



Introduction to Remote Sensing

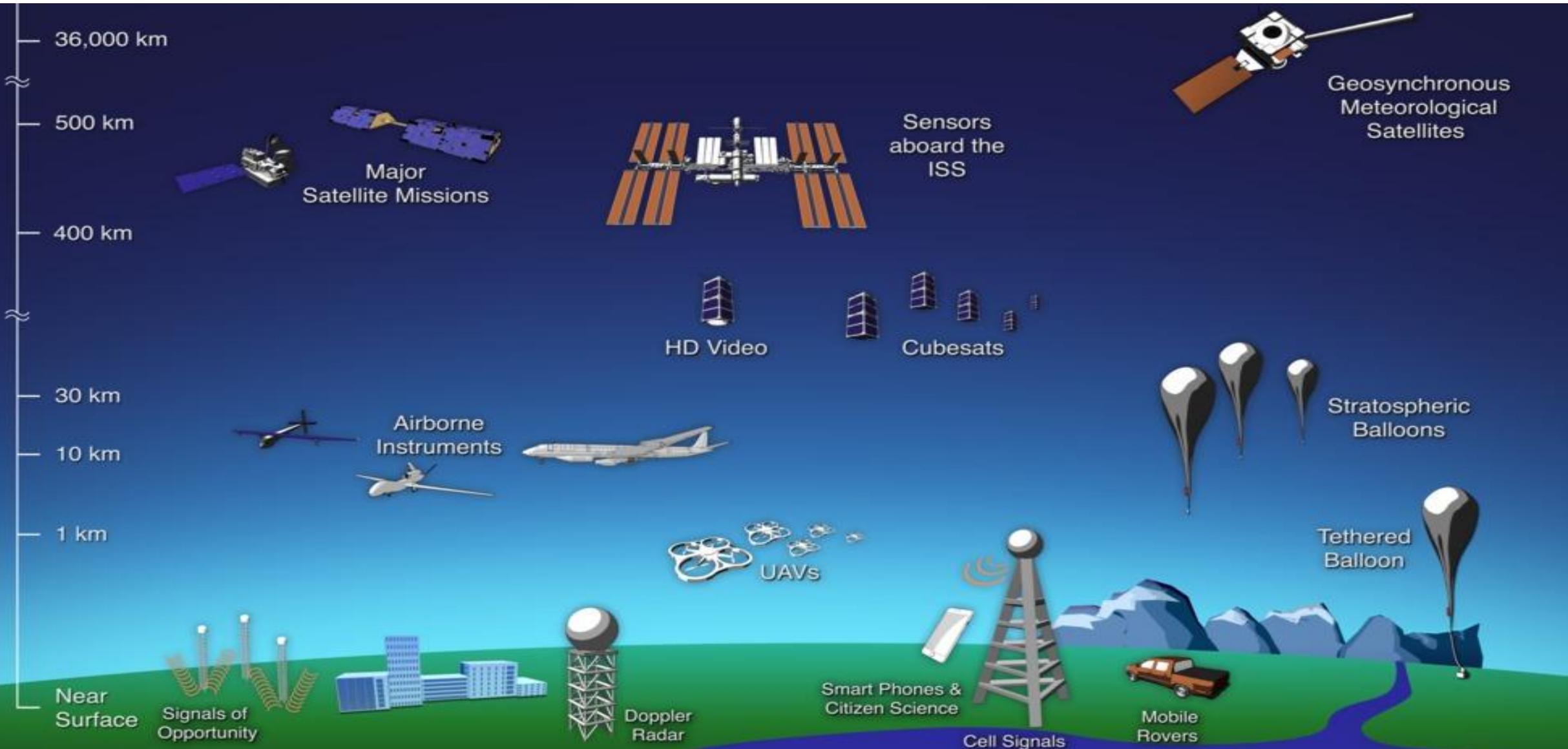
By:

Mohammed El Amin Larabi
Meziane Iftene

Learning Outcomes

- **Comprehensive knowledge of GeoAI (remote sensing, AI, Computer Vision and their applications).**
- **Practical skills in processing and analyzing Earth observation data.**
- **Hands-on experience with tools like Jupyter notebooks and prepared datasets.**
- **Exposure to real-world projects and case studies in the field.**

Remote Sensing, GeoAI, and Sustainable Development: Transforming Our World with Data



1: Introduction to Remote Sensing

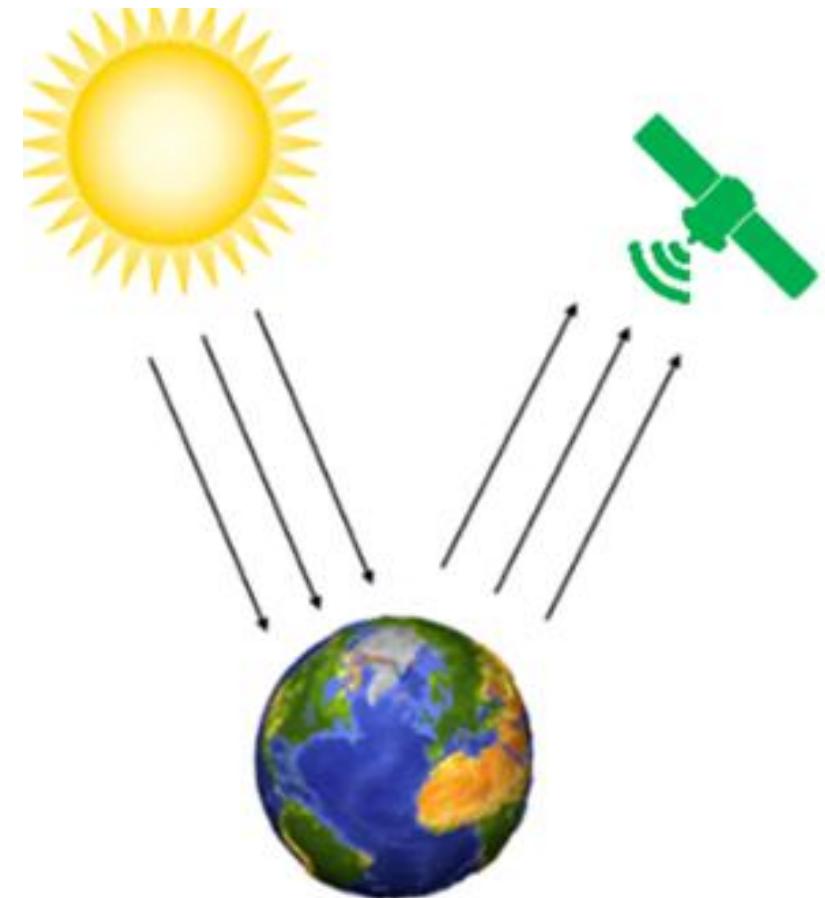
What is Remote Sensing?

Remote sensing is the science of obtaining information about objects or areas from a distance, typically using aircraft or satellites. It involves measuring the reflected and emitted radiation from the Earth's surface to monitor physical characteristics without direct contact. This technology is widely used in fields such as environmental monitoring, agriculture, urban planning, and disaster management.

2: Types of Remote Sensing Data

Passive Remote Sensing (Optical):

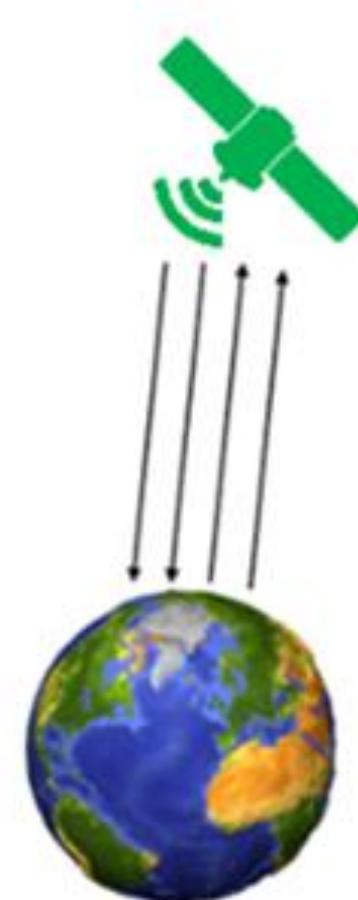
- Utilizes natural energy, primarily sunlight, reflected off surfaces.
- Common examples include satellite imagery and aerial photography.



2: Types of Remote Sensing Data

Active Remote Sensing:

- Involves emitting energy (e.g., radar or laser) and measuring the reflected signals.
- Technologies include RADAR and LiDAR, which provide detailed information about surface features.



Spatial resolution



High Spatial Resolution

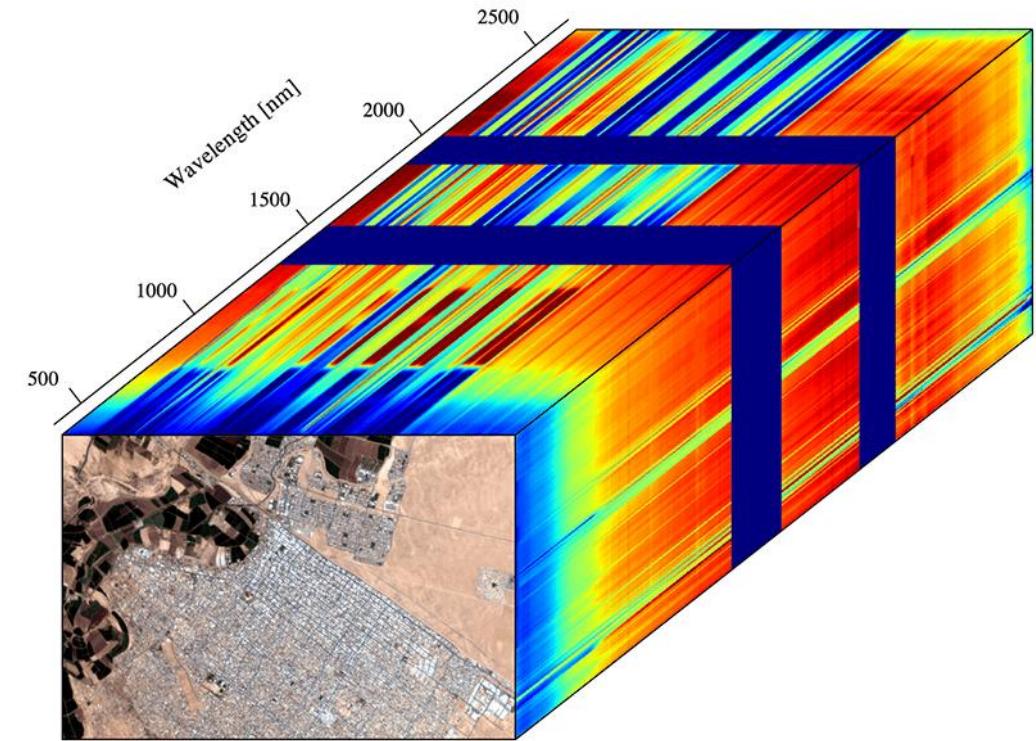


Medium Spatial Resolution



Low Spatial Resolution

Spectral resolution

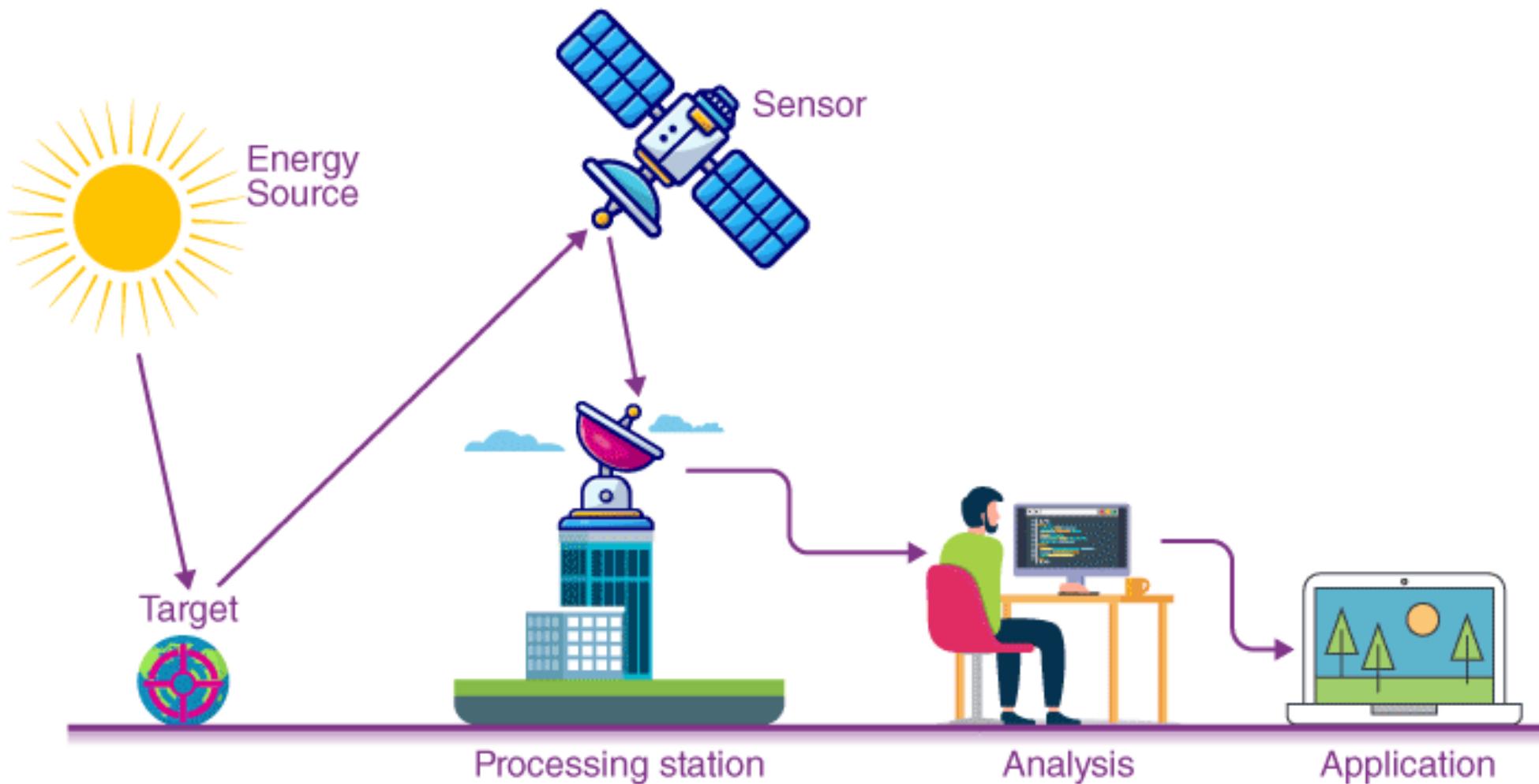


Temporal resolution



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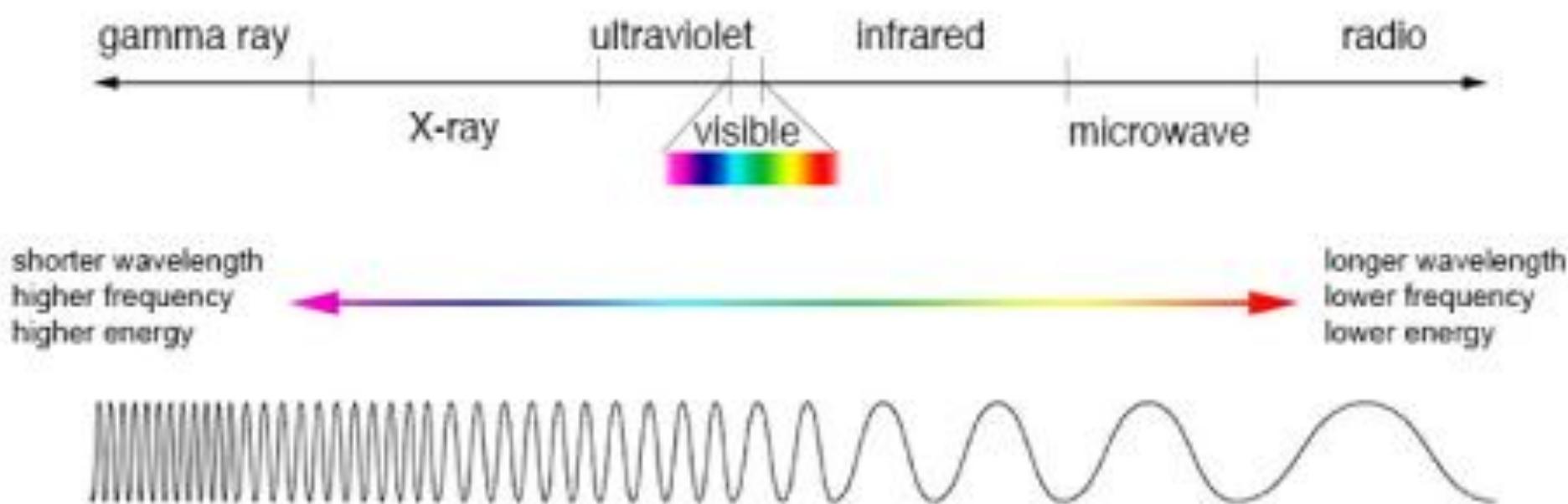
Remote Sensing Process:



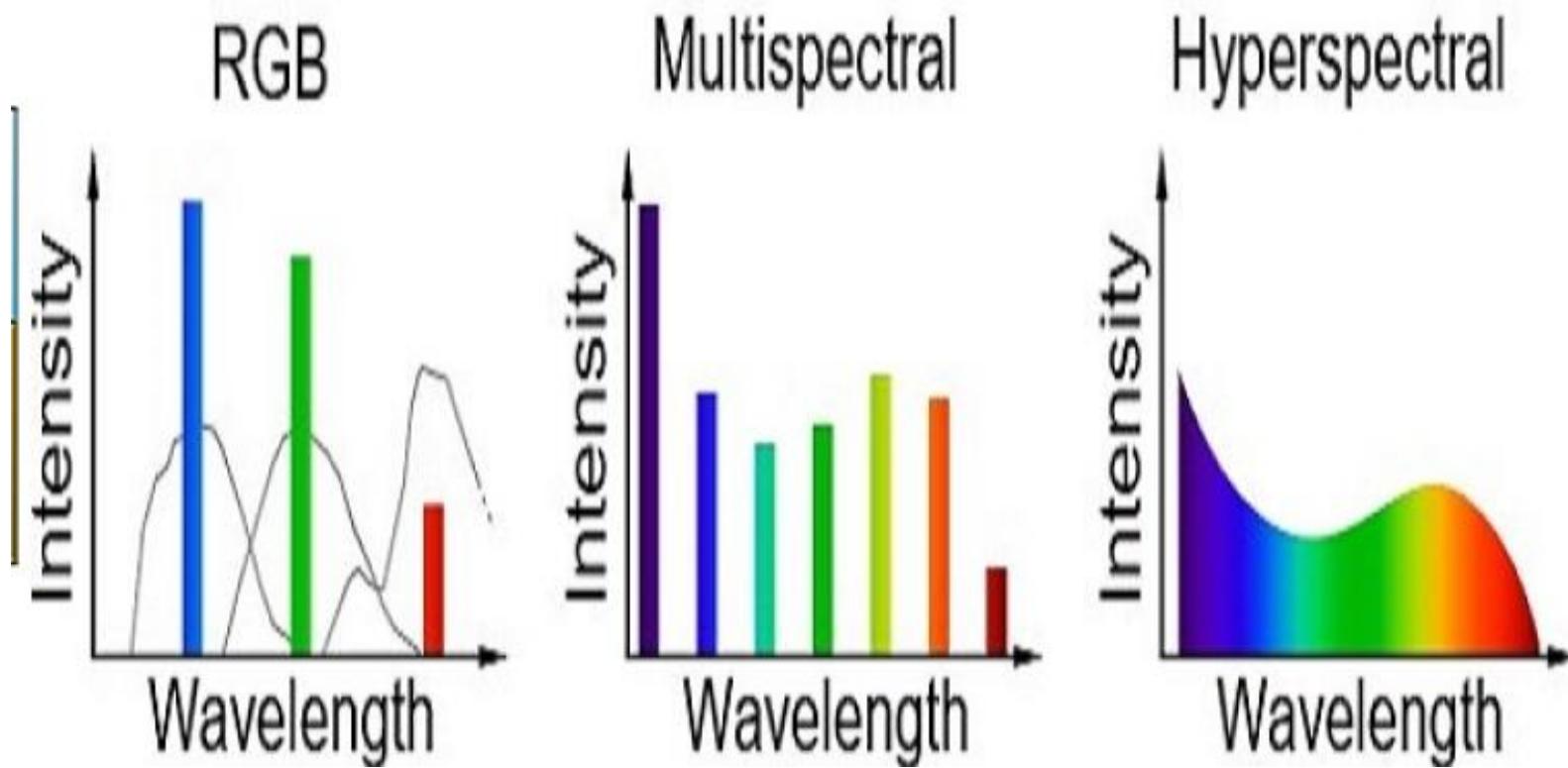
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Electromagnetic Spectrum and Remote Sensing

The electromagnetic spectrum encompasses a range of wavelengths, each of which has unique properties and applications in remote sensing. Different regions of the spectrum are utilized to gather information about the Earth's surface and atmosphere, allowing scientists and researchers to analyze various phenomena.

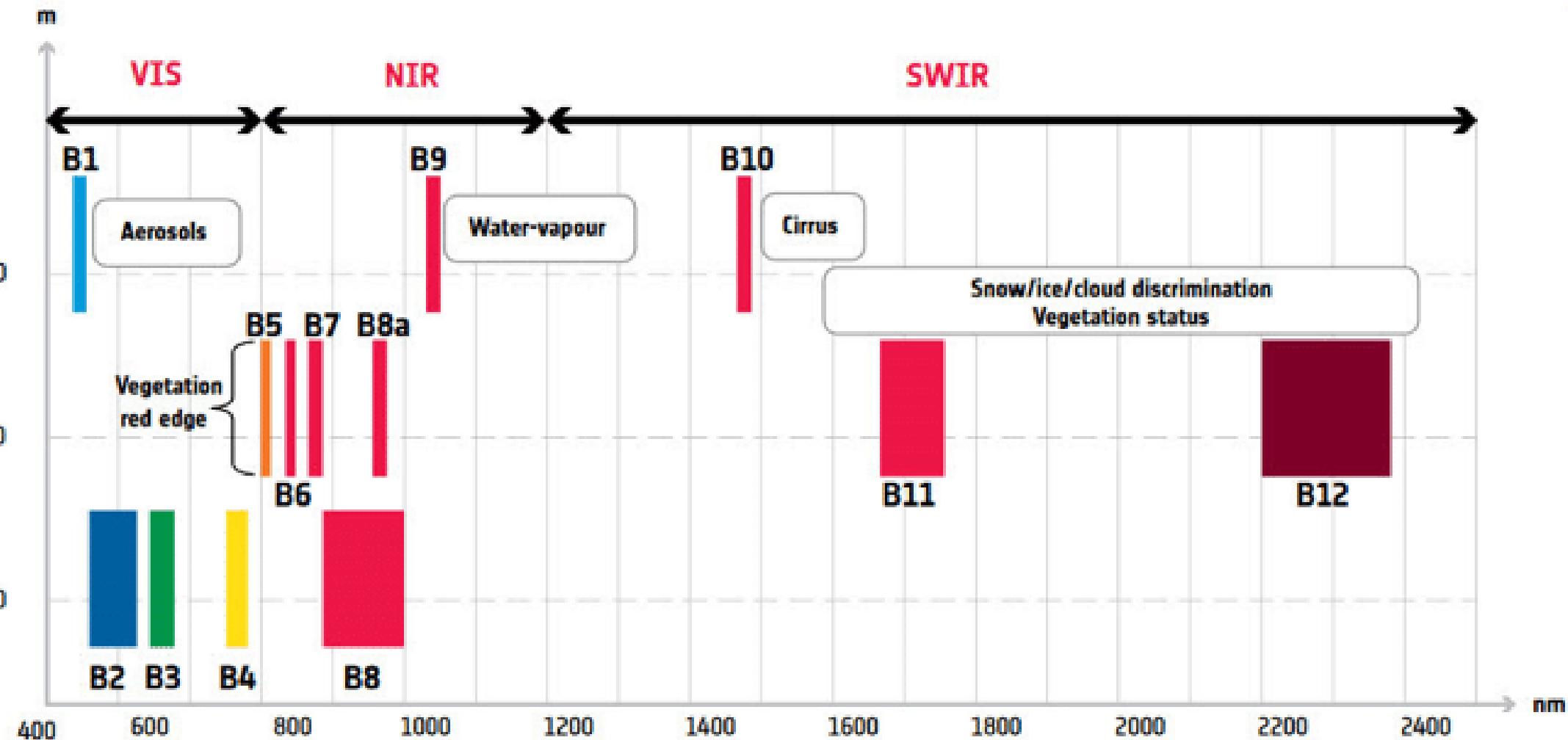


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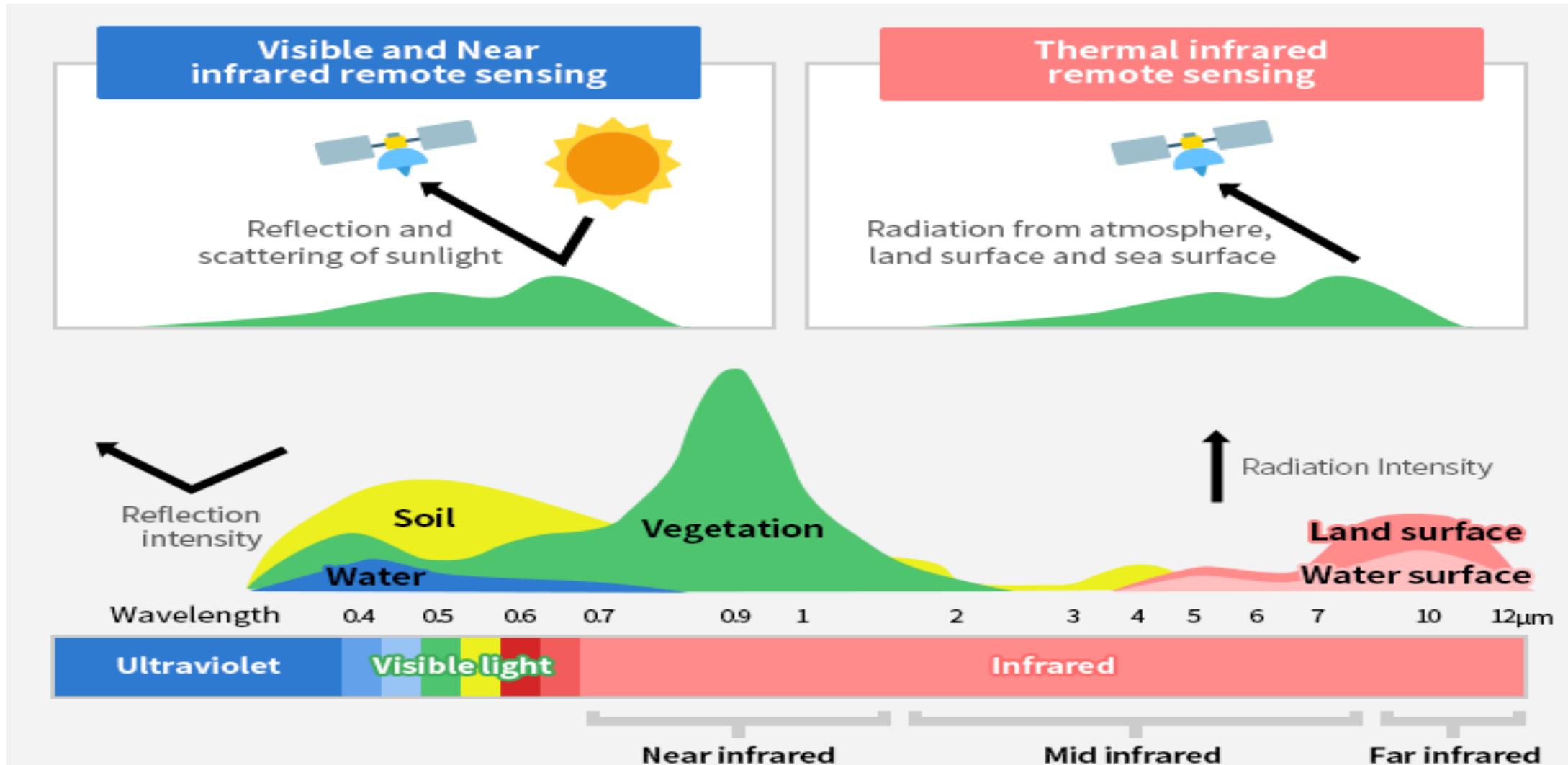
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Multispectral Remote Sensing



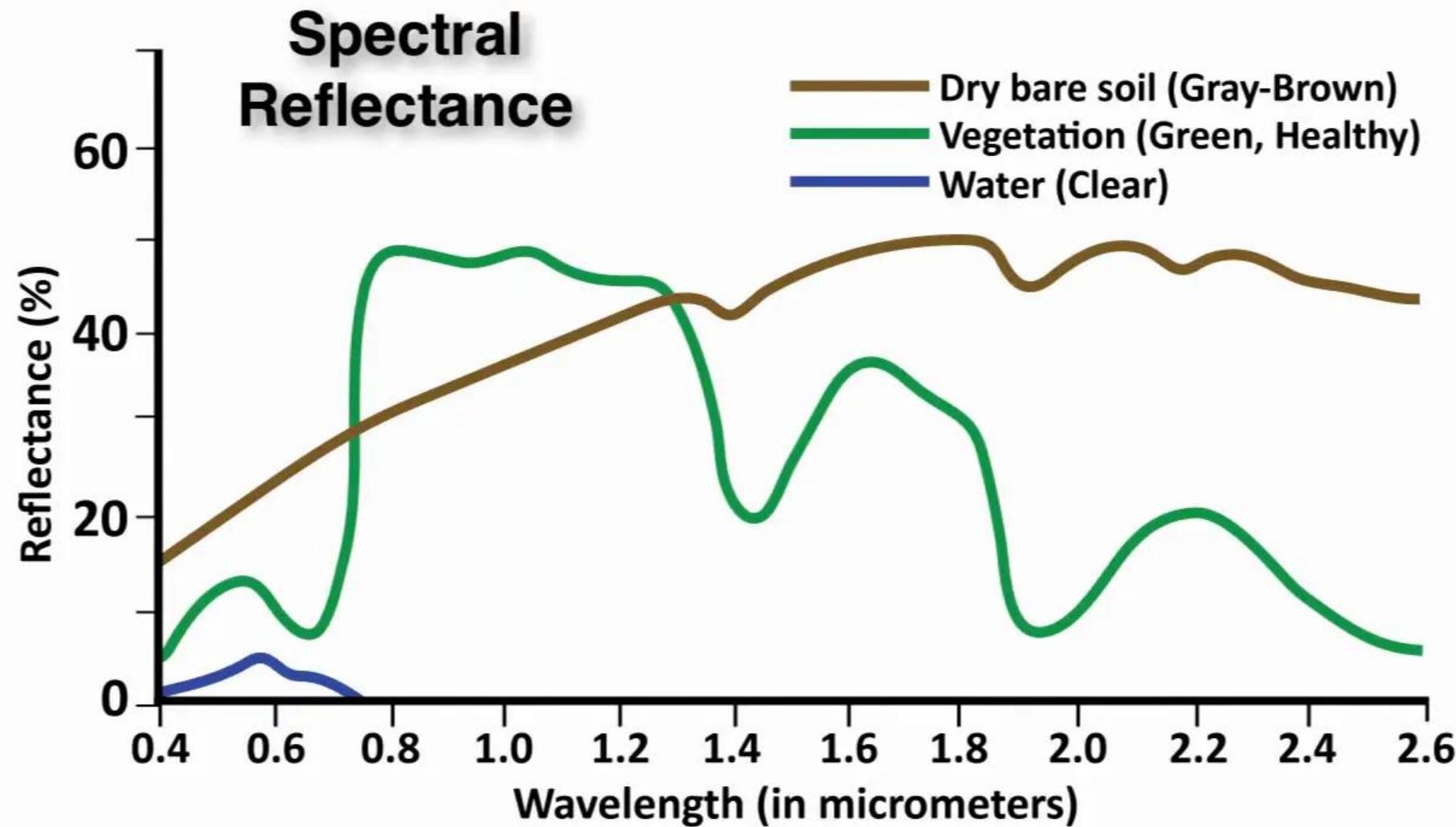
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Electromagnetic Spectrum and Remote Sensing



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Spectral Reflectance



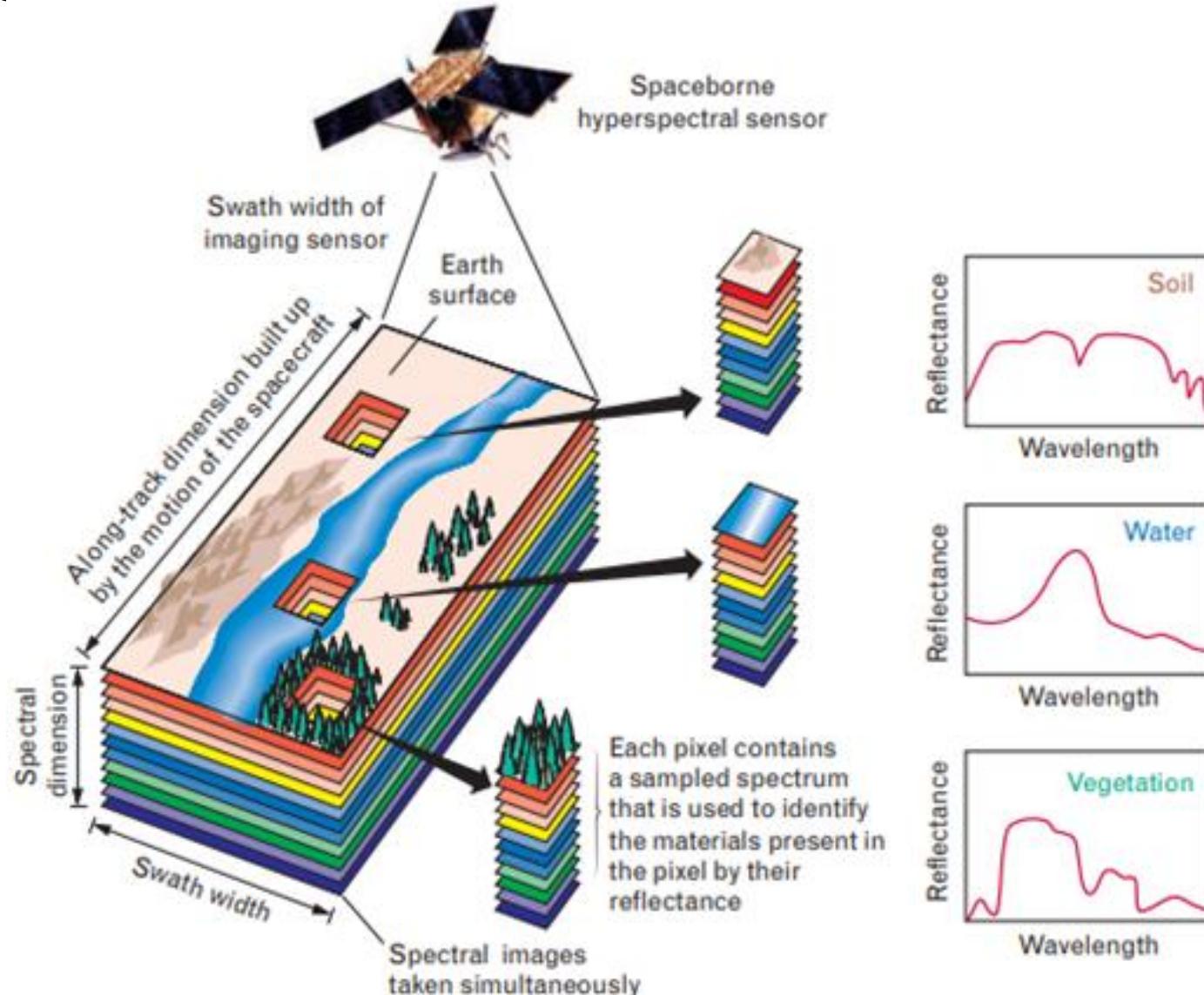
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Multispectral Remote Sensing

Multispectral remote sensing involves the collection of data across multiple discrete wavelengths of the electromagnetic spectrum. Typically, multispectral sensors capture information in 3 to 10 spectral bands, allowing for the analysis of various surface features and materials based on their unique spectral signatures.

Examples of Multispectral Sensors:

- Algerian Satellite “ALSAT”,
- Sentinel-2 (Europe)
- Landsat (US)



1: Introduction to Remote Sensing

Hyperspectral Remote Sensing

Hyperspectral remote sensing involves the collection of data across a wide range of wavelengths, typically capturing hundreds of contiguous spectral bands. This high spectral resolution allows for detailed analysis of materials and their properties, enabling the identification of specific substances based on their unique spectral signatures.

Examples of Hyperspectral Sensors:

AVIRIS (Airborne Visible/Infrared Imaging Spectrometer, 224 spectral bands) by NASA

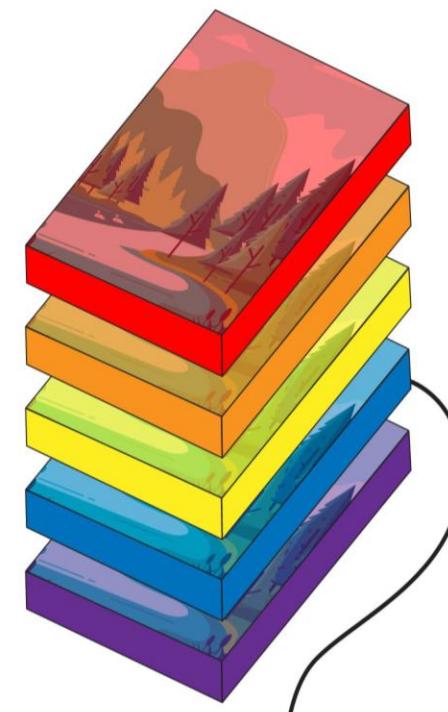
PRISMA (ITALY)

Advantages:

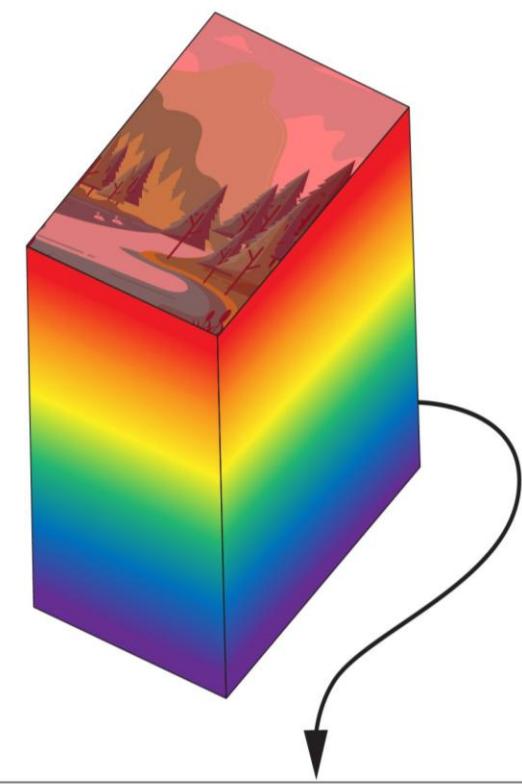
High Spectral Resolution: The ability to capture numerous narrow bands

Material Identification: distinguish between similar materials that may appear identical in multispectral imagery, making it possible to identify specific **minerals**, vegetation types, and pollutants.

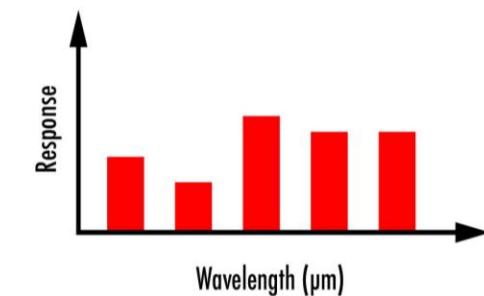
Multispectral



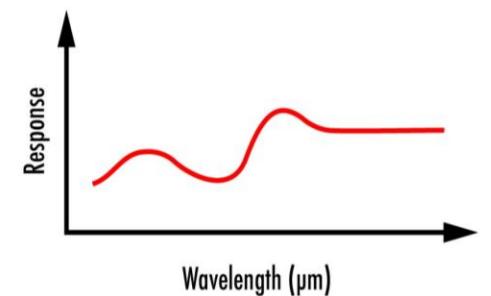
Hyperspectral



Several Spectral Bands



Continuous Spectrum



1: Introduction to Remote Sensing

Radar Remote Sensing (SAR)

Radar remote sensing, specifically Synthetic Aperture Radar (SAR), is an active remote sensing technology that uses microwave radar signals to create high-resolution images of the Earth's surface. Unlike passive sensors that rely on sunlight, SAR emits its own signals and measures the backscatter reflected from the surface, allowing for data collection in various conditions.

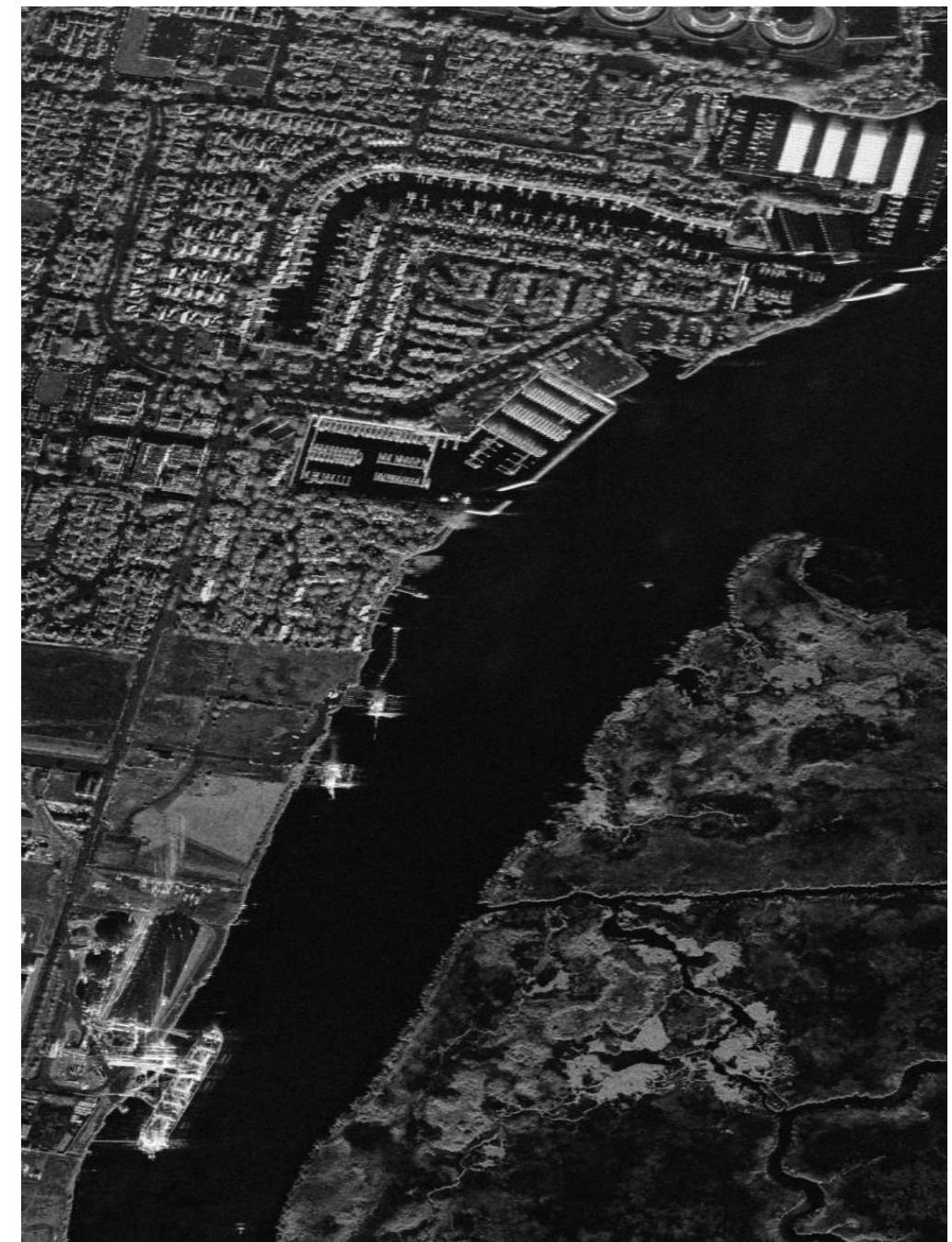
Principles of Synthetic Aperture Radar (SAR):

Signal Emission and Reception: SAR systems emit microwave pulses toward the ground and record the time it takes for the signals to return after bouncing off the surface. The data collected is used to create images.

Interferometry: SAR can also be used in interferometric applications, where two or more SAR images are combined to measure surface deformation, such as land subsidence or tectonic movements.

Advantages:

- All-Weather Capability:,
- Day/Night Operation



1: Introduction to Remote Sensing

Lidar Remote Sensing

Lidar (Light Detection and Ranging) is an active remote sensing technology that uses laser pulses to measure distances to the Earth's surface. By emitting rapid laser beams and recording the time it takes for the light to return, Lidar generates precise, three-dimensional information about the terrain and objects on the surface.

Applications in 3D Mapping and Height Models:

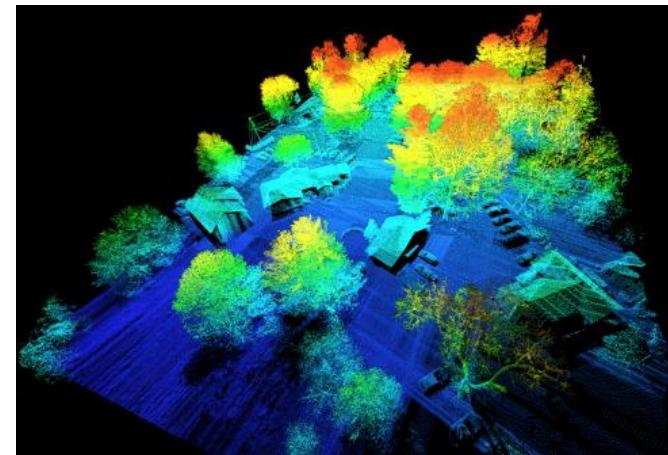
Sign

Topographic Mapping: Lidar is widely used to create high-resolution digital elevation models (DEMs) that accurately represent the terrain, including hills, valleys, and water bodies.

Vegetation Analysis: By analyzing the point cloud data, Lidar can provide information on forest structure, canopy height, and biomass estimation, aiding in ecological studies and forest management.

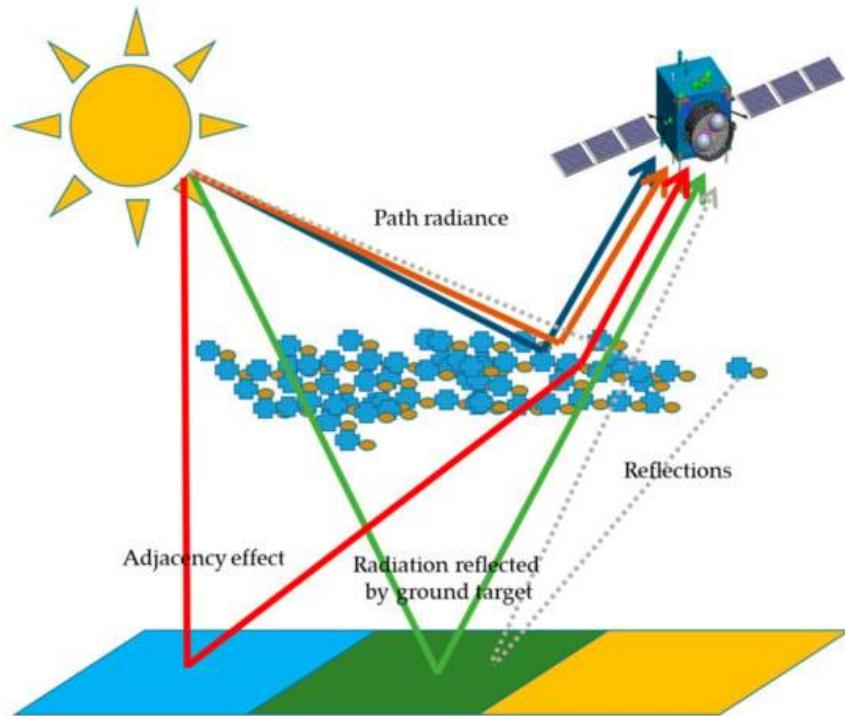
Urban Planning: Lidar data is utilized for creating 3D models of urban environments, helping in infrastructure development, flood modeling, and disaster management.

Archaeology: Lidar can penetrate vegetation to reveal hidden archaeological features, making it a valuable tool for landscape archaeology and site mapping.

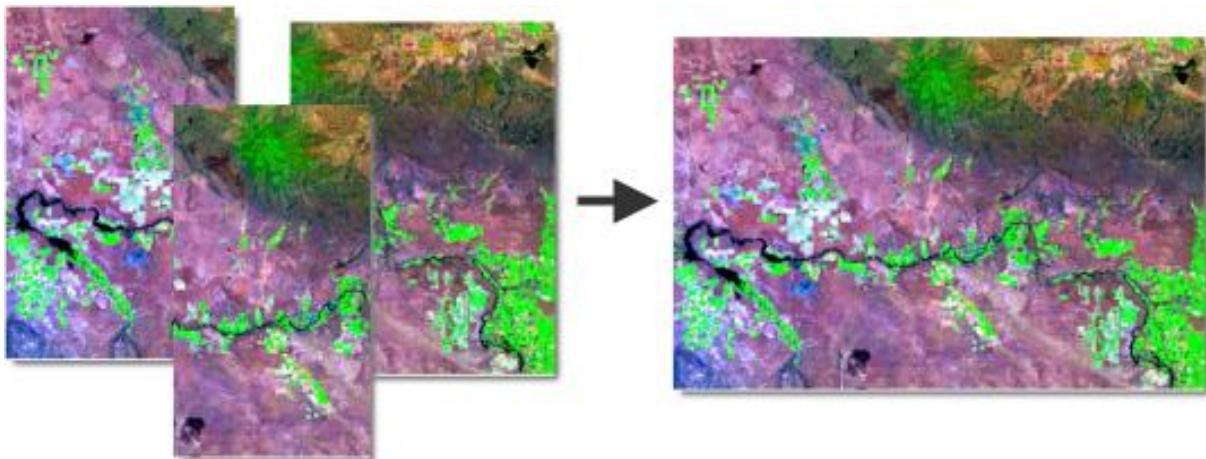
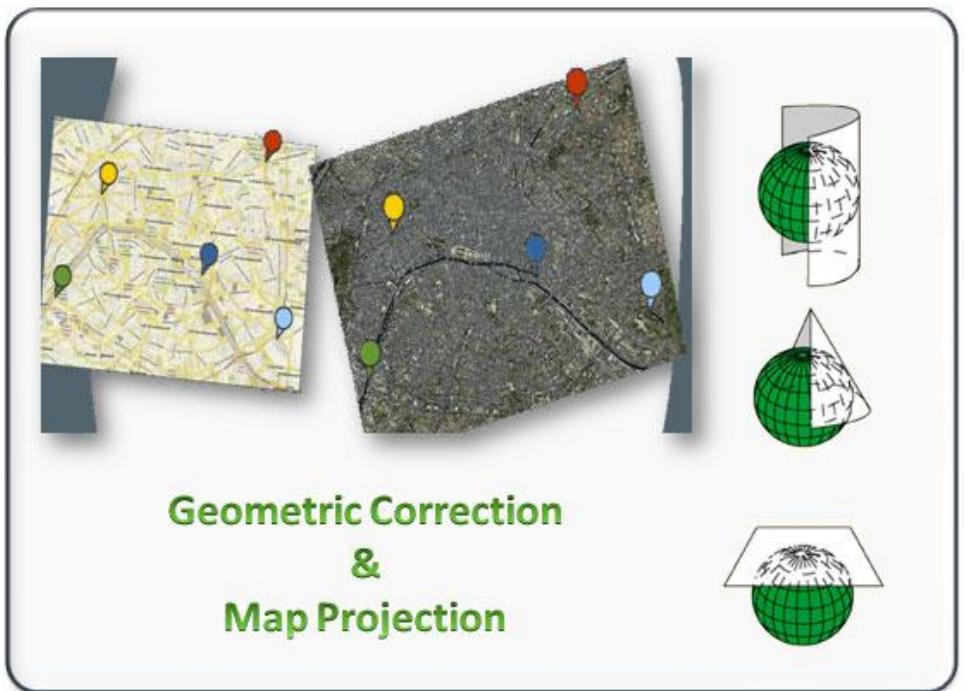


Remote Sensing Preprocessing

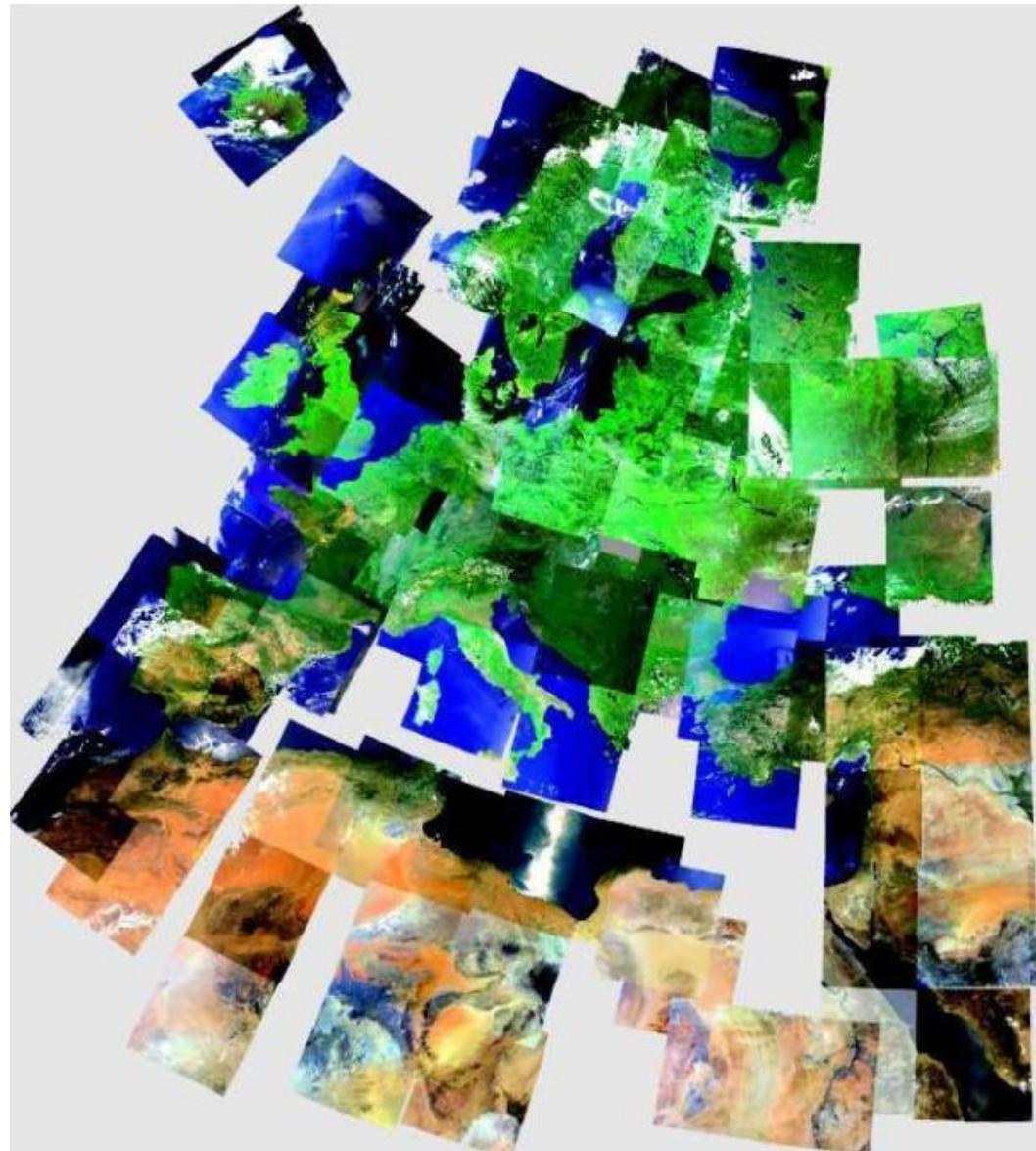
Preprocessing is a crucial step in remote sensing that enhances the quality and usability of satellite and aerial imagery. It involves several techniques to correct and prepare data for analysis, ensuring accurate interpretation of the information captured. Key preprocessing steps include



Remote Sensing Geometric Registration



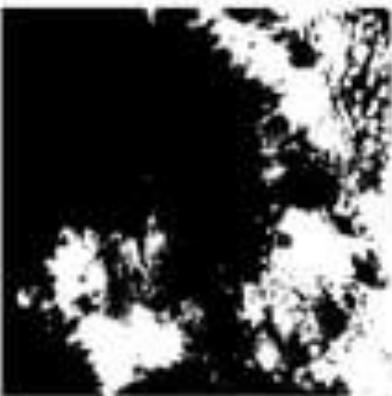
Remote Sensing Mosaic



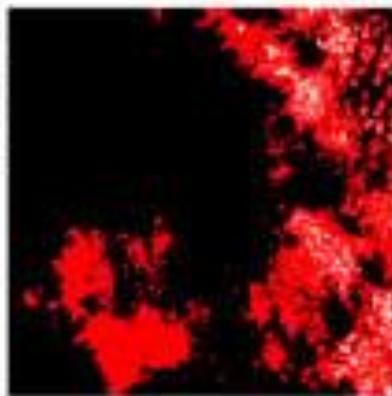
Remote Sensing cloud detection



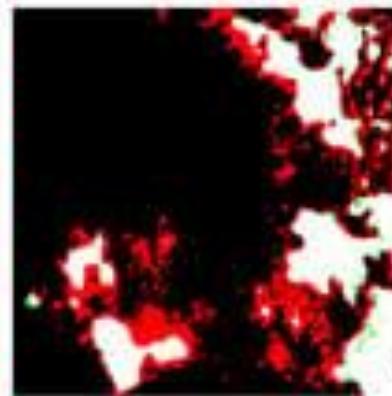
(a)



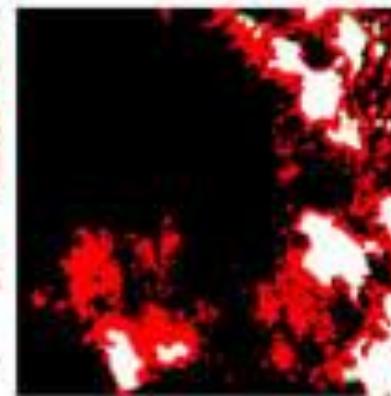
(b)



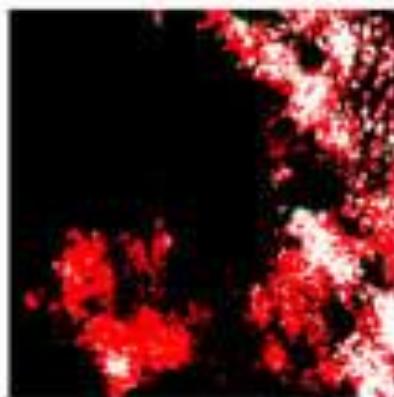
(c)



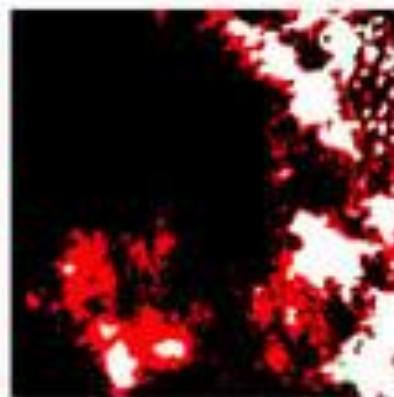
(d)



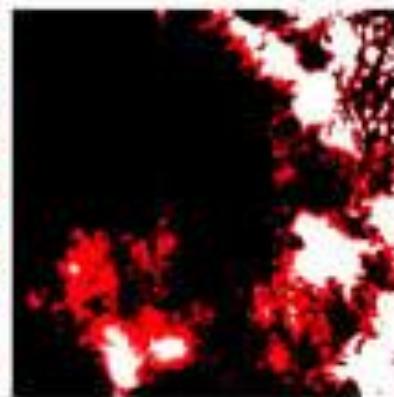
(e)



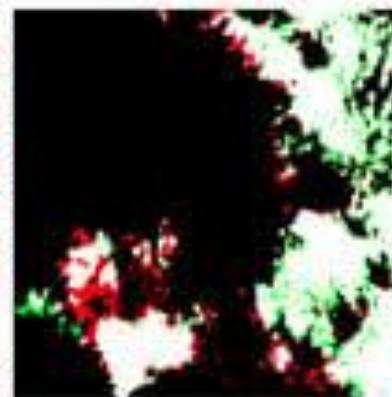
(f)



(g)

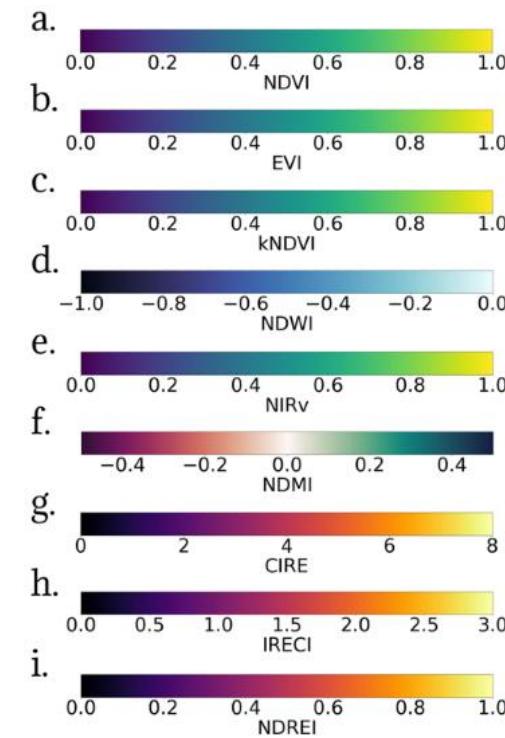
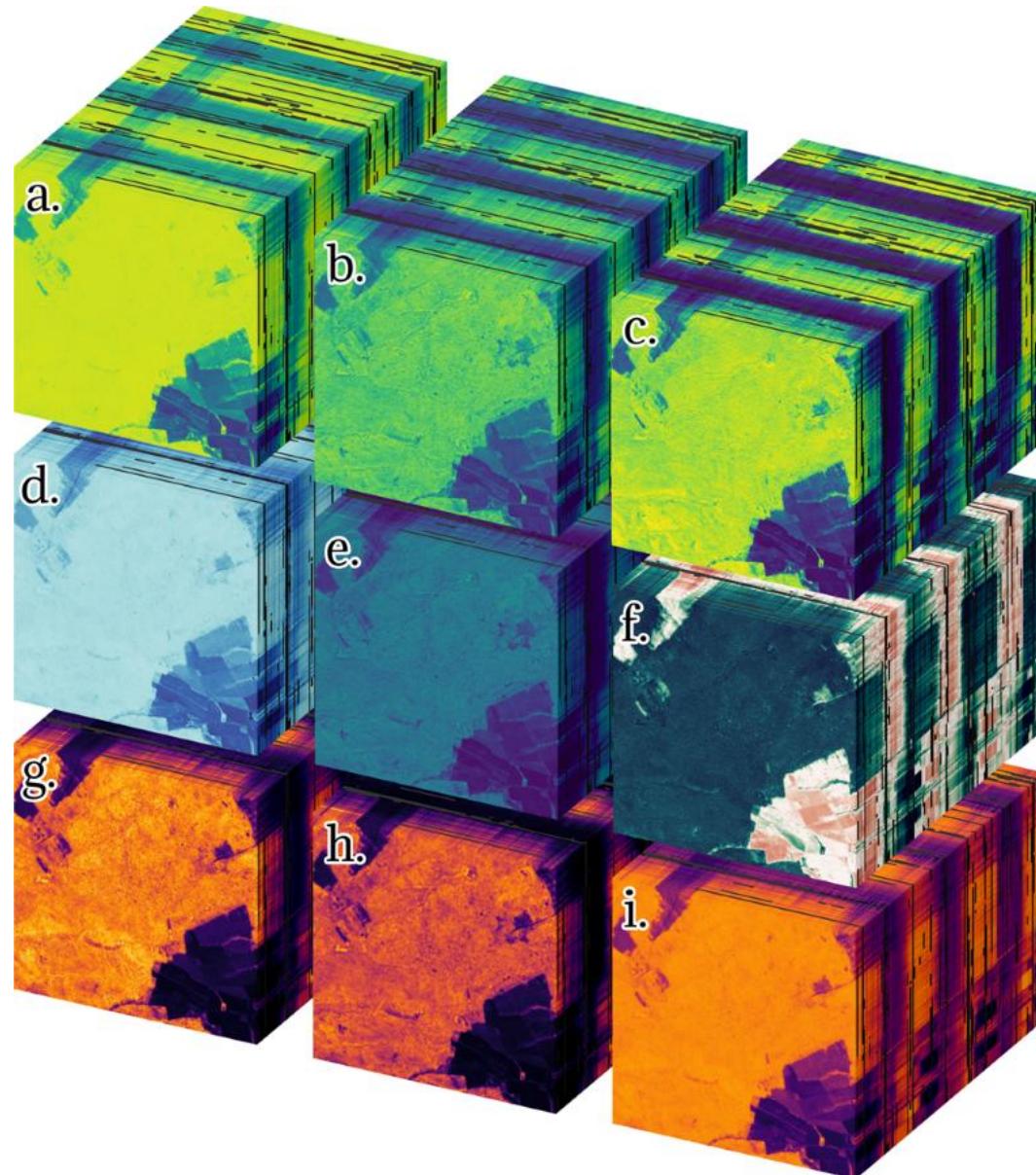


(h)



(i)

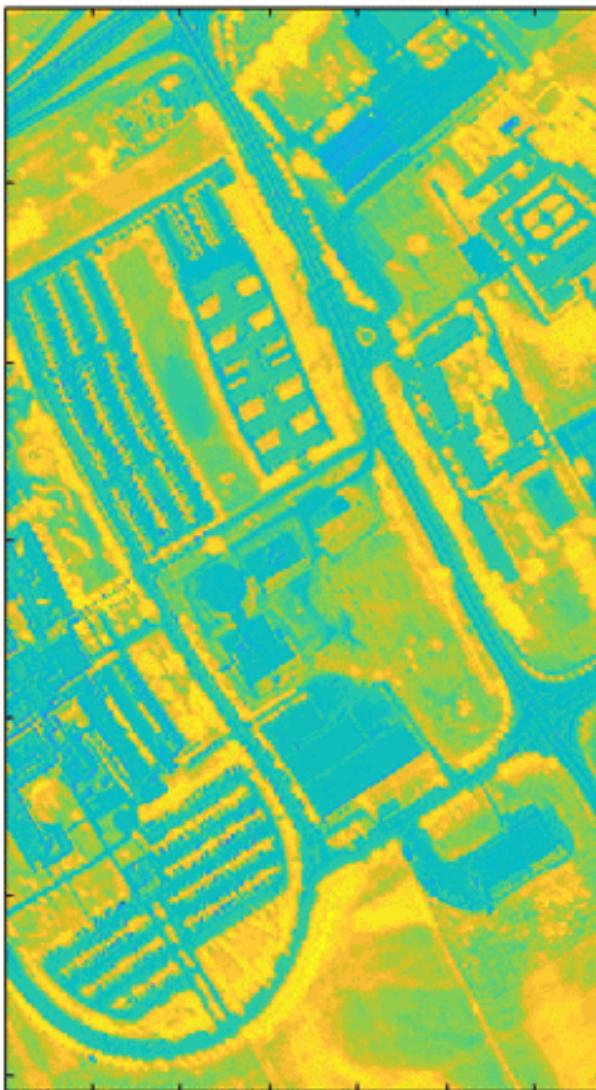
Remote Sensing Spectral Indices



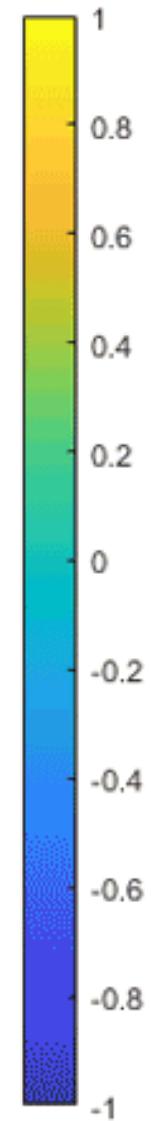
Remote Sensing Spectral Indices (NDVI)



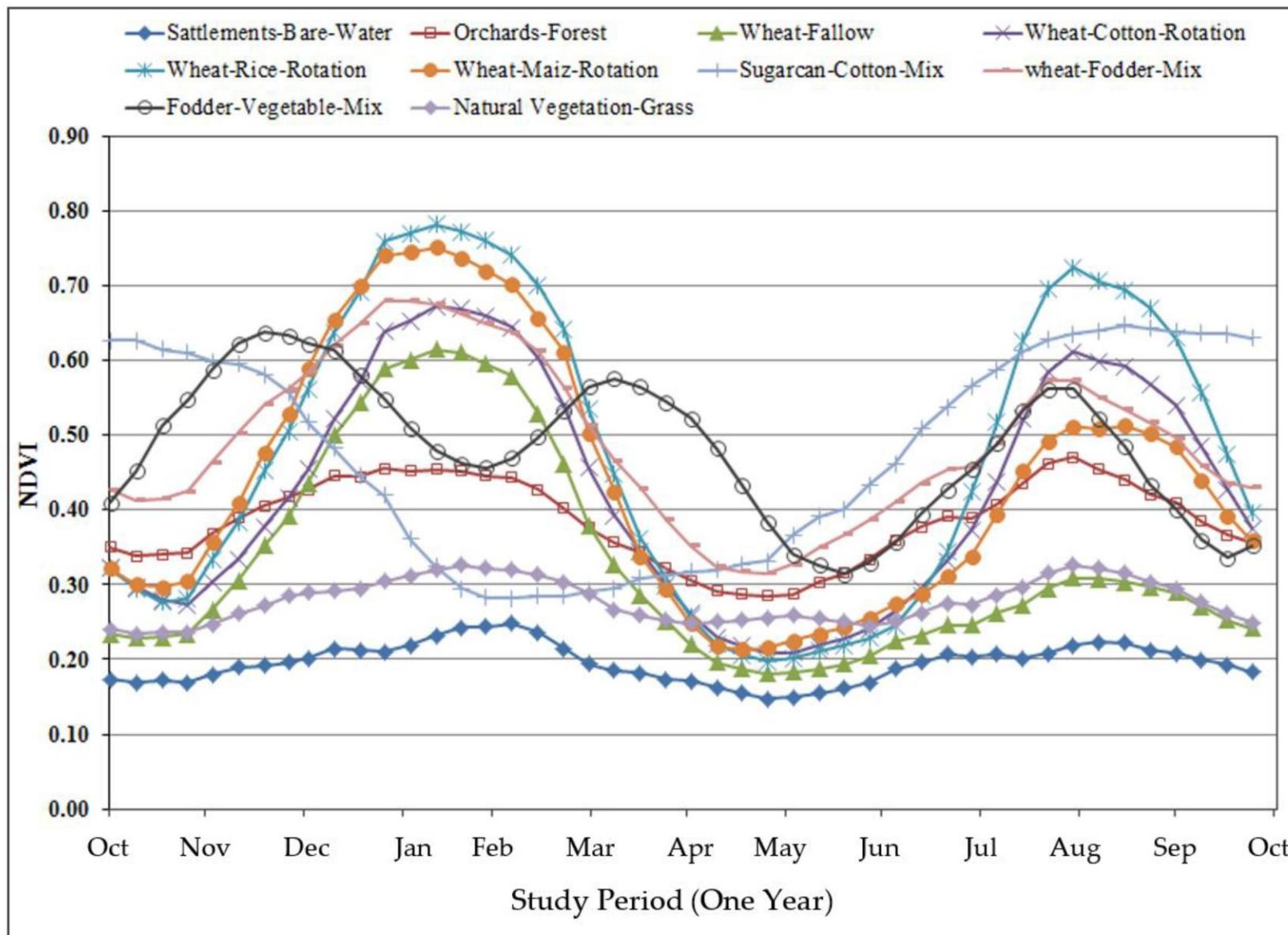
RGB Image



Spectral Index Map

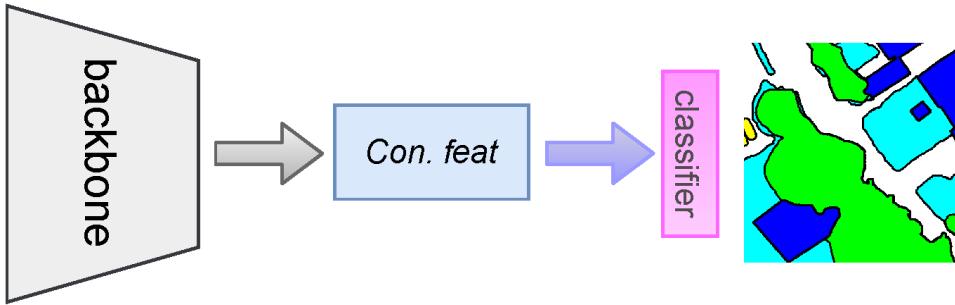


Time series NDVI profile crop mapping



Remote sensing Applications

Semantic segmentation



Fusion & quality enhancement

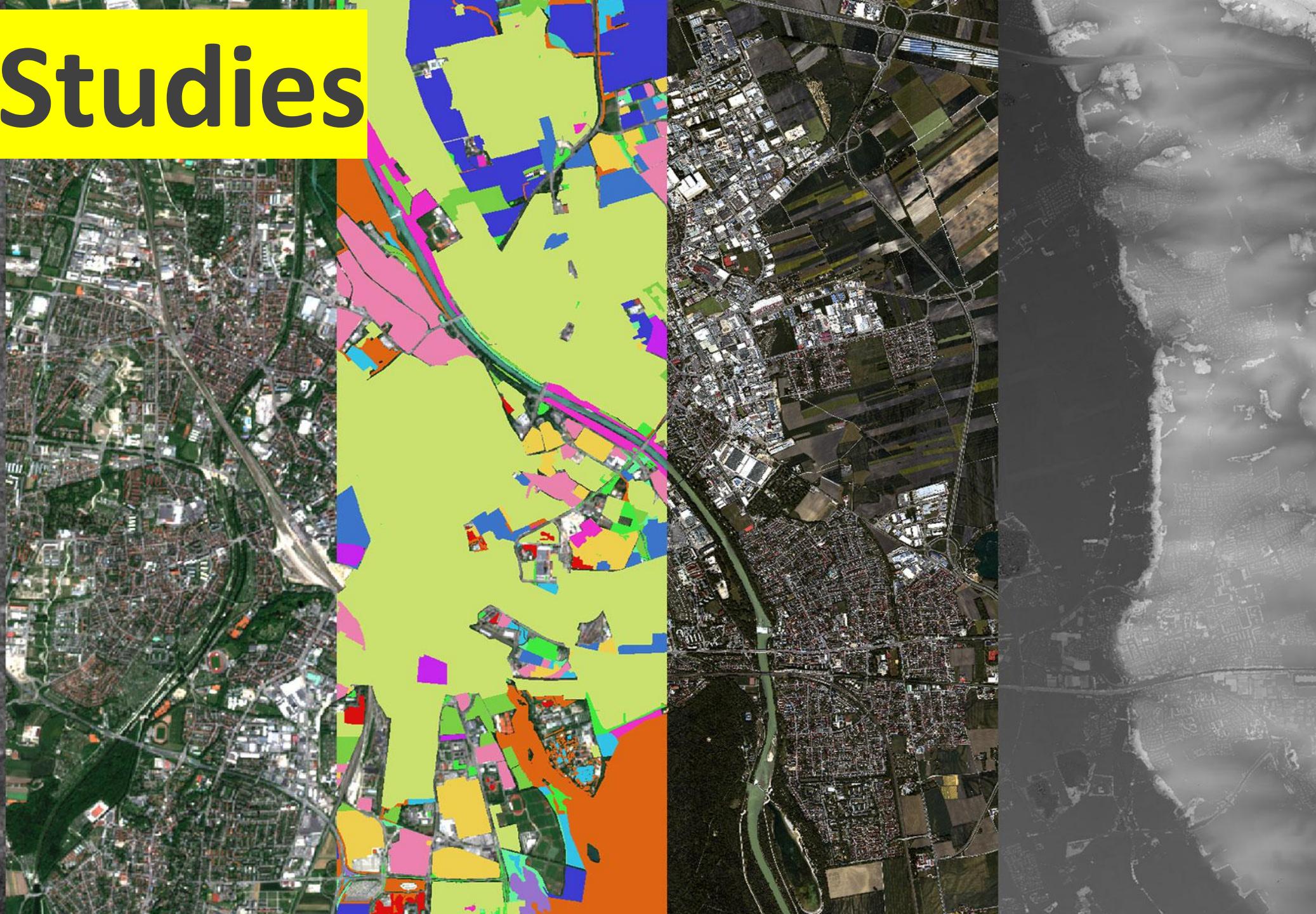


Image source: QuickBird. (C) DigitalGlobe

Object detection



Case Studies



Case Study 1: Urban Heat Island Effect

Scenario: A city is experiencing higher temperatures in urban areas compared to surrounding rural regions.

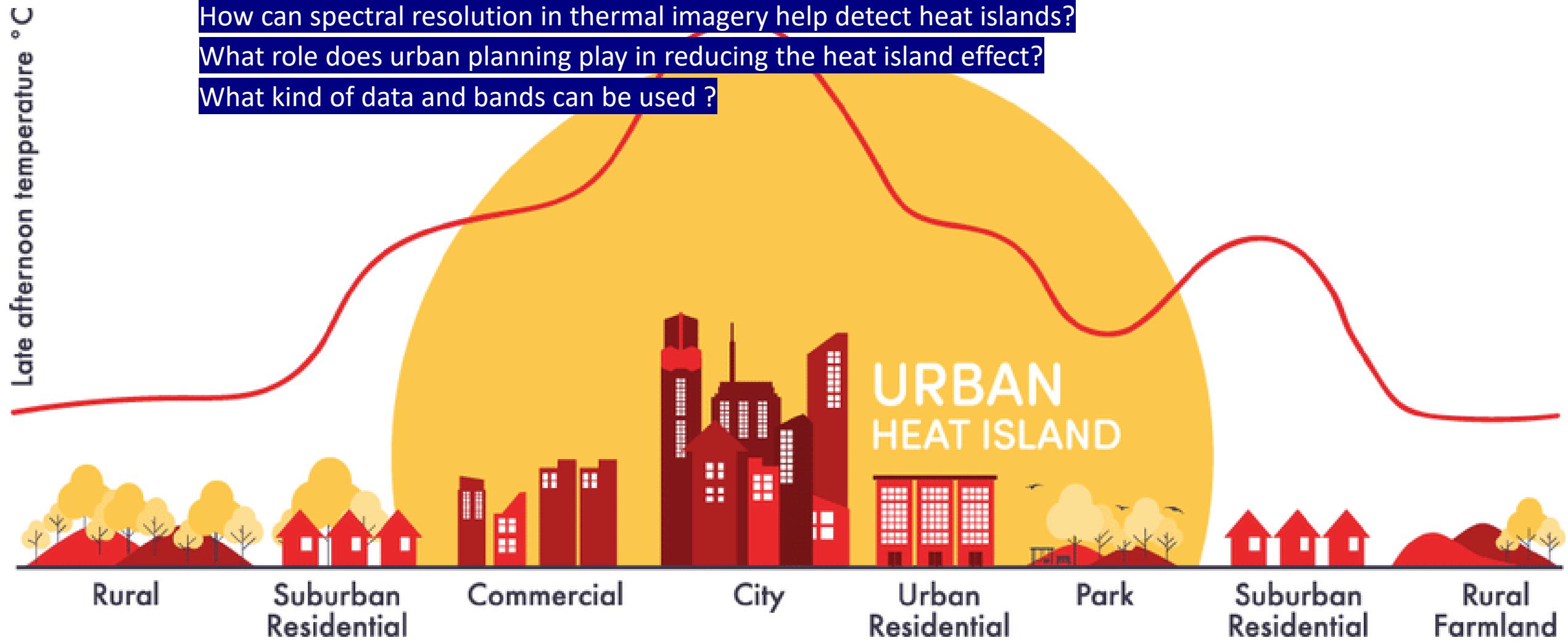
Task: Use **remote sensing** and **GIS** (land use data) to identify heat islands and propose mitigation strategies.

Discussion Points:

How can spectral resolution in thermal imagery help detect heat islands?

What role does urban planning play in reducing the heat island effect?

What kind of data and bands can be used ?



Fundamental Definitions & Data Structures

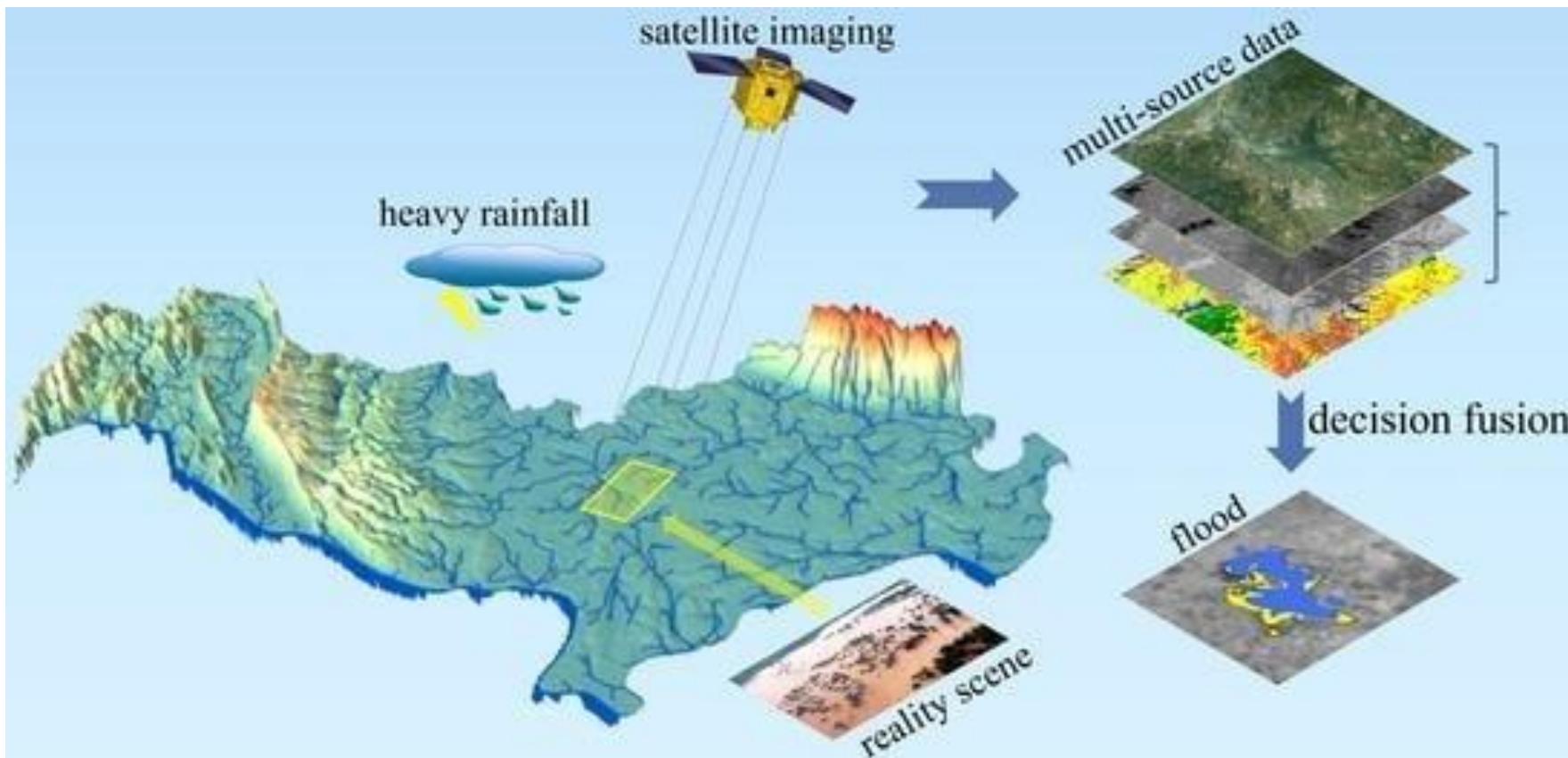
Case Study 2: Flood Risk Assessment

Scenario: A coastal city is at risk of flooding due to rising sea levels and heavy rainfall.

Task: Use **raster data** (DEMs) and **vector data** (land use, infrastructure) to map flood-prone areas and plan evacuation routes.

Discussion Points:

- How does spatial resolution of DEMs impact flood modeling accuracy?
- What additional data (e.g., weather data) would improve the analysis?



Case Study 3: Climate Change Impact Assessment

Scenario: A coastal region is experiencing rising sea levels and increased storm intensity.

Task: Use **weather data** (for historical climate trends) and **raster data** (DEMs for elevation) to assess the impact on coastal communities.

Discussion Points:

- How can time-series analysis of weather data help predict future climate impacts?
- What role does spatial resolution play in assessing vulnerability to sea-level rise?



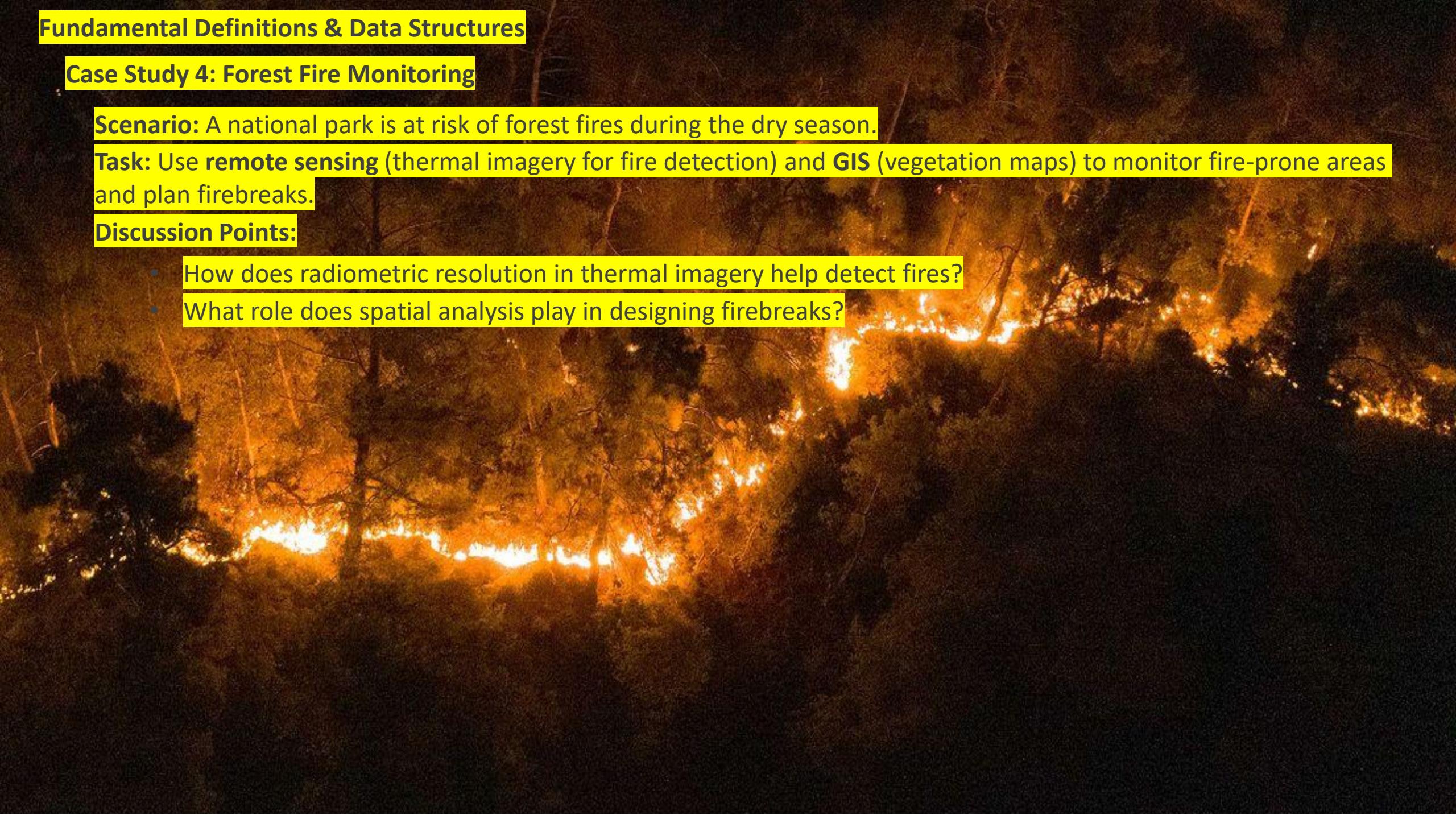
Case Study 4: Forest Fire Monitoring

Scenario: A national park is at risk of forest fires during the dry season.

Task: Use **remote sensing** (thermal imagery for fire detection) and **GIS** (vegetation maps) to monitor fire-prone areas and plan firebreaks.

Discussion Points:

- How does radiometric resolution in thermal imagery help detect fires?
- What role does spatial analysis play in designing firebreaks?



Case Study 5: Crop Mapping

Scenario: A regional agricultural department wants to map crop types across a large area to monitor farming practices and ensure food security.

Task: Use **multisource data** (satellite imagery, drone data, and field surveys) to classify crop types and create a detailed crop map.

Discussion Points:

- How can spectral resolution in satellite imagery help distinguish between different crop types?
- What challenges arise when integrating drone data with satellite imagery?
- How can field survey data improve the accuracy of crop classification?

Case Study 6: Crop Yield Estimation

Scenario: A farming cooperative wants to predict crop yields to optimize harvest planning and resource allocation.

Task: Use **satellite imagery** (NDVI for vegetation health) and **weather data** (precipitation, temperature) to estimate crop yields for different regions.

Discussion Points:

- How does temporal resolution in satellite imagery impact yield prediction accuracy?
- What role does weather data play in crop yield estimation?
- How can machine learning models enhance yield prediction?

Case Study 7: Forest Mapping

Scenario: A national park needs to monitor forest cover and detect illegal logging activities.

Task: Use **multisource data** (satellite imagery, LiDAR, and ground surveys) to map forest cover, identify deforestation hotspots, and monitor changes over time.

Discussion Points:

- How can LiDAR data improve forest canopy height mapping compared to satellite imagery?
- What challenges arise when integrating ground survey data with remote sensing data?
- How can time-series analysis help detect illegal logging activities?

Case Study 8: Urban, Roads, and Population Density Mapping

Scenario: A city planning department wants to map urban areas, road networks, and population density to improve infrastructure planning.

Task: Use **satellite imagery** (for urban extent), **vector data** (road networks), and **census data** (population statistics) to create integrated maps.

Discussion Points:

- How can spatial resolution in satellite imagery impact urban mapping accuracy?
- What role does attribute data play in population density mapping?
- How can road network data be used to optimize public transportation routes?

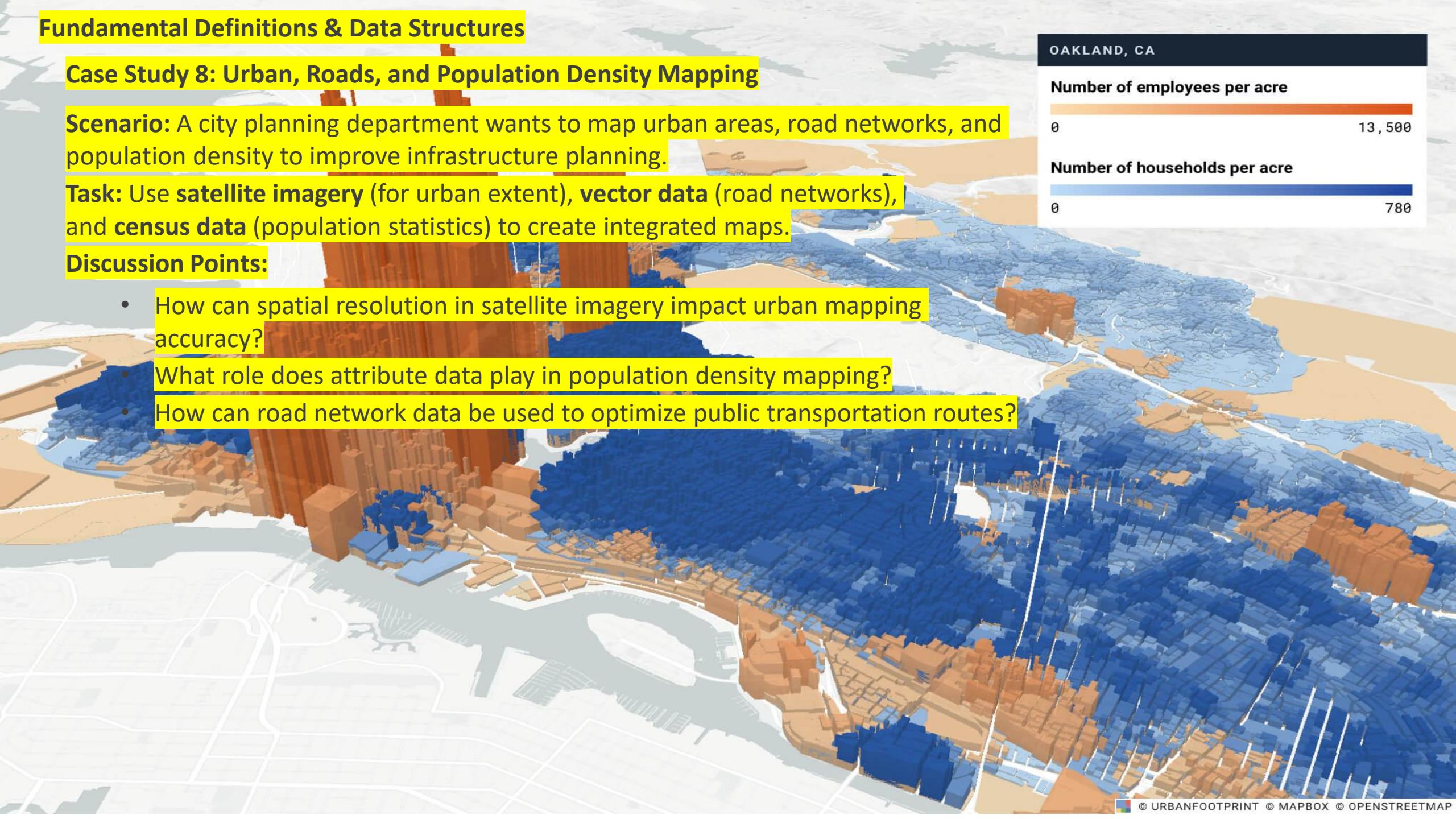
OAKLAND, CA

Number of employees per acre

0 13,500

Number of households per acre

0 780



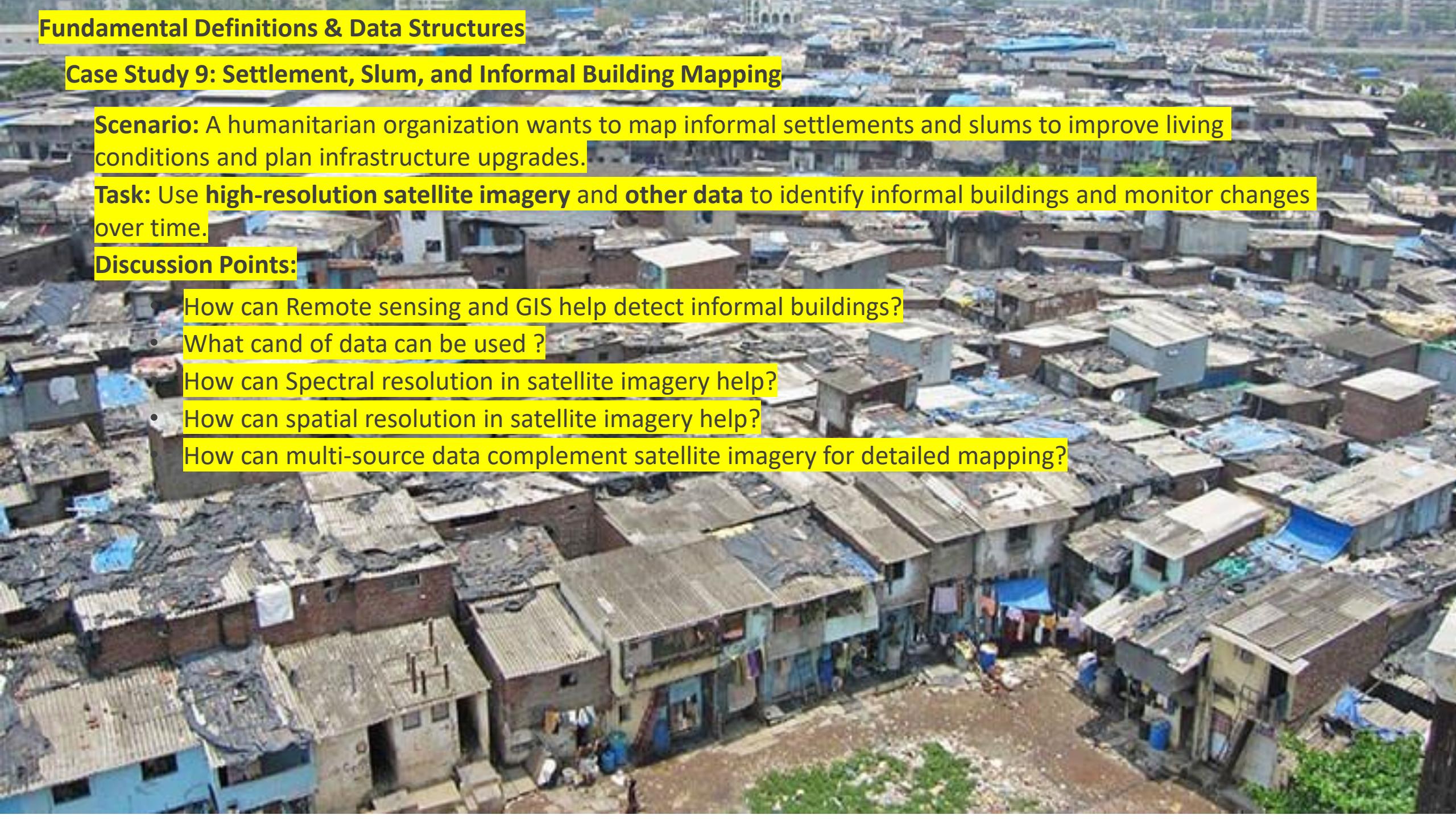
Case Study 9: Settlement, Slum, and Informal Building Mapping

Scenario: A humanitarian organization wants to map informal settlements and slums to improve living conditions and plan infrastructure upgrades.

Task: Use **high-resolution satellite imagery** and **other data** to identify informal buildings and monitor changes over time.

Discussion Points:

- How can Remote sensing and GIS help detect informal buildings?
- What kind of data can be used ?
- How can Spectral resolution in satellite imagery help?
- How can spatial resolution in satellite imagery help?
- How can multi-source data complement satellite imagery for detailed mapping?



Fundamental Definitions & Data Structures

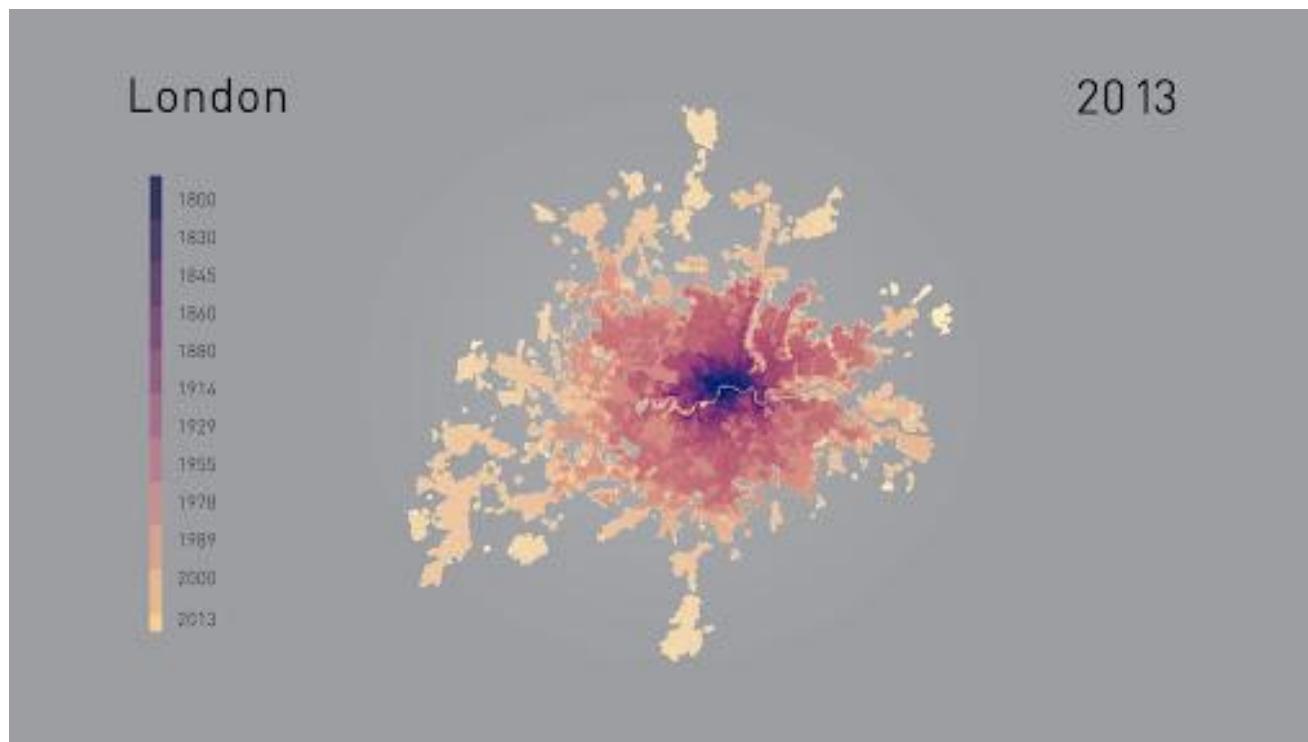
Case Study 10: Monitoring Informal Settlements Over Time

Scenario: A city is experiencing rapid urbanization, leading to the growth of informal settlements.

Task: Use **time-series satellite imagery** to monitor the expansion of informal settlements and assess the impact on surrounding areas.

Discussion Points:

- How can temporal resolution in satellite imagery help track settlement growth?
- What challenges arise when analyzing informal settlements in densely populated areas?
- How can this data inform urban planning and policy decisions?



Case Study 11: Water Body Extraction

- **Scenario:** A water resource management agency wants to map water bodies (rivers, lakes, reservoirs) in a region to monitor water availability.
- **Task:** Use **satellite imagery** to extract water bodies and assess their spatial extent.
- **Discussion Points:**
 - How does spectral resolution help distinguish water bodies from other features?
 - What challenges arise when mapping small or seasonal water bodies?
 - How can this data be used for **drought monitoring**?



Fundamental Definitions & Data Structures

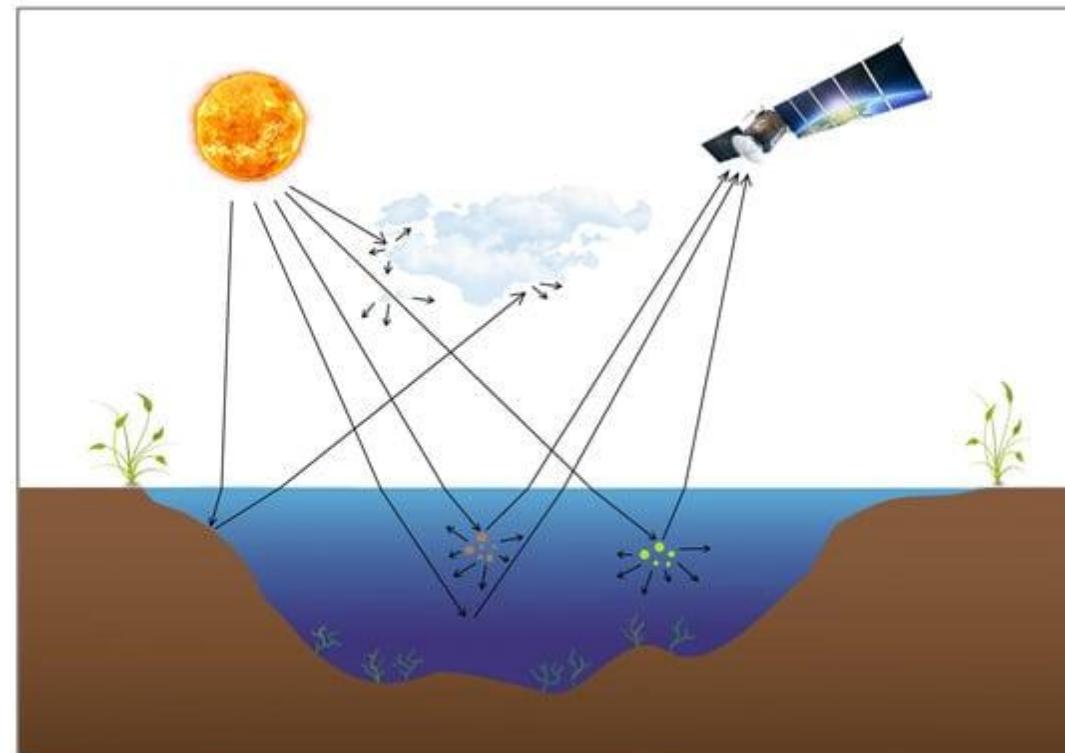
Case Study 12: Water Level Detection

Scenario: A dam management authority wants to monitor water levels in reservoirs to ensure efficient water allocation.

Task: Use **satellite imagery** (radar or optical) and **DEMs** to detect changes in water levels over time.

Discussion Points:

- How can radar imagery improve water level detection compared to optical imagery?
- What role do DEMs play in estimating water volume?
- How can this data be used for flood forecasting?



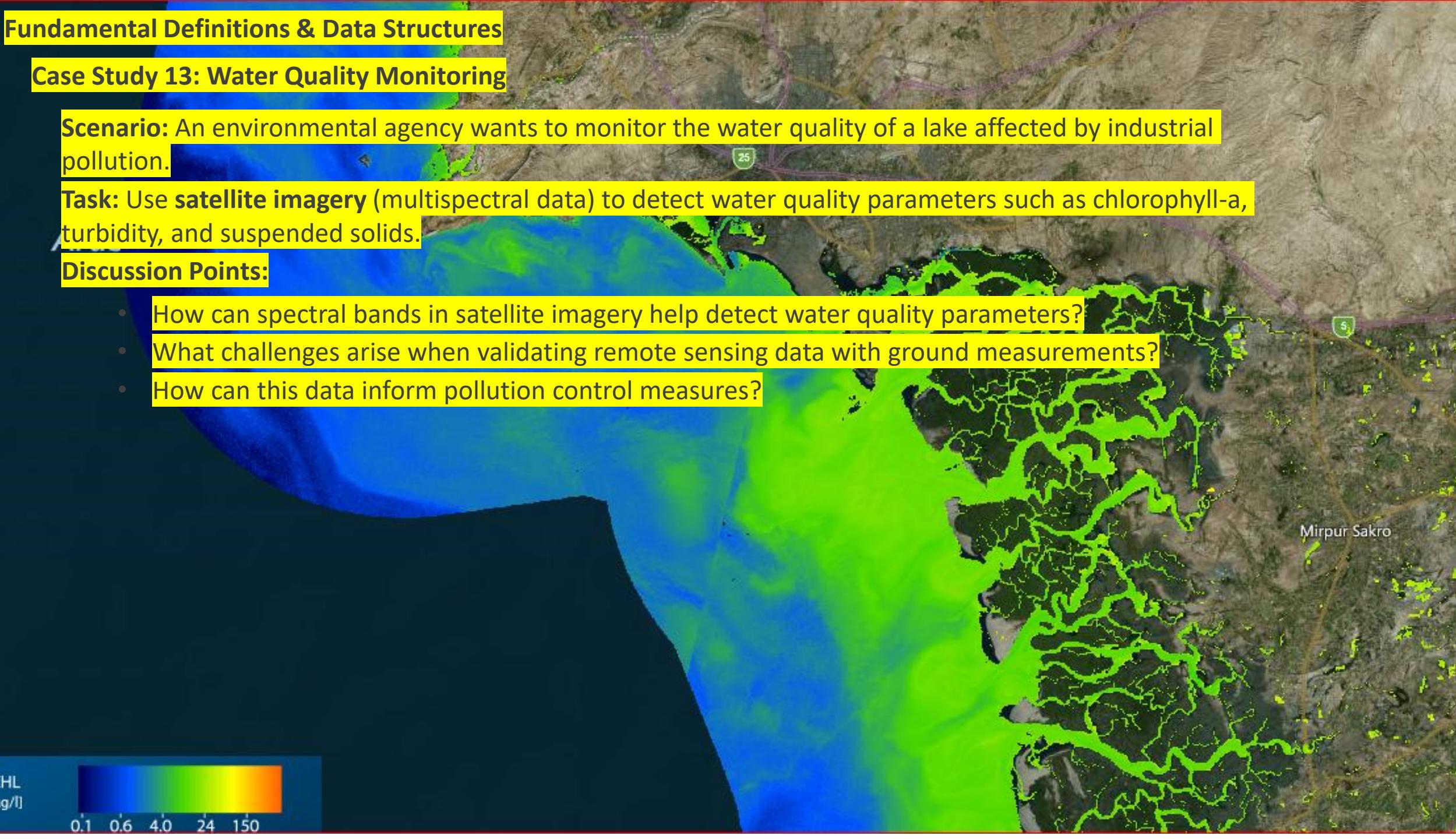
Case Study 13: Water Quality Monitoring

Scenario: An environmental agency wants to monitor the water quality of a lake affected by industrial pollution.

Task: Use **satellite imagery** (multispectral data) to detect water quality parameters such as chlorophyll-a, turbidity, and suspended solids.

Discussion Points:

- How can spectral bands in satellite imagery help detect water quality parameters?
- What challenges arise when validating remote sensing data with ground measurements?
- How can this data inform pollution control measures?



Thank you !