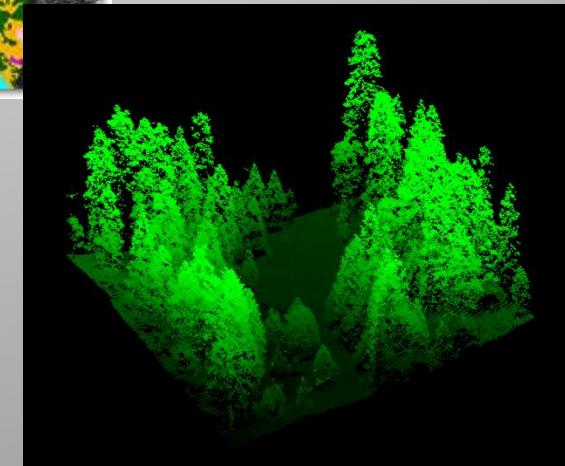
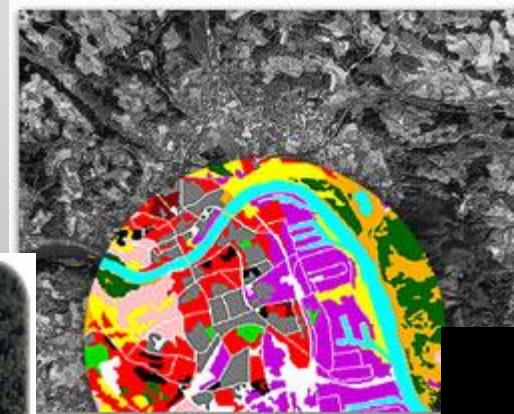
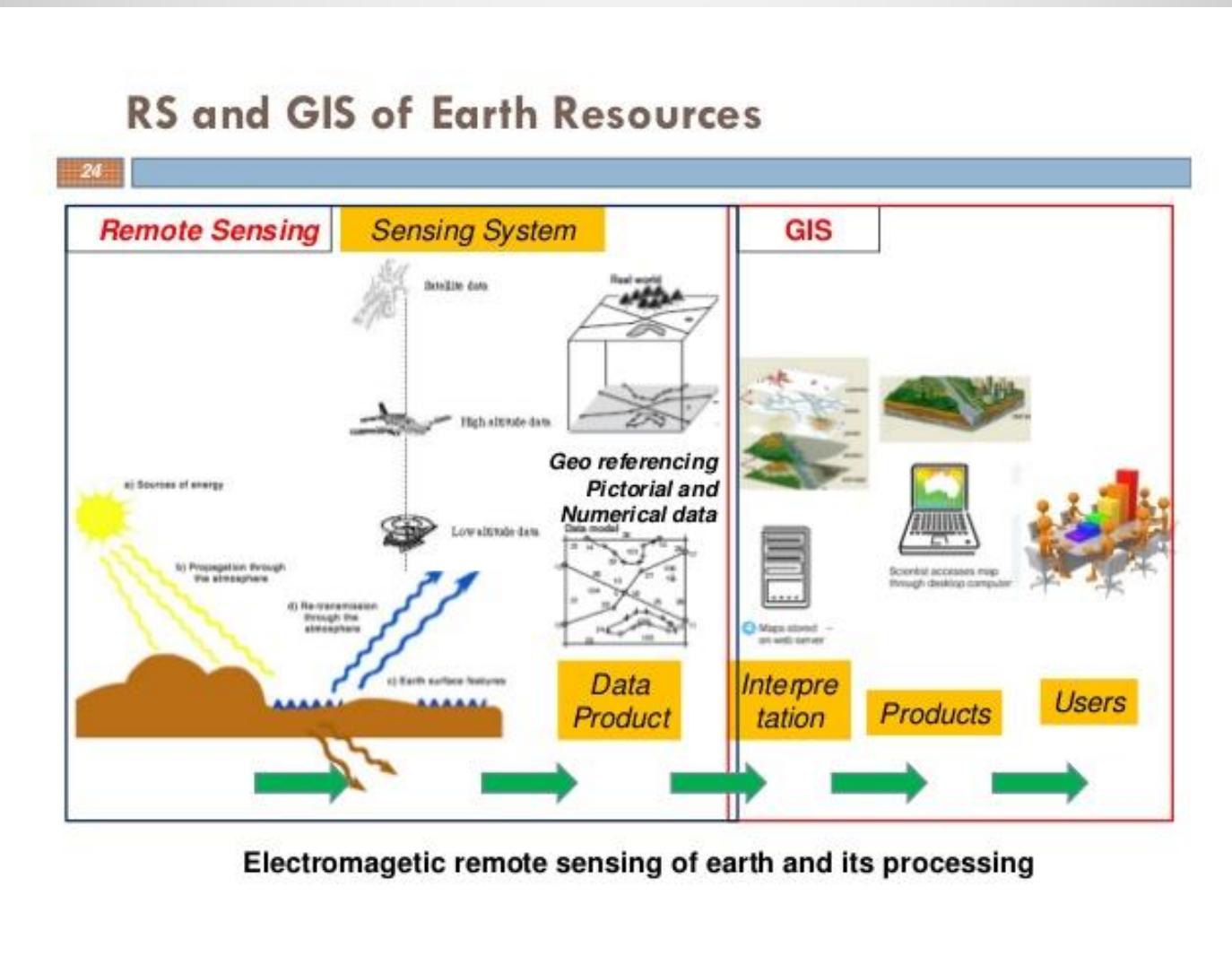


# Remote sensing - Data - Capture - Image analysis & Products

Bjarne Fog  
Geography section 1, IGN



# Remote Sensing and Geographical Information System

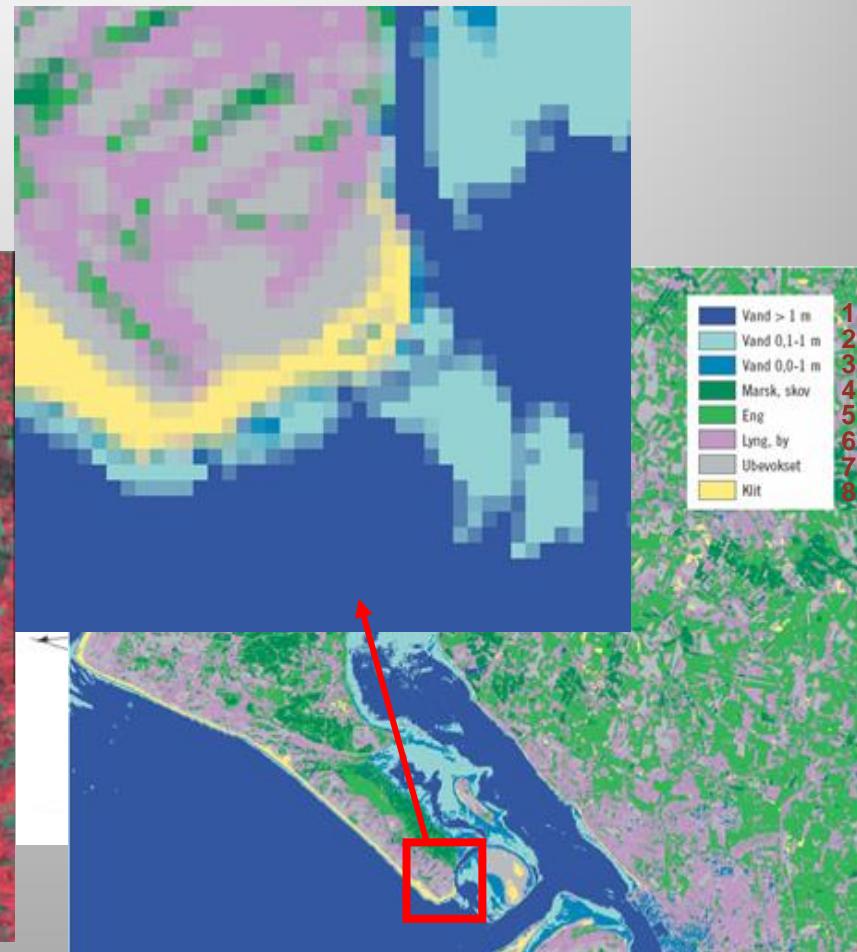


# The overview of this double lecture

- Remote sensing data from passive sensors
  - Satellite images (optical)
  - Aerial photos and Orthophotos
- Remote sensing data from active sensors
  - LiDAR data (point clouds)



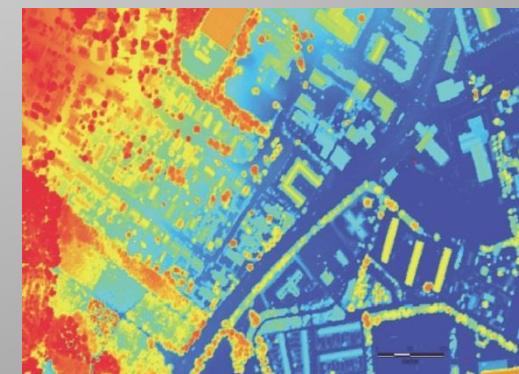
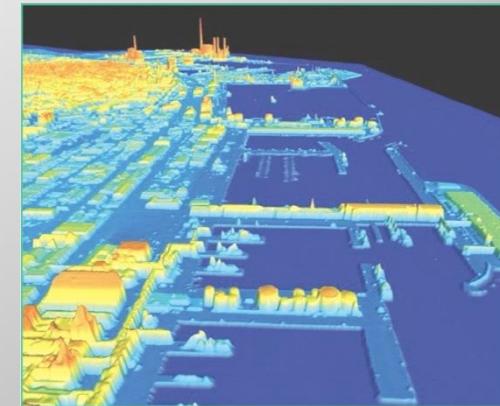
Data from passive sensors on a satellite is used to analyze the Earth's surface, - classification – thematic maps.



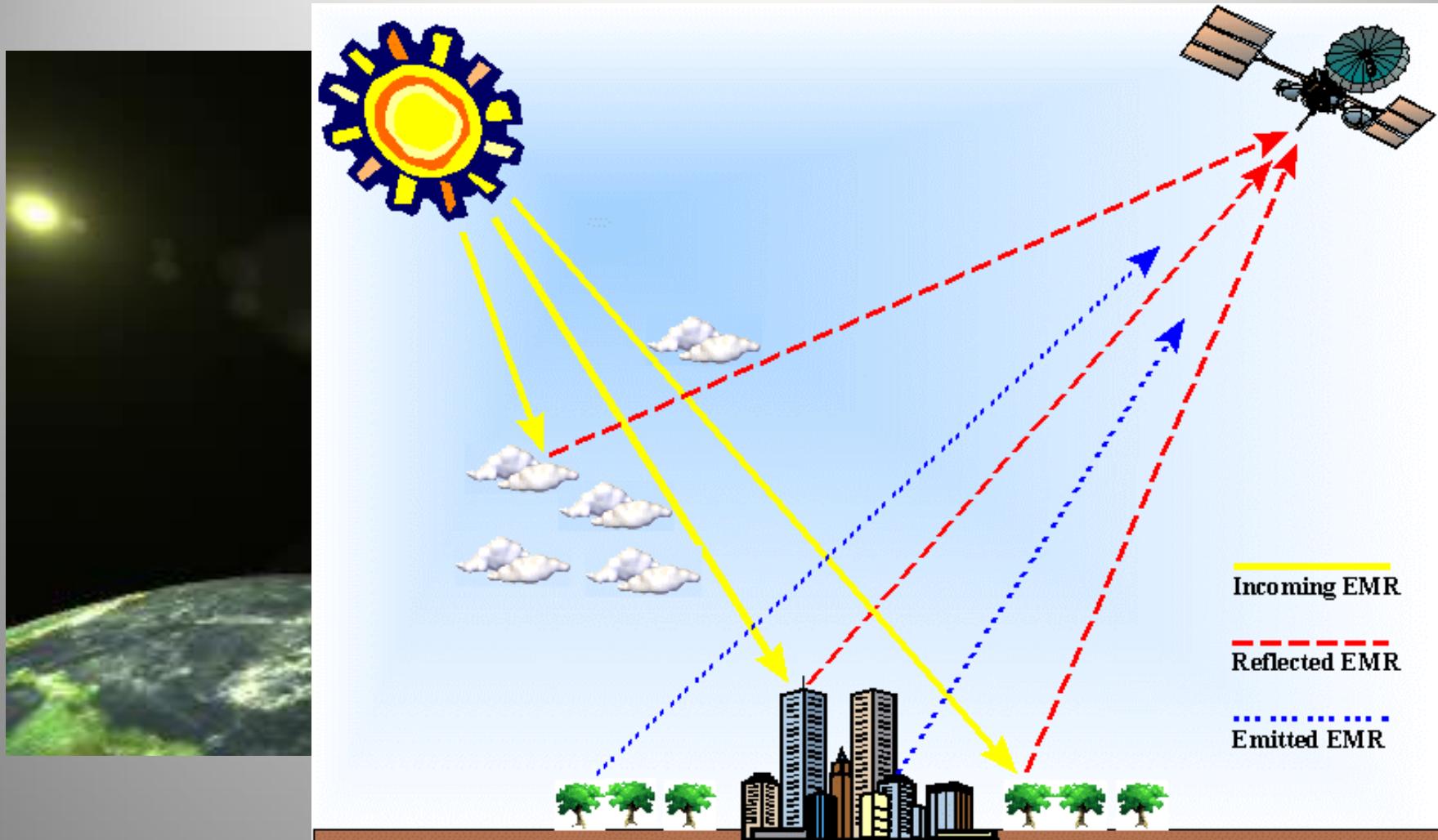
Data from Aerial photo/Orthophoto is used for topographic mapping or the extraction of objects on the ground surface.



Data from the active LiDAR sensor generate a point cloud ie. used for the production of DTM, DEM, DSM  
LiDAR = "Light Detection And Ranging"



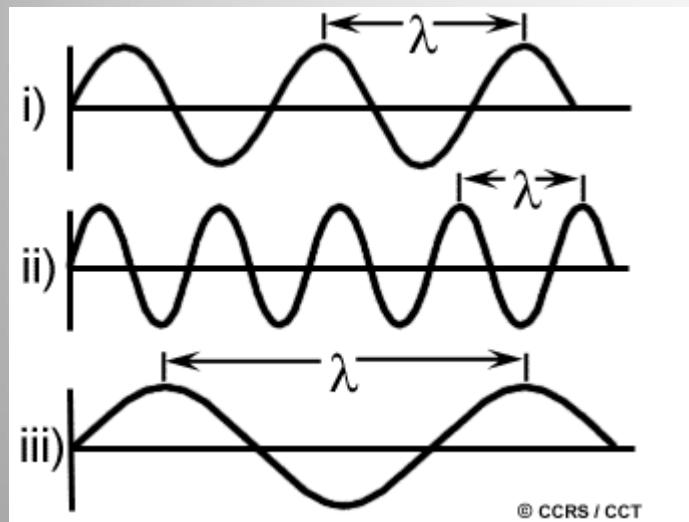
# What does a satellite sensor measure?



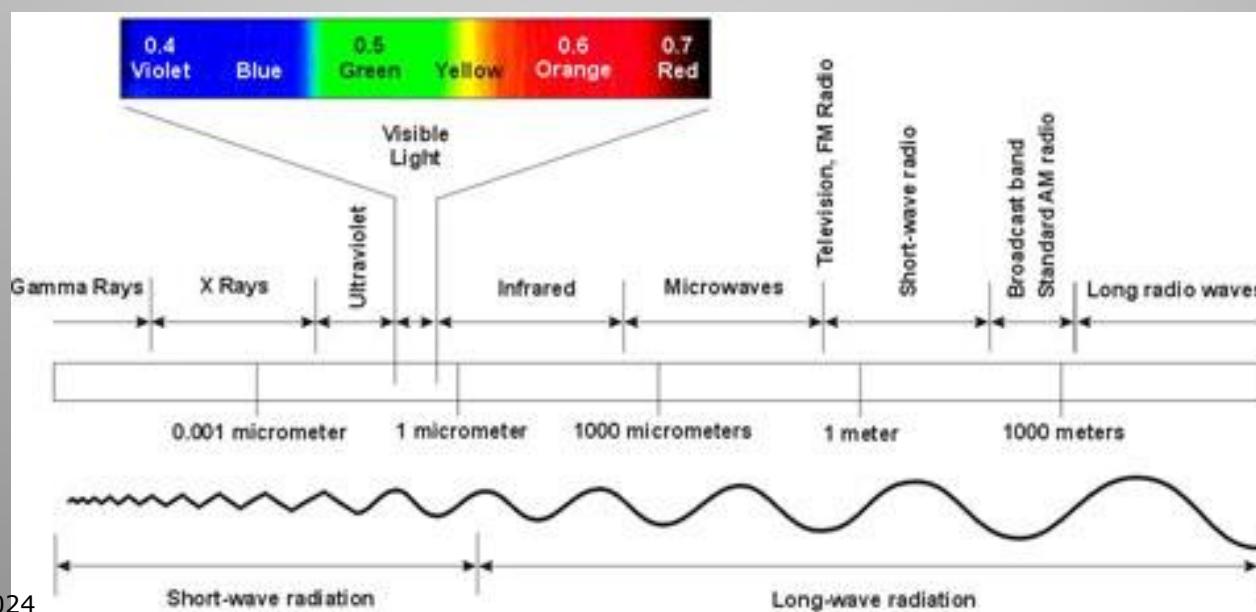
## Electromagnetic radiation



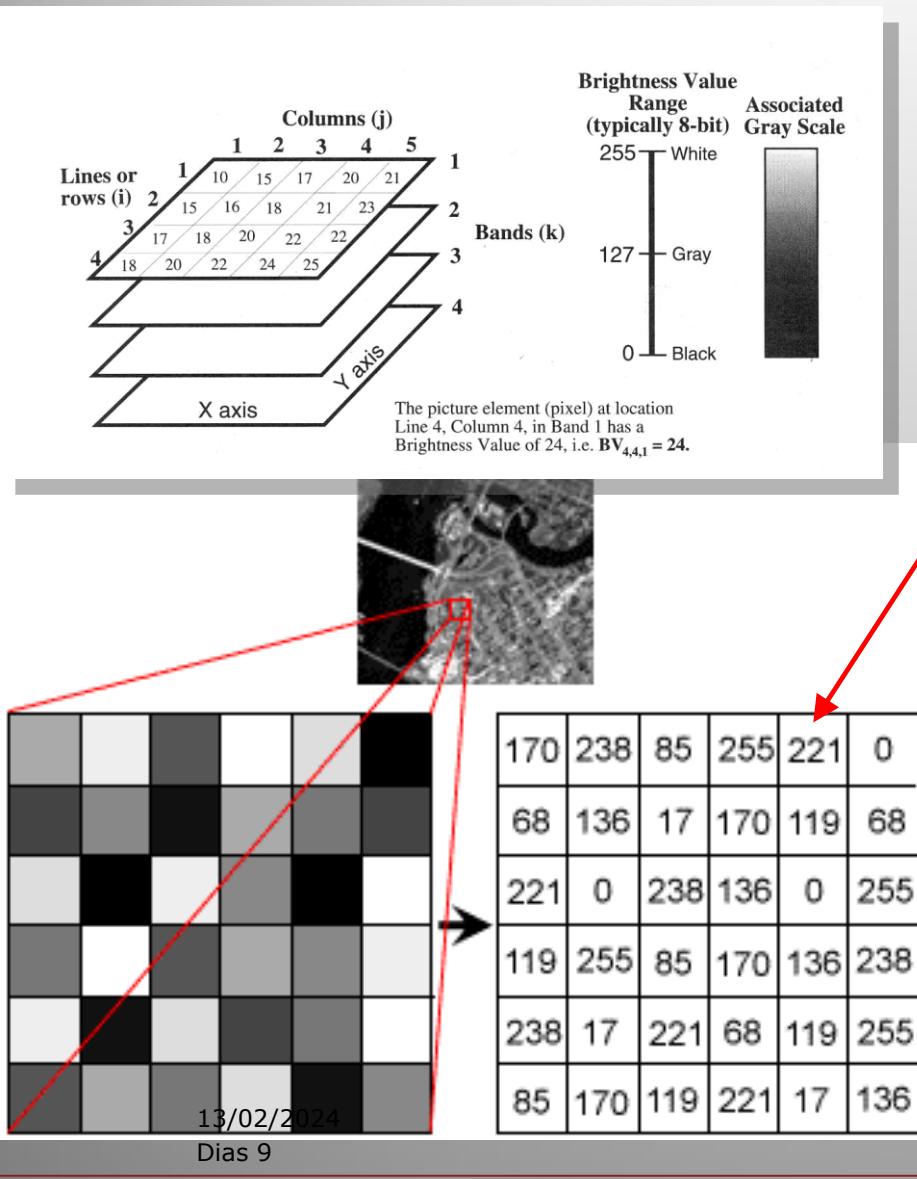
# Electromagnetic radiation and the significance of wavelength



Visible light – 380 to 700 nanometers



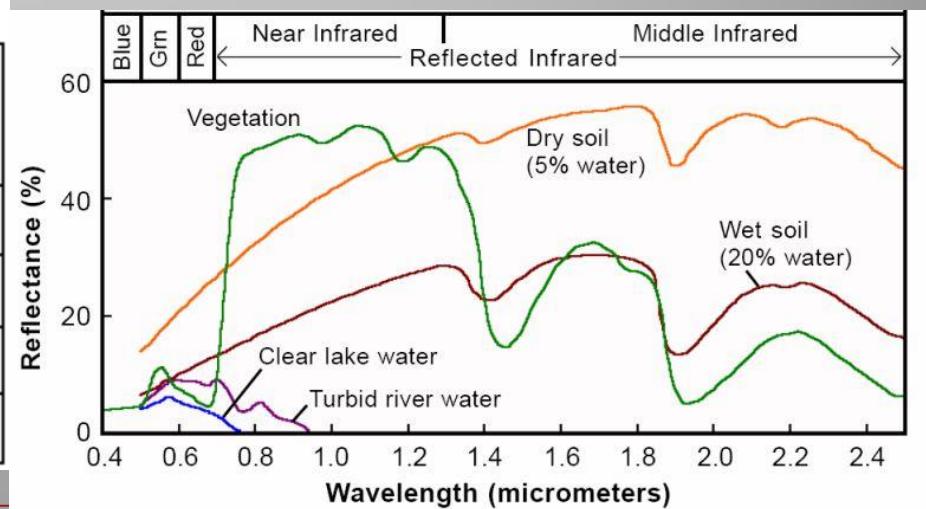
# Satellite image characteristics



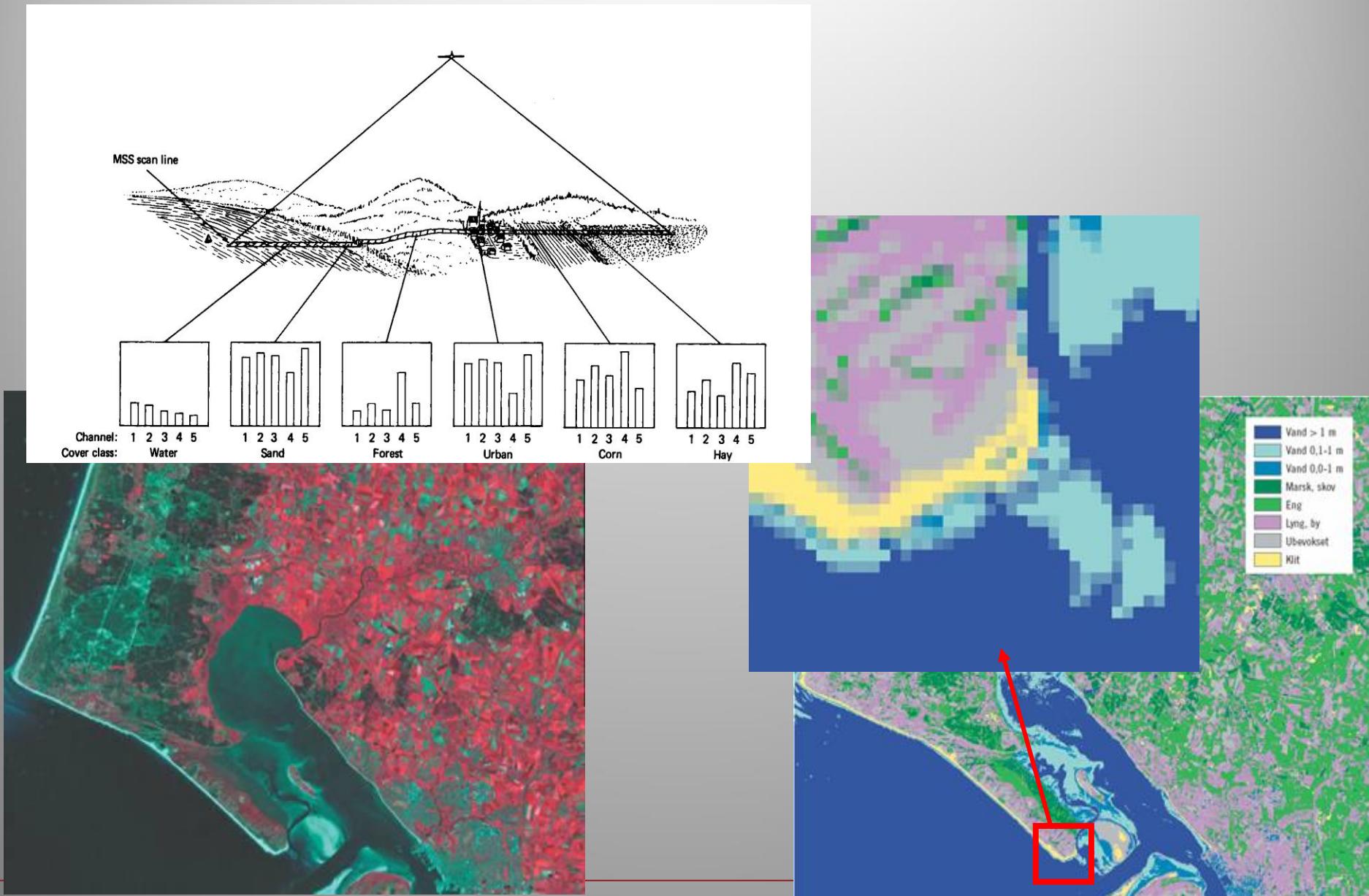
Every cell has a numeric value (0 – 255) this value is then converted into a colour (black – white) representing the size of the value

Like a digital camera, just more bands

Spectral reflection from objects (surface) depends on wavelength (image bands)



# From satellite image to landuse/landcover map



# From satellite image to landcover/landuse map

## Supervised classification

In a supervised classification the user need to select training areas, where the cover is known.

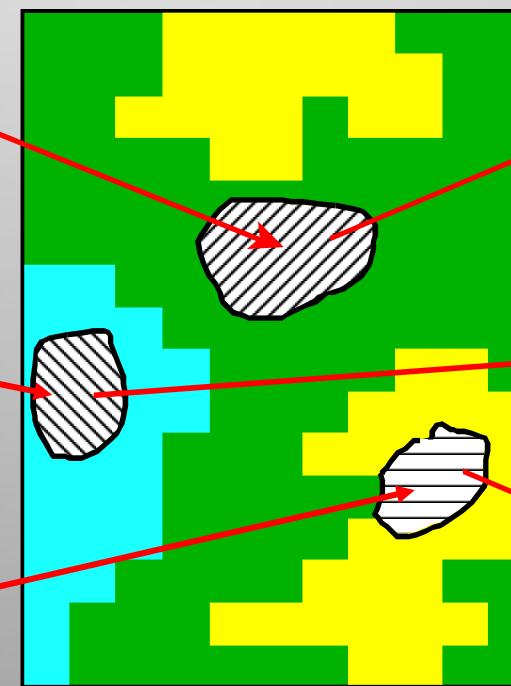
Computeren calculate then...

Avg. spectral signature

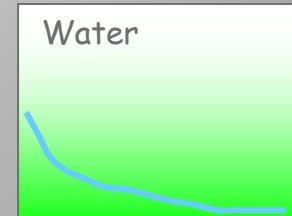
Known coniferous forest area

Known water area

Known Deciduous forest area



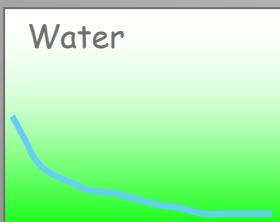
Multispectral satellite image



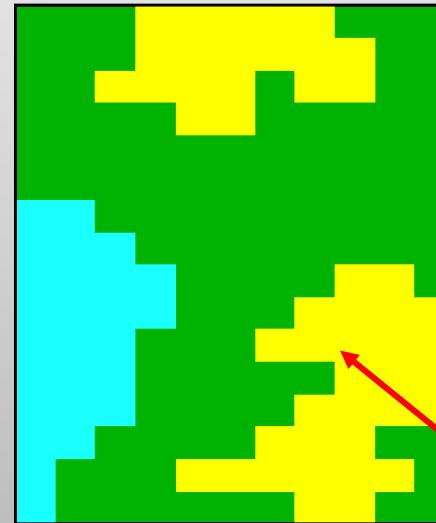
# From satellite image to landcover/landuse map

## Supervised classification

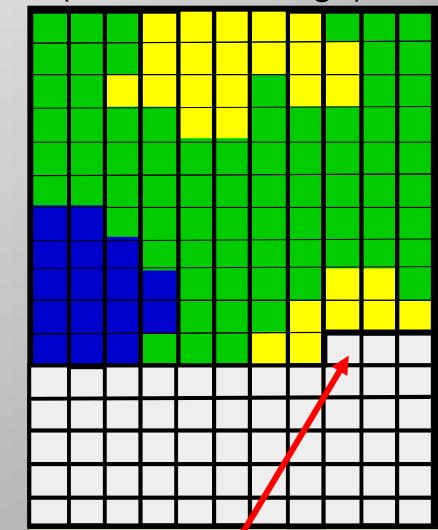
Avg. spectral  
signature



Multispectral satellite image



Information  
(Classified image)

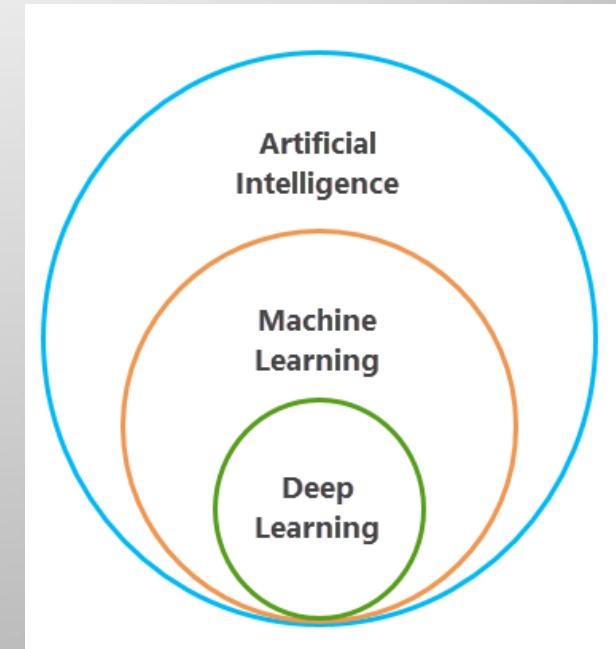


Spectral signature  
of the next Pixel  
to be classified



# AI – Machine Learning – Deep Learning

Esri has developed tools that allow you to perform image classification, object detection, semantic segmentation, and instance segmentation.



# Methods

Image classification

Object detection

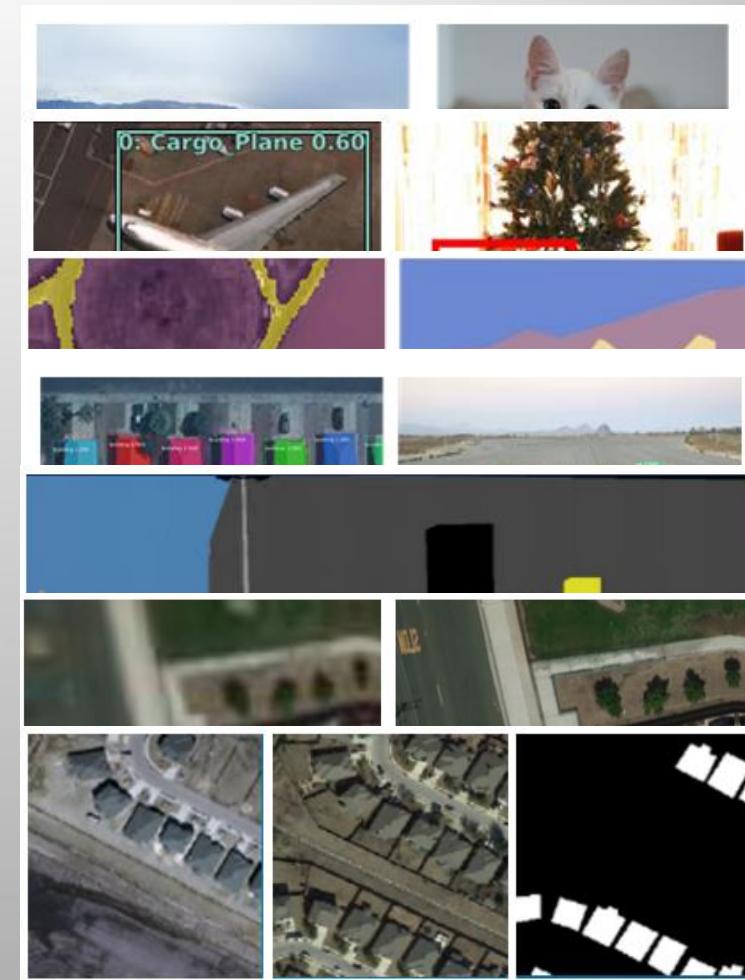
Semantic segmentation

Instance segmentation

Panoptic segmentation

Image translation

Change detection



# Satellite images – different characteristics –different applications

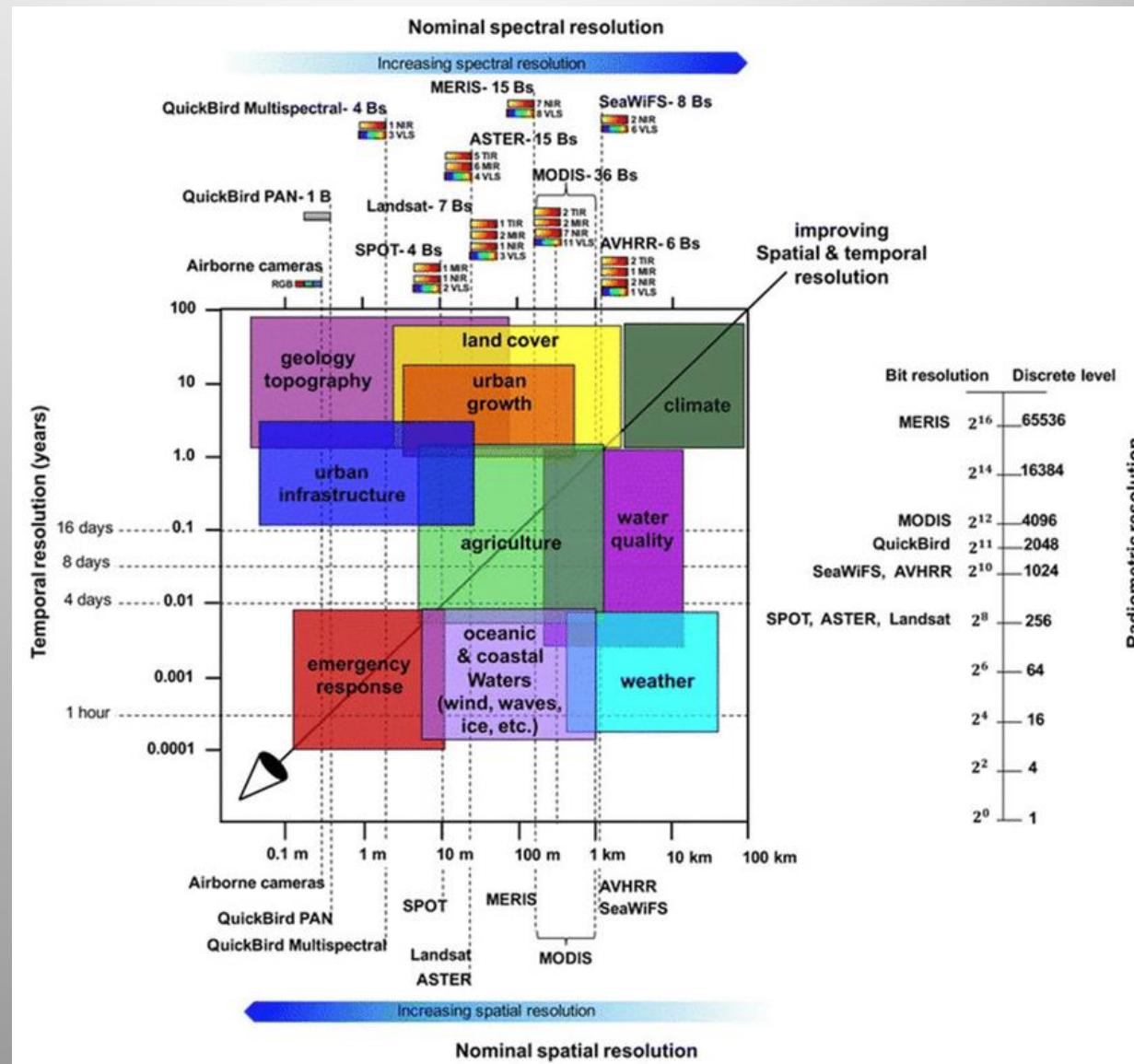
Temporal resolution

Spectral resolution

Spatial resolution

Radiometric resolution

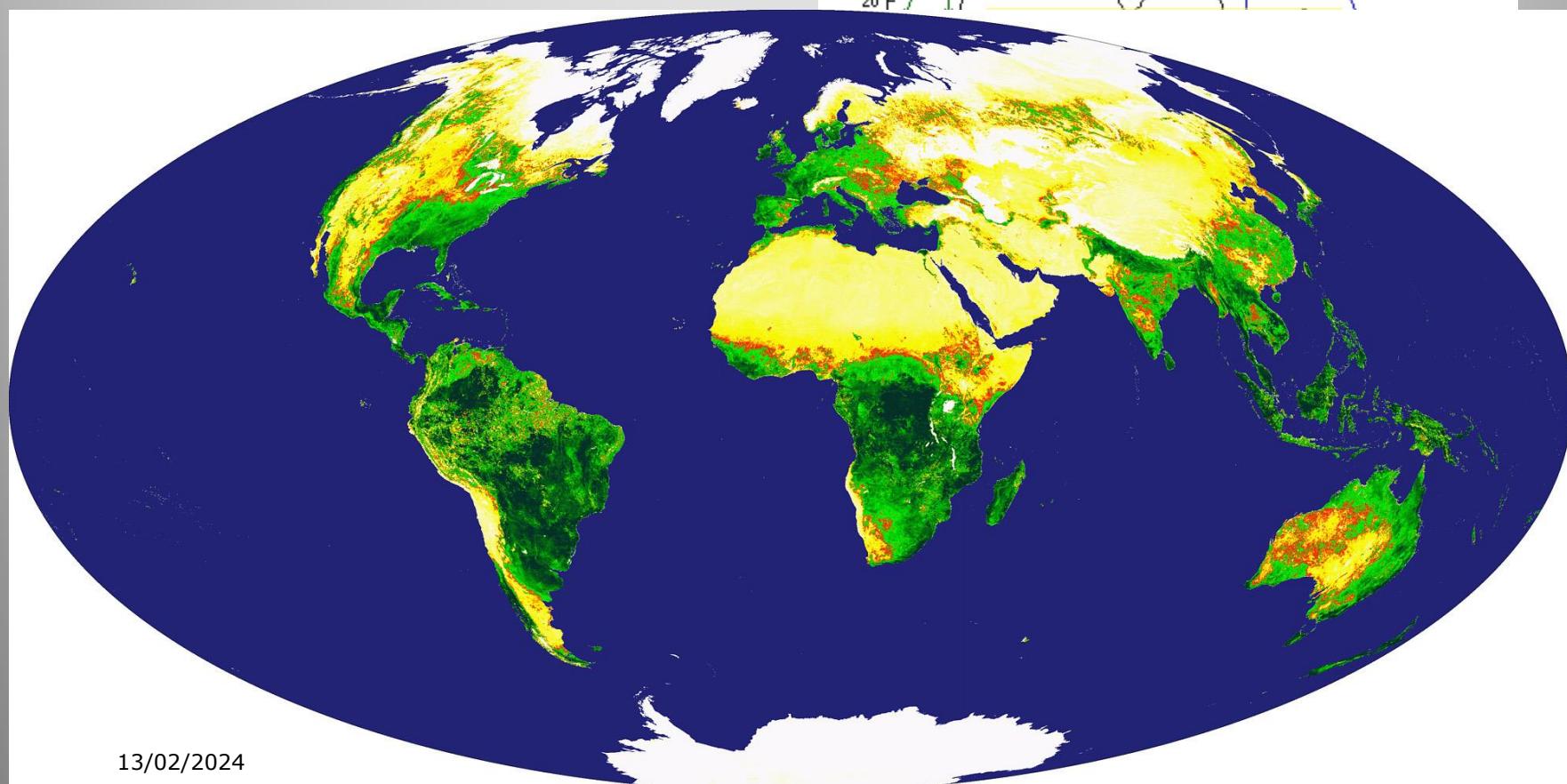
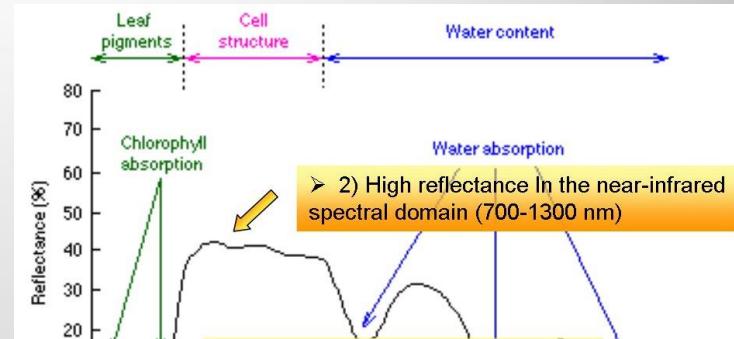
Leads to different applications



## Vegetation index - NDVI

Typical spectral response  
for vegetation covered surface

$$\text{NDVI} = (\text{NIR} - \text{Red}) / (\text{NIR} + \text{Red})$$



# Image Classification & Object Based Image Analysis (OBIA)



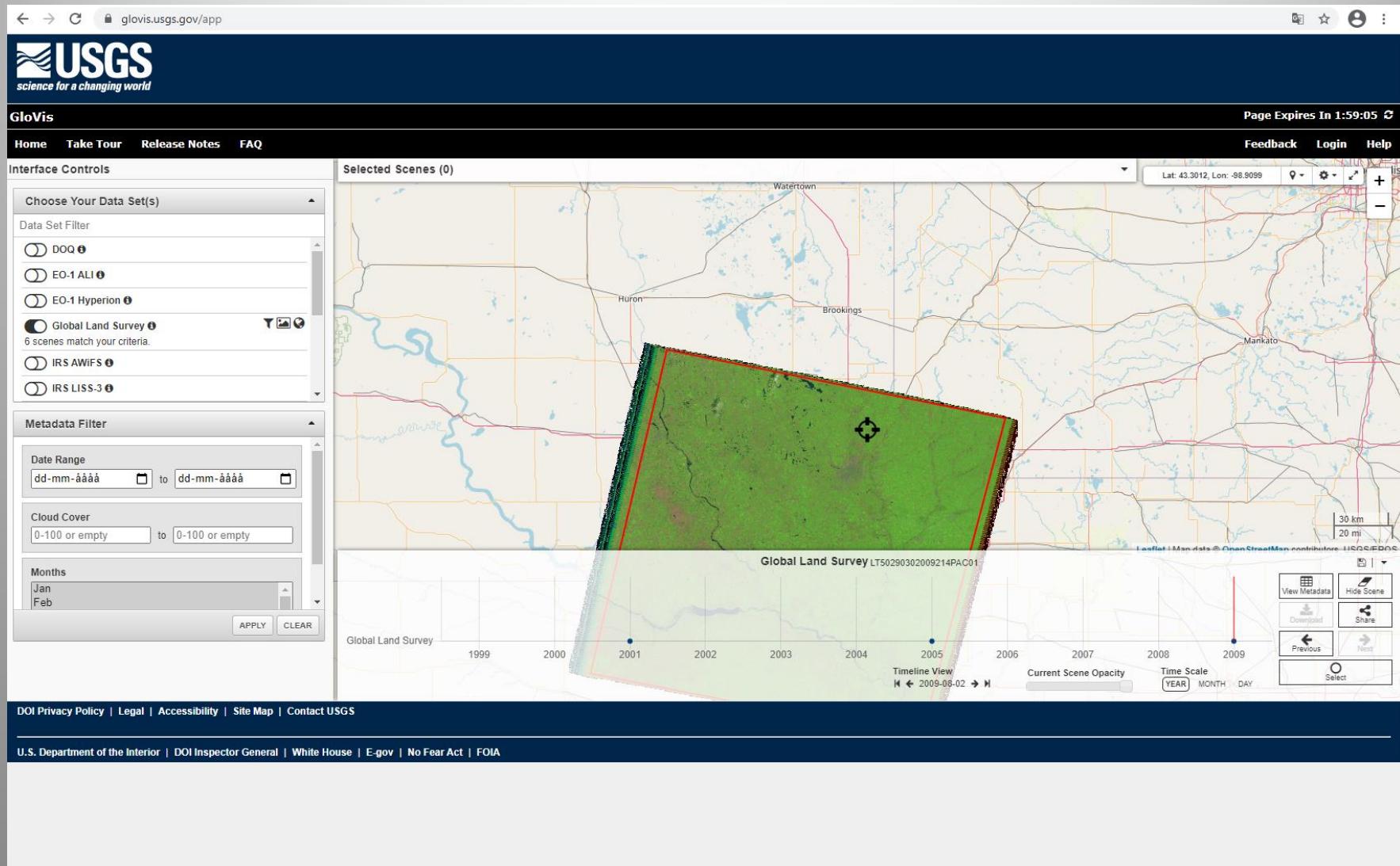
13/02/2024

Source: <http://usda-ars.nmsu.edu/PDF%20files/laliberteAerialPhotos.pdf>

Dias 19



# Data archives - <http://glovis.usgs.gov/>



# Copernicus archives - <https://scihub.copernicus.eu>

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esa copernicus

Insert search criteria...

Display 1 to 25 of 398 products. Order By: Ingestion Date ▾ 0 products selected

Request Done: ( footprint:"Intersects(POLYGON((8.876953124999991 52.722985524570674, 18.2812500000000004 52.722985524570674, 28.187695312499991 57.44494943583982, 8.876953124999991 57.44494943583982, 8.876953124999991 52.722985524570674))") )"

S2A MSI S2A\_MSIL2A\_20190216T102111\_N0211\_R065\_T33VUU\_20190216T130428

Download URL: <https://scihub.copernicus.eu/dhusodata/v1/Products/335eda08-81ef-4d44-808b-e1cc40a3a835>?Sval Mission: Sentinel-2 Instrument: MSI Sensing Date: 2019-02-16T10:21:11.024Z Size: 1.08 GB

S2A MSI S2A\_MSIL2A\_20190216T102111\_N0211\_R065\_T33VWC\_20190216T130428

Download URL: <https://scihub.copernicus.eu/dhusodata/v1/Products/744d7003-b323-4b05-b487-c8d303ca7f76>?Sve Mission: Sentinel-2 Instrument: MSI Sensing Date: 2019-02-16T10:21:11.024Z Size: 942.14 MB

S2A MSI S2A\_MSIL2A\_20190216T102111\_N0211\_R065\_T33UWA\_20190216T130428

Download URL: <https://scihub.copernicus.eu/dhusodata/v1/Products/164fe533-bb30-46cd-be50-f24076bb0a89>?Sve Mission: Sentinel-2 Instrument: MSI Sensing Date: 2019-02-16T10:21:11.024Z Size: 292.55 MB

S2A MSI S2A\_MSIL2A\_20190216T102111\_N0211\_R065\_T33VWD\_20190216T130428

Download URL: <https://scihub.copernicus.eu/dhusodata/v1/Products/59ff79-5c5b-41ee-9e42-0635539a7bc9>?Sval Mission: Sentinel-2 Instrument: MSI Sensing Date: 2019-02-16T10:21:11.024Z Size: 1.07 GB

S2A MSI S2A\_MSIL2A\_20190216T102111\_N0211\_R065\_T32UQD\_20190216T130428

Download URL: <https://scihub.copernicus.eu/dhusodata/v1/Products/c6e519-9765-4224-821a-de6f4fafe57>?Sval Mission: Sentinel-2 Instrument: MSI Sensing Date: 2019-02-16T10:21:11.024Z Size: 1.08 GB

S2A MSI S2A\_MSIL2A\_20190216T102111\_N0211\_R065\_T32UQE\_20190216T130428

Download URL: <https://scihub.copernicus.eu/dhusodata/v1/Products/59021475-ab2c-4b65-b336-e02f0fc14fc1>?Sva Mission: Sentinel-2 Instrument: MSI Sensing Date: 2019-02-16T10:21:11.024Z Size: 1.06 GB

S2A MSI S2A\_MSIL2A\_20190216T102111\_N0211\_R065\_T33UVL\_20190216T130428

Download URL: <https://scihub.copernicus.eu/dhusodata/v1/Products/7441b400-9b7a-4cbf-87b4-243ddcb8f4eb>?Sval Mission: Sentinel-2 Instrument: MSI Sensing Date: 2019-02-16T10:21:11.024Z Size: 1004.95 MB

S2A MSI S2A\_MSIL2A\_20190216T102111\_N0211\_R065\_T33UVE\_20190216T130428

Download URL: <https://scihub.copernicus.eu/dhusodata/v1/Products/53ddccac-21d1-4e15-85a7-155f9204867>?Sval Mission: Sentinel-2 Instrument: MSI Sensing Date: 2019-02-16T10:21:11.024Z Size: 1.07 GB

S2A MSI S2A\_MSIL2A\_20190216T102111\_N0211\_R065\_T33UVB\_20190216T130428

Download URL: <https://scihub.copernicus.eu/dhusodata/v1/Products/9d7e4f04-f95c-4220-86b9-b19a3fbedaa3>?Sval Mission: Sentinel-2 Instrument: MSI Sensing Date: 2019-02-16T10:21:11.024Z Size: 851.71 MB

S2A MSI S2A\_MSIL2A\_20190216T102111\_N0211\_R065\_T33UUA\_20190216T130428

Download URL: <https://scihub.copernicus.eu/dhusodata/v1/Products/9d7e4f04-f95c-4220-86b9-b19a3fbedaa3>?Sval Mission: Sentinel-2 Instrument: MSI Sensing Date: 2019-02-16T10:21:11.024Z Size: 851.71 MB

Products per page: 25 << page: 1 of 16 >>

The map displays a yellow rectangular area over the Netherlands, indicating the satellite's field of view. The map covers a large portion of Europe and parts of Africa, with numerous city names labeled across the continent.

13/02/2024

Dias 21



# Google Earth Engine – an advanced cloud-based processing platform

Google Earth Engine

Search places and datasets...

**Scripts** **Docs** **Assets** NEW

**New Script \***

```

Imports (1 entry) 
  var geometry: Polygon, 4 vertices 
  var sentinel2 = ee.ImageCollection('COPERNICUS/S2')
  var imagefilter = sentinel2
    .filter(ee.Filter.lt('CLOUDY_PIXEL_PERCENTAGE', 20))
    .filterBounds(geometry)
    .filterDate('2019-01-20', '2019-08-28');
  print(imagefilter);
  var imagedata = imagefilter.mosaic().clip(geometry)
  var visualisation = {bands: ['B4', 'B3', 'B2'], max: 2000,};
  Map.centerObject(geometry);
  Map.addLayer(imagedata, visualisation, 'Image');

```

**Owner**  
No accessible repositories. Click Refresh to check again.

**Writer**  
No accessible repositories. Click Refresh to check again.

**Reader**  
No accessible repositories. Click Refresh to check again.

**Archive**  
No accessible repositories. Click Refresh to check again.

**Examples**

- Image
  - From Name
  - Normalized Difference
  - Expression
  - Hillshade
  - Landcover Cleanup

**Inspector** **Console** **Tasks**

```

type: ImageCollection
id: COPERNICUS/S2
version: 1644920983012685
bands: []
features: List (26 elements)
  0: Image COPERNICUS/S2/20190216T102111_2019...
  1: Image COPERNICUS/S2/20190224T103019_2019...
  ...
  2: Image COPERNICUS/S2/20190331T103021_2019...
  3: Image COPERNICUS/S2/20190402T102029_2019...
  4: Image COPERNICUS/S2/20190405T103029_2019...
  5: Image COPERNICUS/S2/20190415T103029_2019...
  6: Image COPERNICUS/S2/20190417T102031_2019...
  7: Image COPERNICUS/S2/20190420T103031_2019...
  8: Image COPERNICUS/S2/20190422T102029_2019...
  9: Image COPERNICUS/S2/20190425T103029_2019...

```

Layers Kort Satellit

Dias 22

**USGS**  
science for a changing world

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▲ Interface Controls      2024-01-11T00:00:00-06:00      Lat: 55.6724 / Lon: 12.1035

Selected Data Set(s)      +   
 Landsat 8-9 OLI/TIRS C2 L1      9 scene(s) match your filter.

Dataset Metadata Filters      +   
 No filters have been added.      Clear

Common Metadata Filters      +   
 Cloud Cover 0 to 20   
  Include Unknown

Acquisition Date Range 07/01/2023 to 02/13/2024      Clear

Geographic Filter      +   
 Filter Type Map Location   
 Find Data Located At Center of Map

Scene Navigator LC08\_L1TP\_195021\_20240111\_20240123\_02\_T1      Landsat 8-9 OLI/TIRS C2 L1

Download Metadata Share Hide Previous Select Scene Next

The provided maps are not for purchase or for download; they are to be used as a guide for reference and search purposes only; they are not owned or managed by the USGS.

Leaflet | © OpenStreetMap contributors

# Aerial photography

Aerial photos as source for extraction of features. Change detection

Geometric "problems" in the aerial photo

How to go from aerial photos to orthophotos.



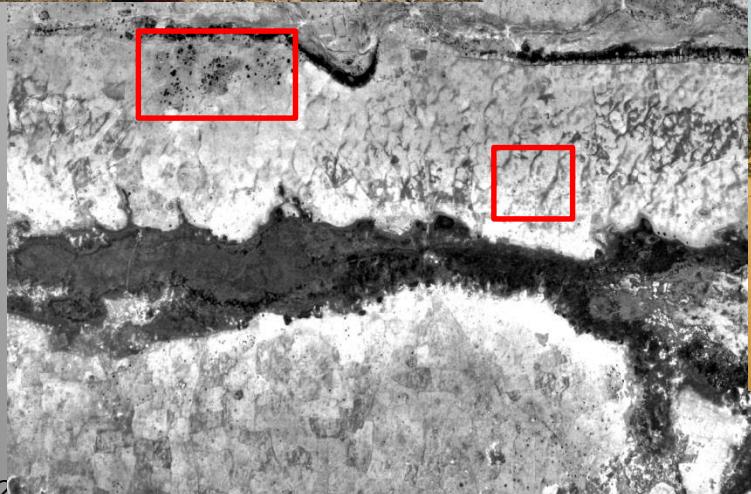
## Aerial photo

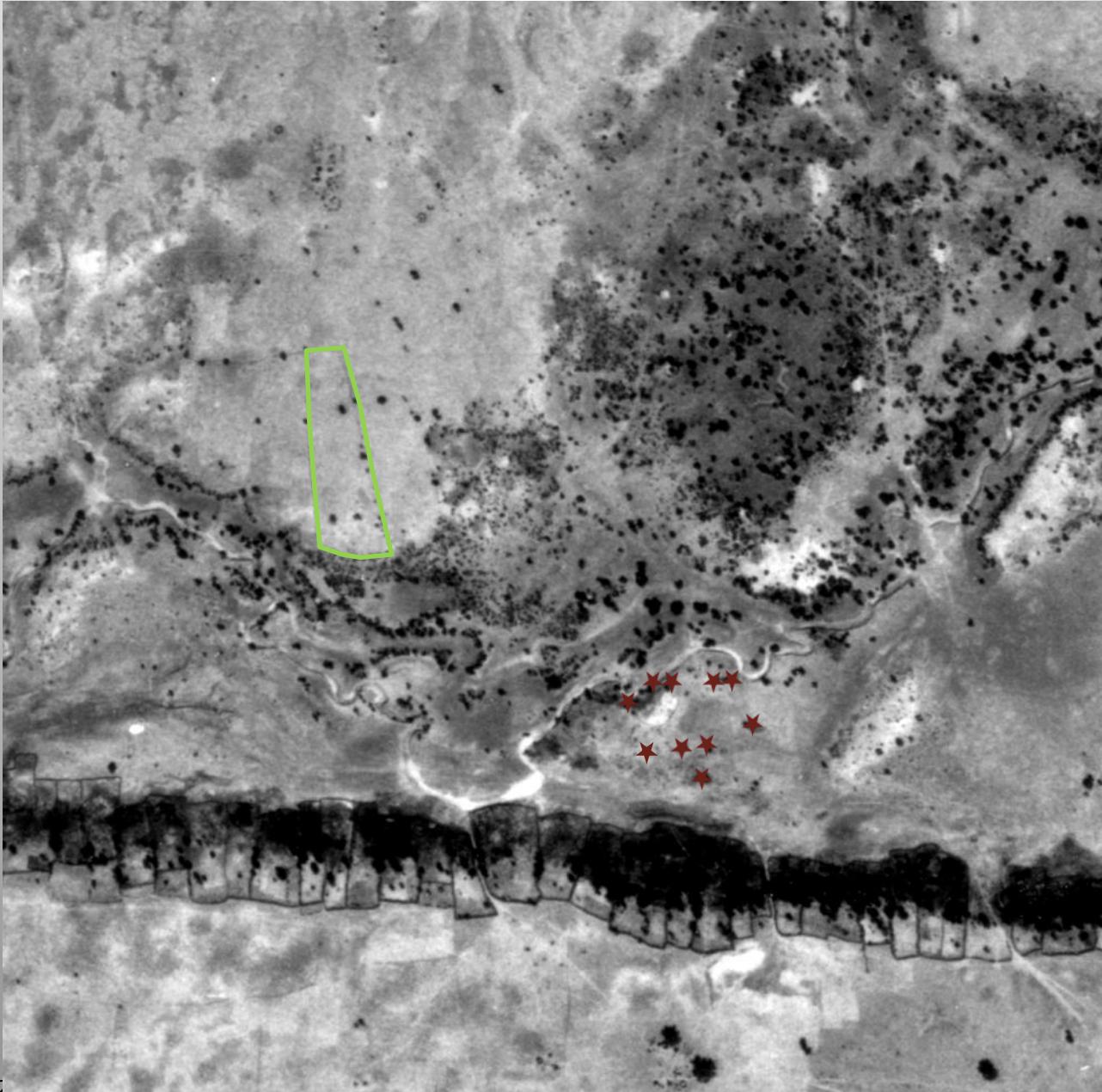


13/02/2024

Dias 26







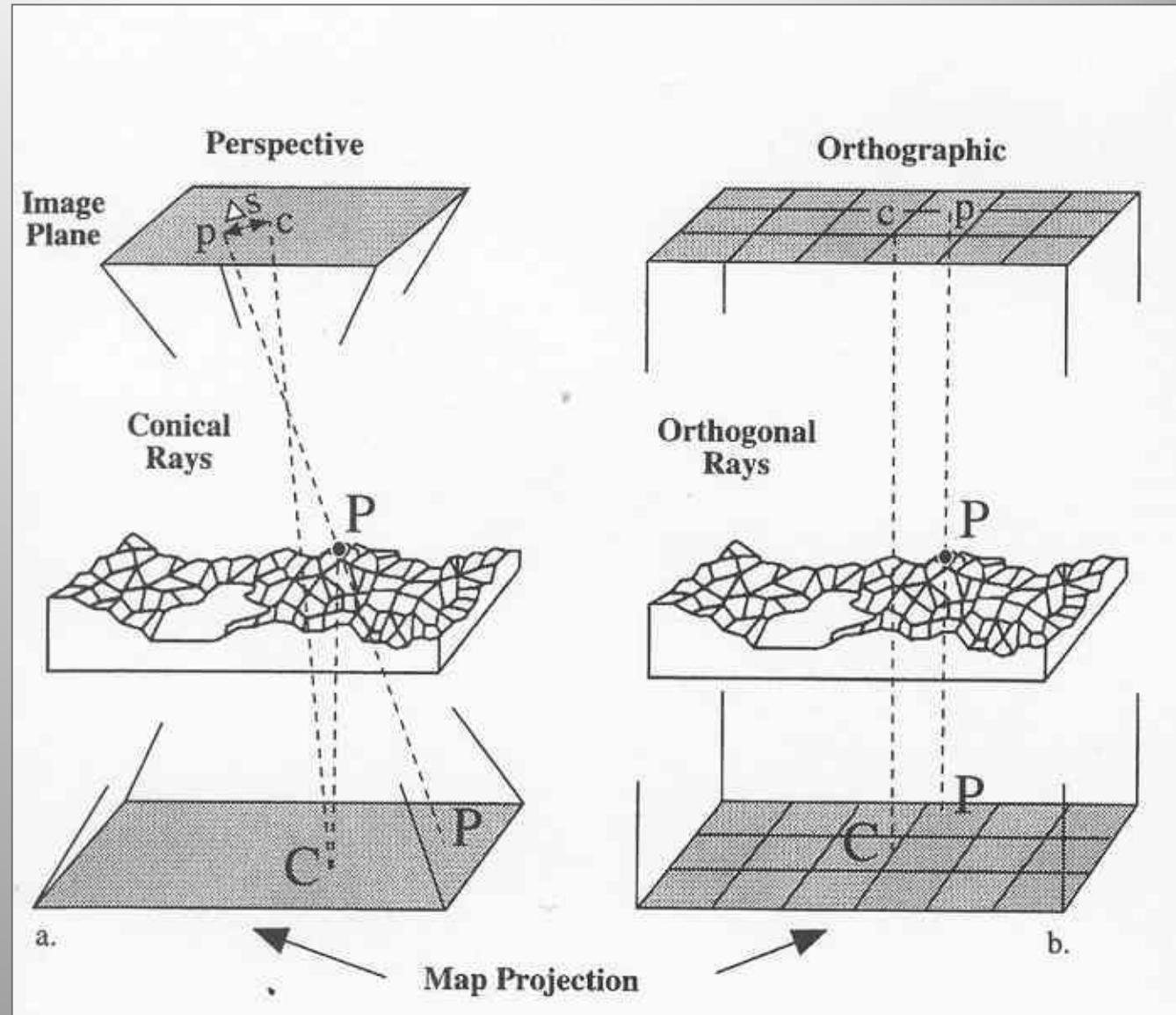
13/02/2024

Dias 28



Aerial photo:  
central perspective  
projection

Orthofoto:  
plane perspective  
projection



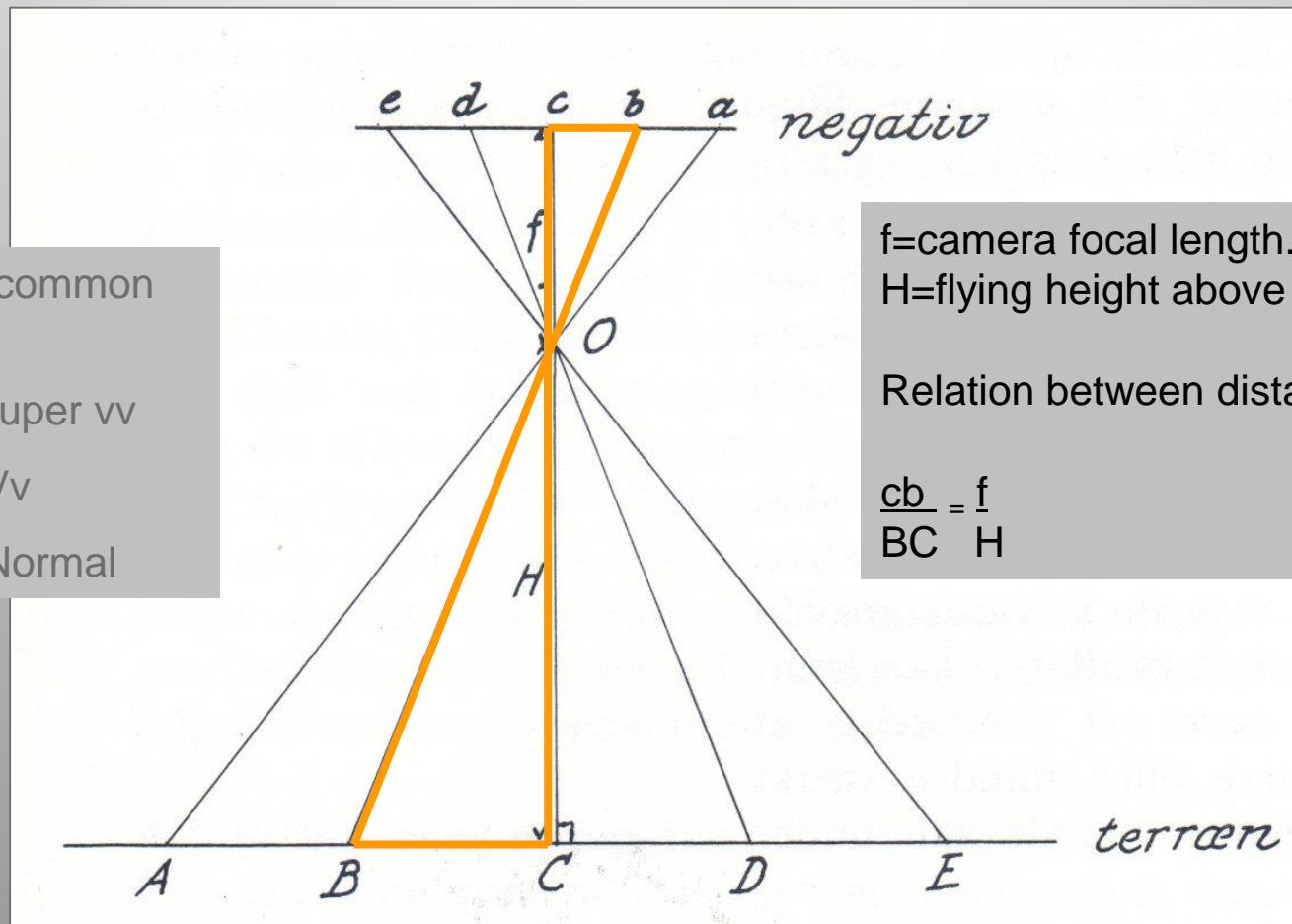
# The ideal aerial photo

The most common lenses

88 mm Super vv

153 mm Vv

300 mm Normal



$f$ =camera focal length.  
 $H$ =flying height above terrain

Relation between distances.

$$\frac{cb}{BC} = \frac{f}{H}$$

Simpel relation between a distance in the aerial photo and the distance on the ground

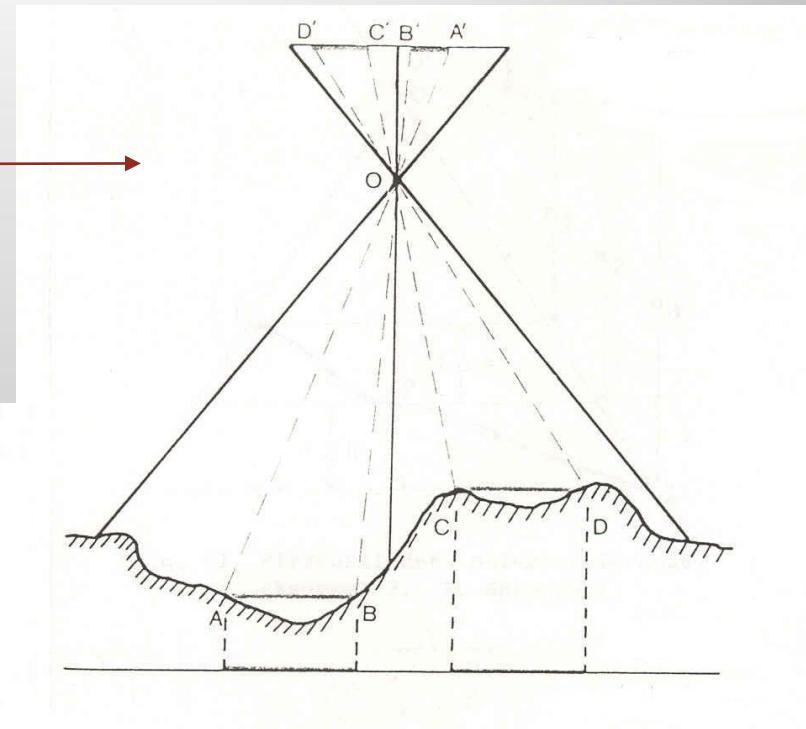
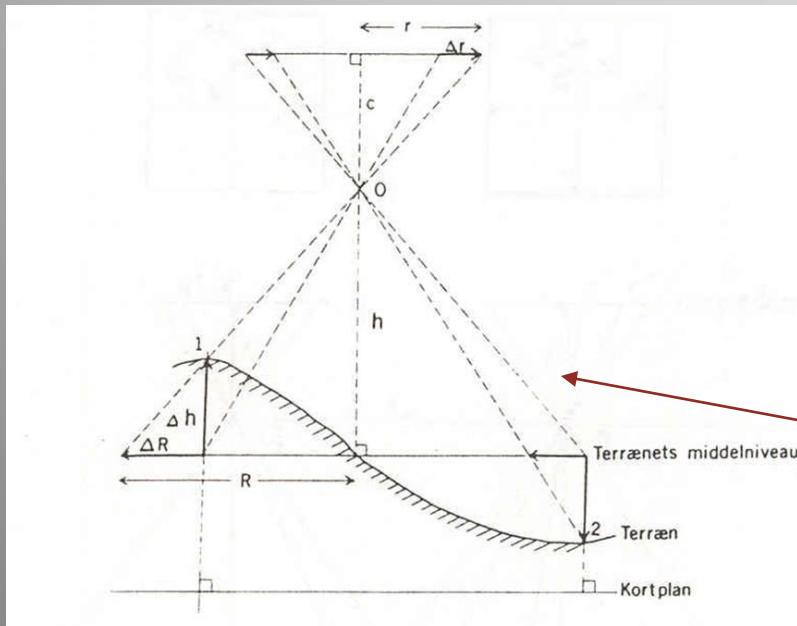
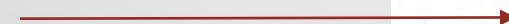
13/02/2024

Dias 30



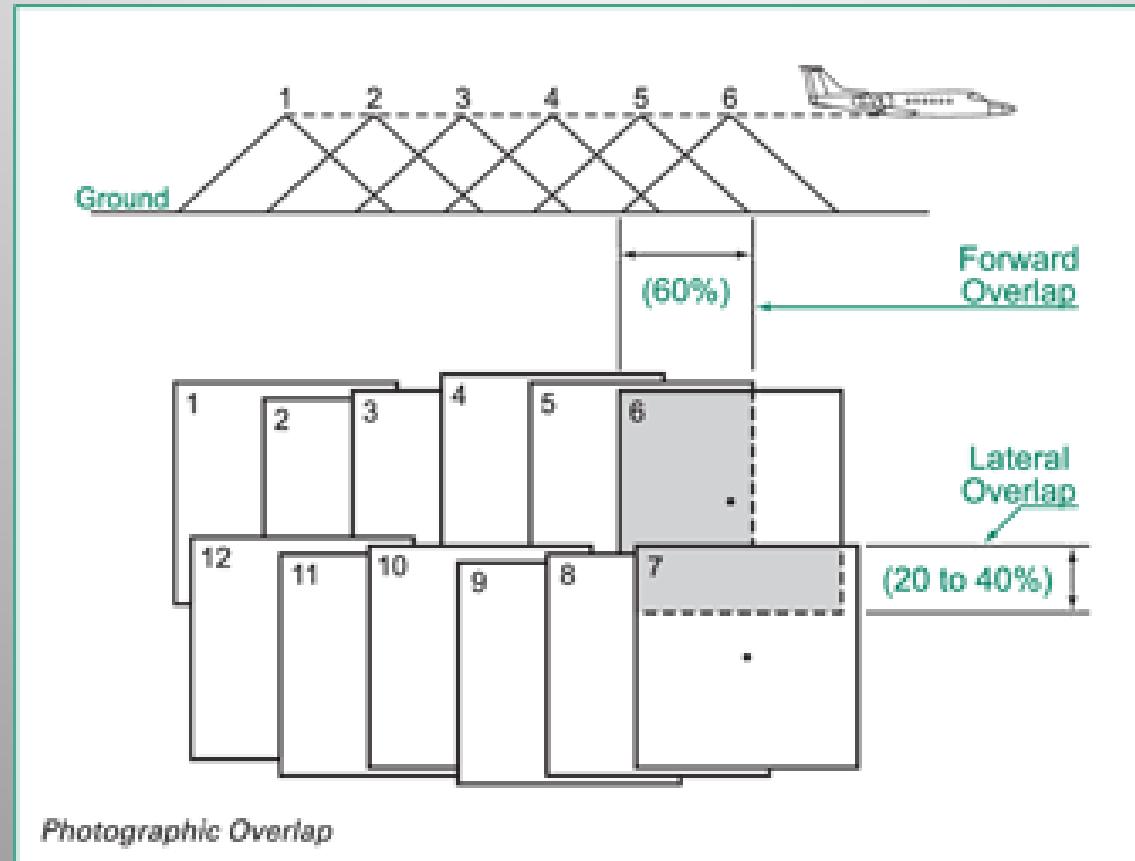
## Errors in aerial photos caused by relief.

Distances



Displacement

# Flight lines and overlap in flight direction



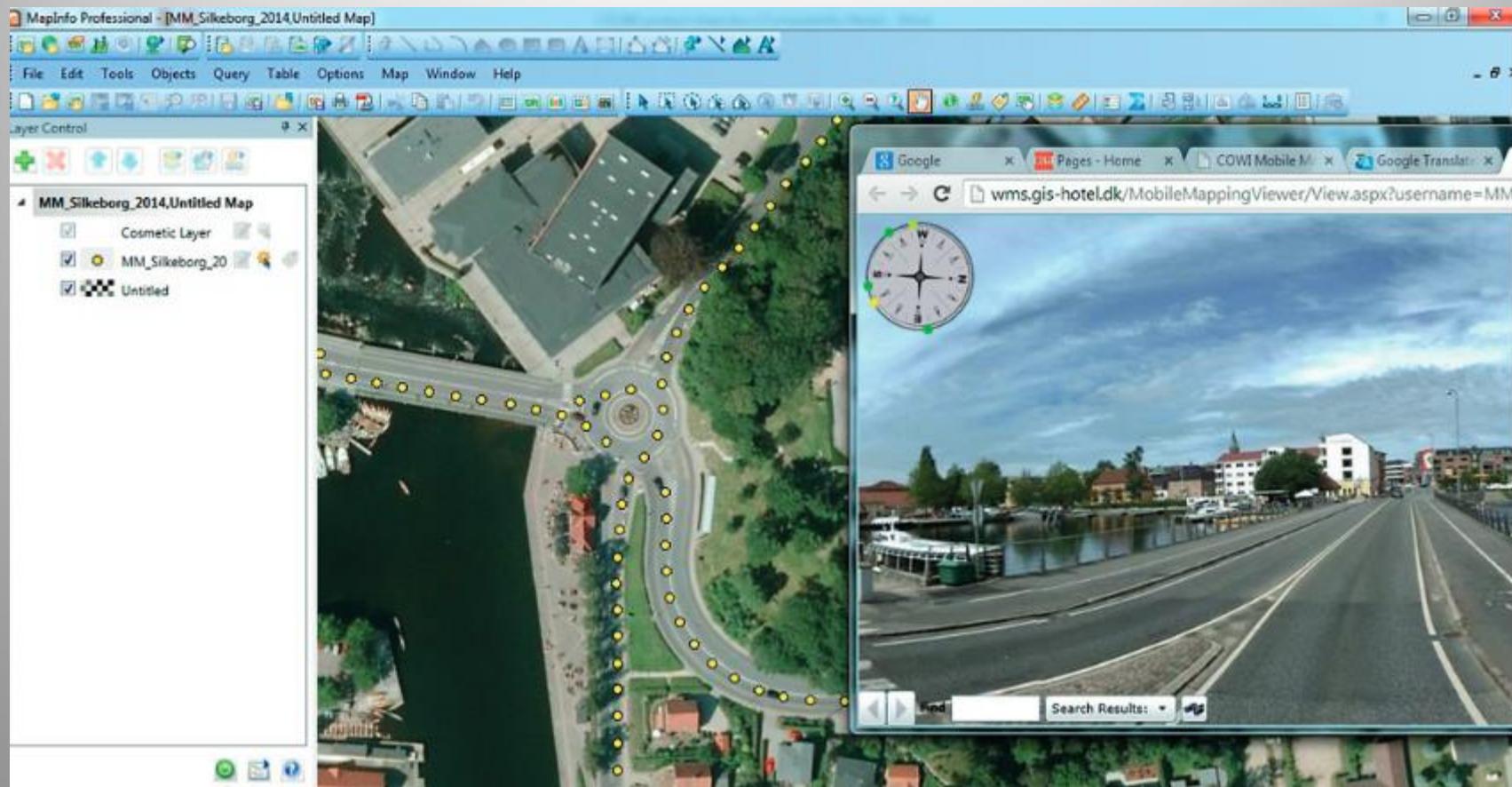
## Aerial photos and orthophoto generation



## Oblique aerial photos



## Street view – Google & “Gadefoto” - COWI



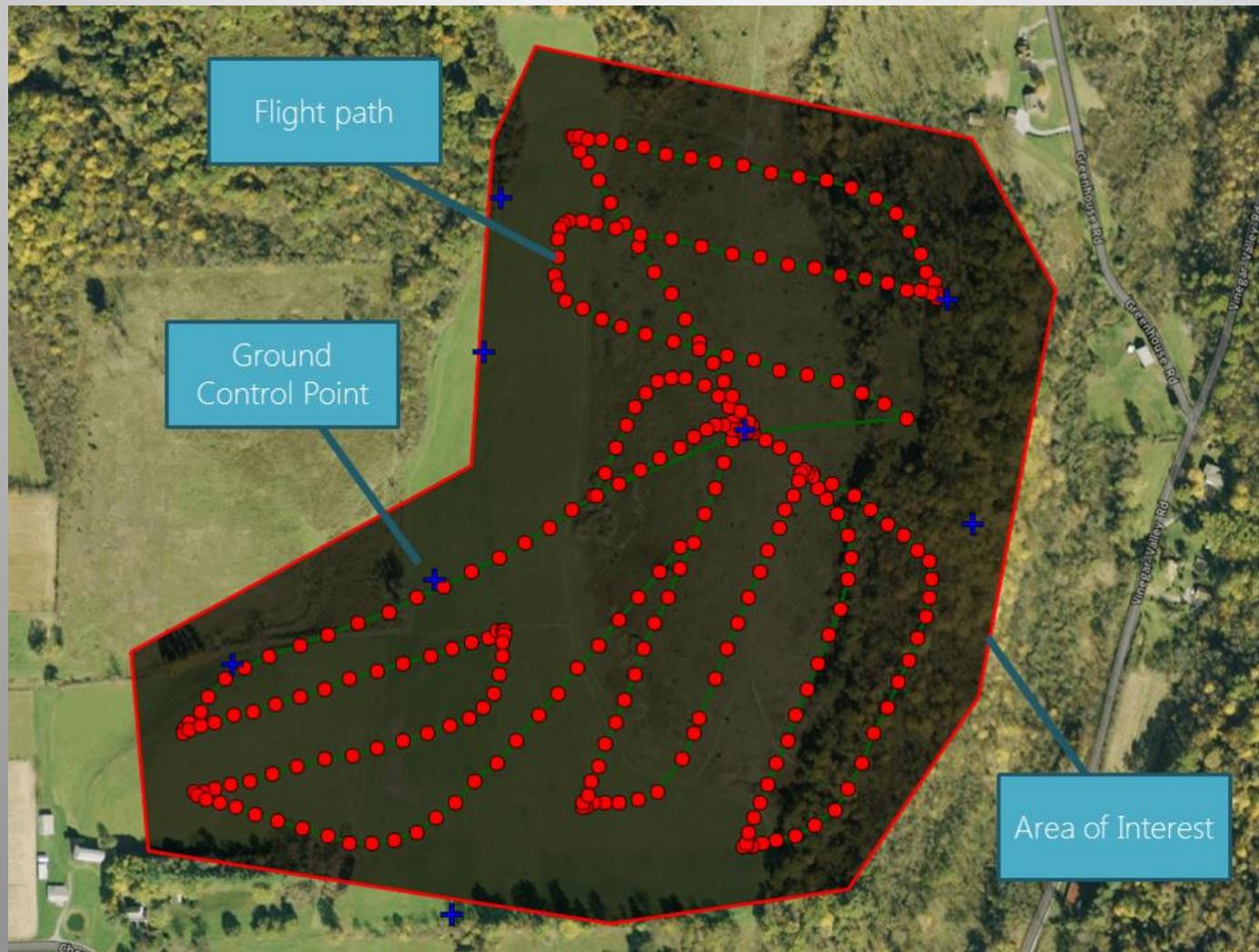
# Drones



## Konfiguring the drone and flight path



## Flight path and area of interest



13/02/2024

Dias 41



# Digitale orthophoto

How to create orthophotos from satelite images, aerial photos from planes and drones?

- The images – must have overlab
- Ground control points (GCPs)
- Digital elevation model
- Software and computer power



## Photo

- digital photo, satellite images



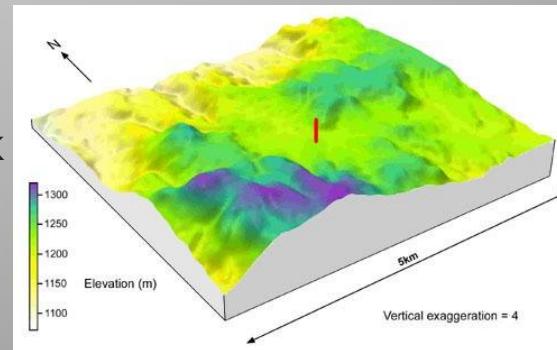
## Ground Control Points (GCP)

- Create GCP by the use of GPS
- GCPs from older orthophotos

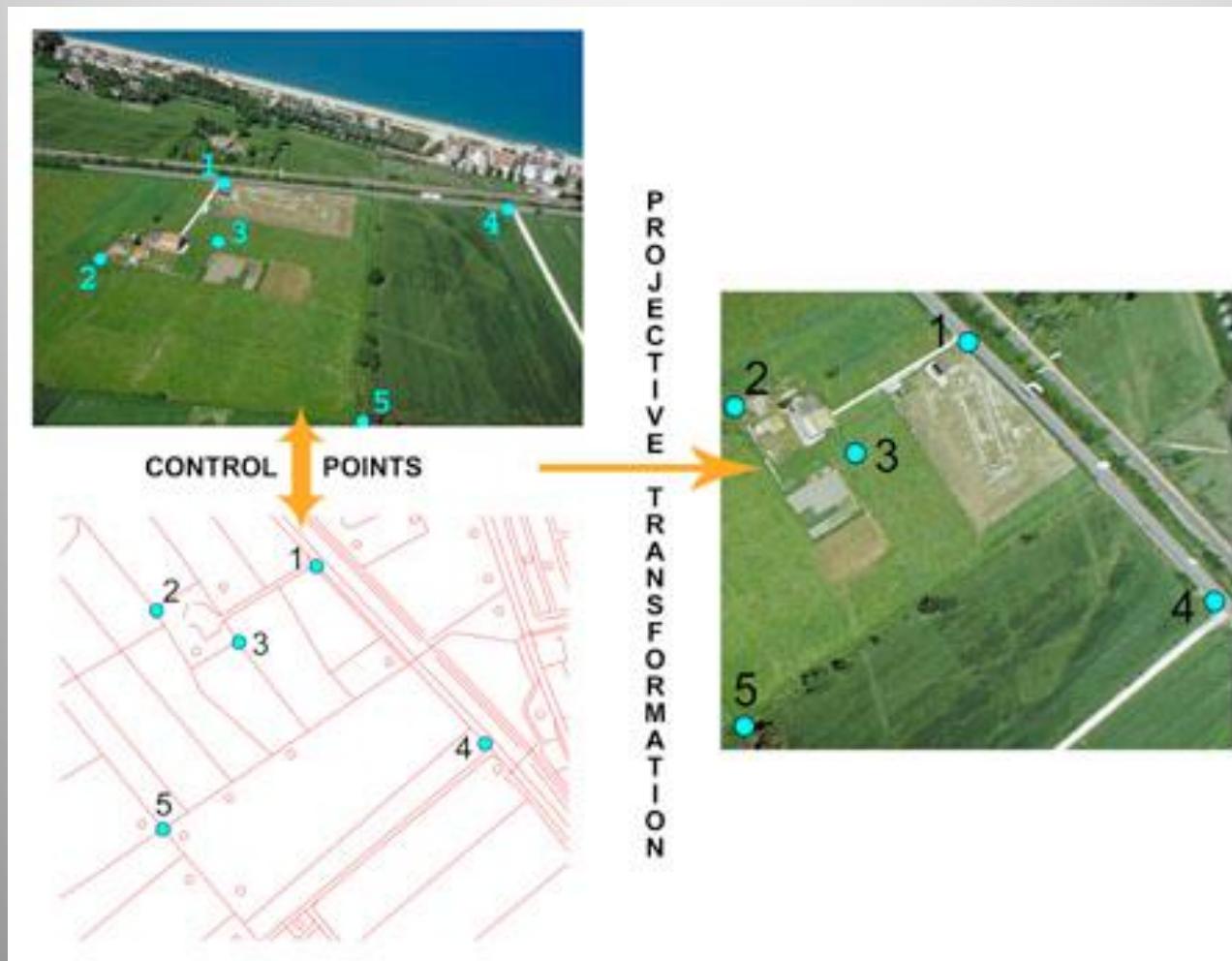


## Digital elevation model

- Measured in the images (manually)
- Automatic correlation + manual check (parallax)
- Existing digital elevation model



# Orthophoto production -georeferencing



# The advantages using Orthophotos as background in GIS

Un-interpreted information

- It is not a map

Easy to understand for an untrained map reader

- Better communication of spatial information

Flexible in use - digital format

- GIS and other software.

Useful as background for other layers

- It looks like the “real” World

Problems with buildings and other tall objects

- Orthophotos are normally not “true” orthophotos”



# Digitale orthophotos and spatial resolution available in Denmark

**Nation coverage:** DDO95: 80cm; DDO99land: 40cm; DDO99by: 10cm

DDO 2004: 25cm, SCANKORT 2005: 40cm, DDO 2006: 25cm, DDO 2008:12,5cm, DDO 2010: 12,5cm, DDO 2012: 10 – 20cm, DDO 2016: 10 – 20cm, DDO 2018: 30cm, DDO 2020: 12,5 cm, DDO 2022: 12,5 cm

**Urban areas or municipality** – down to 3cm



DDO95: 80cm



DDO2022: 12,5cm

## Digitale orthophoto from the commercial market

Private Danish companies like COWI, SWECO and NIRAS can produce/deliver orthophotos on demand.

Alternatives from satellites:

- IKONOS 1m panchromatic, 4m color.
- Planet panchromatic 2 m
- SPOT 10m panchromatic
- Indian IRS-1C 5m panchromatic
- Quickbird 0.65m panchromatic
- Pleiades 0.50 m panchromatic
- WorldView 1 og 2: 30cm panchromatic, 2m MS



## Examples

## Background as images in GIS

# 3D flightsimulator

# 3D models of cities

