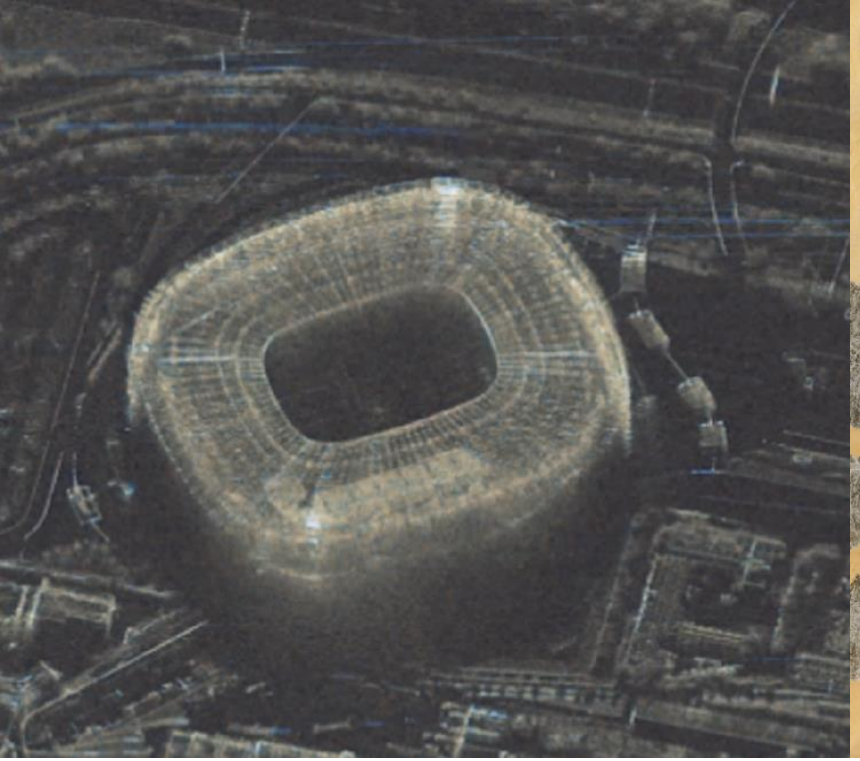

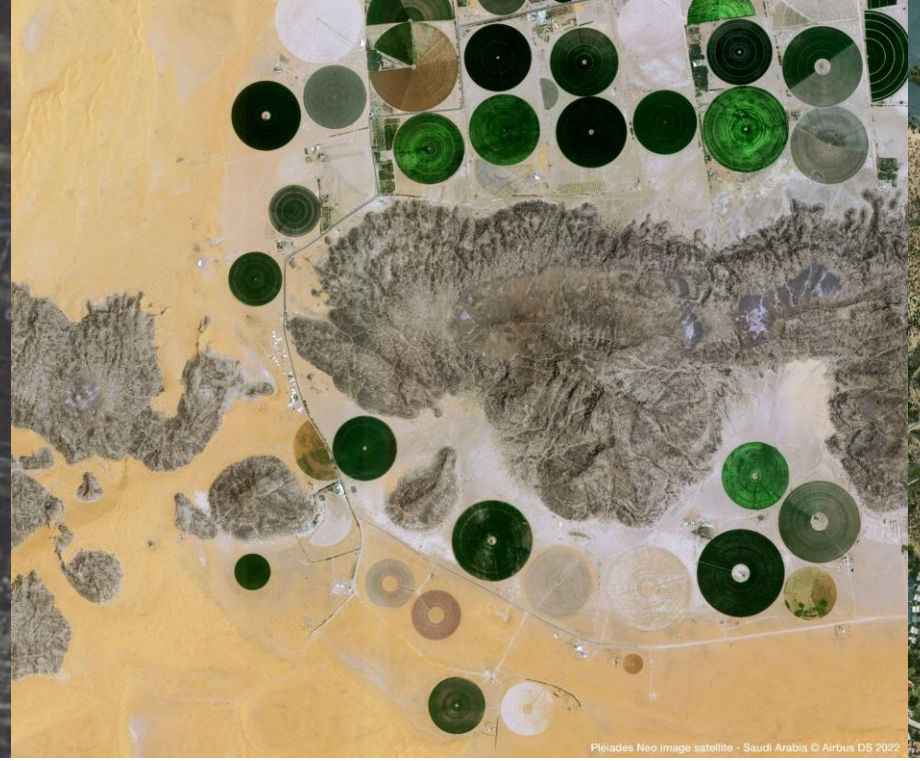





DEFENCE AND SPACE

# Earth Observation and X-Band: Enabled Applications and Impact

Matteo Emanuelli, Program Manager, Airbus Defence and Space

Training Workshop on Use and Management of Radio Spectrum for Meteorology – Singapore – 04.03.2025

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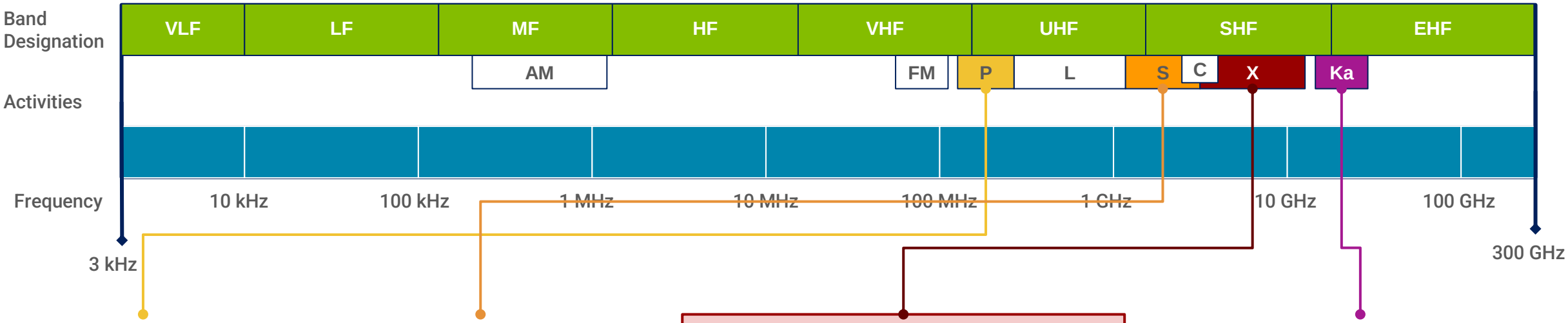
# Spectrum availability directly impacts what we can accomplish through space.

# What we can accomplish through space directly impacts what our lives look like on Earth.

**Spectrum is fundamental for** carrying out **Earth Observation** as Radio Frequencies (RF) are used for downlink data, uplink commands and as well for various imaging and scientific payloads.

# Available Spectrum for Earth Observation Up/Downlink

**Allocations to remote sensing satellites, are divided across various frequency bands** to optimize and enable specific functions of satellite systems.




**401 - 403 MHz**

- Utilised for TT&C
- Limited bandwidth available and power limitations

**2025-2110 MHz | 2200-2290 MHz**

- Utilised for telemetry and commands (primarily)
- SOS, SRS
- Heavily utilised and limitations in bandwidth exist

**7190-7250 MHz | 8025-8400 MHz**

- Lower band utilised for commands
- Upper band utilised for data downlink

**X-Band**

**25.5-27 GHz**

- Reliable use limited (rain fade)
- IMT 2020/5G also identified in the band



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# Available Spectrum for Earth Observation Sensors (EESS Active)

*IEEE Designation: https://standards.ieee.org/standard/521-2002.html*

## P-Band
432 - 438 MHz

**Applications**
- Vegetation mapping and assessment

## L-Band
1 215 – 1 300 MHz

**Applications**
- Biomass and vegetation mapping
- Forest Monitoring
- Earth deformation (i.e. volcano, earthquakes)
- InSAR

**Resolution:** Medium (Best: 3 m)

## S-Band
3 100 – 3 300 MHz

**Applications**
- Agriculture

**Resolution:** Medium (Best: 6 m)

## C-Band
5 250 – 5 570 MHz

**Applications**
- Agriculture
- Sea Surface
- Ice

**Resolution:** Medium (Best: <3 m)

## X-Band
9 2 – 10 4 GHz

**Applications**
- Object/Change detection
- InSAR
- GCP
- DEM and Topography
- Ice and snow

**Resolution:** (Very) High (Best: <.25m)

## Ku-Band
13 25 -13 75 GHz
17 2 - 17 3 GHz

**Applications**
- Satellite Altimetry
- Satellite Scatterometer

## K-Band
24 05 - 24 25 GHz

## Ka-Band
35 5 - 36 GHz

Wind radar
Rainfall radar

## W-Band
94 – 94 1 GHz

Cloud radar

## mm-Band
130 - 134 GHz

**Commercial**

Because of the difference in wavelength and thus penetration of the electromagnetic waves, frequency bands and applications are closed connected and although some level of overlapping is possible, physical limitations apply.



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# Available Spectrum for Earth Observation Sensors (EESS Active)

| P-Band | L-Band | S-Band | C-Band | X-Band | Ku-Band | K-Band |
|---|---|---|---|---|---|---|
| 432 - 438 MHz | 1 215 – 1 300 MHz | 3 100 – 3 300 MHz | 5 250 – 5 570 MHz | 9 2 – 10 4 GHz | 13 25 -13 75 GHz<br>17 2 - 17 3 GHz | 24 05 - 24 25 GHz |
| **Missions**<br>*BIOMASS* | **Missions**<br>SAOCOM-1<br>*SAOCOM-2*<br>ALOS-2<br>*ALOS-4*<br>*NISAR-L*<br>*ROSE-L*<br>*TanDEM-L*<br>*SAR XL* | **Missions**<br>NovaSAR-S<br>*NISAR-S* | **Missions**<br>Sentinel-1<br>Radarsat-2<br>RCM<br>*EOCS*<br>*Chorus-C*<br>CHEOS<br>Hisea<br>*MicroSAR* | **Missions**<br>TerraSAR /<br>TanDEM PAZ<br>*Kompsat-6*<br>CSK / CSG / CTG<br>ICEYE<br>*Chorus-X*<br>Capella Space<br>Synspective<br>iQPS<br>UMBRA<br>*NOX*<br>*NimBUS SAR*<br>*SAR XL* [...] | **Missions**<br>Sentinel-3<br>Sentinel-6 | **Ka-Band**<br>35 5 - 36 GHz<br><br>**W-Band**<br>94 – 94 1 GHz<br><br>**mm-Band**<br>130 - 134 GHz |

**Commercial**

*IEEE Designation: https://standards.ieee.org/standard/521-2002.html*

Due to the large bandwidth available, the consequent application potential (coupling good swath and high-res) and leveraging opportunities offered by tech miniaturisation, X-Band has imposed as the dominant band for commercial space-based radar systems

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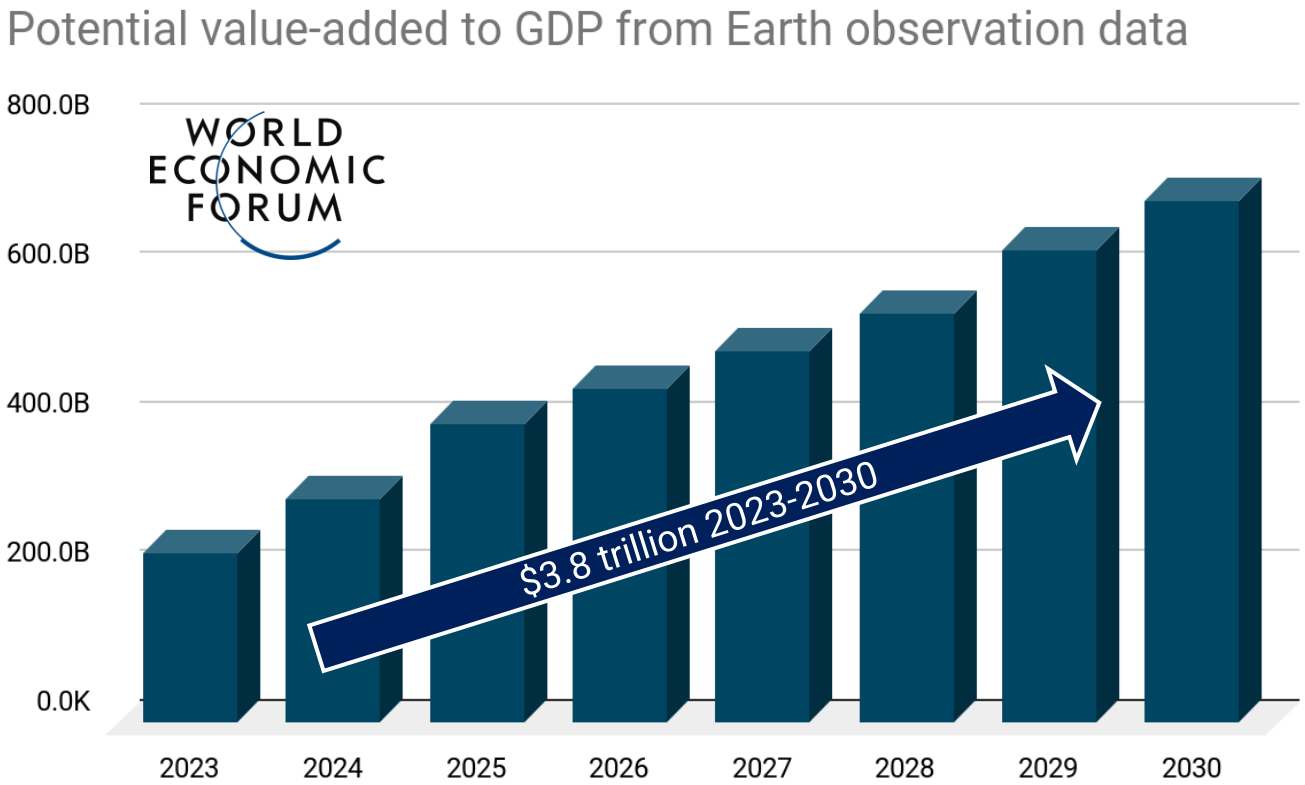
# The Value of Earth Observation

**Earth observation satellites are established as essential tools for various applications and domains**, including agriculture, risk and disaster management, critical mineral exploration and subsurface mapping, climate change and environmental monitoring and adaptation, urban planning, defence and security, scientific research, etc.



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# APPLICATIONS

## SELECTION OF COMMERCIAL EARTH OBSERVATION APPLICATIONS

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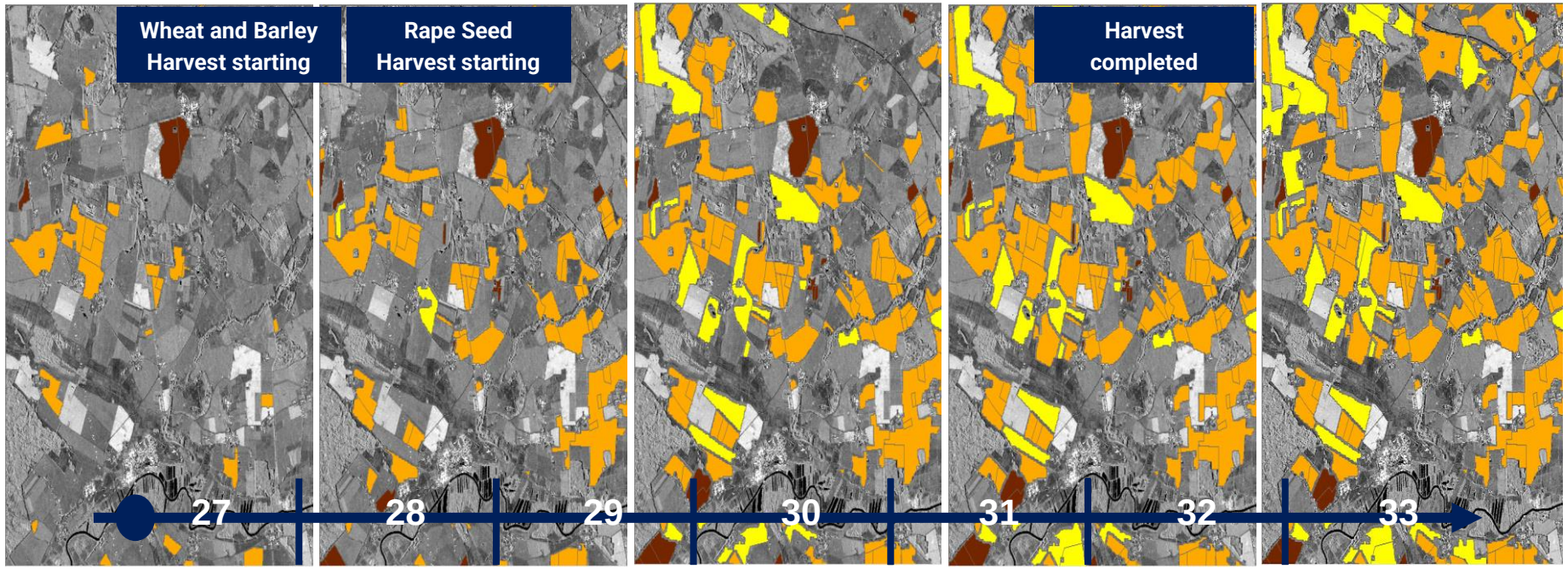



# Sustainable Agriculture

Earth observation is able to assess the growth status, yield estimate, damage mapping and classification of the crops


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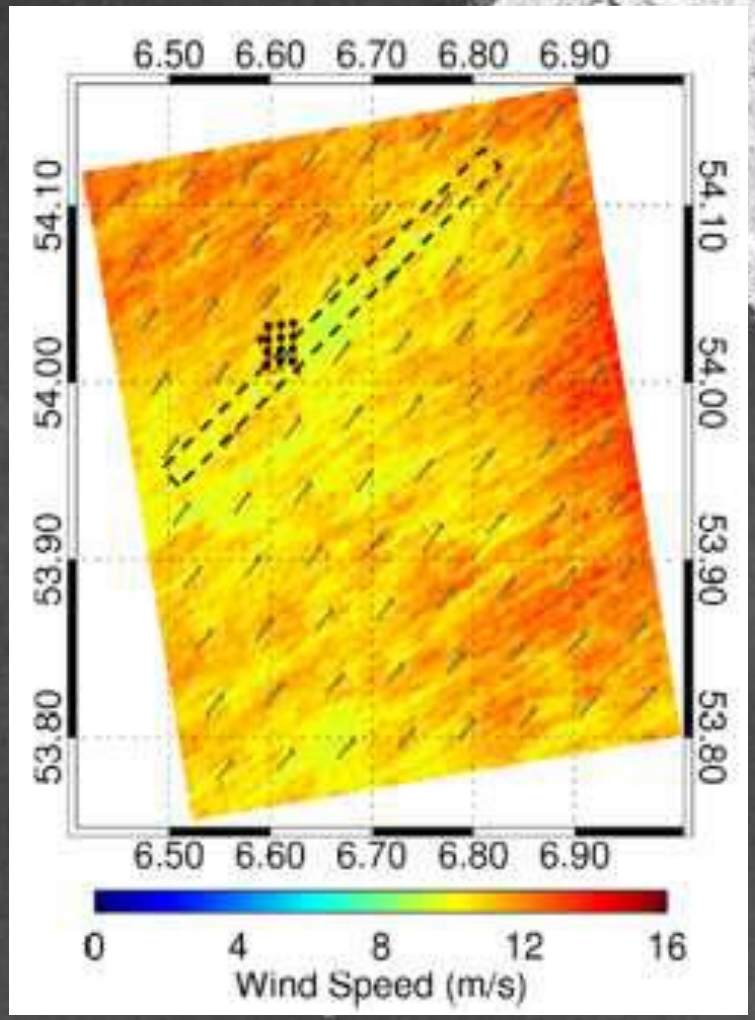
# Optimal placement of wind farms

Space-based EO measurements and derived products support the renewable energy industry

## Determination of the wind direction




7 AFFORDABLE AND CLEAN ENERGY

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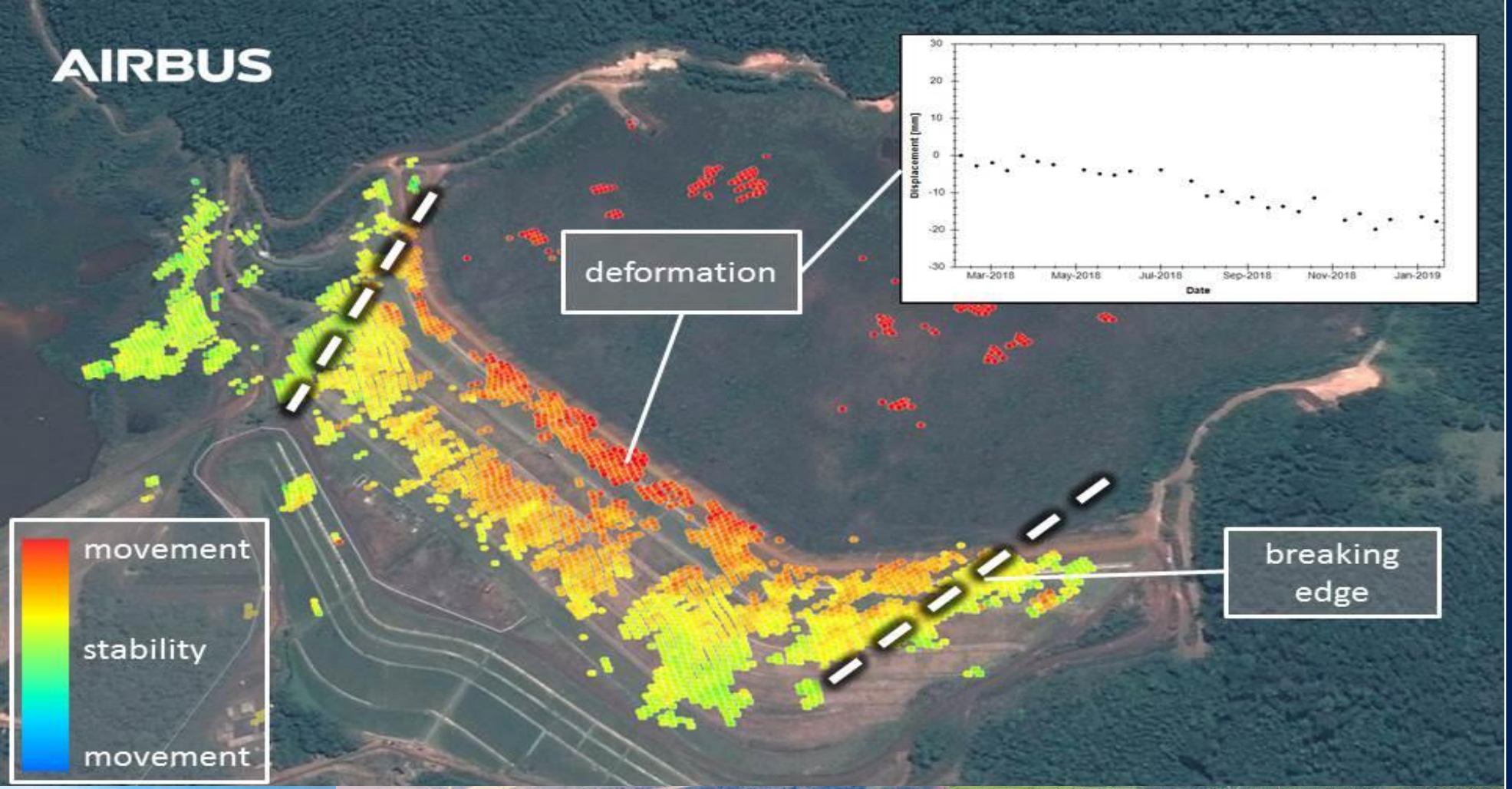
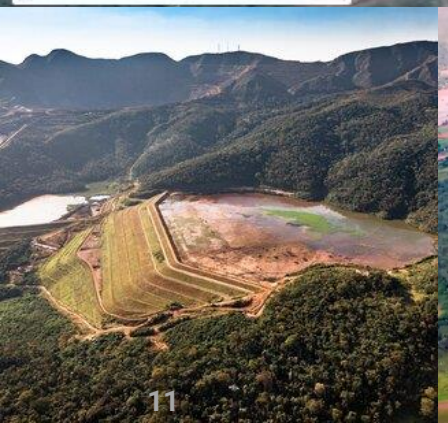
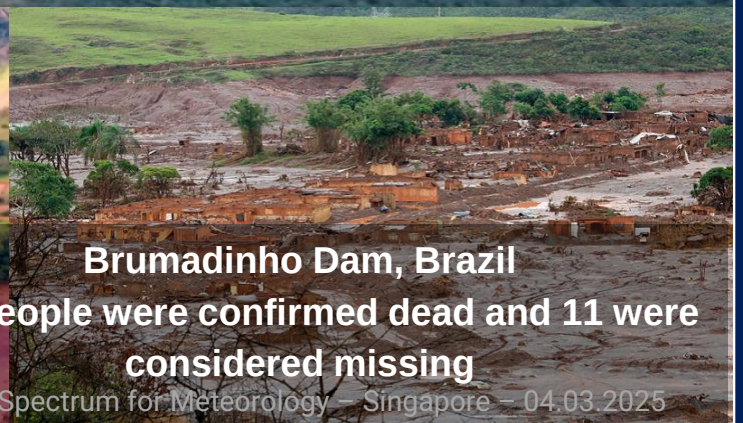
# Landslide Monitoring

Radar sensors allow frequent and extremely precise assessments of the buildings and infrastructure integrity supporting monitoring and preventive actions.





**Brumadinho Dam, Brazil**
**259 people were confirmed dead and 11 were considered missing**





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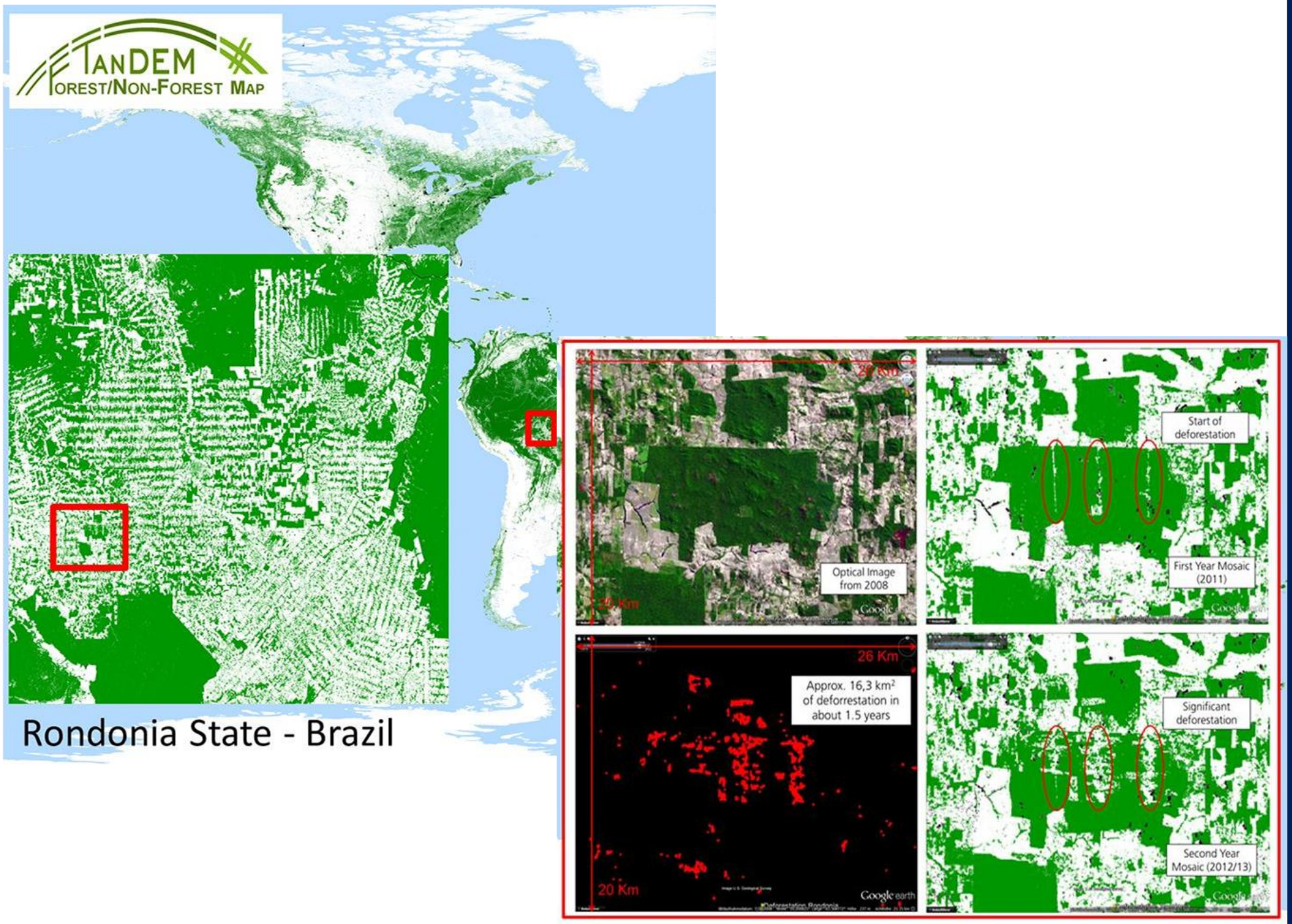
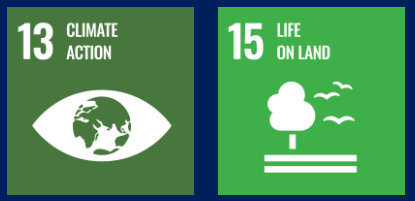



# Deforestation monitoring down to single-log precision

EO is watchful eye enabling precise, actionable and near real-time information to protect biodiversity on land.

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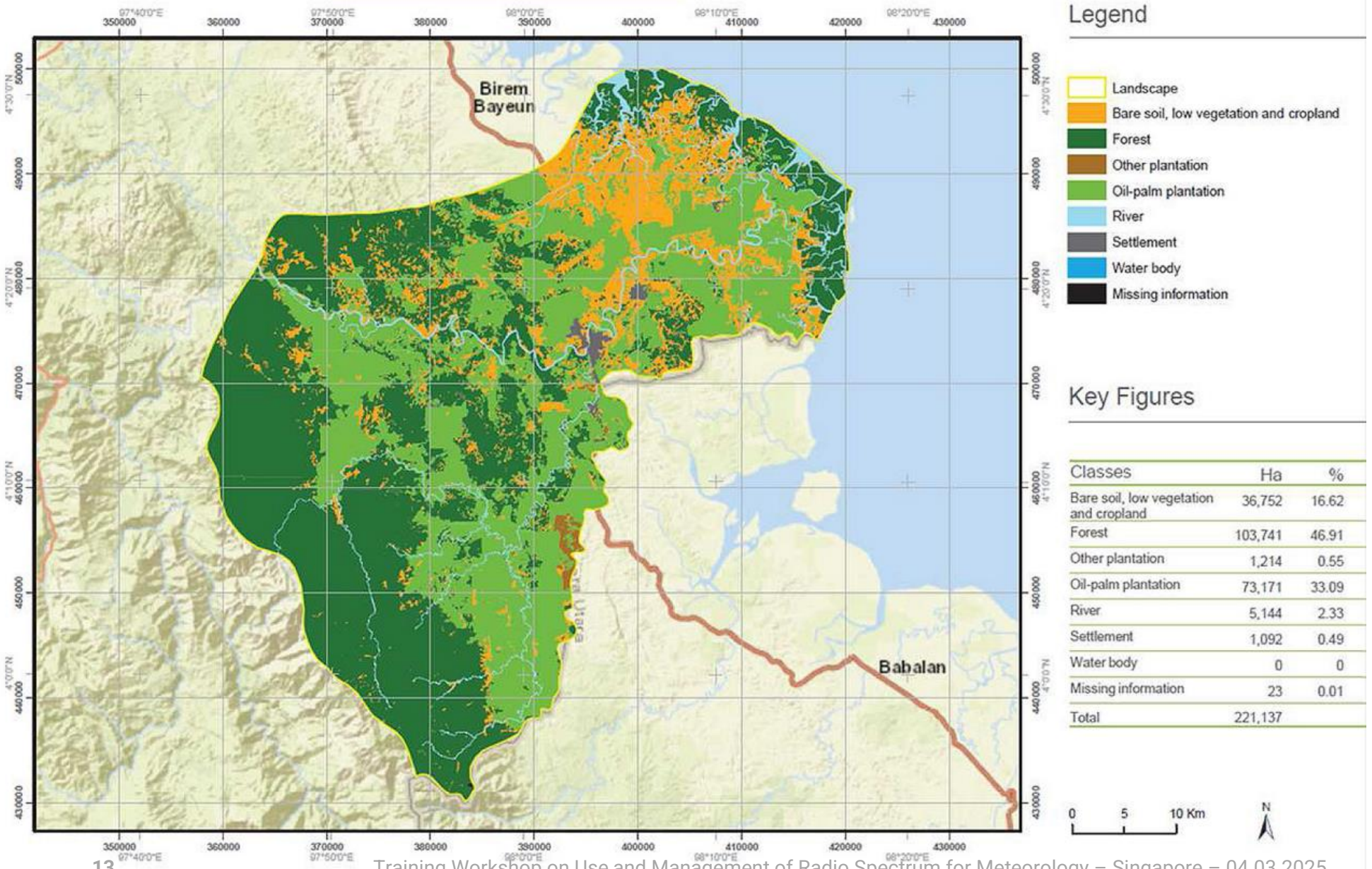
## Digitalized map




### Key Figures

| Classes | Ha | % |
|---|---|---|
| Bare soil, low vegetation and cropland | 36,752 | 16.62 |
| Forest | 103,741 | 46.91 |
| Other plantation | 1,214 | 0.55 |
| Oil-palm plantation | 73,171 | 33.09 |
| River | 5,144 | 2.33 |
| Settlement | 1,092 | 0.49 |
| Water body | 0 | 0 |
| Missing information | 23 | 0.01 |
| Total | 221,137 | |



# Sustainable Palm Oil Production

EO offers tools to monitor global supply chains from extractions to shipment and delivery monitoring both sustainable exploitation of resources and respect of human rights.

11 SUSTAINABLE CITIES AND COMMUNITIES

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

15 LIFE ON LAND

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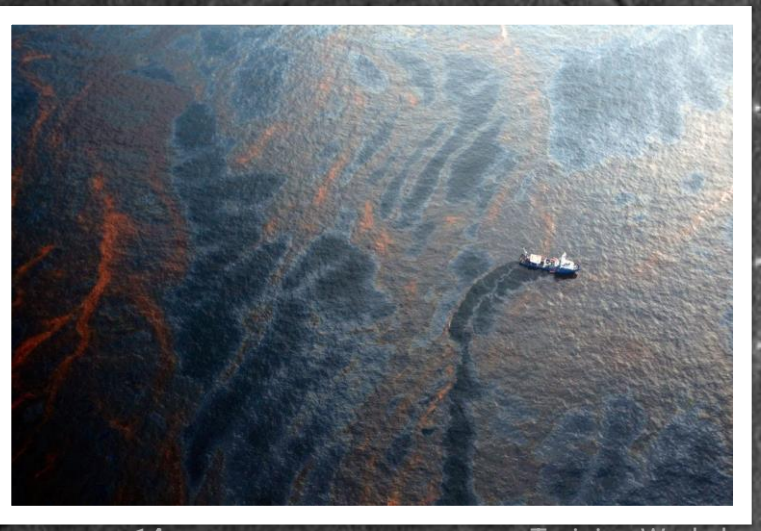
Gulf Of Mexico

# Deep Water Horizon



Oil Slick

Support Vessels



## Oil Spilling

EO enables easier identification of sea polluters via frequent data acquisitions utilising diverse sensors

13 CLIMATE ACTION

14 LIFE BELOW WATER

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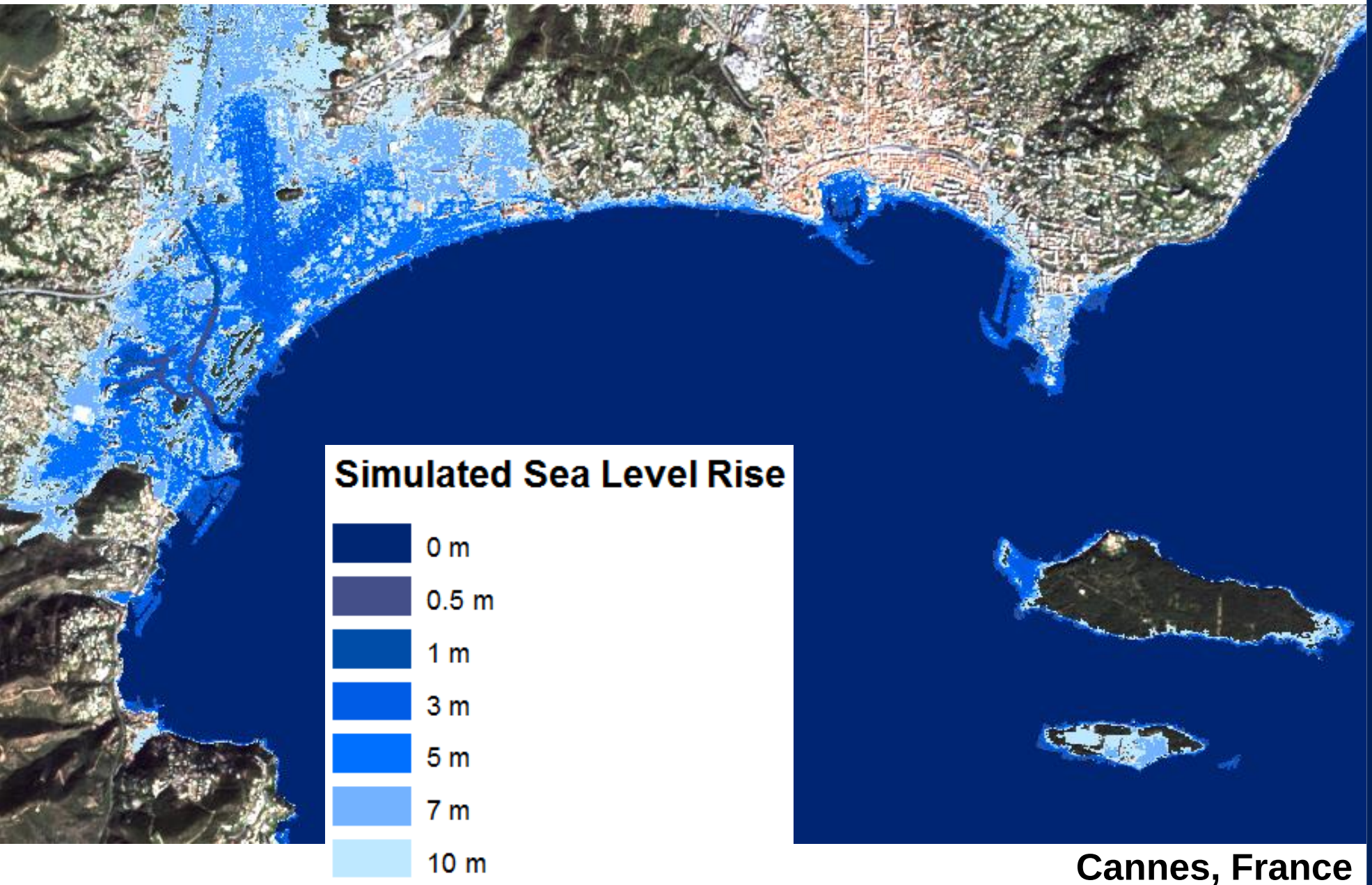
# Flooding Scenarios

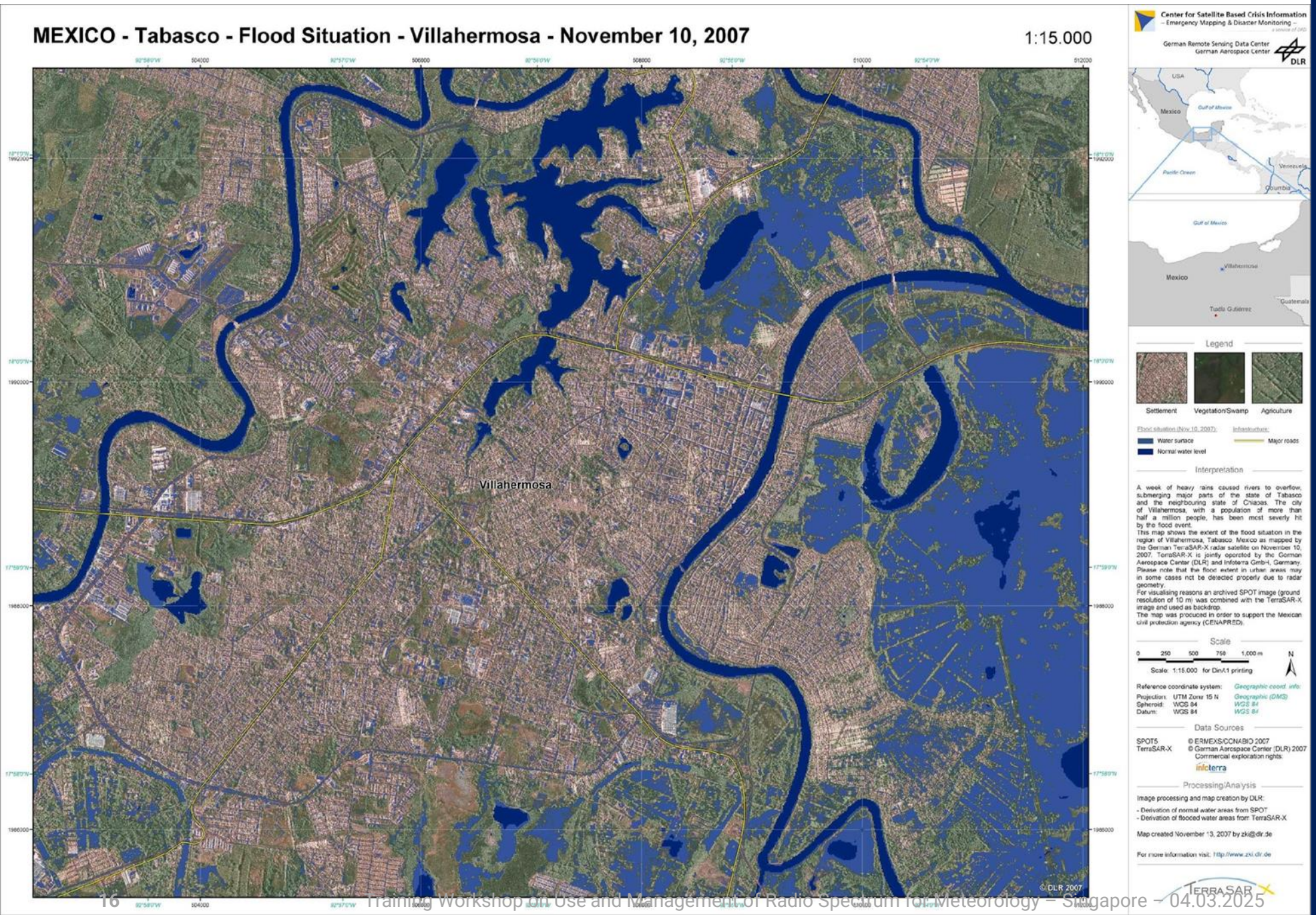
Digital terrain and 3D models derived, by leveraging high resolution data and thus the enhanced level of details, allows for an excellent delineation of the water distribution and potential passes between structures and buildings.

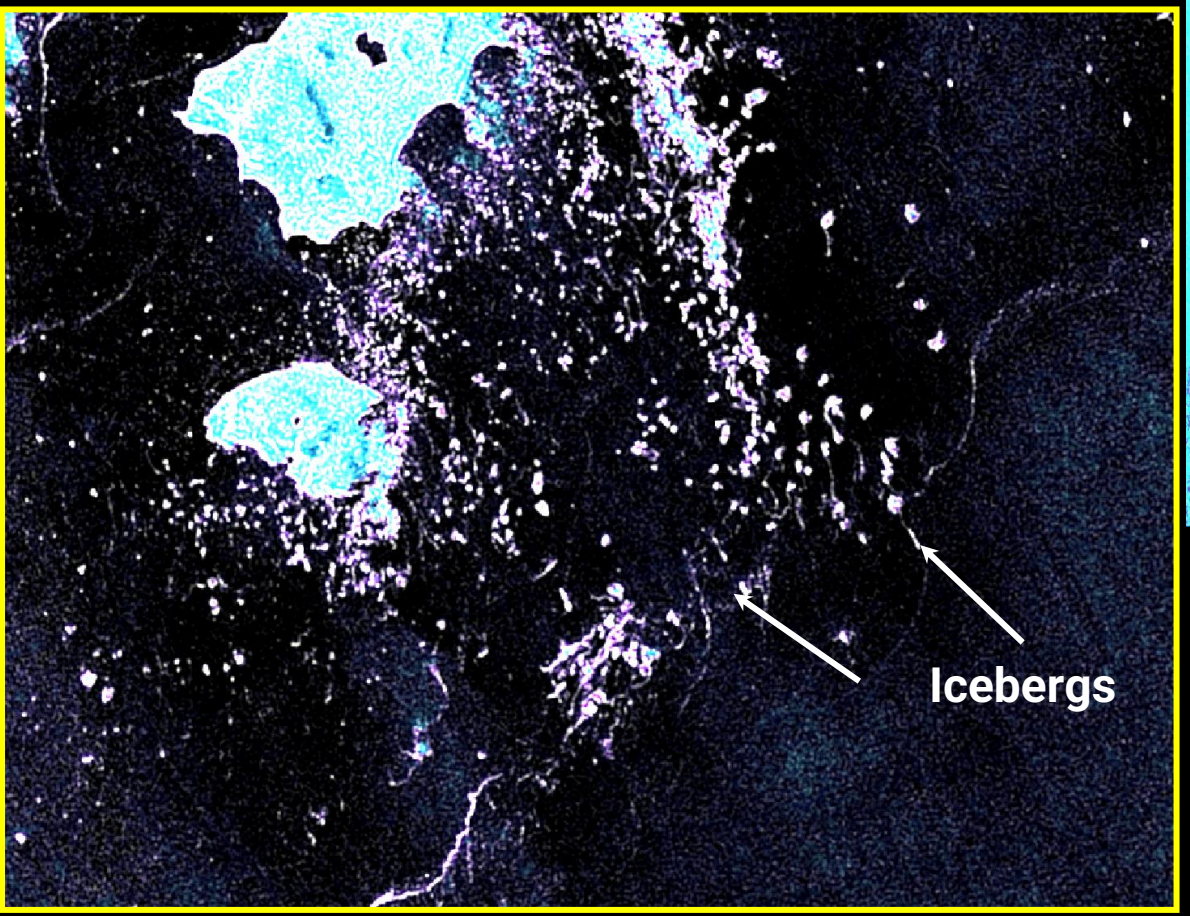


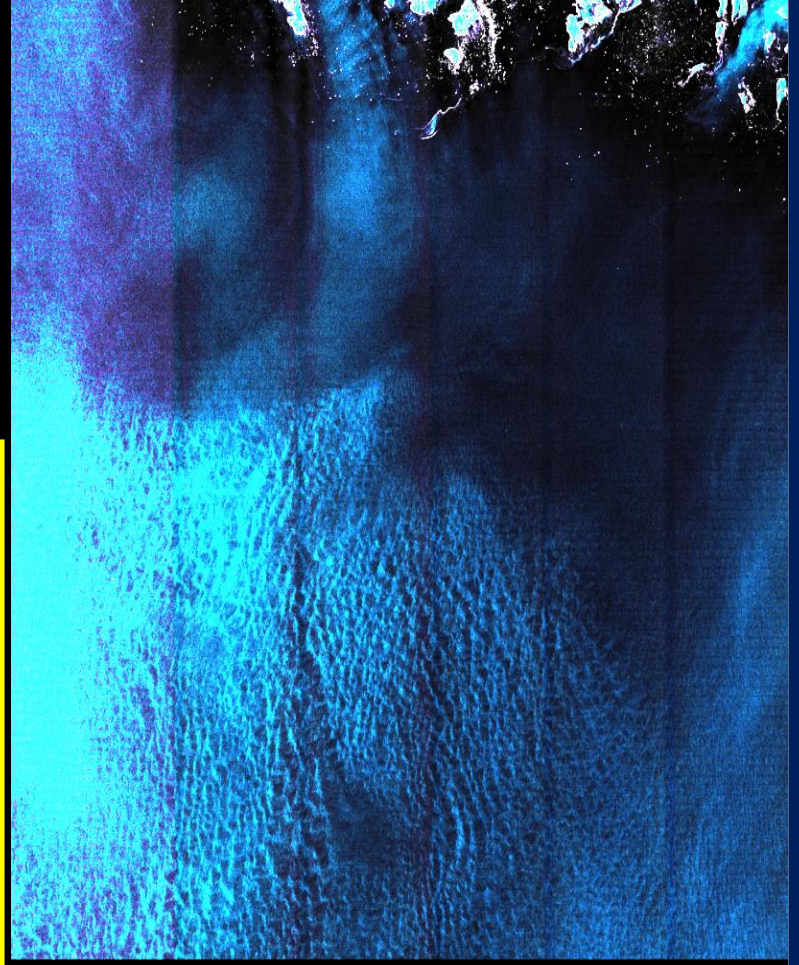

**Cannes, France**

# Flood Mapping

Earth observation satellites are now able to provide high-resolutions and shorter revisit time, which can facilitate effective resource allocation during emergency response





# Iceberg Monitoring

Iceberg Monitoring and sea ice mapping at every latitude is not only a useful method to monitor climate change but also to avoid disasters at sea which could pollute newly opened water transportation ways

13 CLIMATE ACTION

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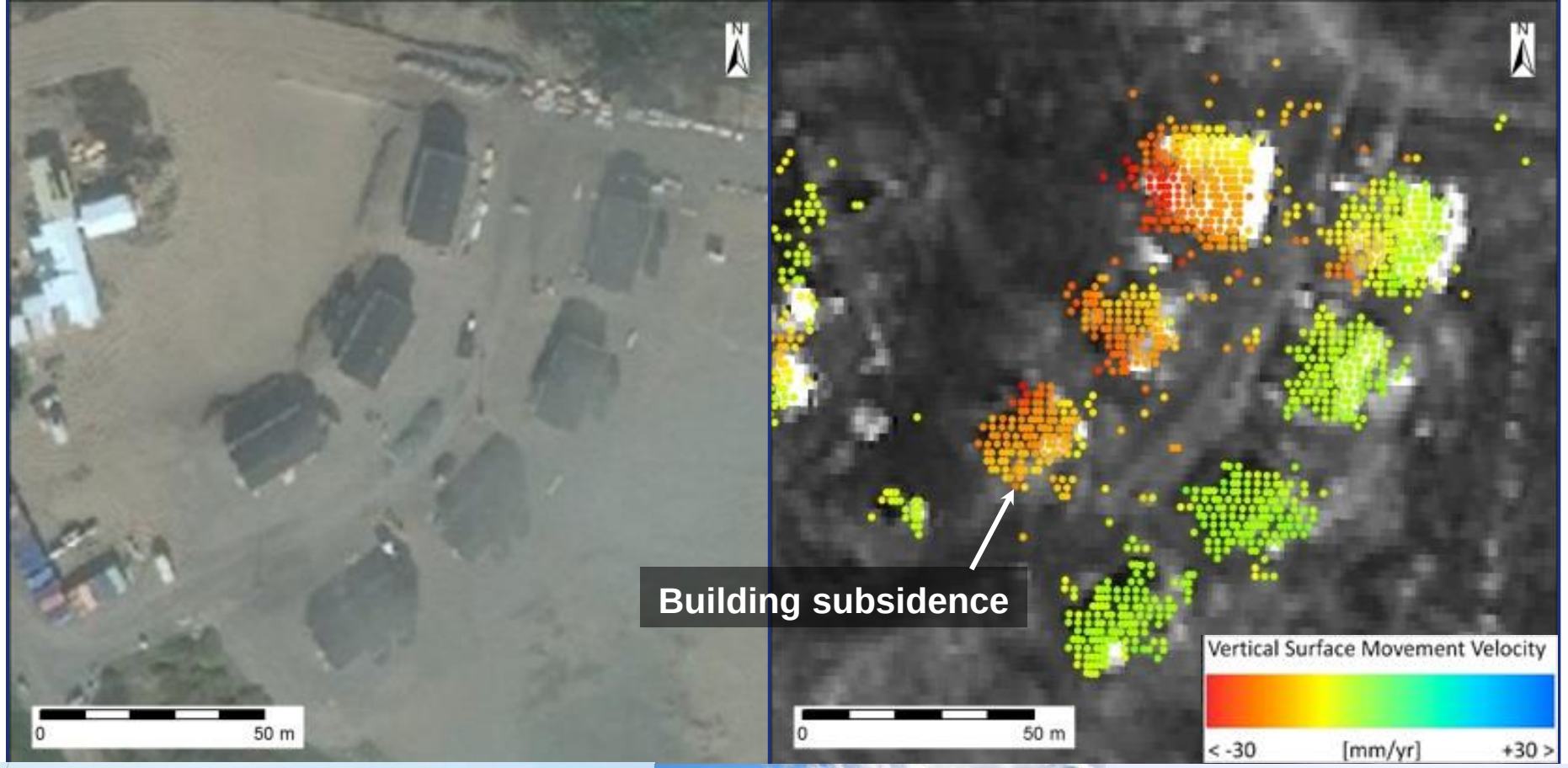
# Performafrost Thaw




EO allows for more efficient quantitative measures of the stability of infrastructure that is affected by the thawing permafrost soils.



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# WRC-27: The Earth Observation Challenge

**In 2023, WRC adopted a new agenda** looking into the **introduction of new mobile phone networks** (i.e. 6G) **in the frequency band 7 125-8 400 MHz** (or parts thereof).

| Region 1 (*Europe & Africa*) | Region 2 (*Americas*) | Region 3 (*Asia-Pacific*) |
|---|---|---|
| 4 400-4 800 MHz | | 4 400-4 800 MHz |
| 7 125-7 250 MHz<br>7 750-8 400 MHz | 7 125-8 400 MHz | 7 125-8 400 MHz |
| 14.8-15.35 GHz | 14.8-15.35 GHz | 14.8-15.35 GHz |

**Earth observation satellites could become severely constrained, impacting the collective ability to timely react to natural disasters, security threats, monitor weather and climate variables and support economy and developments**



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# The Vital Role of X-Band for Earth Observation

**X-band is the single most significant spectrum portion for downlinking Earth observation data acquired by satellites**, due to:

- **Physics**: the 8025-8400 MHz waves allows cloud- and weather-independent links,
- **Coexistence** with current coprimary services, including FS and FSS.
- **Global harmonization** for remote sensing satellite applications; and

**No current alternative to X-band downlink exists at scale**, due to:

- Lack of available protected, large enough bandwidth in other frequency ranges;
- Lack of standardization and/or technological maturity; and
- Physics: other bands are subjected to weather fade

# The Vital Role of X-Band for Earth Observation

**X-Band remains the most important downlink band because**

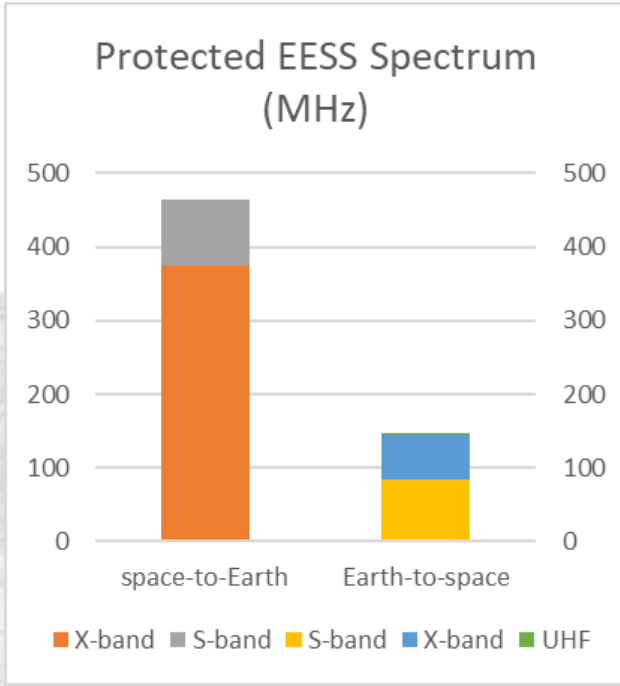
- **Capacity**

*Higher data rate if compared to S-Band (2 GHz)*

- **Transmission condition**

*Weather-independent link better than Ka-Band (26 GHz)*

- **Existing worldwide ground network**




The contiguous 375 MHz of protected bandwidth is the backbone to the remote sensing sector with no current viable alternative.



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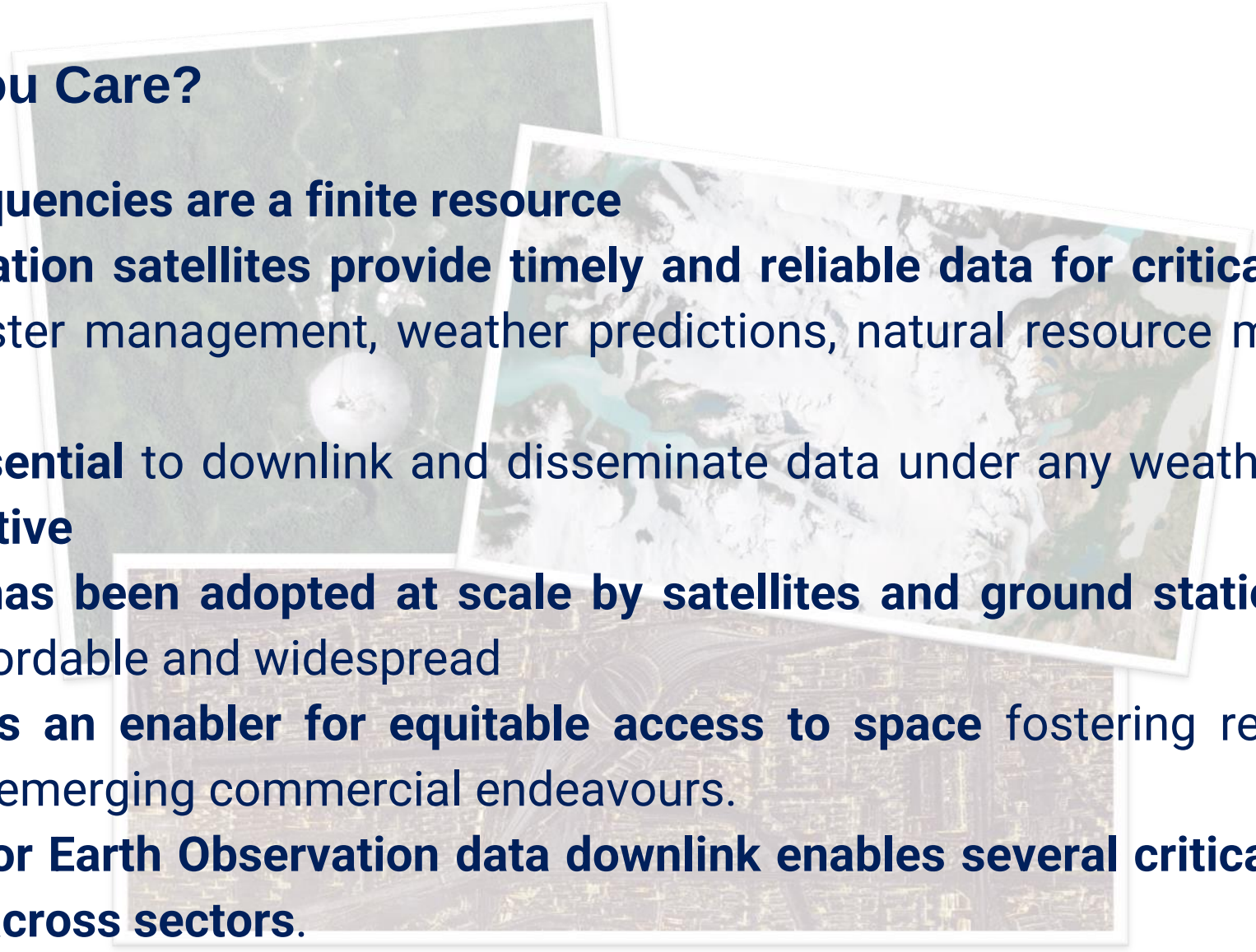
# Why Should You Care?



- The **radio frequencies are a finite resource**
- **Earth Observation satellites provide timely and reliable data for critical applications** such as disaster management, weather predictions, natural resource monitoring and security.
- **X-band is essential** to downlink and disseminate data under any weather **and has no viable alternative**
- The **X-band has been adopted at scale by satellites and ground stations**, making it ever more affordable and widespread
- The **X-band is an enabler for equitable access to space** fostering remote sensing programs for emerging commercial endeavours.
- **The X-band for Earth Observation data downlink enables several critical applications globally and across sectors**.

Imagery courtesy of:
Airbus Defence and Space GmBH
Airbus DS
EU Copernicus Programme
DLR e.V
Hisdesat Servicios Estratégicos S.A.
Leaf Space
Planet Labs PBC
Umbra Lab Inc.

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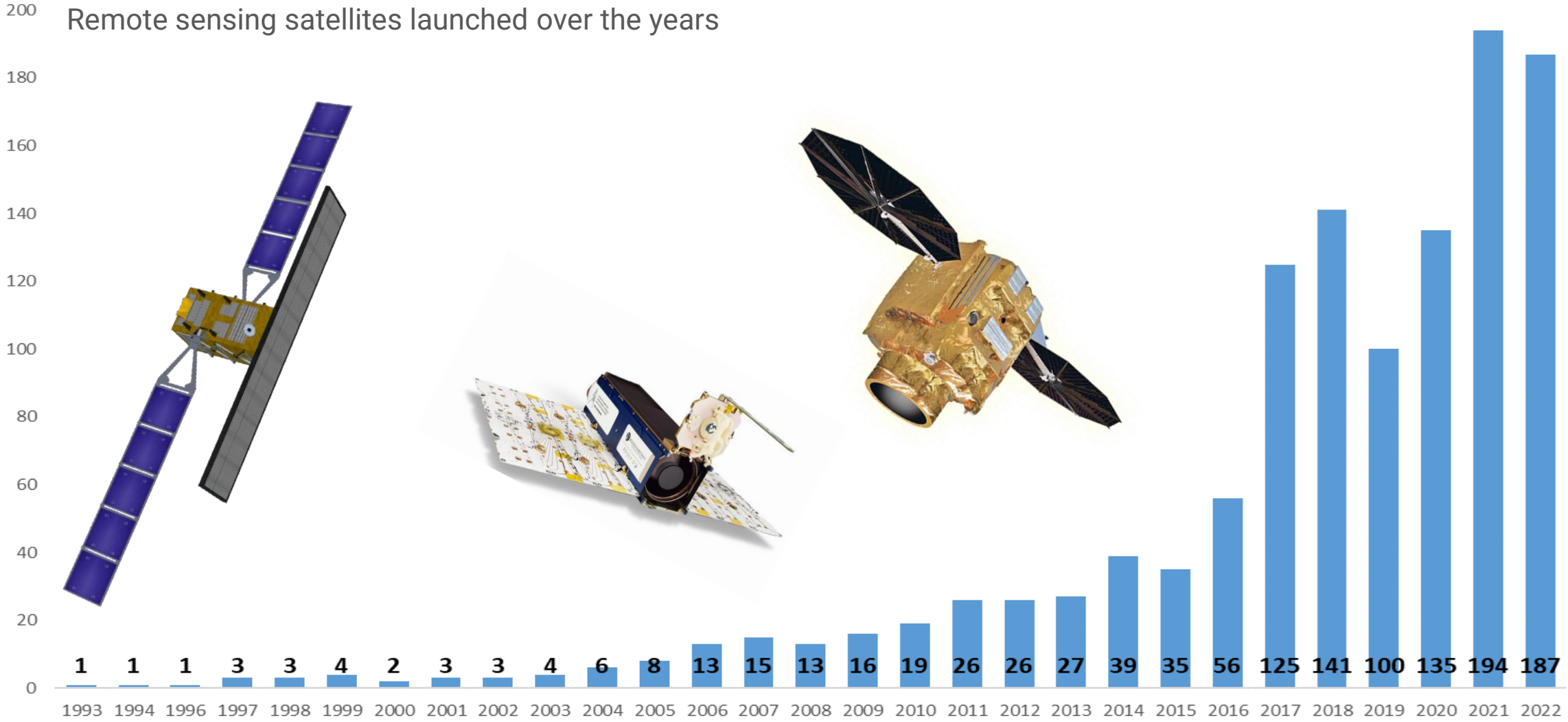
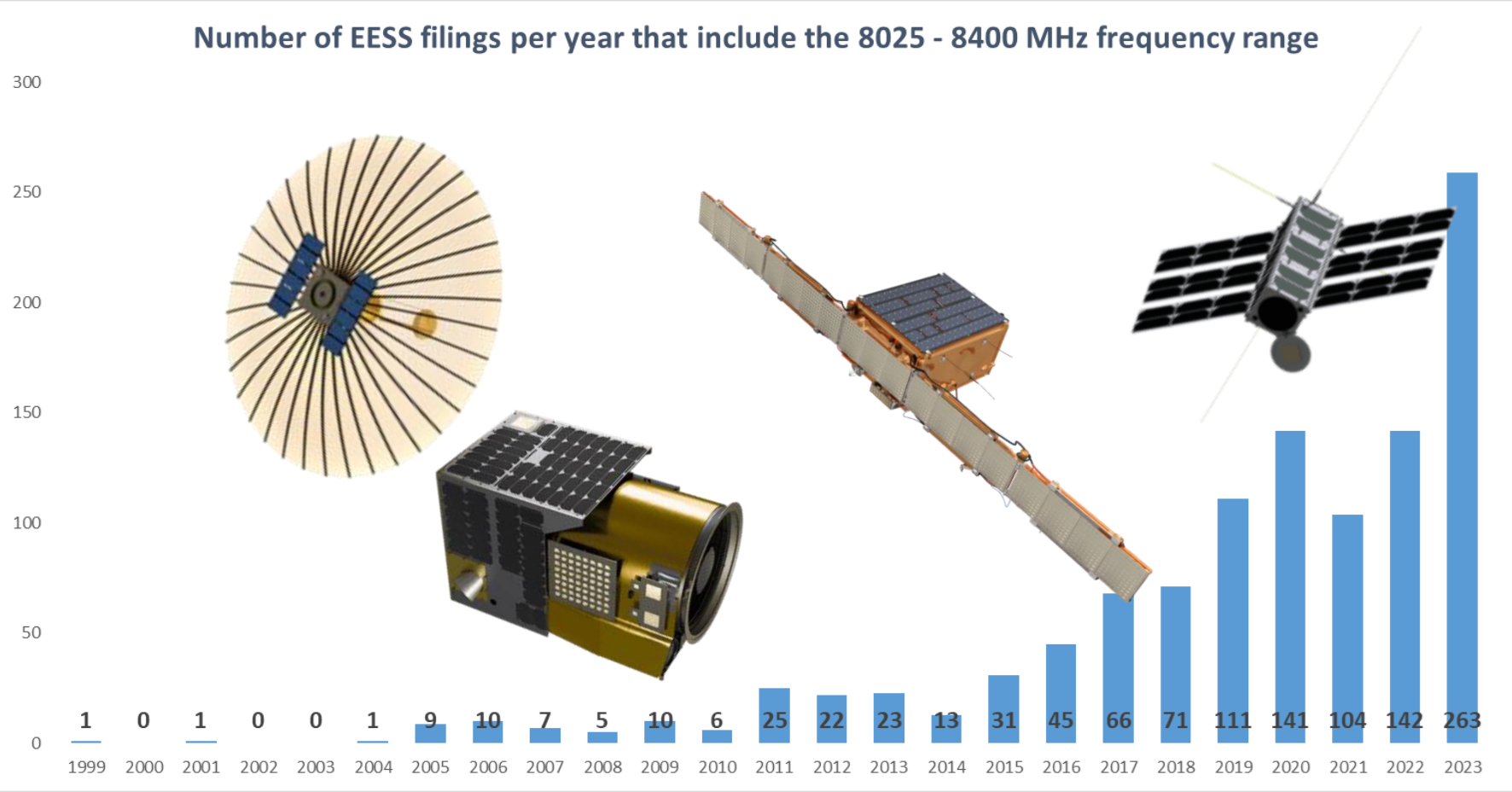
# Backup

# The Surge of Earth Observation Satellites



# Adoption Rate of X-Band for Downlinking EO data




X-Band is the present and future standard for Earth observation missions and needs reliable ground infrastructure.



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# A Global Industry Interest