



# International Autumn School The EGSIEM School for Satellite Gravimetry Applications

11 – 15 September 2017

GFZ Helmholtz Centre, Potsdam, Germany

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Session: Remote Sensing

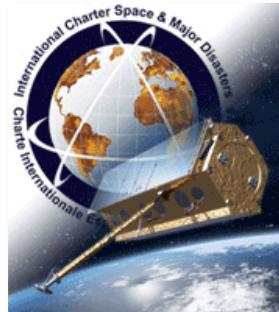
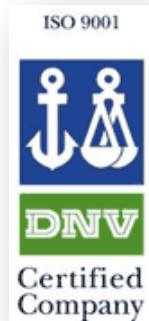
Thursday, 14 Sept 2017

A satellite image of the Earth showing clouds and landmasses. Overlaid on the bottom right is the German motto "Wissen für Morgen".

Wissen für Morgen

# Center for Satellite-based Crisis Information (ZKI)

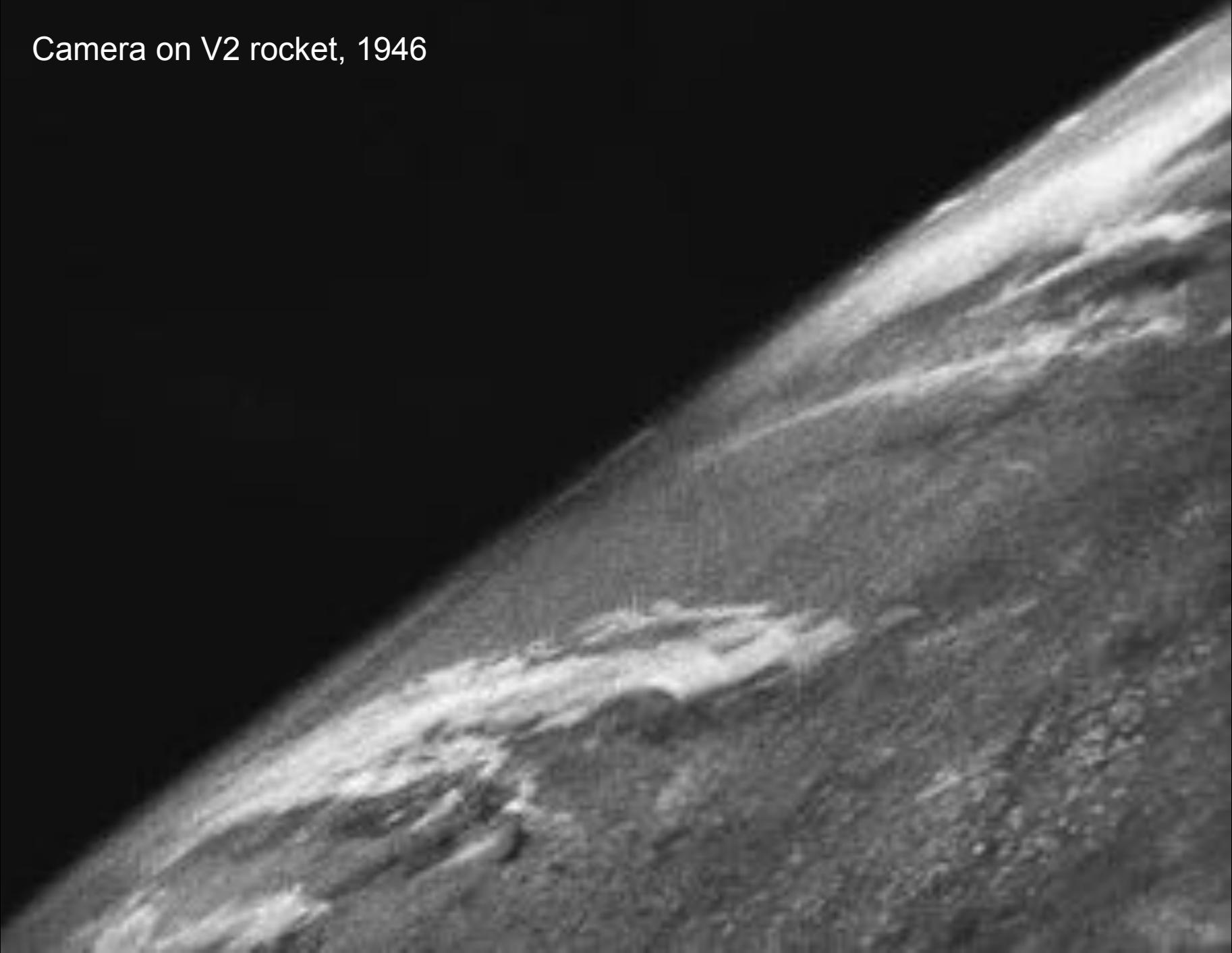
- Operational service of DLR since 2004
- Rapid **provision, processing** and **analysis** of remote sensing data in case of
  - natural and environmental disasters
  - humanitarian relief activities
  - civil security issues
- Activities on national/international level
  - Pre-operational Copernicus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



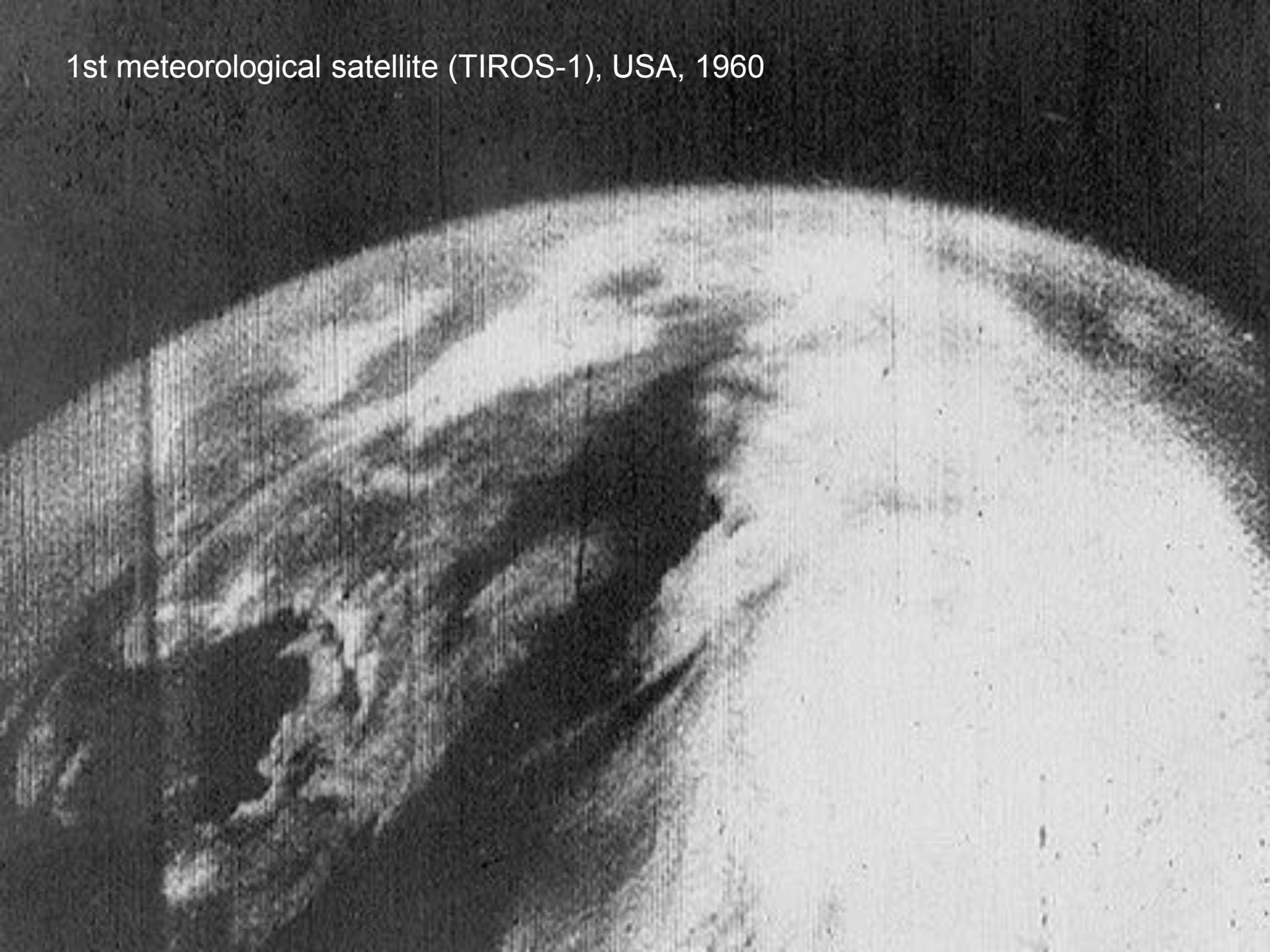
# Introduction

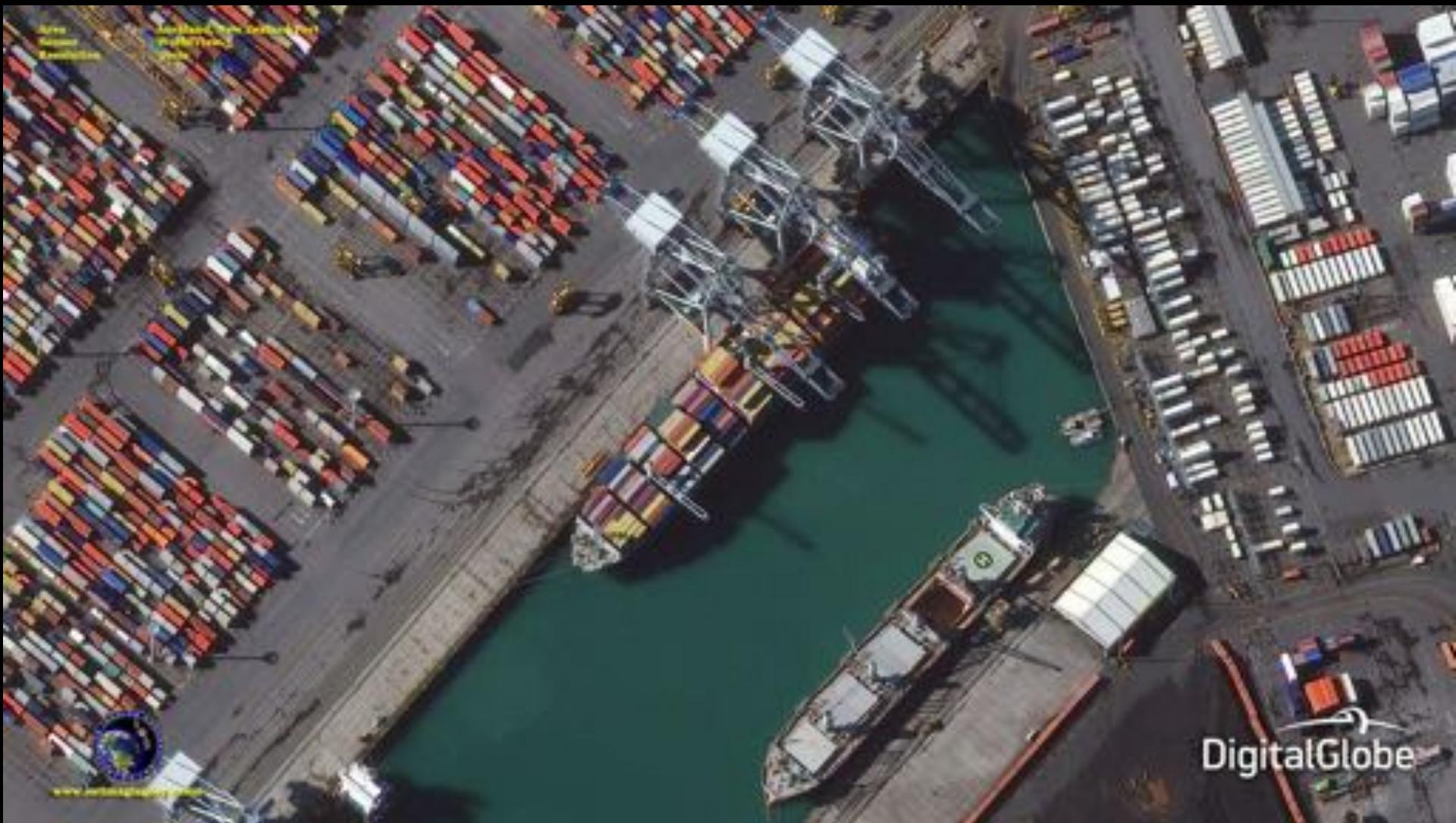


Camera on V2 rocket, 1946



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*

## Categorization

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





MERIS, forest fires, Greece



TerraSAR-X, dam break, Nepal



SPOT-5, landslide, Tadzhikistan



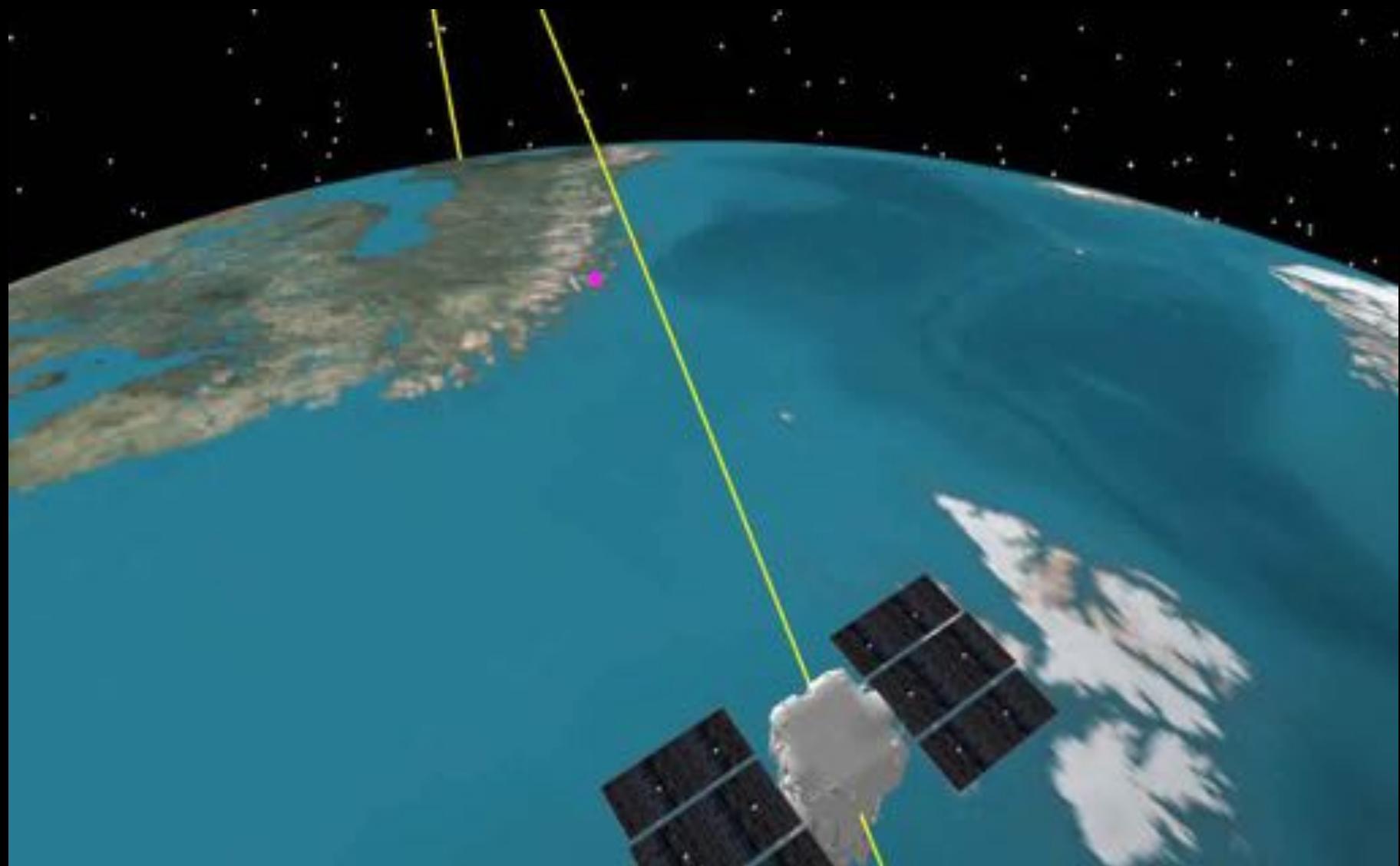
VHR optical, refugee camp, Ethiopia

# 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

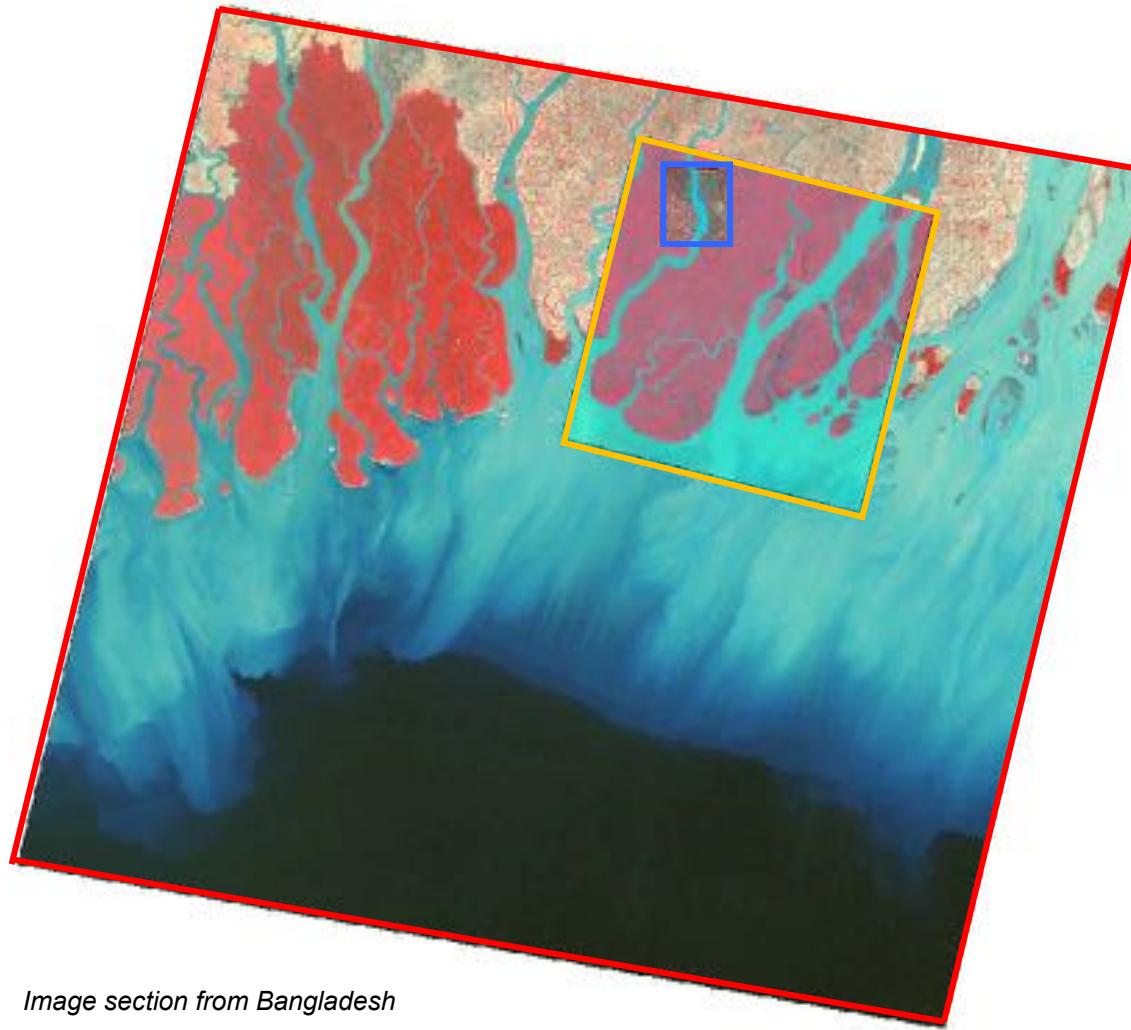


WORLDVIEW-2  
0.5 m

South Sudan, Oil refinery



# 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

# Determining factors of satellite-based Earth observation

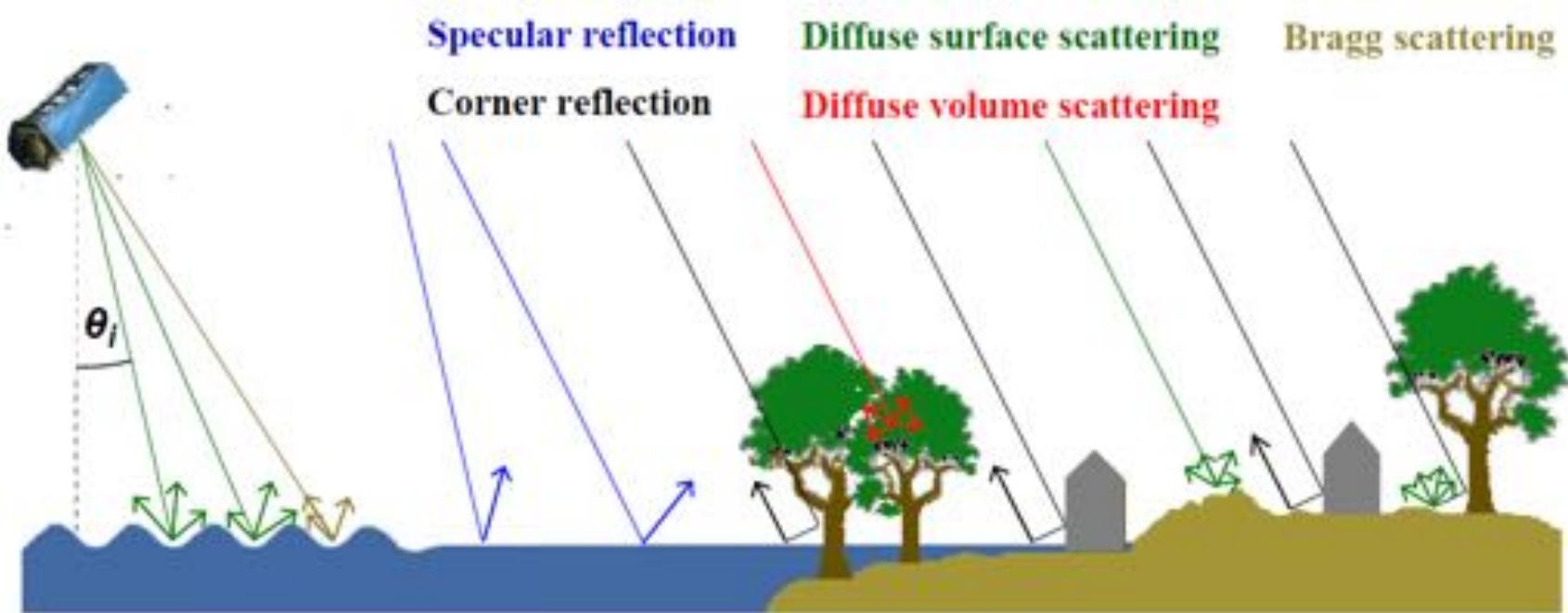
## 3. Synthetic Aperture Radar (SAR) sensors





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



# ZKI Application: Rapid Flood Mapping, Germany, June 2013

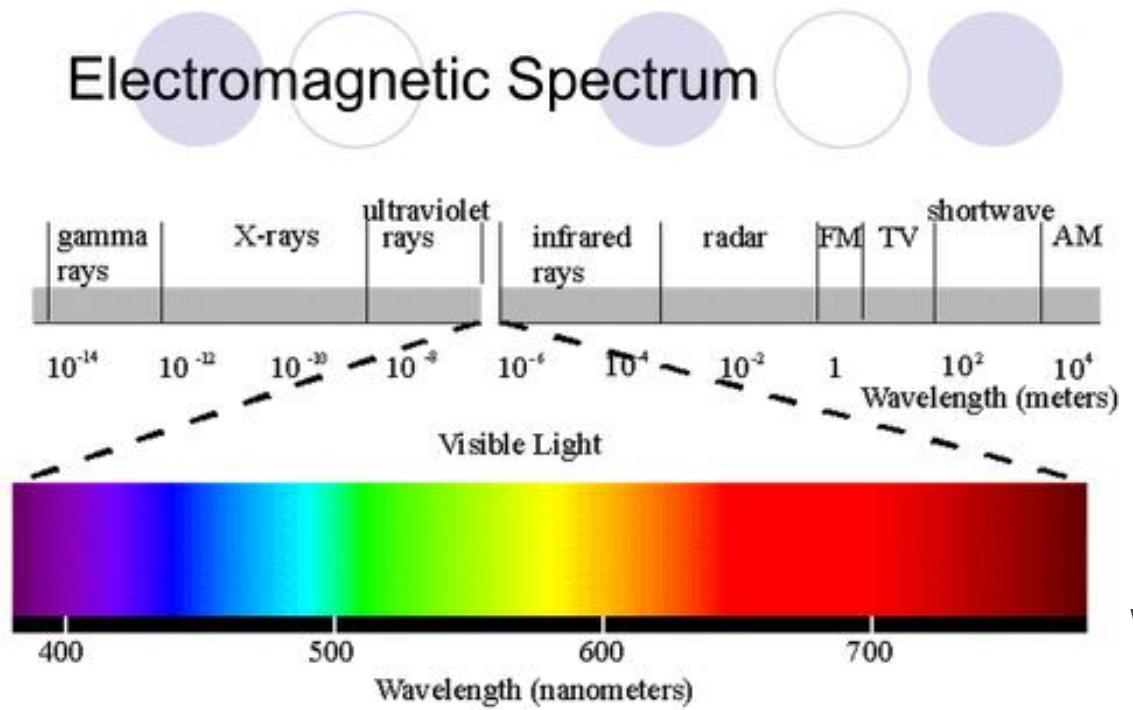


# Determining factors of satellite-based Earth observation

## 4. Characteristics of optical sensors

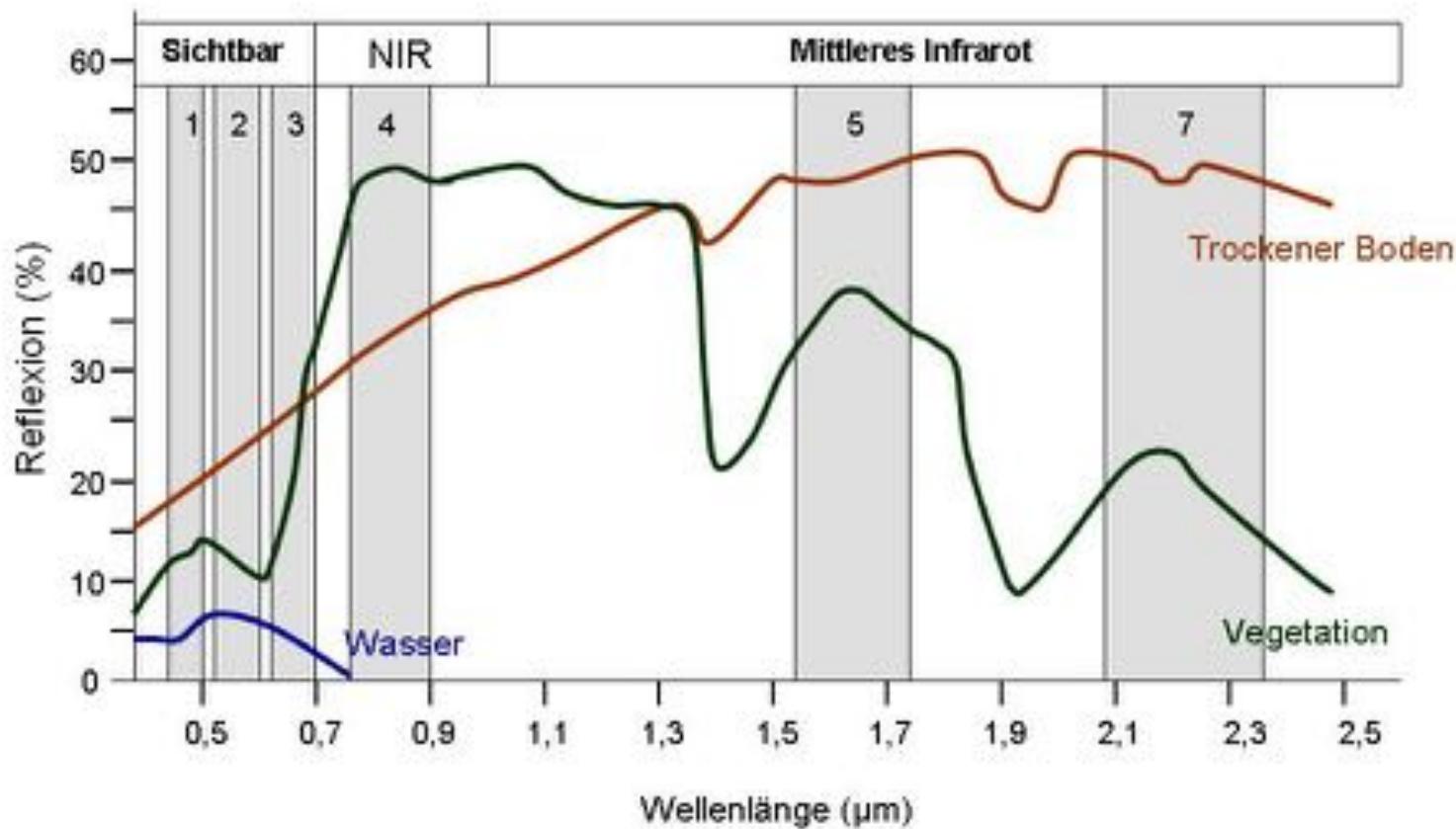


# Characteristics of optical sensors



Optical sensors „see“ more  
than the human eye!

# Spectral signatures



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

## example 1

Football Stadium  
Dresden

Satellite  
*Pléiades* (50 cm)

View:  
„Hatscat colors“  
→ **RIRG, RB G**



example 2

**South Sudan**  
(15 km x 19 km)

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

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

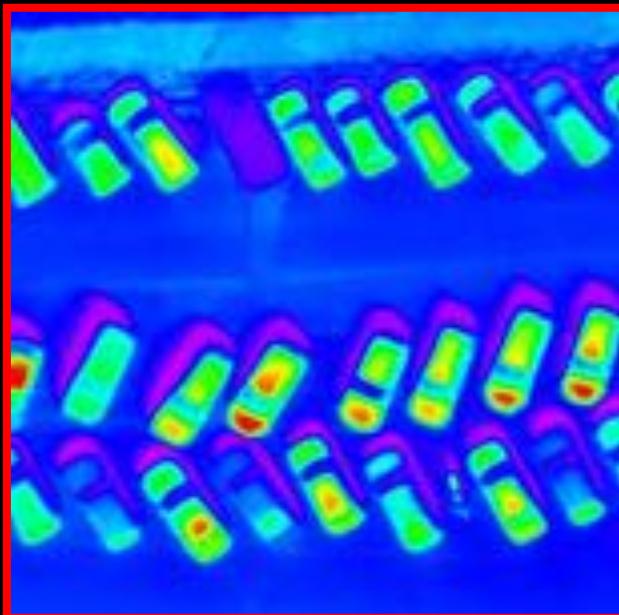


### example 3

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

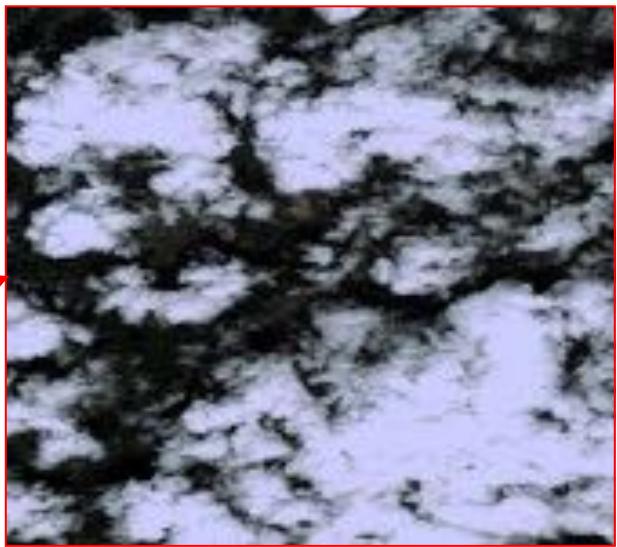
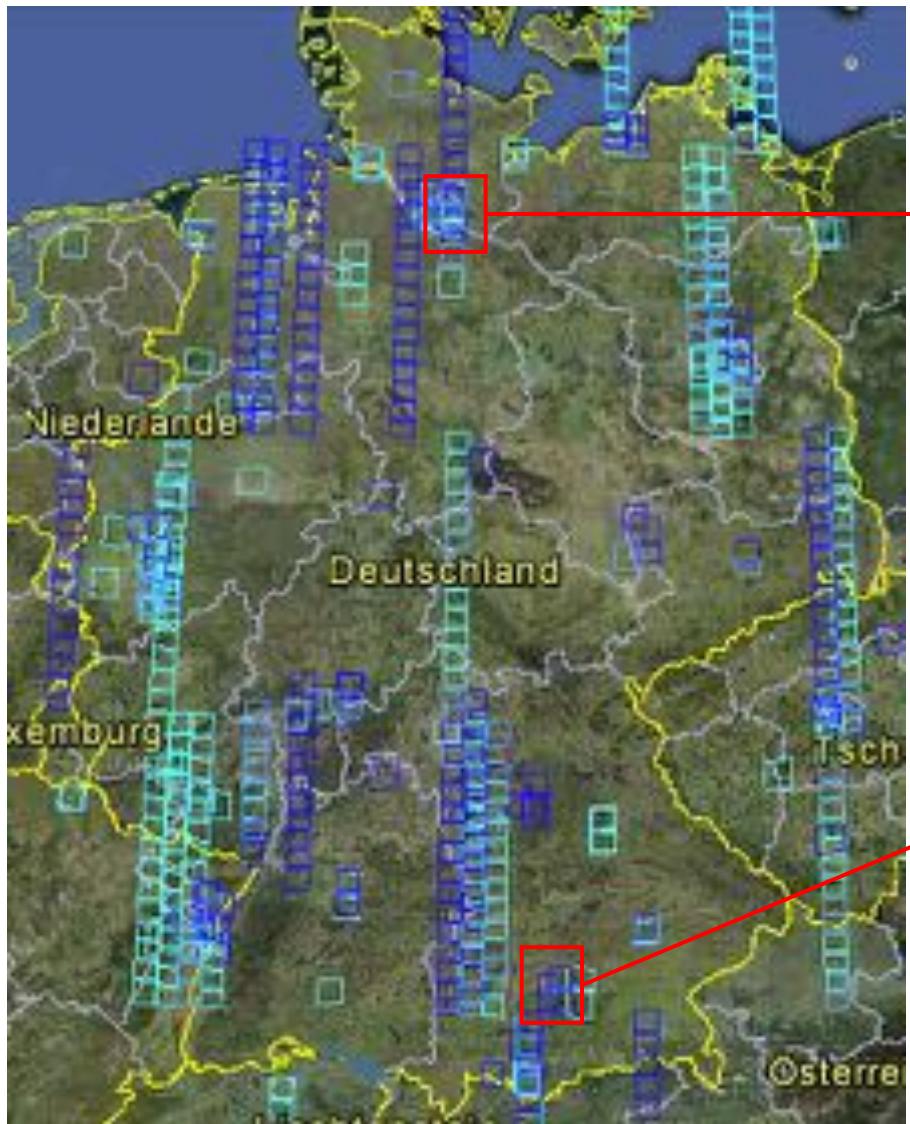


# Limitations

- Limited number of available satellites at a certain time
- Limited availability of archive images



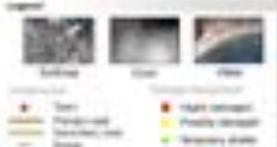
# Overview of all QuickBird scenes acquired over Germany during the year 2009 (incl. cloudy images)



# Limitations

- Limited number of available satellites at a certain time
- Limited availability of archive images
- Weather-induced limitations with optical data (clouds, haze)





**Description:** On October 26, 2011, assessments were conducted in Izmir, Turkey. At 10:00 UTC on October 26, 2011, a major earthquake struck the Aegean Sea, centered approximately 10 km off the coast of Izmir, Turkey. The magnitude of the quake was 7.2. The epicenter was located at approximately 38° 45' N, 27° 15' E. The quake caused significant damage to buildings and infrastructure throughout the region, particularly in Izmir and surrounding areas.

**Assessments:** Assessments were conducted in Izmir, Turkey, on October 26, 2011. The assessments focused on identifying areas of major damage, possible damage, and recovery shelters. The results of the assessments are shown in the map below.

**Geographic Information:** Location: Izmir, Turkey. Date: October 26, 2011. Scale: 1:13,000. Source: Satellite imagery provided by DigitalGlobe.

**Data Sources:** Satellite imagery from DigitalGlobe, October 26, 2011.

**Assessments:** Major damage (Red dots) is present in several locations, including the central business district of Izmir and surrounding residential areas. Possible damage (Yellow dots) is also present in these same areas. Recovery shelters (Green lines) are indicated by green lines connecting various points of interest.

**Footnotes:** This assessment was conducted by the Humanitarian Affairs and Disaster Prevention and Mitigation General Directorate, under the Ministry of National Defense of Turkey. The results of the assessment are based on satellite imagery and ground truth data collected on October 26, 2011. The results may not be fully accurate due to the limitations of the imagery and the potential for changes in the situation over time.

**Disclaimer:** The information contained in this document is for informational purposes only and does not constitute a formal assessment or recommendation. The results of the assessment are based on satellite imagery and ground truth data collected on October 26, 2011. The results may not be fully accurate due to the limitations of the imagery and the potential for changes in the situation over time.

**Attribution:** © European Union 2011, processed by the Humanitarian Affairs and Disaster Prevention and Mitigation General Directorate, Ministry of National Defense of Turkey. All rights reserved.

**Logos:** European Union flag, DigitalGlobe logo, and other logos of the Humanitarian Affairs and Disaster Prevention and Mitigation General Directorate, Ministry of National Defense of Turkey.

**Links:** [http://www.eurodisaster.eu](#), [http://www.dmdc.mil.tr](#), [http://www.mnn.gov.tr](#)

**Software:** ArcGIS 9.3, QGIS 1.7.4, and other software used for processing and analysis.

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# 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



# **Application in crisis response**

*Refugees*





# Application in crisis response

*Flooding*





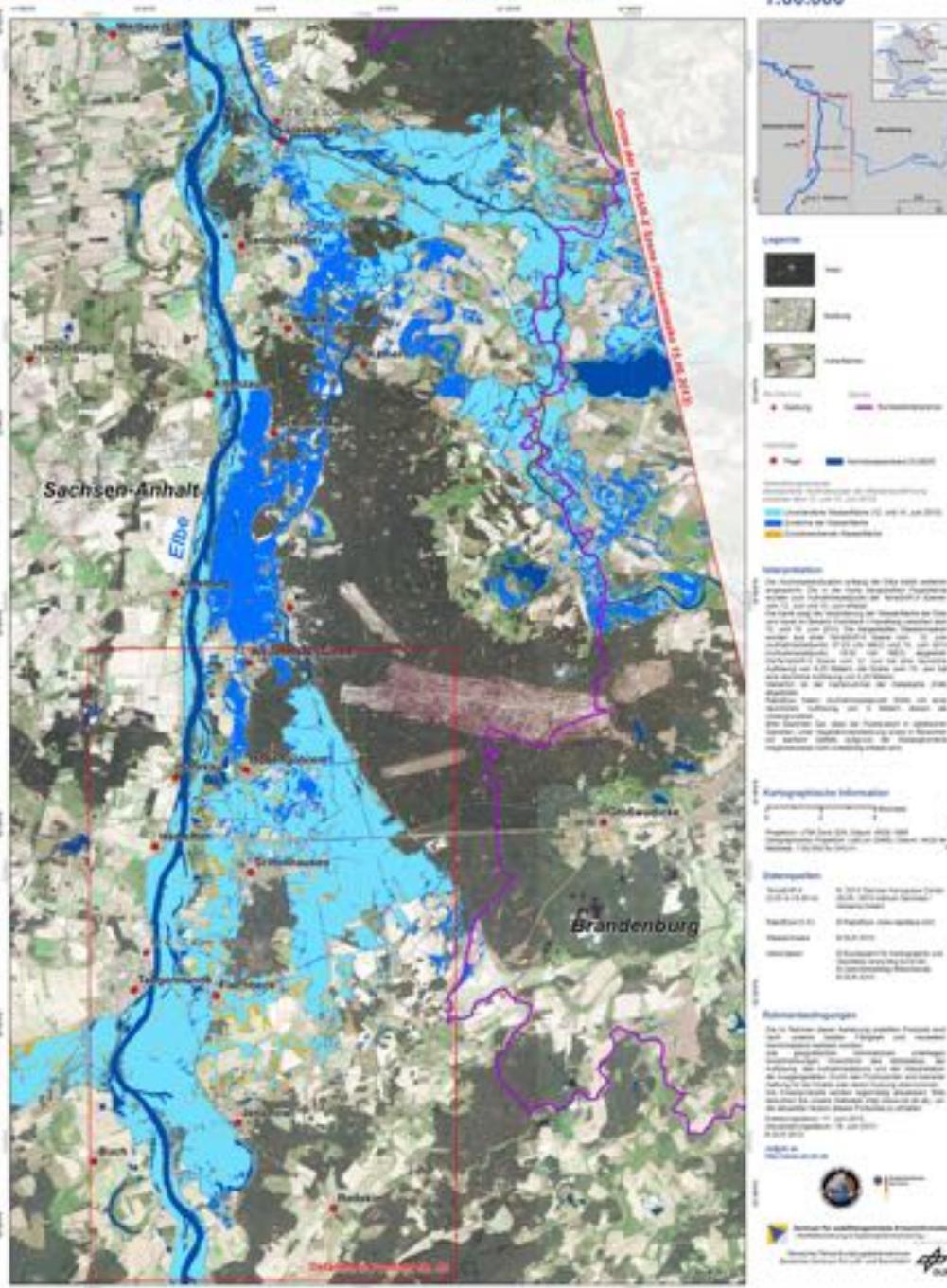


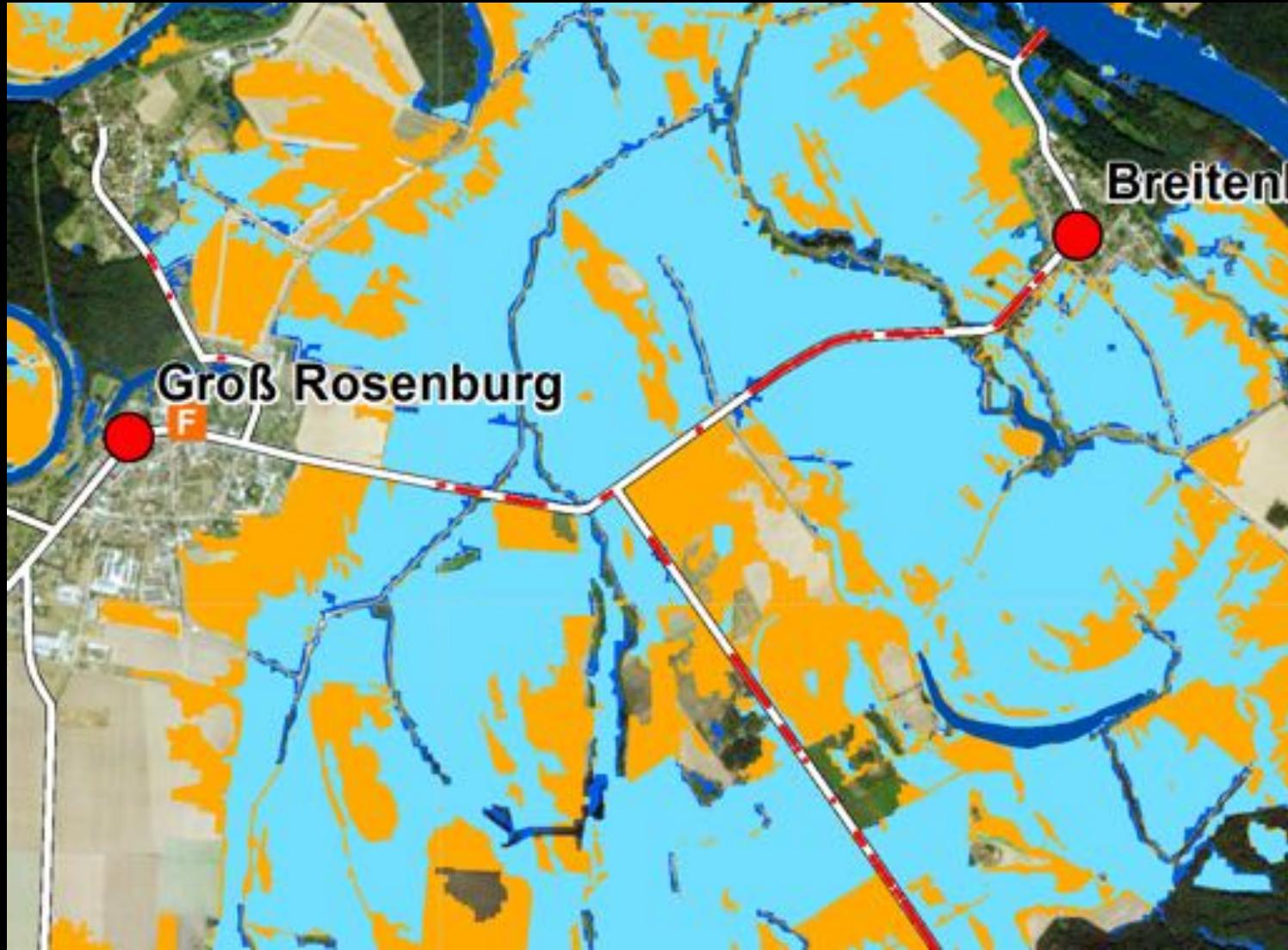






1:60,000







# **Application in crisis response**

***Building damage***



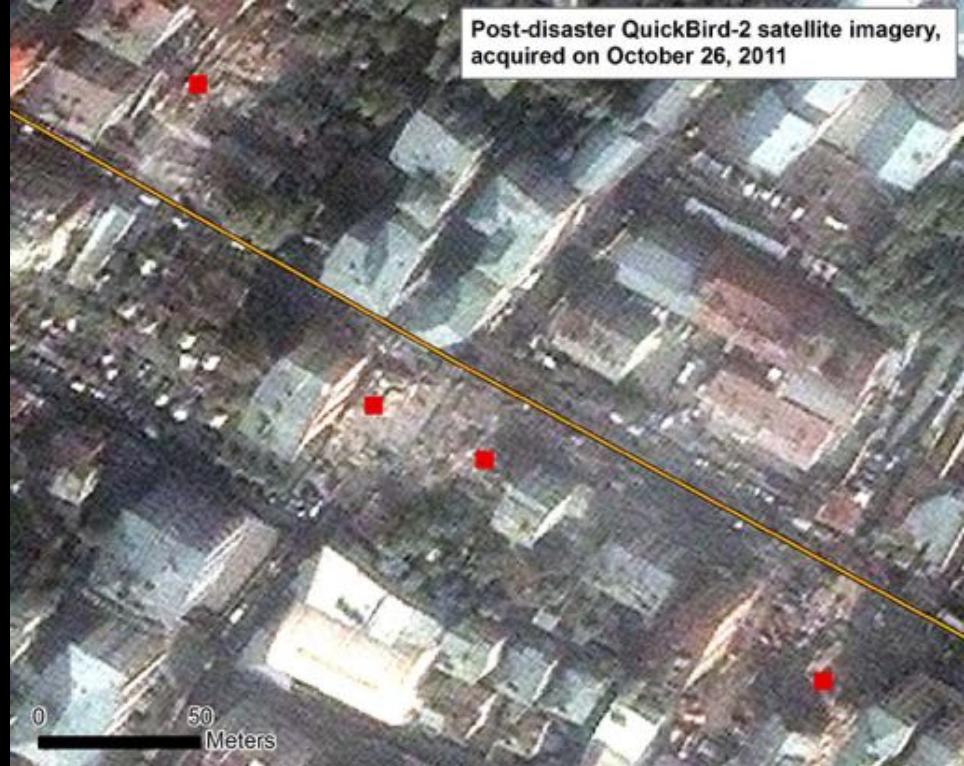
1



0 100  
Meters

earth





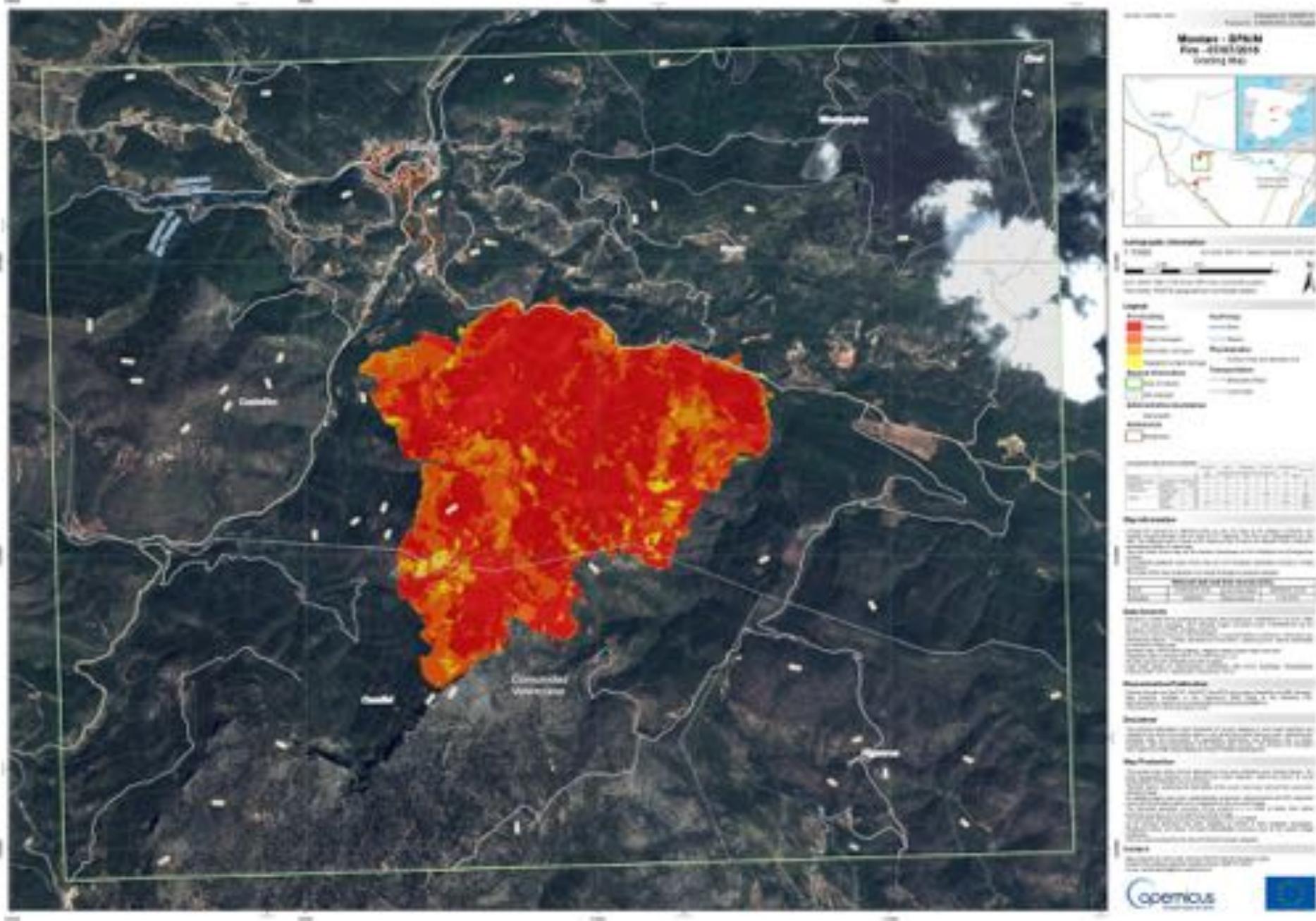


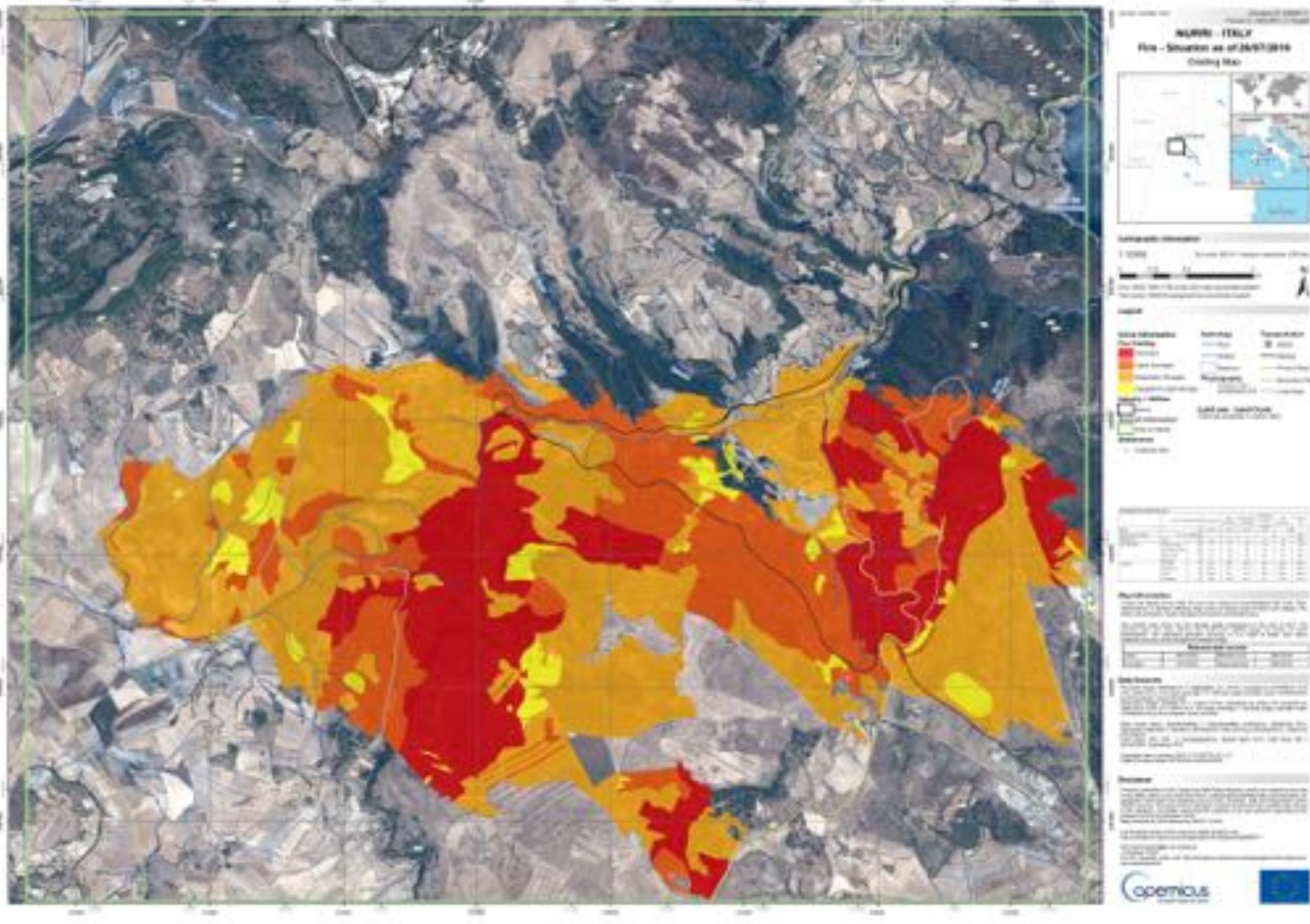
# **Application in crisis response**

*Fire*









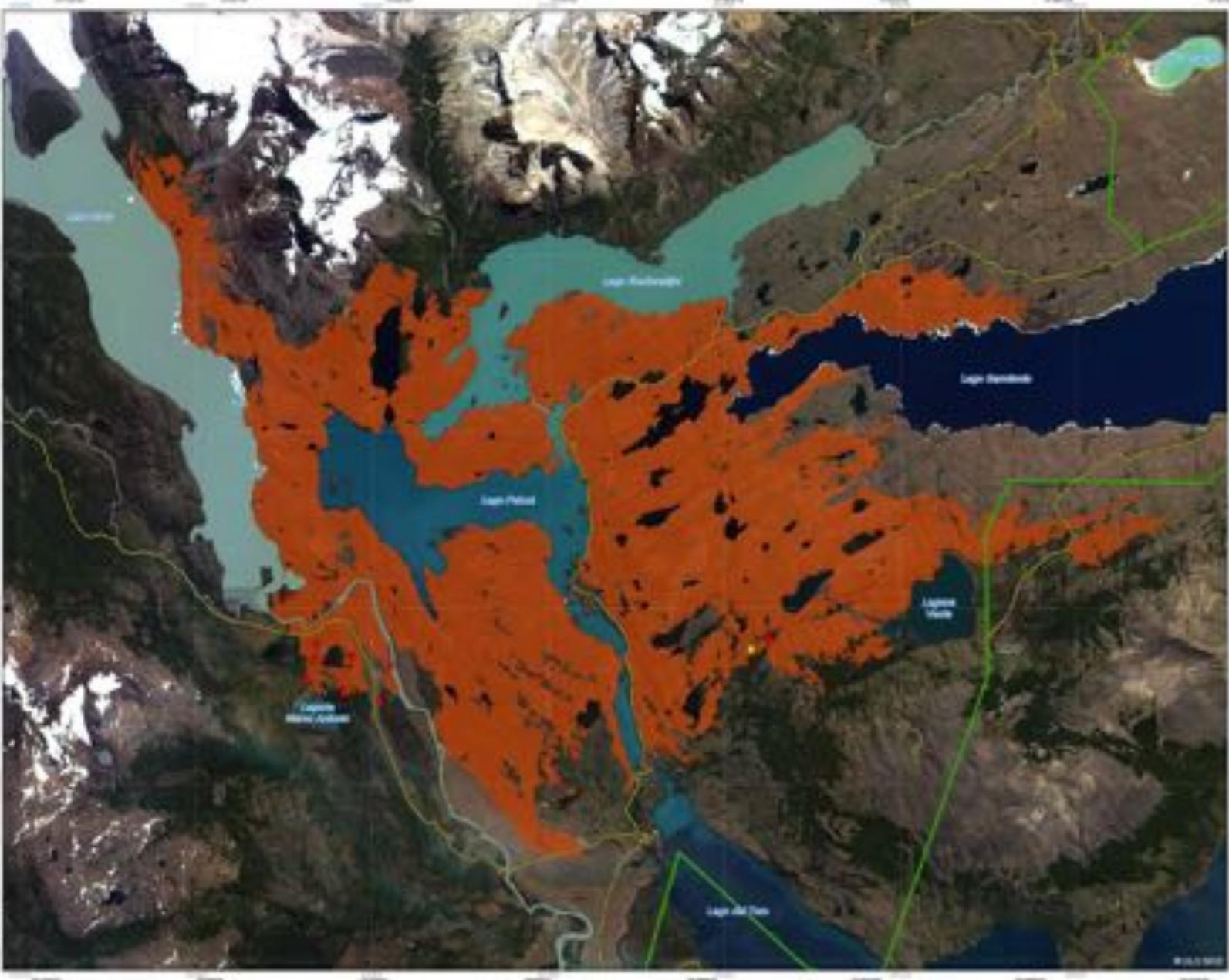


# CHILE - Torres del Paine

Fire as of January 07, 2012 - Disaster Extent Map

1:50,000

International Charter  
Space and Major Disasters



#### Disaster description

Since December 21, 2011, a massive fire has been burning around the town of Puerto Natales in Chilean Patagonia. The fire reached a total area of approximately 100,000 ha. The fire spread very rapidly due to strong winds and dry conditions.

The following satellite image shows the extent of the fire as of January 07, 2012. The fire front is visible as a line of smoke plumes extending from the town of Puerto Natales towards the south. The fire is currently spreading rapidly and threatening several settlements and infrastructure in the area.

#### Geographic Information

Coordinates: 52°S 72°W, 53°S 73°W, 54°S 74°W, 55°S 75°W, 56°S 76°W, 57°S 77°W, 58°S 78°W, 59°S 79°W, 60°S 80°W, 61°S 81°W, 62°S 82°W, 63°S 83°W, 64°S 84°W, 65°S 85°W, 66°S 86°W, 67°S 87°W, 68°S 88°W, 69°S 89°W, 70°S 90°W, 71°S 91°W, 72°S 92°W, 73°S 93°W, 74°S 94°W, 75°S 95°W, 76°S 96°W, 77°S 97°W, 78°S 98°W, 79°S 99°W, 80°S 100°W, 81°S 101°W, 82°S 102°W, 83°S 103°W, 84°S 104°W, 85°S 105°W, 86°S 106°W, 87°S 107°W, 88°S 108°W, 89°S 109°W, 90°S 110°W, 91°S 111°W, 92°S 112°W, 93°S 113°W, 94°S 114°W, 95°S 115°W, 96°S 116°W, 97°S 117°W, 98°S 118°W, 99°S 119°W, 100°S 120°W, 101°S 121°W, 102°S 122°W, 103°S 123°W, 104°S 124°W, 105°S 125°W, 106°S 126°W, 107°S 127°W, 108°S 128°W, 109°S 129°W, 110°S 130°W, 111°S 131°W, 112°S 132°W, 113°S 133°W, 114°S 134°W, 115°S 135°W, 116°S 136°W, 117°S 137°W, 118°S 138°W, 119°S 139°W, 120°S 140°W, 121°S 141°W, 122°S 142°W, 123°S 143°W, 124°S 144°W, 125°S 145°W, 126°S 146°W, 127°S 147°W, 128°S 148°W, 129°S 149°W, 130°S 150°W, 131°S 151°W, 132°S 152°W, 133°S 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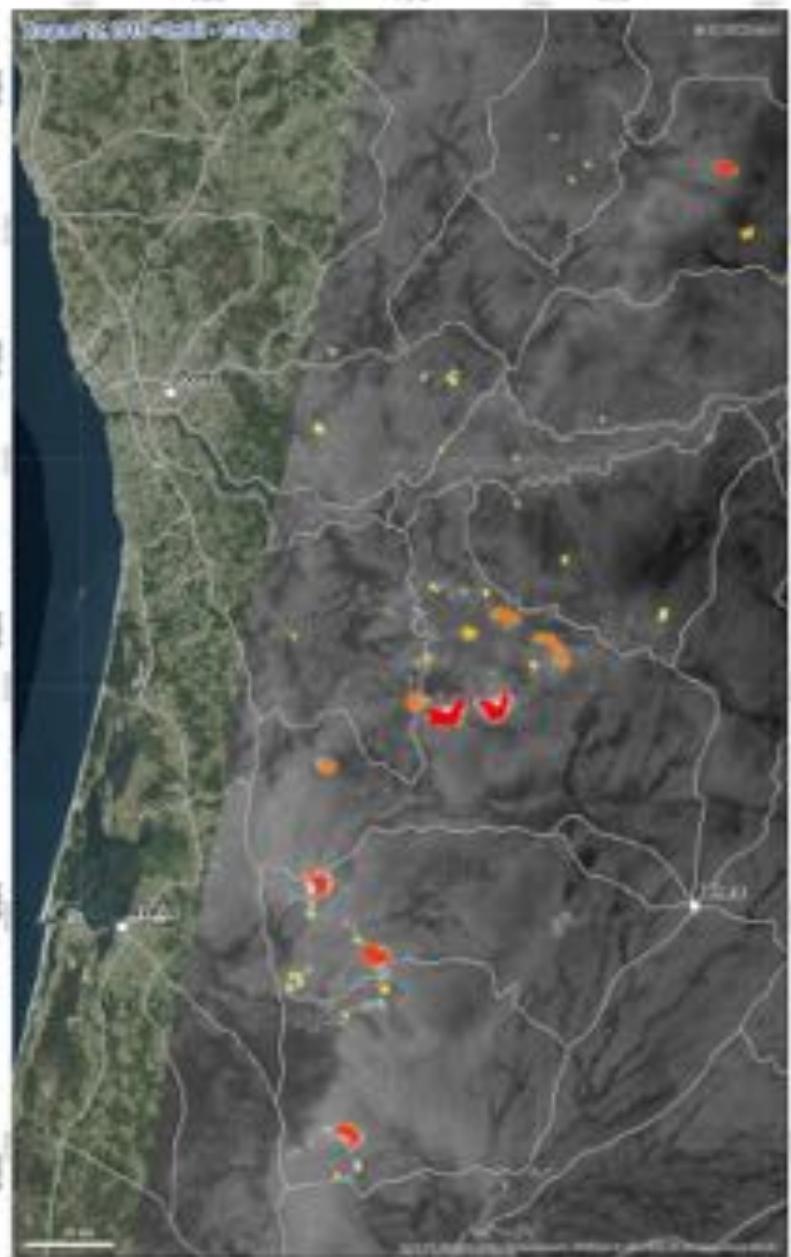


# PORTUGAL

## Fires as of August 12, 2016 - Situation Map

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

Version 2.0



### Legend

Fire Radiative Power (W/m²)
0.01-100
100-1000
1000-5000
5000-10000

### Information

The fire areas for the date in Portugal shown here correspond to the areas as of August 12, 2016.

The estimated areas represent the total areas of individual fires combined with the areas of the adjacent power fires. The estimated areas are based on the latest available data from the European Forest Fire Information System (EFFIS) and the European Space Agency's Global Forest Monitoring system (GFMS). The estimated areas of the individual fires and their locations in each case may be used for operational purposes, while the EFFIS and GFMS data are used for monitoring and reporting purposes.

New and/or unassessed areas are reflected in current estimates of the total area of the fires. Areas used for operational purposes are not reflected in the current estimates of the total area of the fires.

### Geographic Information

Coordinates: 38.50 long 0.50 lat  
Scale: 1:1,200,000 / 1:250,000

### Data Sources

Map: Google Earth (http://www.google.com/earth/)

Fire: Forest Watch (http://www.forestwatch.pt/)

### Disclaimer

The fire areas shown here represent the total areas of individual fires combined with the areas of the adjacent power fires. The estimated areas are based on the latest available data from the European Forest Fire Information System (EFFIS) and the European Space Agency's Global Forest Monitoring system (GFMS). The estimated areas of the individual fires and their locations in each case may be used for operational purposes, while the EFFIS and GFMS data are used for monitoring and reporting purposes.

The estimated August 12, 2016, data is preliminary.

Source: EFFIS (http://www.effis.jrc.ec.europa.eu/)

Source: GFMS (http://www.esa-gfms.org/)



Satellite Remote Sensing Data Center  
National Aerospace Center



# **Application in crisis response**

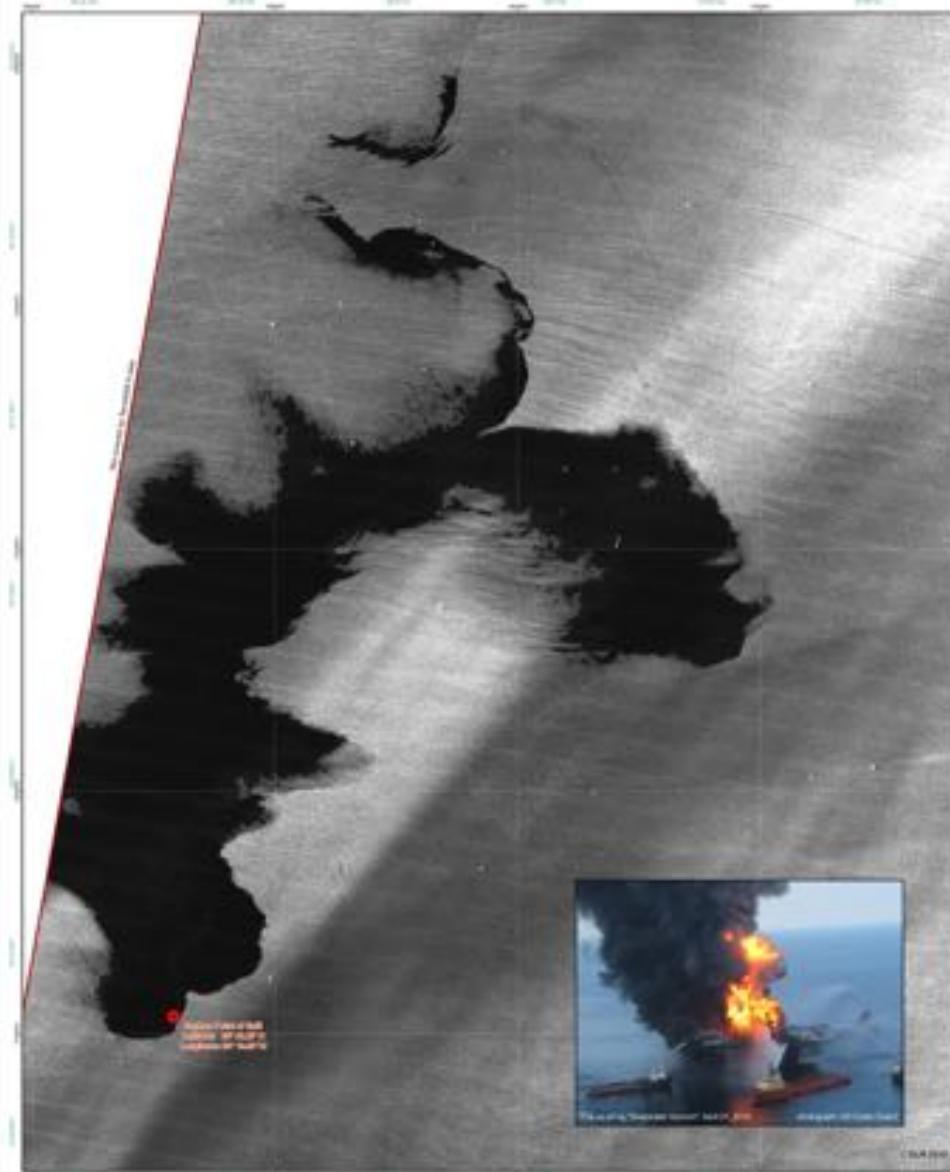
***Technical accident***





## Gulf of Mexico - Oil spill, as seen on April 25, 2010

1:150.000



# **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





# Current trends in satellite remote sensing

- New platforms 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



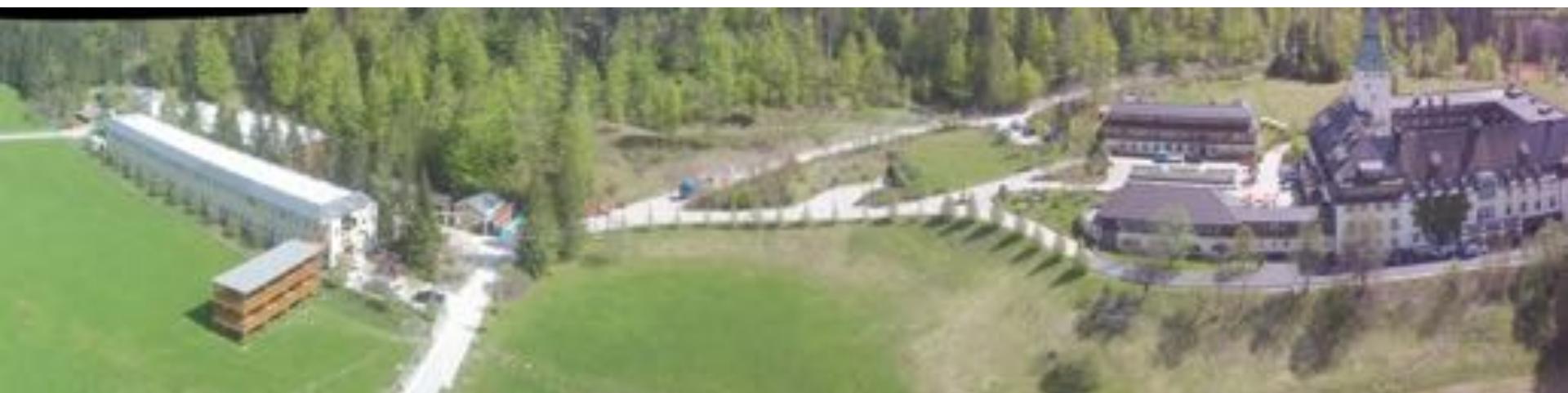
Schloss Elmau  
Pléiades (50 cm)

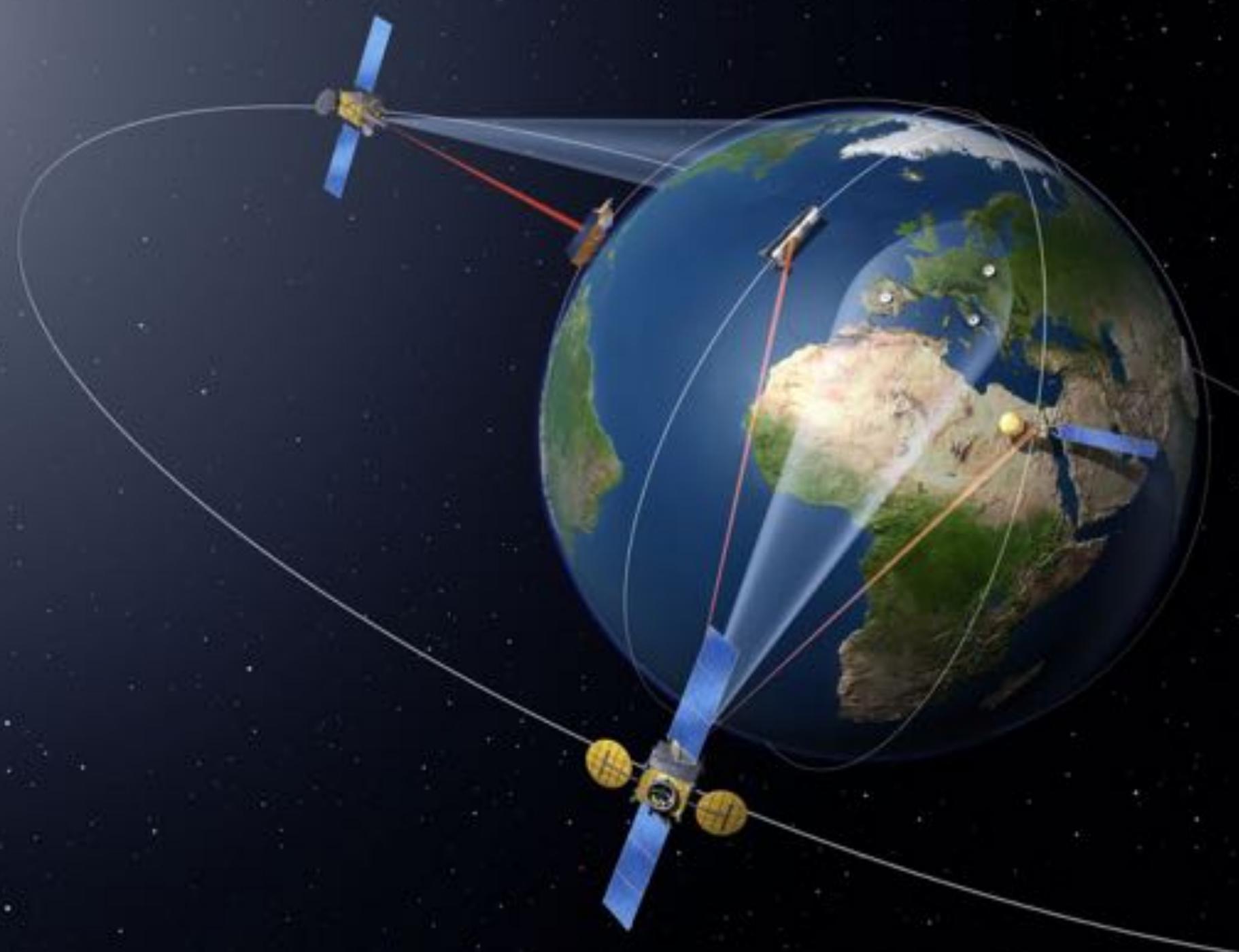
# Remote sensing with air planes



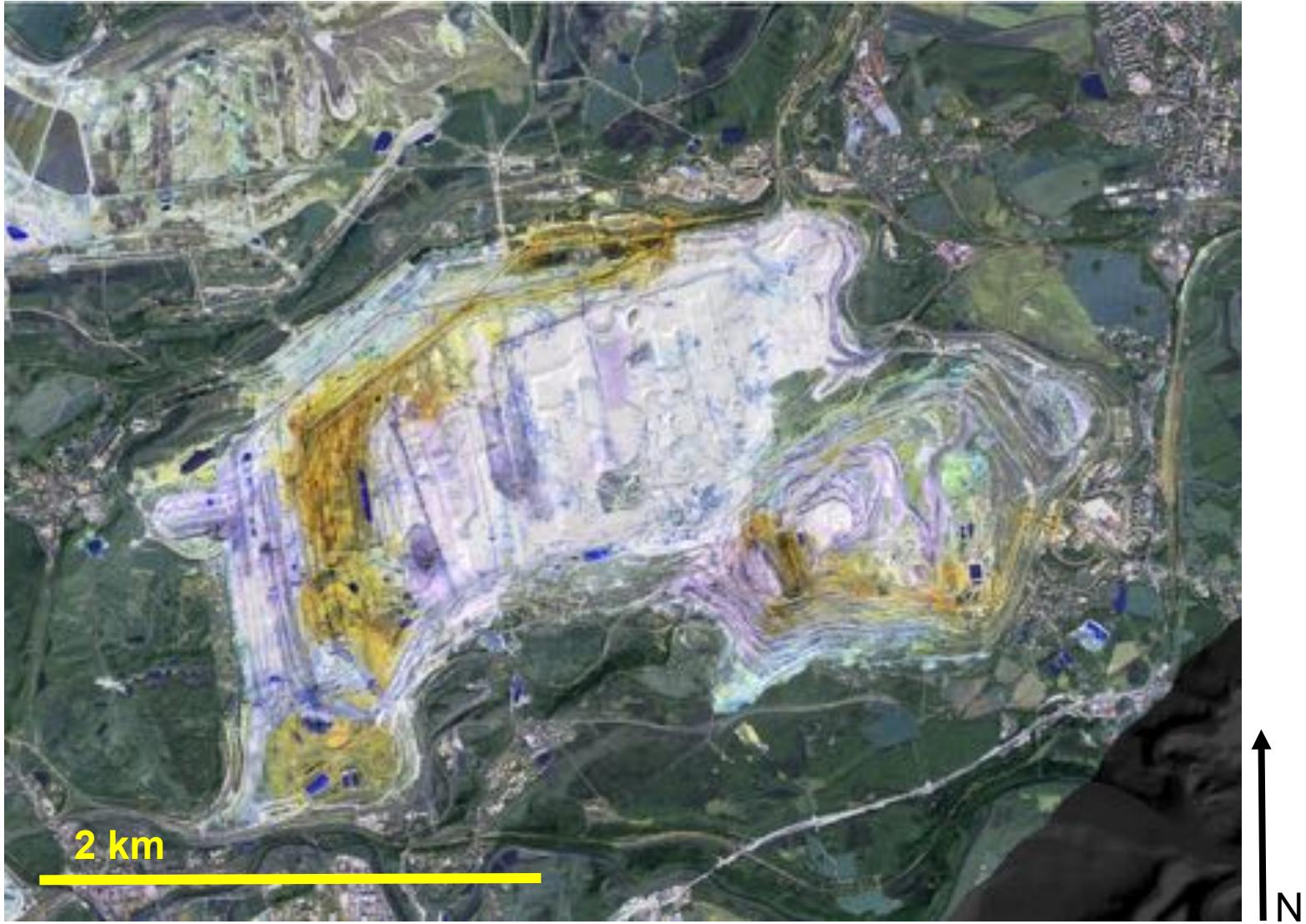
Schloss Elmau  
Luftbild 15 cm

# Remote sensing with UAVs/ drones

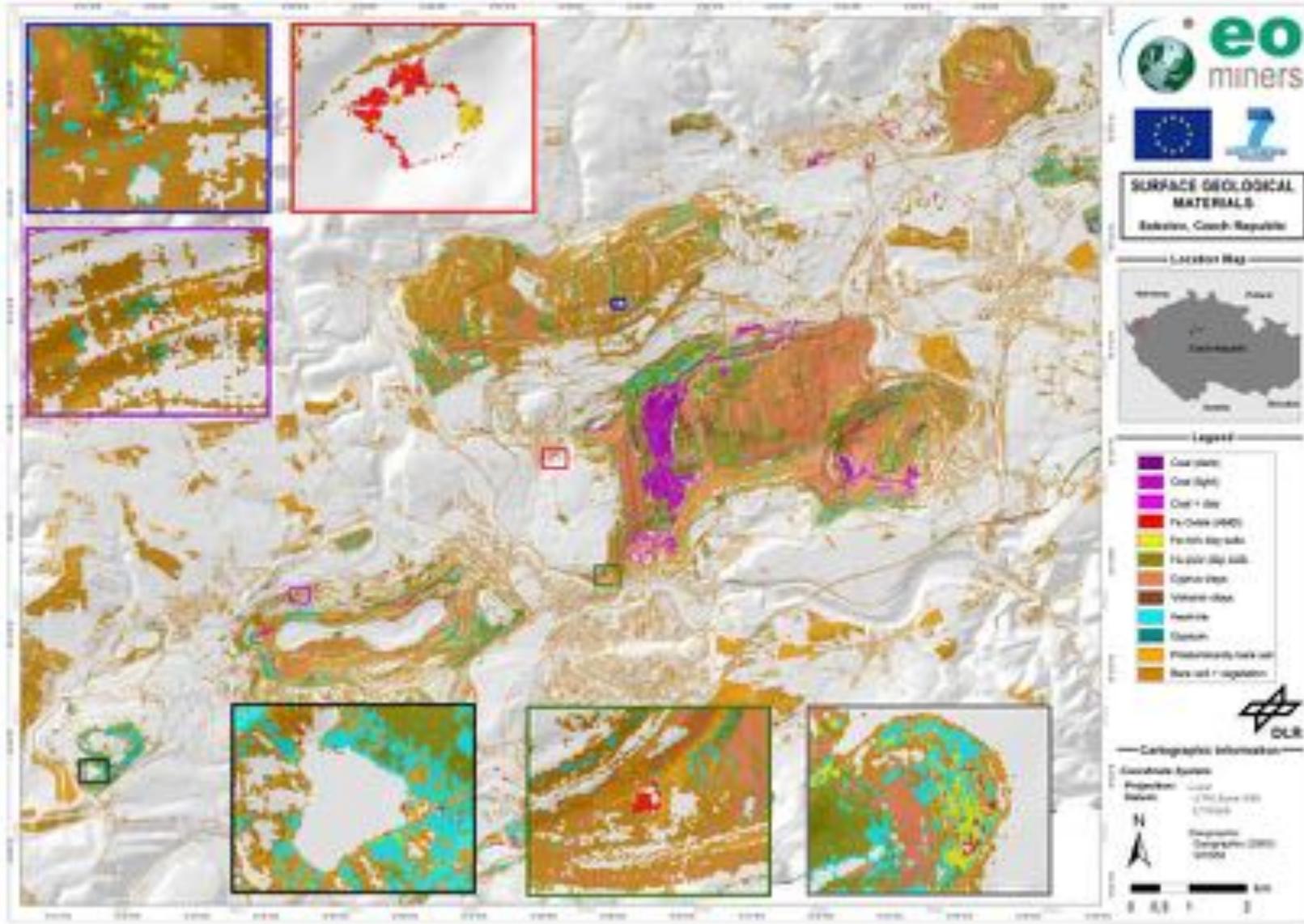




# Air-borne hyperspectral acquisition (Czech Republic)



# Air-borne hyperspectral acquisition (Czech Republic)



# 3D: earthquake Nepal



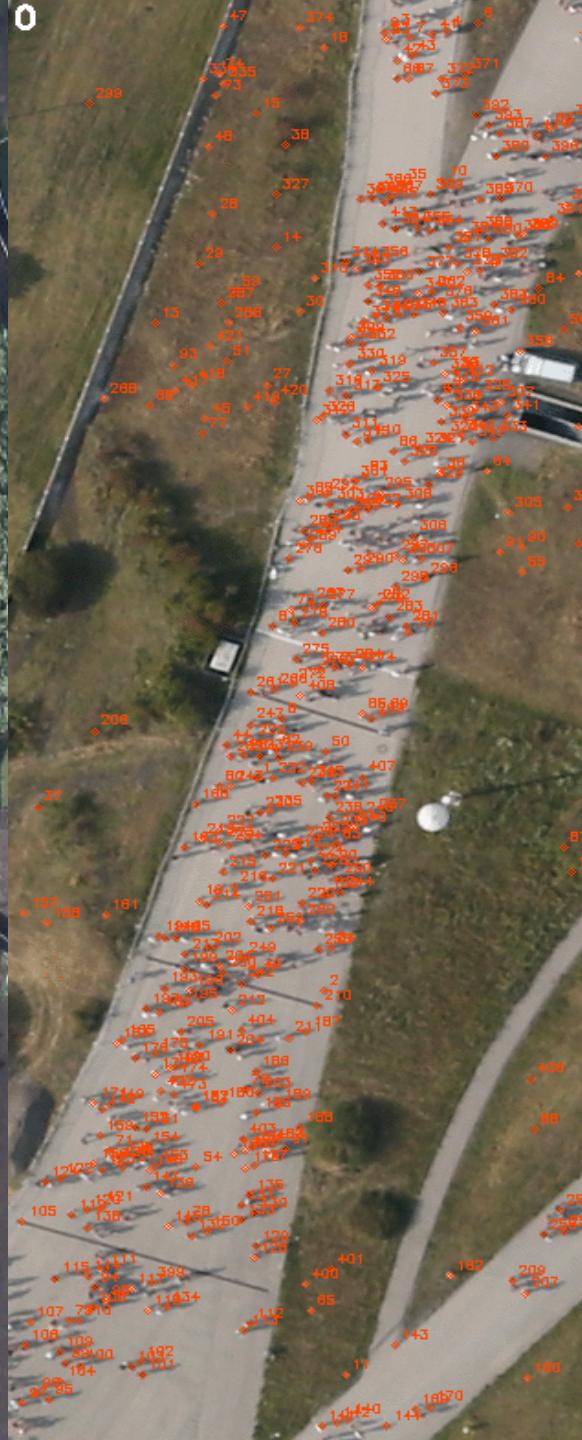




# Person Tracking

- **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





# 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

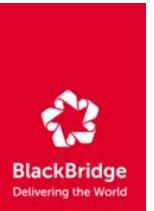
Fires  
Ice jams  
Ocean storms  
Volcanic eruptions

### Man-made events

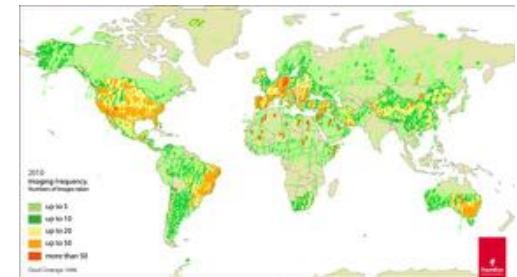
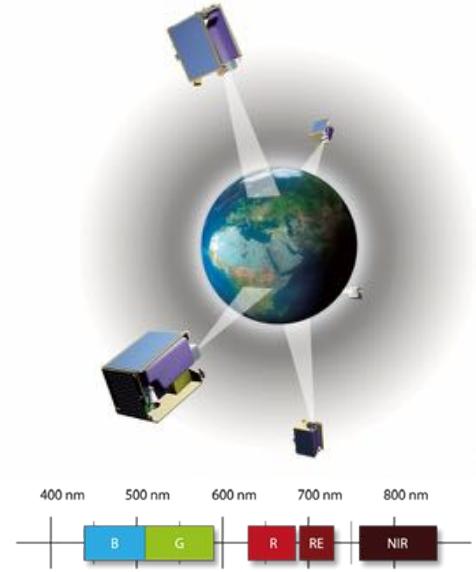
Oil spills  
Industrial accidents



# 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

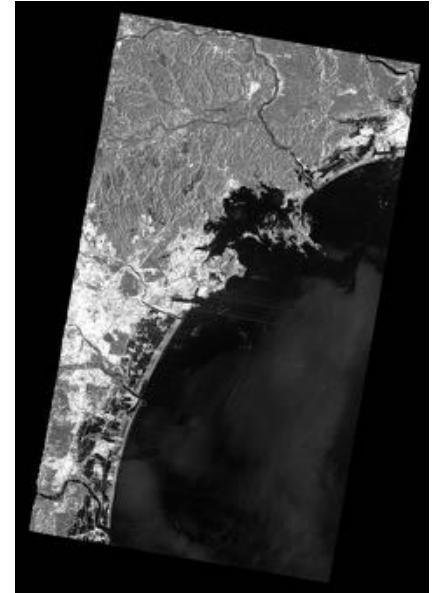


# DLR contribution to the Charter

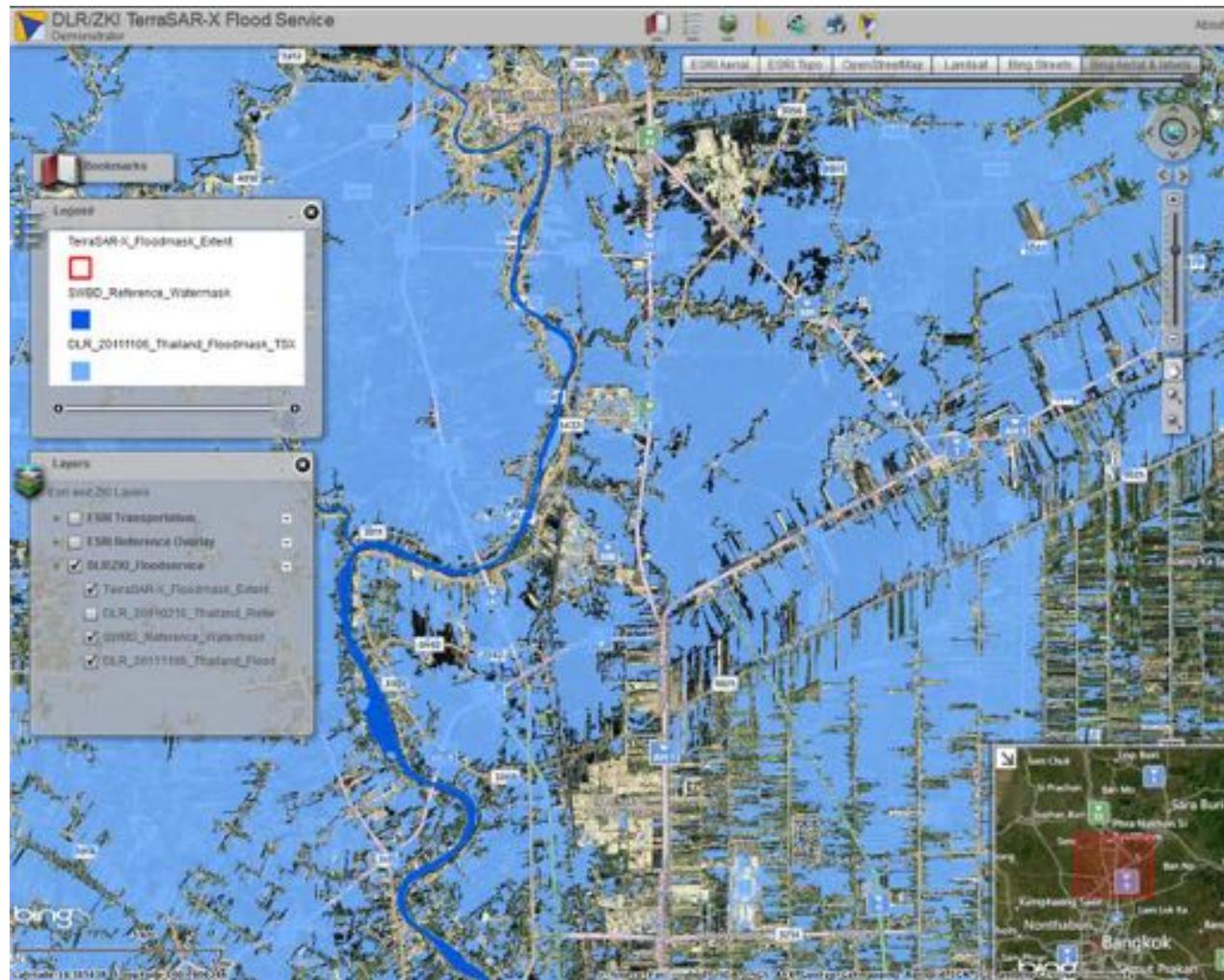
## – TerraSAR-X/TanDEM-X standard products

- 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

## **Exercise: Flood Mapping**

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

