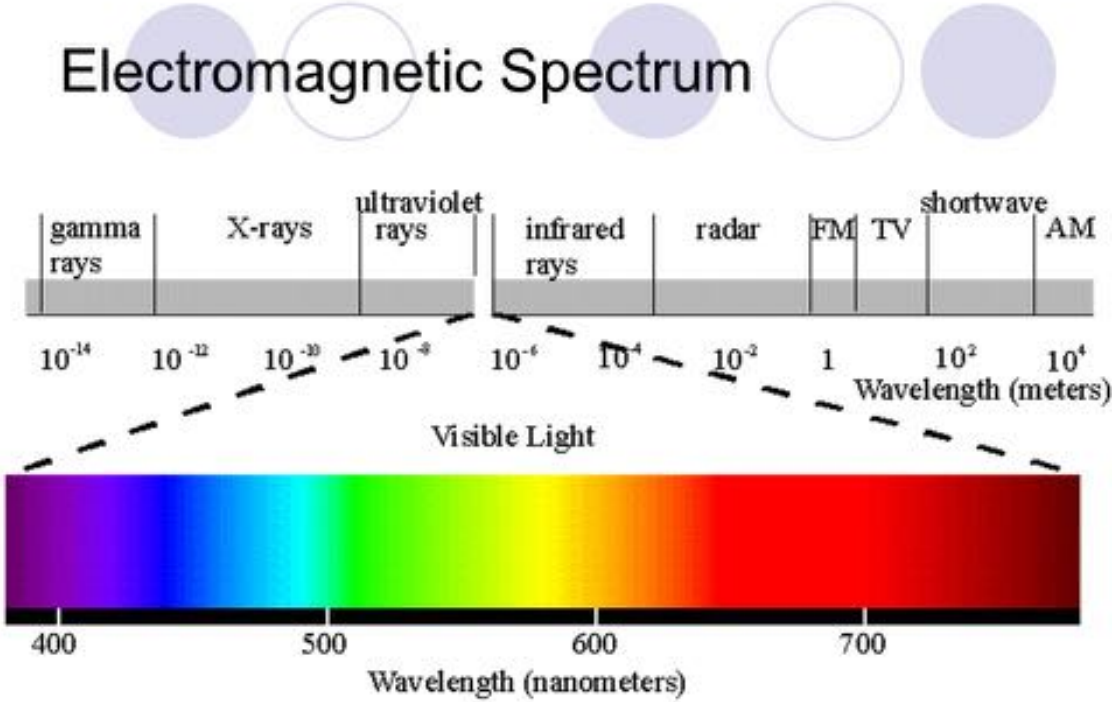
ZKI Application: Rapid Flood Mapping, Germany, June 2013



Determining factors of satellite-based Earth observation

4. Characteristics of optical sensors

Characteristics of optical sensors

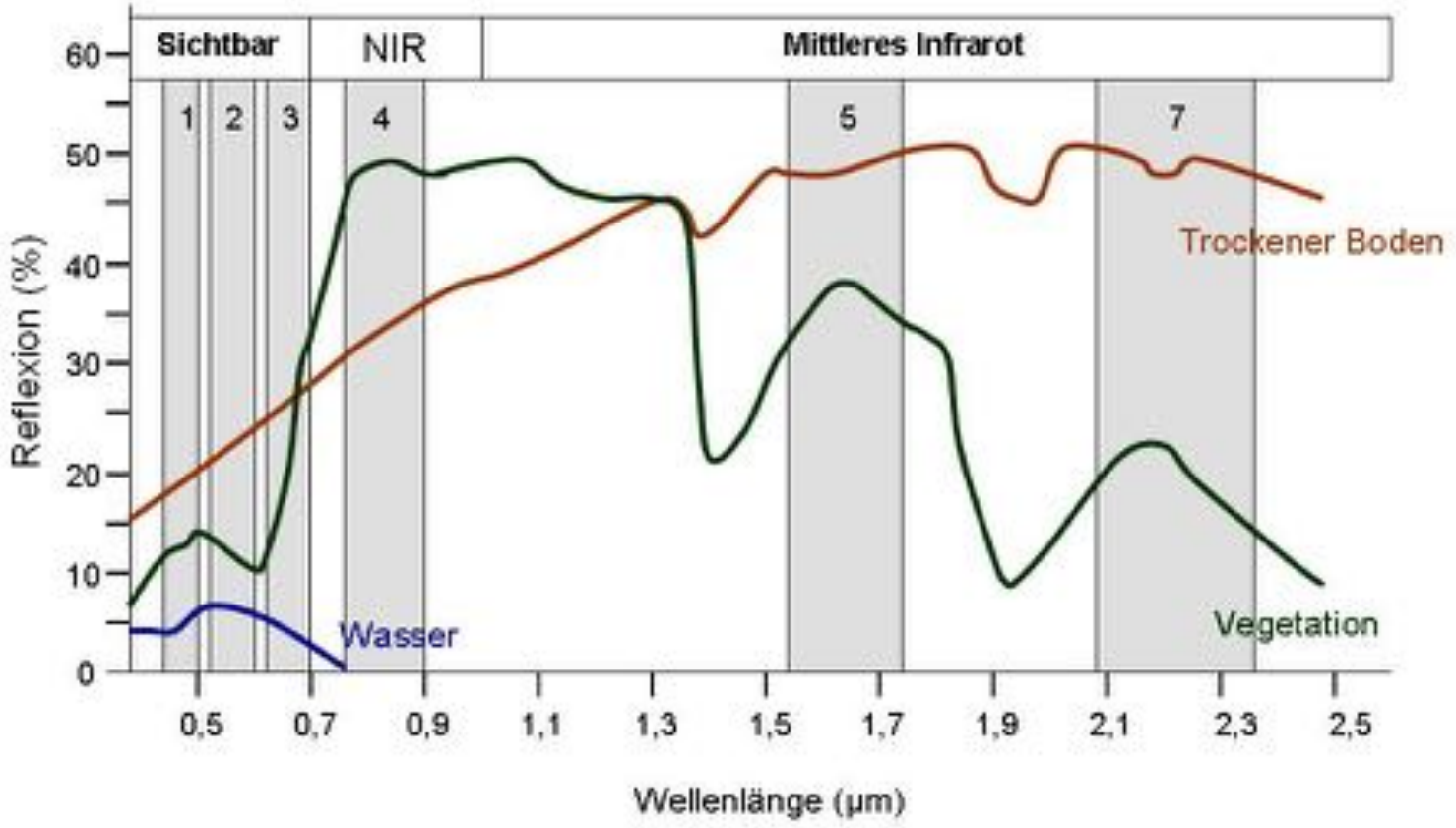


Wikipedia

Optical sensors „see“ more than the human eye!

http://slideplayer.com/slide/5287993/17/images/10/Electromagnetic+Spectrum.jpg

Spectral signatures



http://www.seos-project.eu/modules/remotesensing/remotesensing-c01-p05.de.html

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example 1

Football Stadium Dresden

Satellite
***Pléiades* (50 cm)**

View:
„Natural colors“
→ NIR, R, G

example 2

South Sudan
(15 km x 19 km)

Satellite
***Landsat*-7 (15 m)**

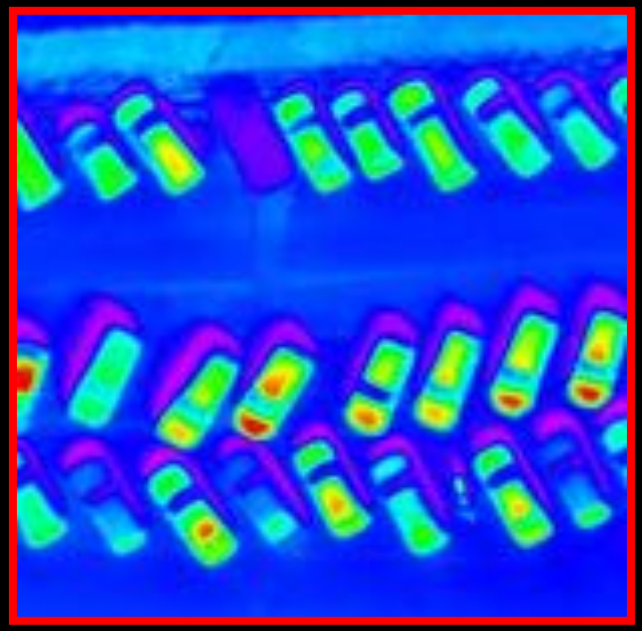
View:
Mid IR II, Mid IR I, Near IR

example 3

Thermal information

DLR site,
Oberpfaffenhofen

UAV with camera
FLIR Tau640



cold **warm**

Summary

Prospects and limitations of remote sensing

Prospects and Advantages

- Worldwide coverage
- Quick spatial overview, also in inaccessible areas
- Detailed monitoring applications
- Cost-efficient observation of large areas
- Different Sensors and their advantages:
  - SAR
    - Image capture during night time and penetration of clouds
  - Optical
    - Larger electromagnetic spectrum than the human eye (Infrared, Thermal, …)
    - „False color images“ provide „hidden“ information

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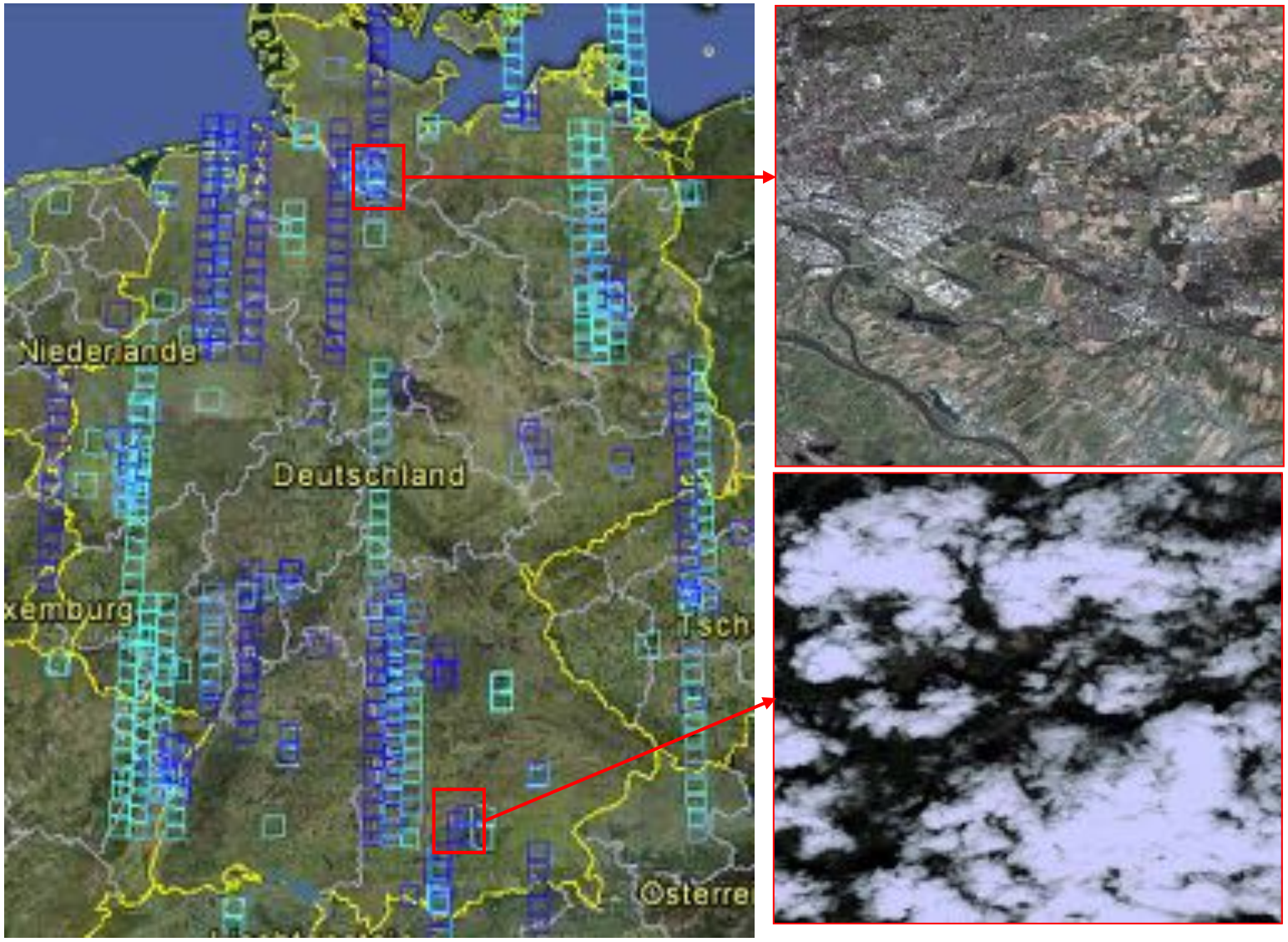
Limitations

- Limited number of available satellites at a certain time

- Limited availability of archive images

Overview of all QuickBird scenes acquired over Germany during the year 2009 (incl. cloudy images)

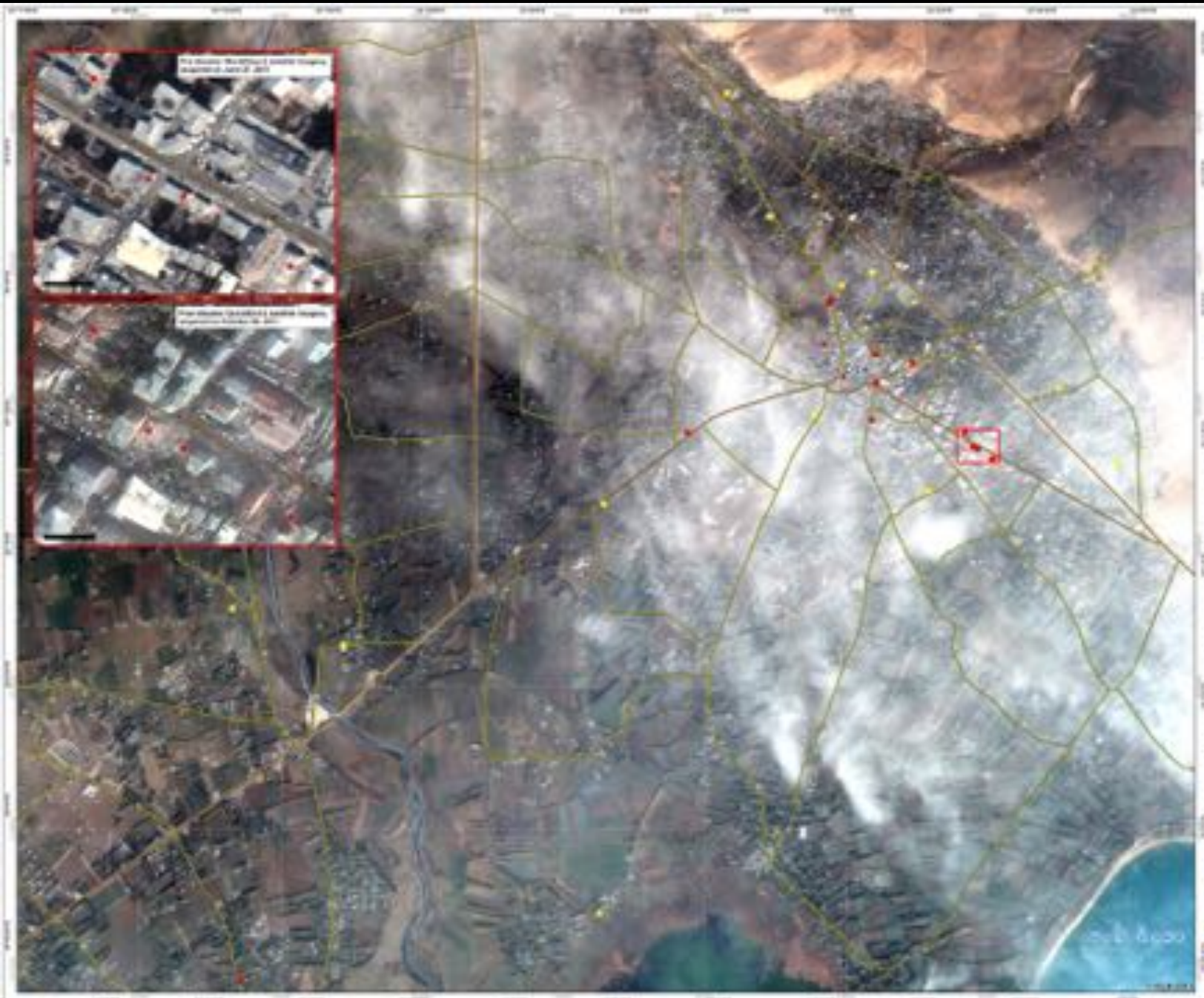


Limitations

- Limited number of available satellites at a certain time

- Limited availability of archive images

- Weather-induced limitations with optical data (clouds, haze)



TURKEY - ERCIS

Situation as of October 26, 2011

Damage Assessment Map - Detail

Scale: 1:12,000

Location Diagram

Legend

Cartographic Information

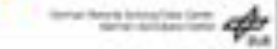
Publication Info

Publication Date: 27 October 2011, provided by ERCIS under the KOERI/ERCIS MoU as ad-hoc service

Version: 1.0

Version date: 27/10/2011

Disclaimer



Limitations

- Begrenzte Anzahl von verfügbaren Satelliten in bestimmtem Zeitraum
- Beschränkte Anzahl von verfügbaren Archivaufnahmen
- Weather-induced limitations with optical data (clouds, haze)
- Compromise between spatial coverage and resolution
- Sometimes there is a significant lead time for new acquisitions

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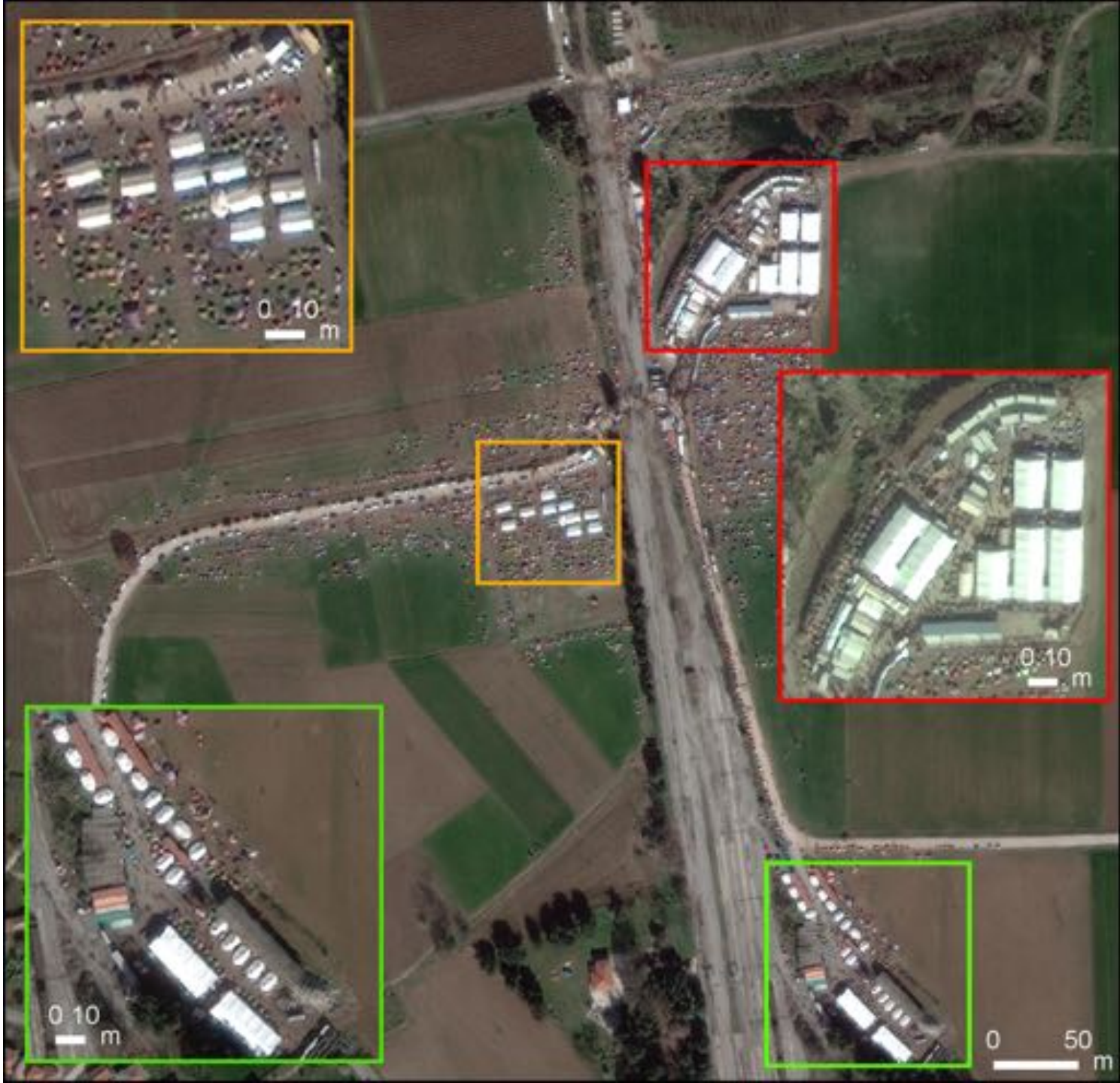
Application in crisis response

Refugees



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Application in crisis response

Flooding

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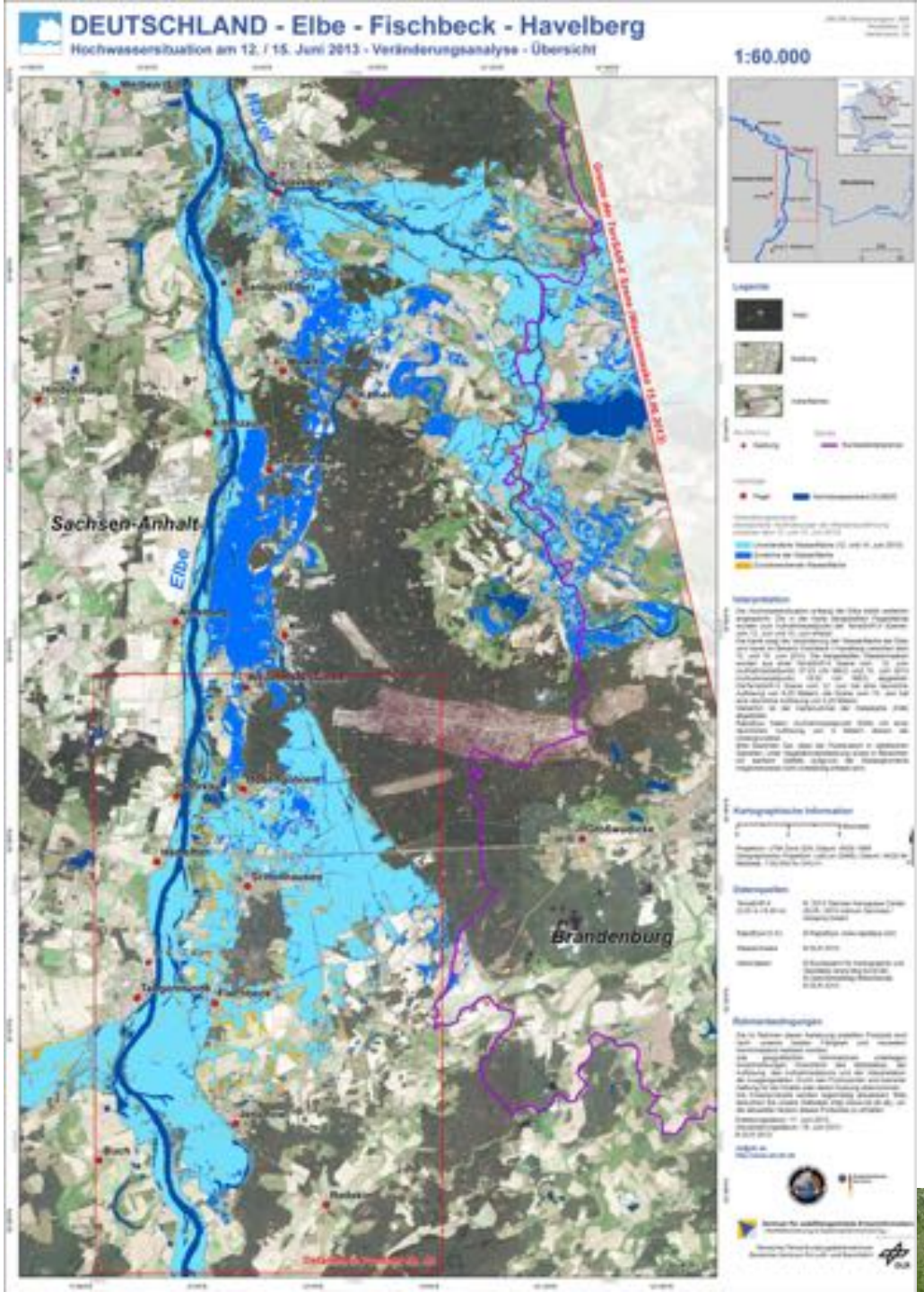
B
100 m
Luftbild (0,2 m), 31.05.2011
B
100 m
Satellitenbild (Pléiades 0,5 m), 05.06.2013


DEUTSCHLAND - Elbe - Fischbeck - Havelberg
Hochwassersituation am 12. / 15. Juni 2013 - Veränderungsanalyse - Übersicht
1:60.000
Sachsen-Anhalt
Elbe
Havel
Brandenburg

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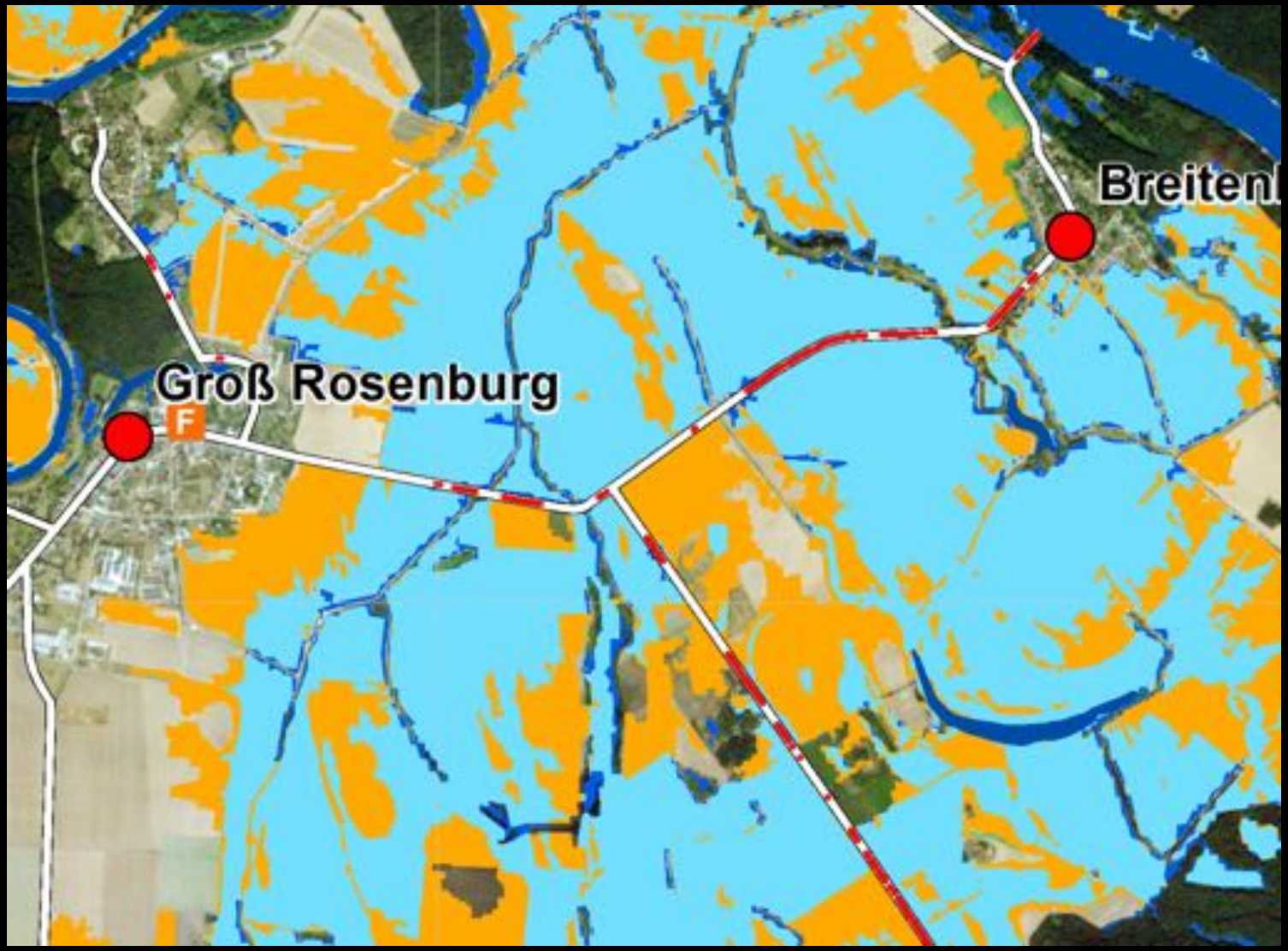
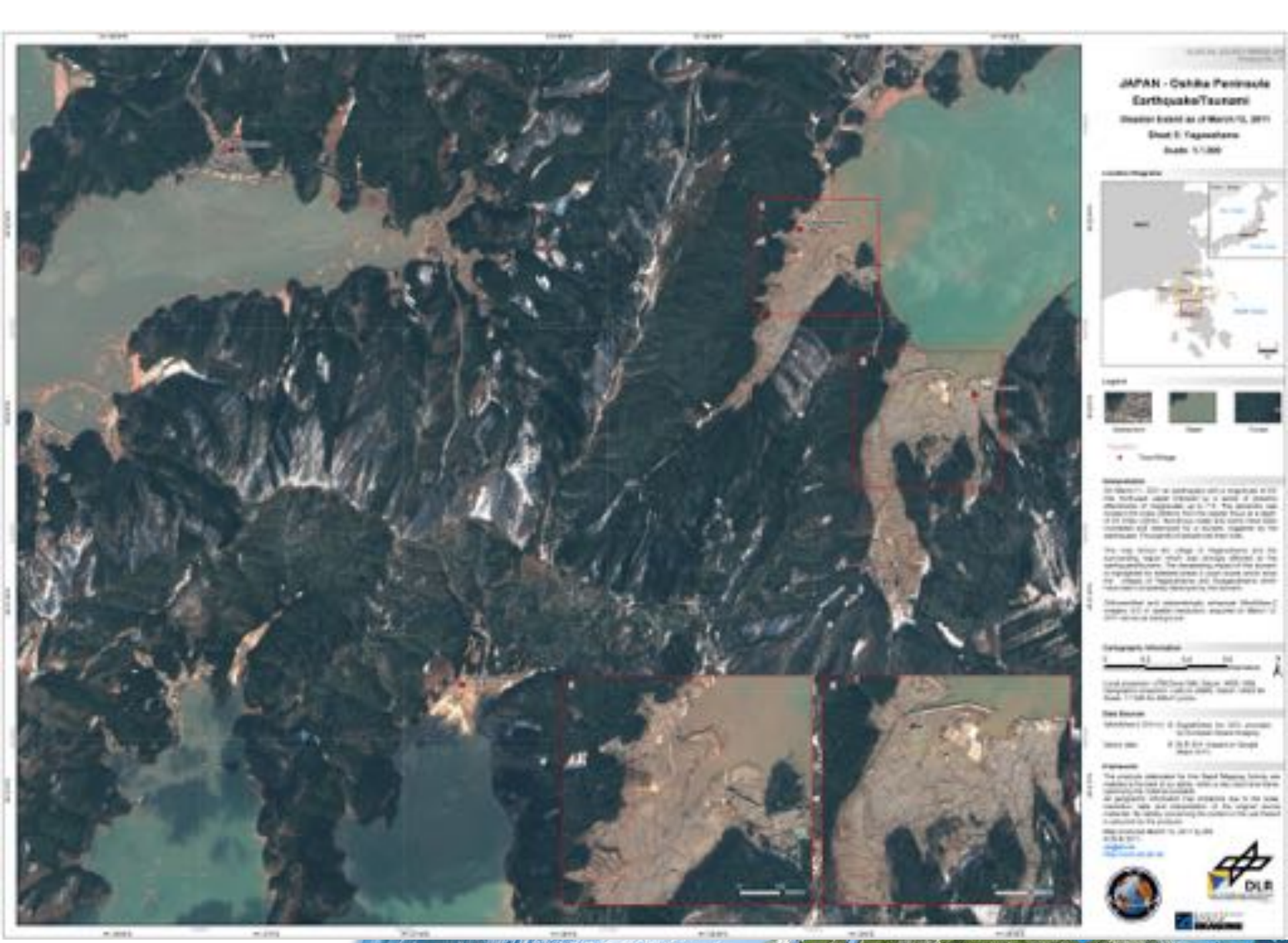

Groß Rosenburg
F
Breiten

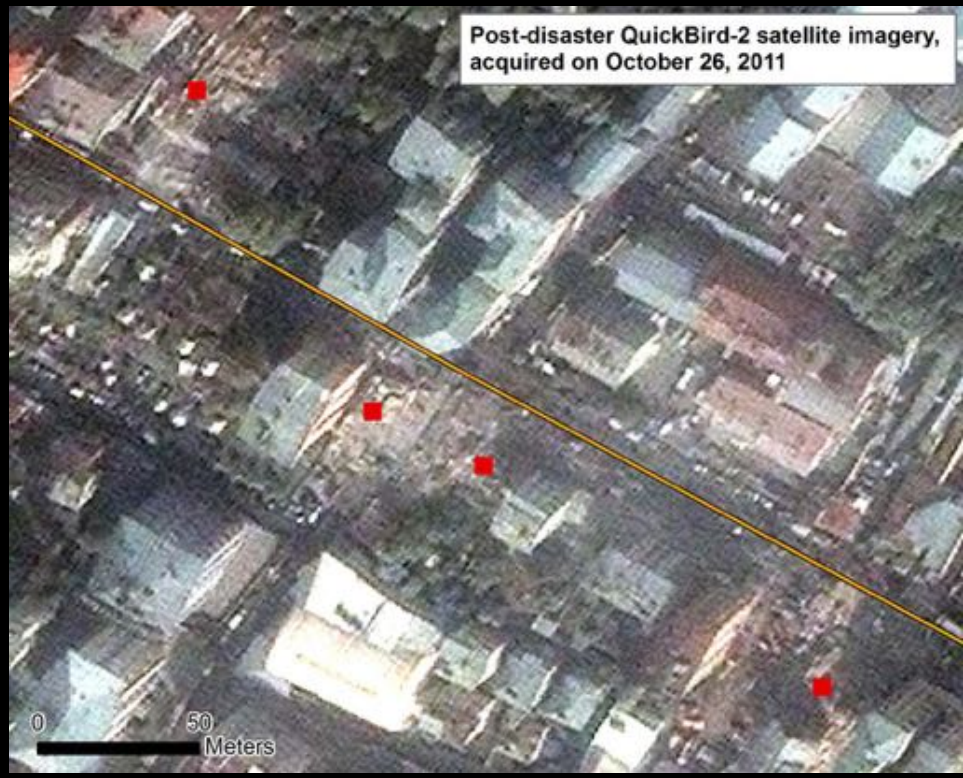
Application in crisis response

Building damage


1
0
100
Meters
arth


JAPAN - Oshika Peninsula
Earthquake/Tsunami


Pre-disaster WorldView-2 satellite imagery, acquired on June 27, 2011
0
50
Meters


Post-disaster QuickBird-2 satellite imagery, acquired on October 26, 2011
0
50
Meters

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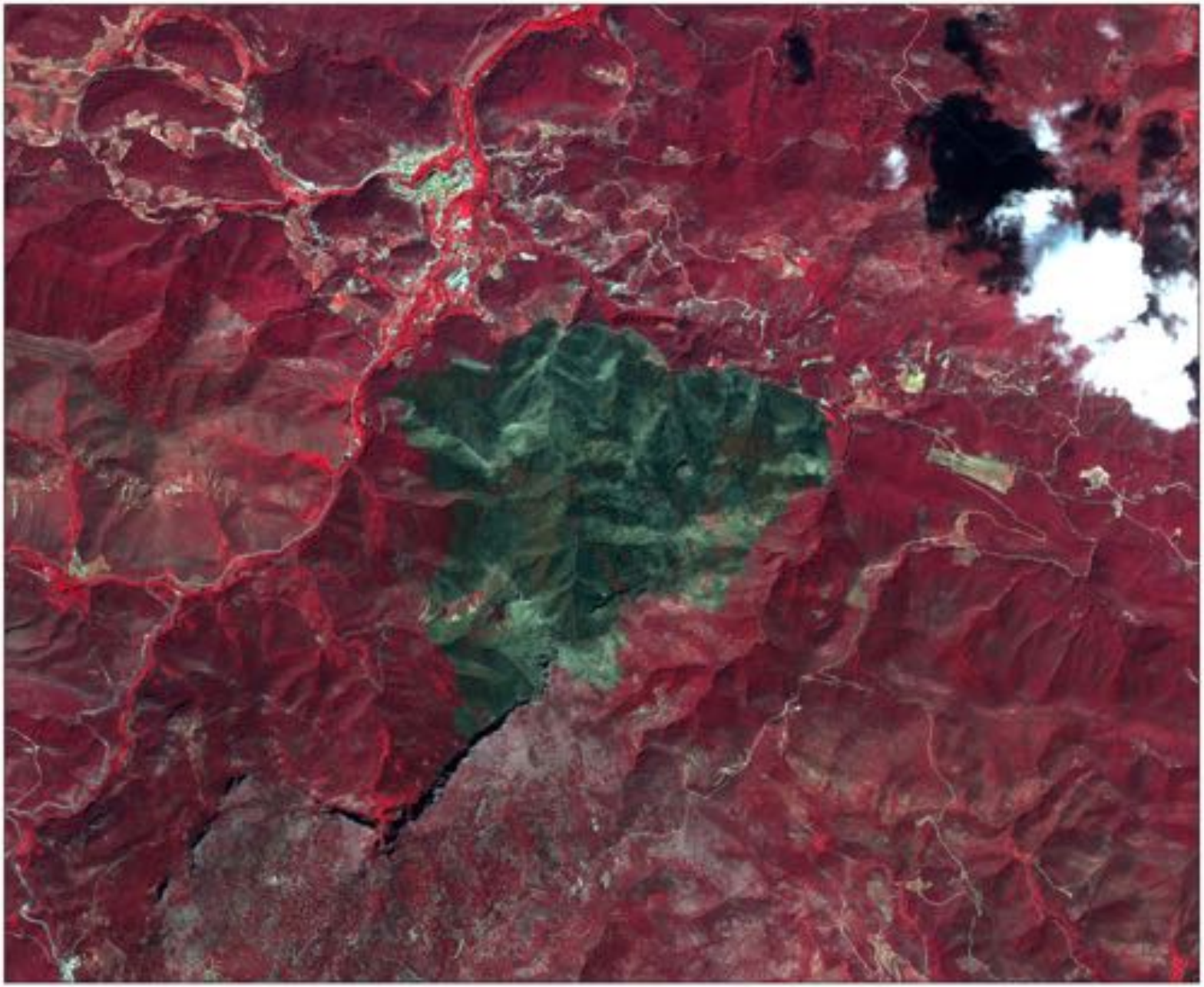
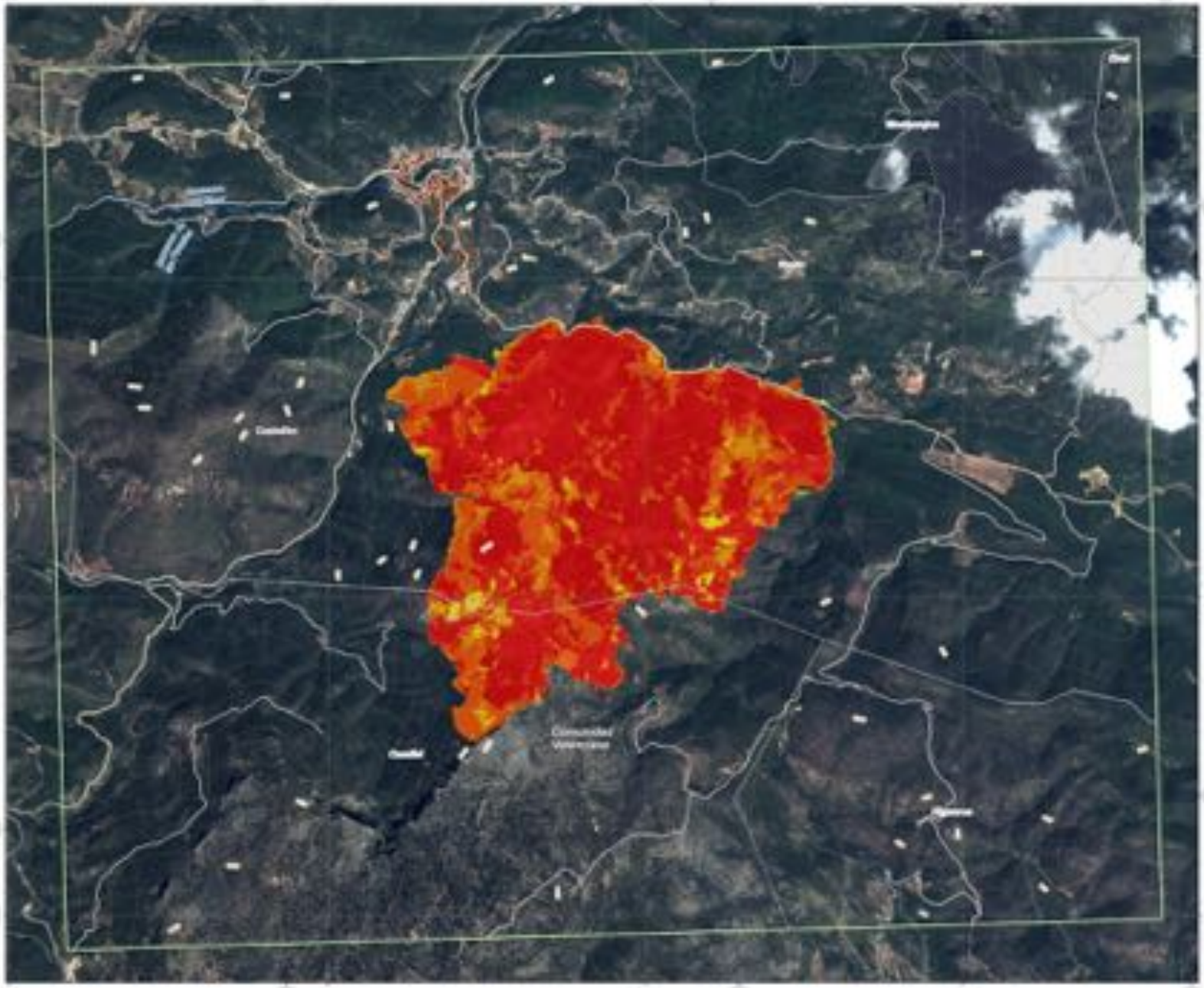
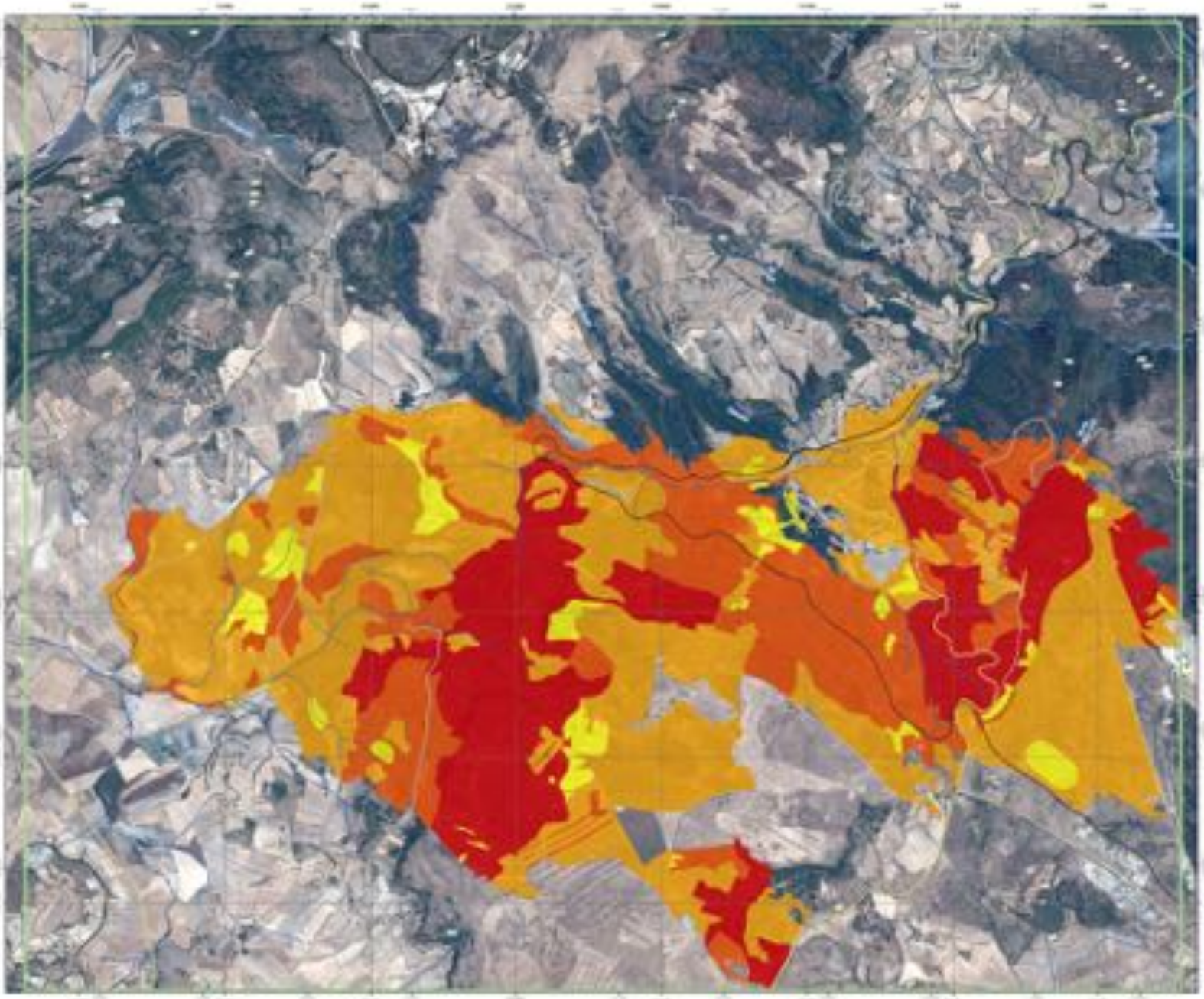
Application in crisis response

Fire




Castellón
Comunidad Valenciana

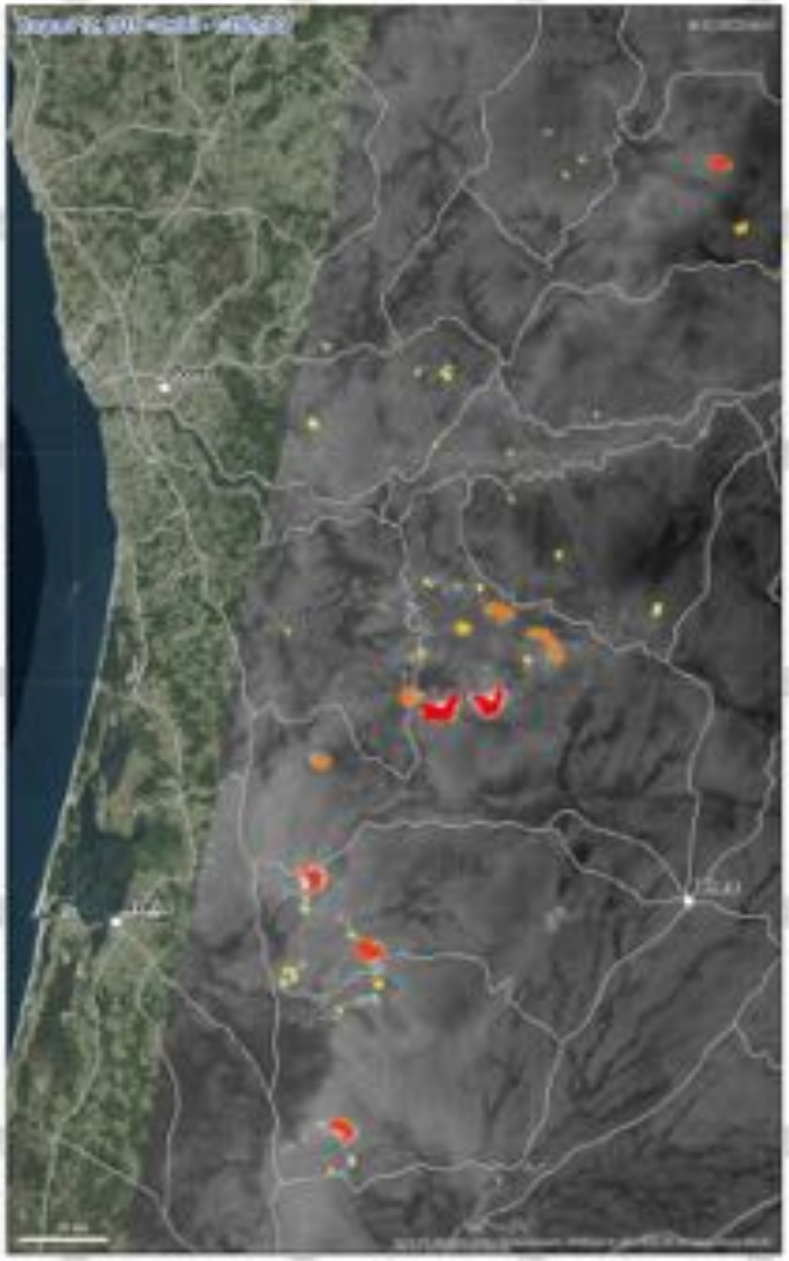



CHILE - Torres del Paine
Fire as of January 07, 2012 - Disaster Extent Map
1:50,000
Legend
Interpretation
Cartographic Information
Data Sources
Framework
DLR
RapidEye

PORTUGAL

Fires as of August 12, 2016 - Situation Map

1:1,200,000 / 1:250,000



Legend

Interpretation

Cartographic Information

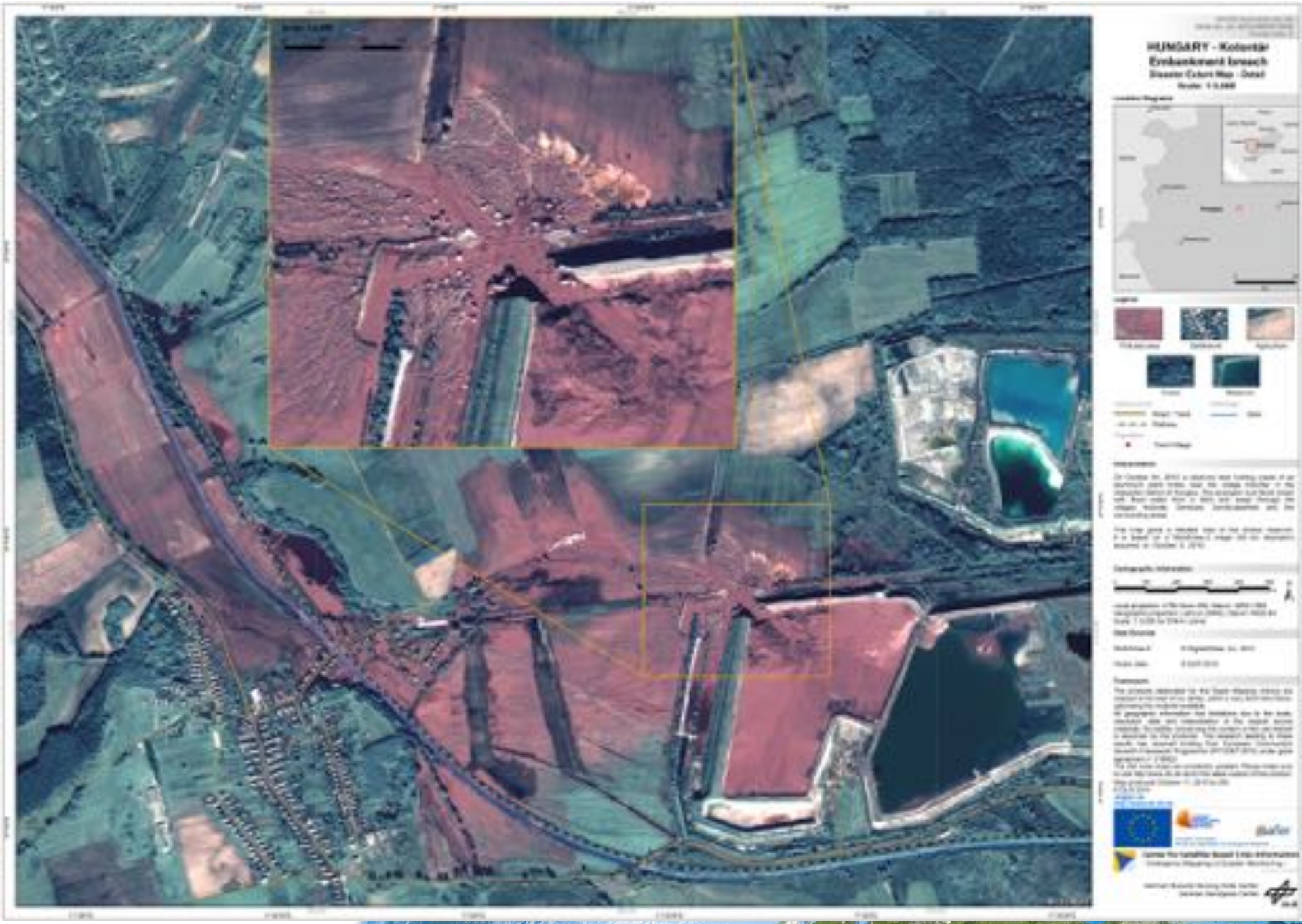
Data Sources

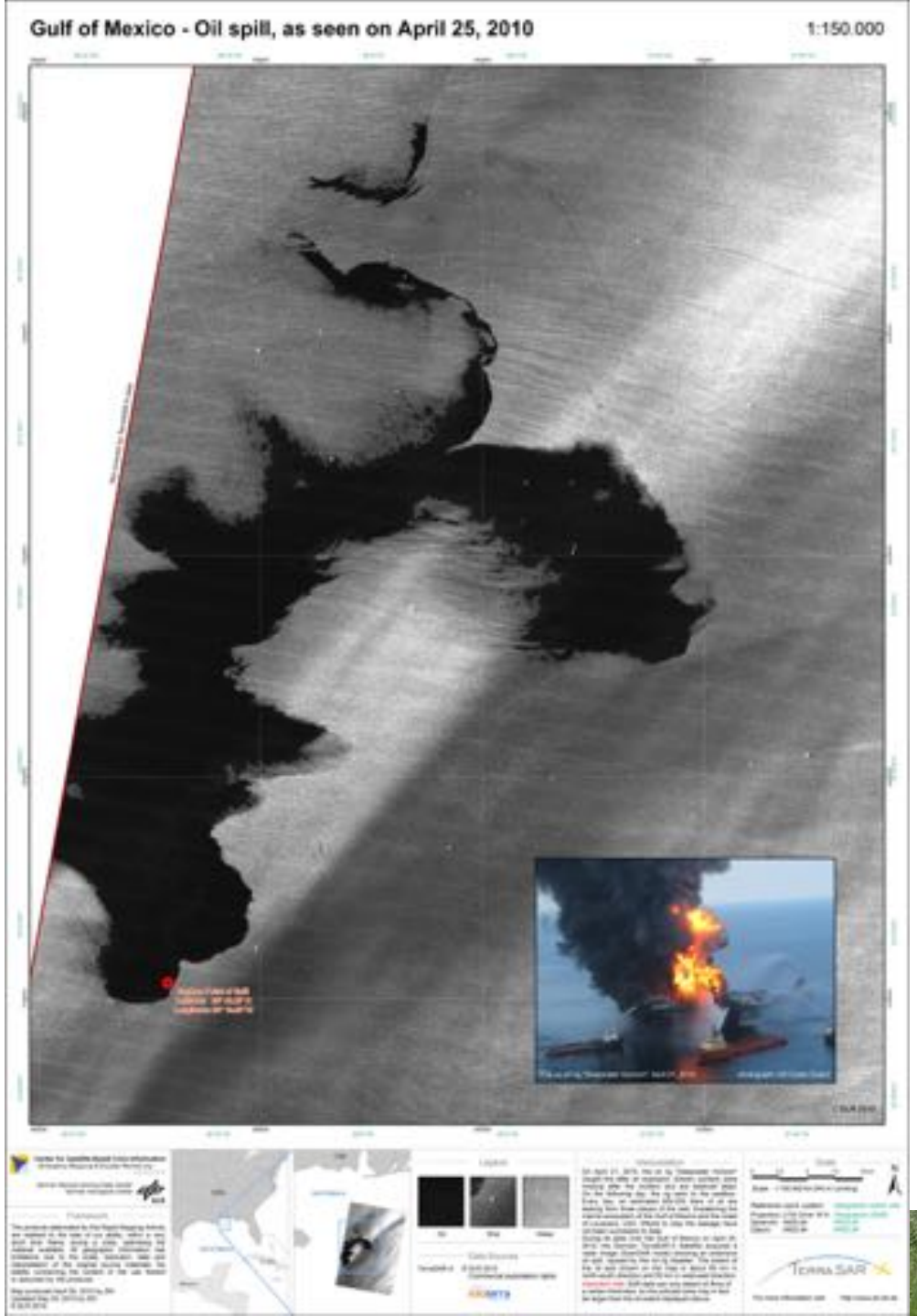
Framework

ZKI

Application in crisis response

Technical accident


HUNGARY - Kolontár
Embankment breach
Disaster Cohort Map - Detail



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Current trends in satellite remote sensing

Current trends in satellite remote sensing

- **Copernicus (EU): Sentinel Missions**
  - Sentinel-1 (4 Satellites): SAR (5m – 40m)
  - Sentinel-2 (2 Satellites): Optisch (10m, 20m, 60m)
  - Sentinel-3 (2 Satellites): Ocean monitoring (300m- 1km)
  - Sentinel-4/5: Atmospheric monitoring from 2017/2019

- **UrtheCast (Canada): OptiSAR**
  - 16 Satellites: 8 pairs, each with the combination of a SAR and an optical satellite, two orbits (four pairs per orbit)

- **BlackSky (USA)**
  - planned: 60 micro satellites until 2020, spatial resolution 1 m

- **Planet Labs (USA)**
  - Currently ca. 50 micro satellites (CubeSat), spatial resolution 3-5 m

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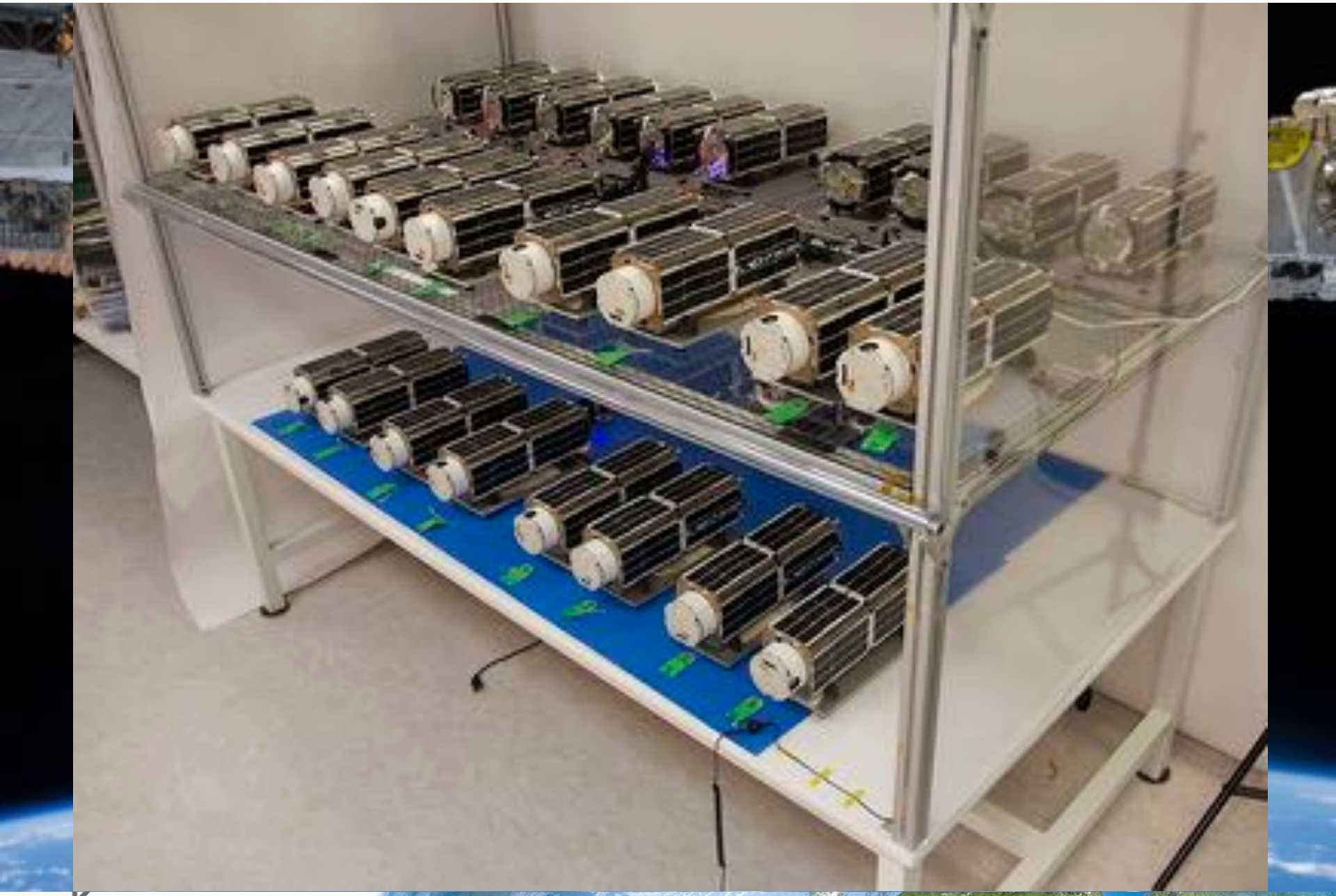

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Current trends in satellite remote sensing

- New plattforms and sensors (UAV)
- Video (max. 90 seconds) from space: BellaTerra (Skybox)
- Permanent contact between satellites and ground station: European Data Relay System (EDRS)
- Hyperspectral sensors
- 3D-Modelling
- Person tracking at mass events (e.g. Festivals)

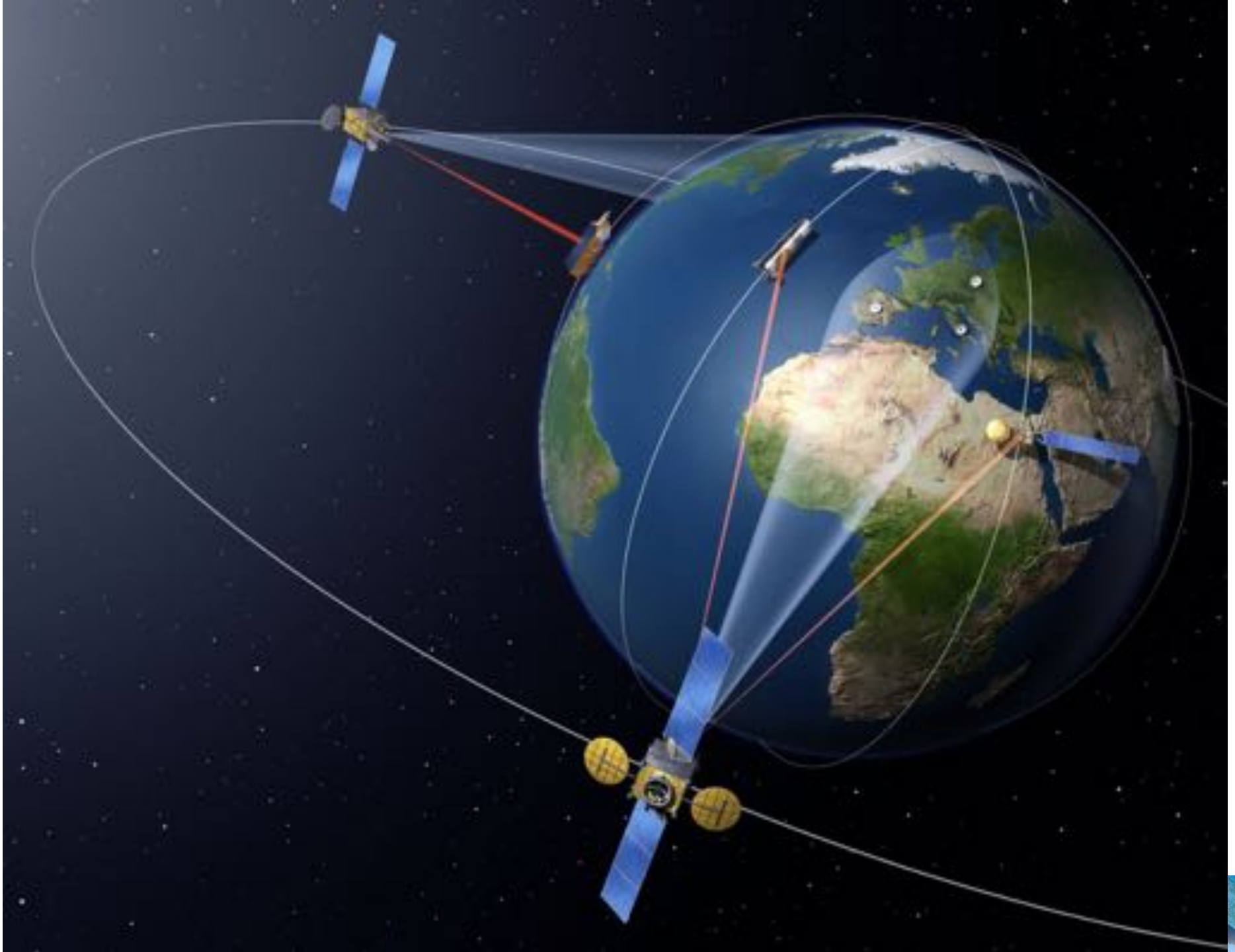
Space-based remote sensing

Schloss Elmau
Pléiades (50 cm)

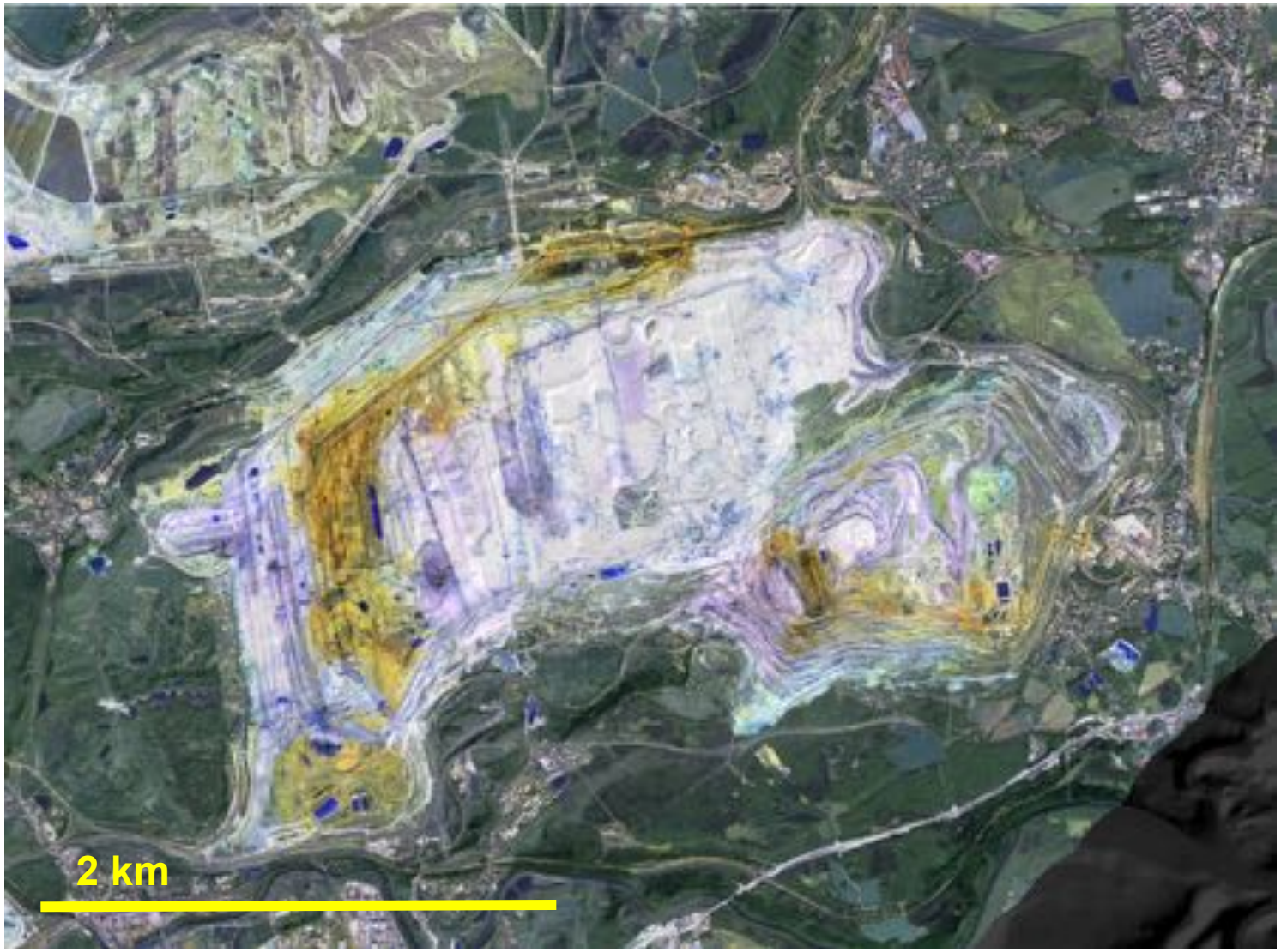
Remote sensing with air planes

Schloss Elmau
Luftbild 15 cm

Remote sensing with UAVs/ drones



Air-borne hyperspectral acquisition (Czech Republic)



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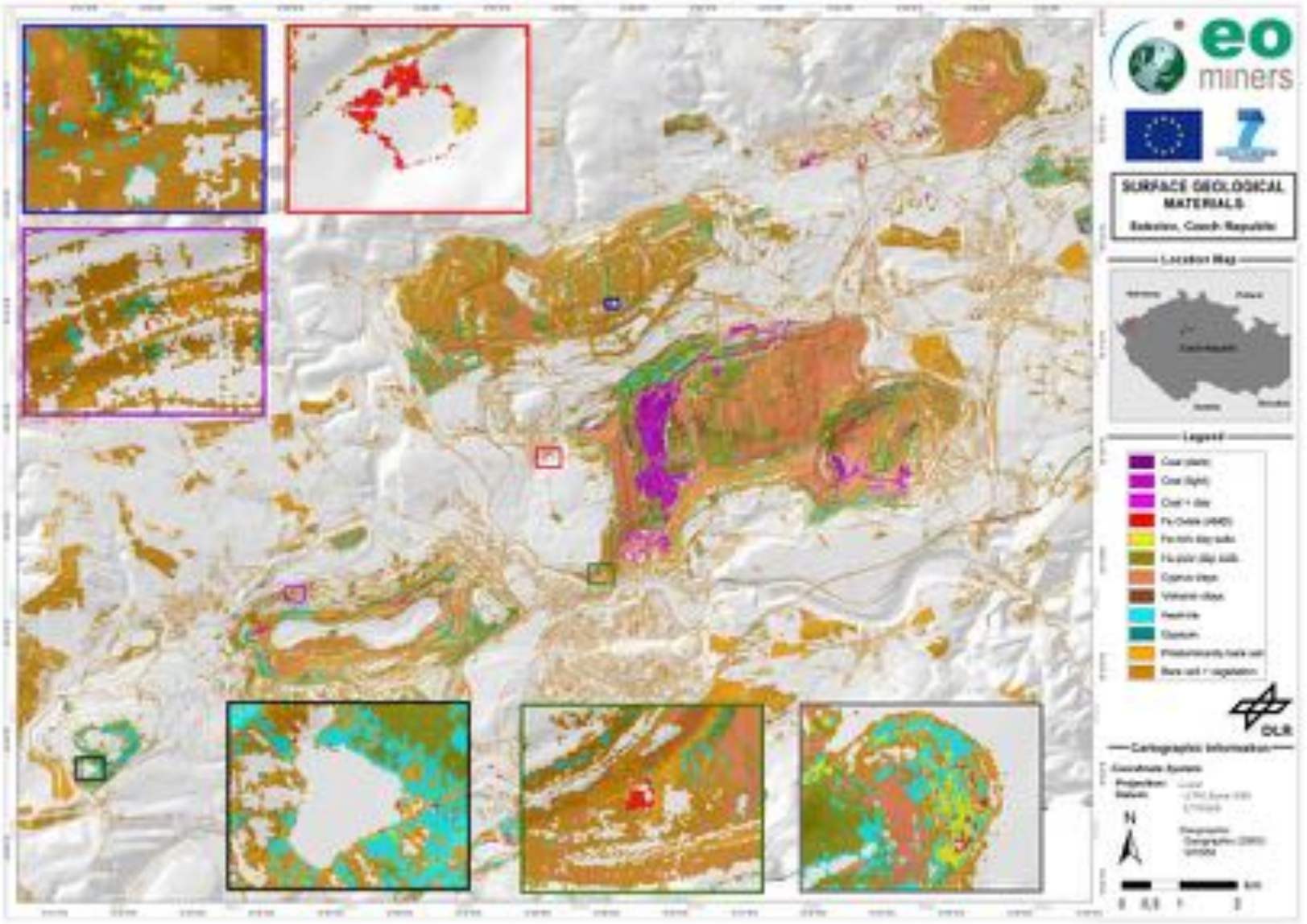
Air-borne hyperspectral acquisition (Czech Republic)



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3D: earthquake Nepal

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Person Tracking

- **Goal**: understanding behavioral dynamics of large groups of people can help avoid catastrophes
- **How**: by detecting and tracking individuals in aerial image sequences
- **Method**: Tracking-by-Detection
  - **Detector**: AdaBoost classifier on Haar-like features
  - **Tracker**: Multiple-Hypothesis Tracking
- **Work in progress**: deep-learning methods to improve person detection

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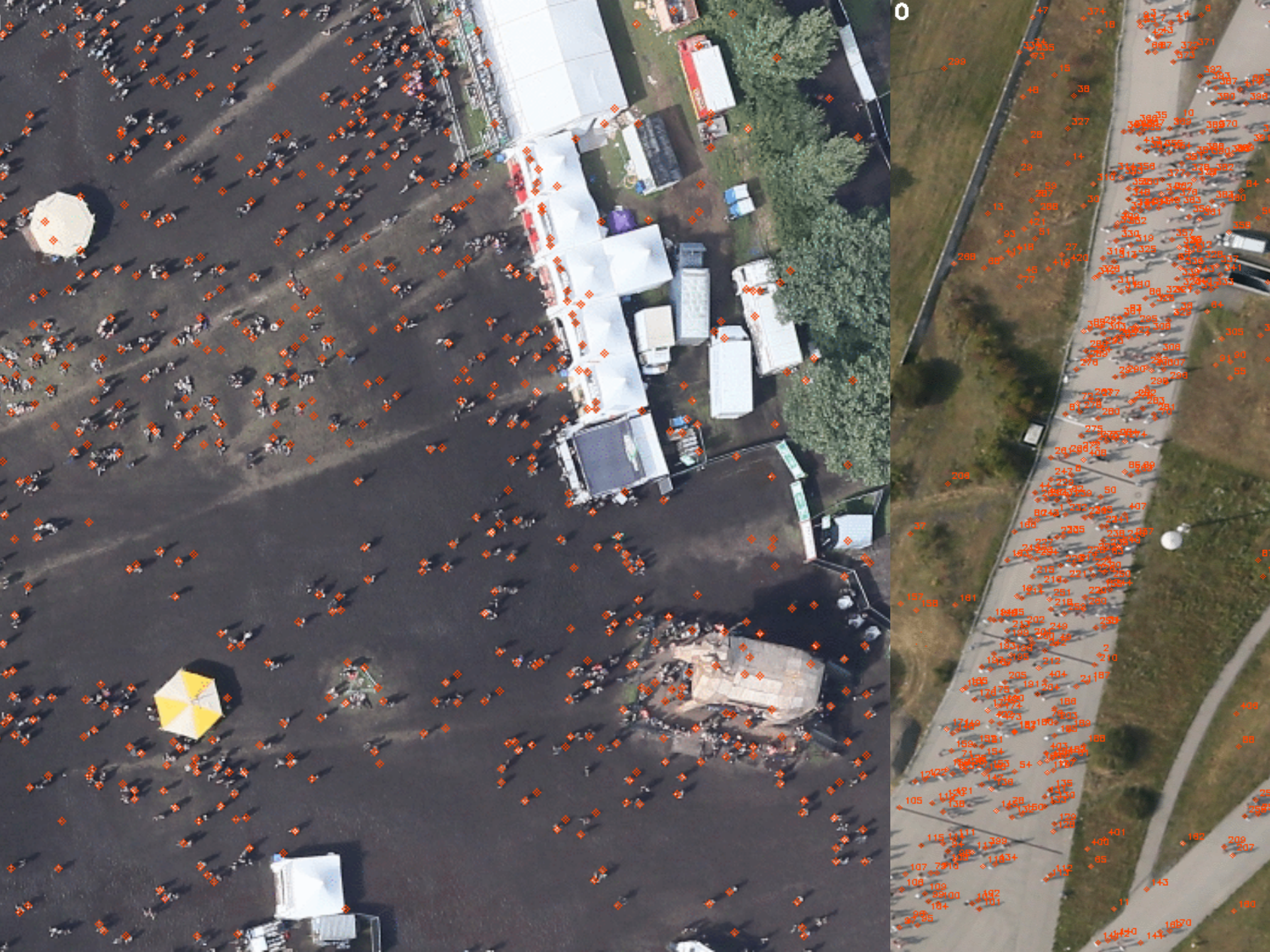


The international Charter ‚Space and Major Disasters‘

Disaster types supported

The International Charter executes priority tasking of different EO missions in a rapid fashion; it is designed to address requests concerning major disasters caused by:

Natural events

- Earthquakes
- Floods
- Landslides
- Tsunamis
- Fires
- Ice jams
- Ocean storms
- Volcanic eruptions

Man-made events

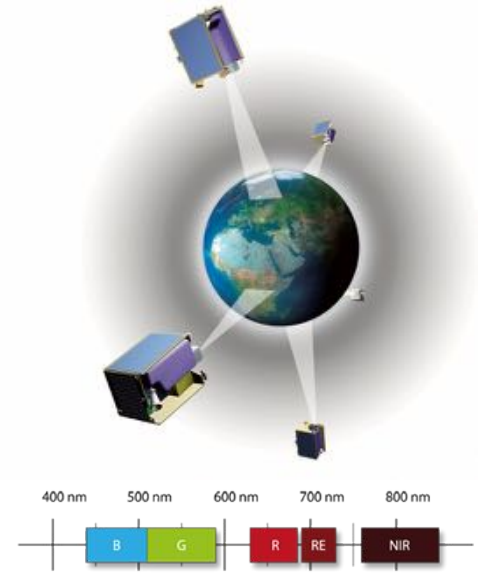
- Oil spills
- Industrial accidents

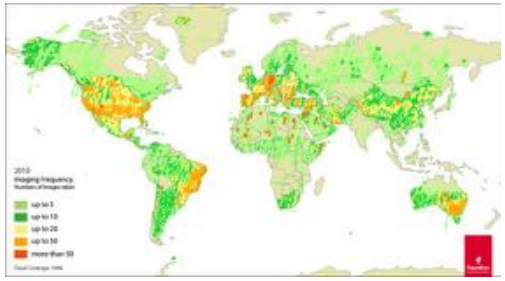




RapidEye - characteristics

- constellation of 5 satellites
  - *Quick response time*
- Solar-synchronous orbit in 630 km height
- 5 bands (blue, green, red, Red Edge, NIR)
- GSD 6,5m; pixel size (orthorectified) 5m
- Swath width: 77 km

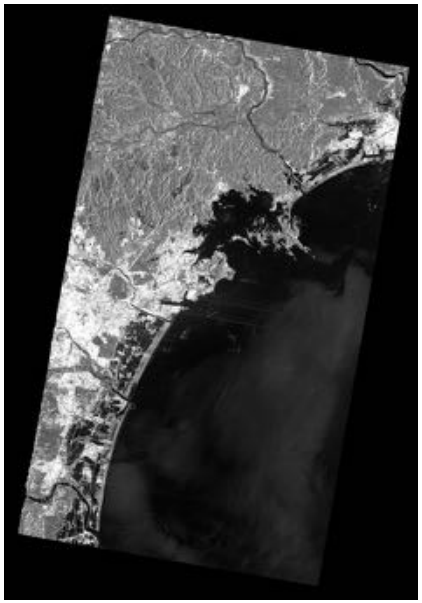




DLR contribution to the Charter

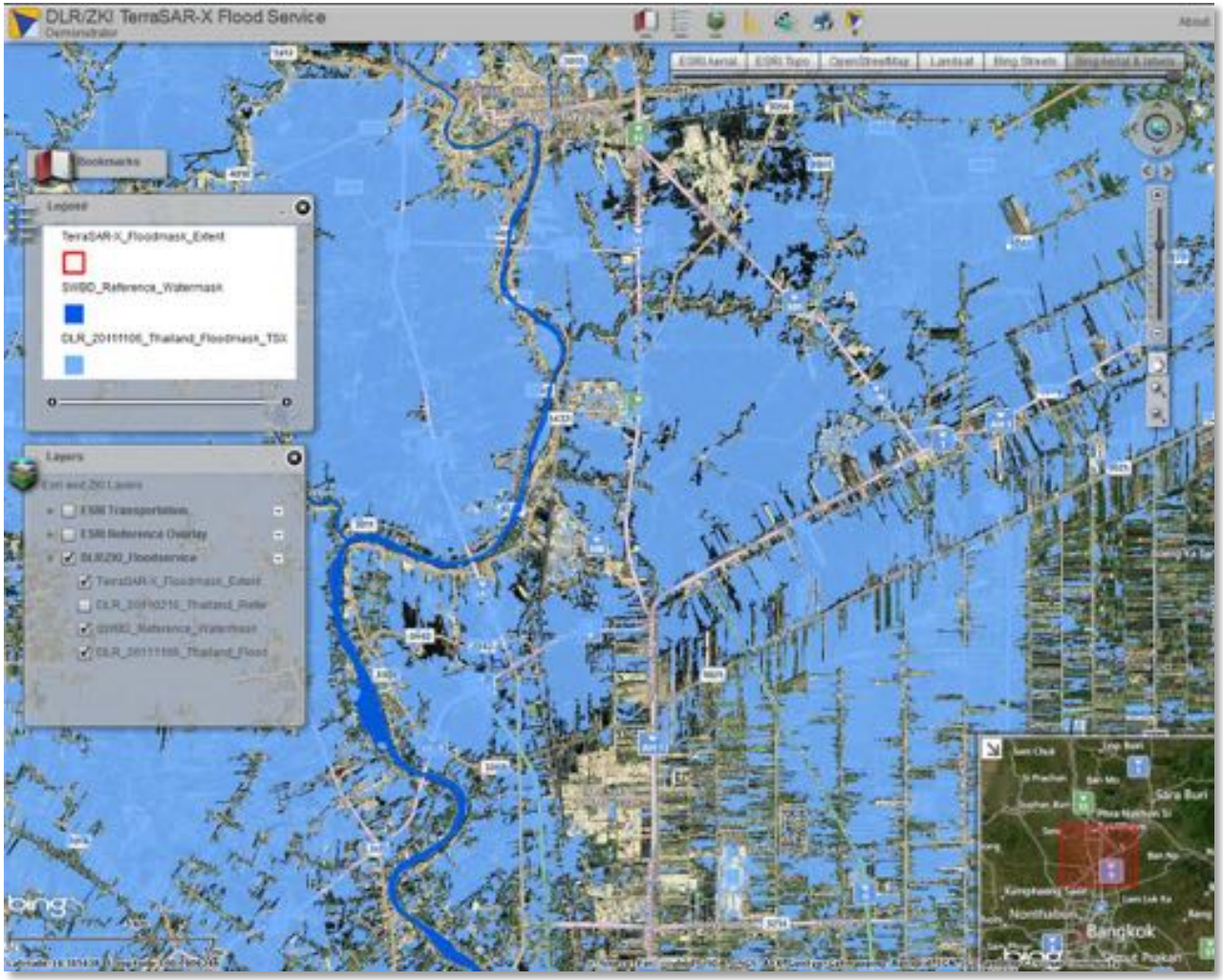
– **TerraSAR-X/TanDEM-X** standard products

  – WideScanSAR (WS)
  – ScanSAR (SC)
  – StripMap (SM)
  – Spotlight (SL)
  – HighResSpotlight (HS)



Acquisitions are realized through TerraSAR-X and TanDEM-X (but no DEMs)

TerraSAR-X Flood Service



- Fully automatic service
- TSX resolution: ~0.25-40.0m
- Local to regional scale flood mapping
- On-demand triggering in case of emergencies

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Exercise: Flood Mapping

http://www.un-spider.org/advisory-support/recommended-practices