# Introduction to selected areas of geomatics

Lecture 2

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# Data capturing

- Satellite data  km-30cm(nowadays)
- Aerial data  (dm-cm)
- Drone data (cm)
- Terrestrial data (field spectrometer, spectroscopy)

# Type of remotely sensed data

- Multispectral data
- Hyperspectral data
- Lidar data
- Radar data
- Panchromatic data (very high resolution)
- Declasified data (historical)

# Data processing

four basic tasks:

- Image rectification and restoration (geodetical system, atmospheric correction)
- Image enhancement (histogram modification, filterring)
- Classification (multispectral, deep learning)
- Post-classification adjustments (for thematical map creating mostly)

# rectification

= transformation to the geodetical or geographical systém (to the coordinates)

- Polynomial of (e.g.) 1st order:
  - shift, rotate, scale change - at least 3 pairs of GCPs

$$X = a_0 + a_1 x + a_2 y + a_3 xy + a_4 x^2 + a_5 y^2 + a_6 x^2 y + a_7 xy^2 + a_8 x^3 + a_9 y^3$$

$$Y = b_0 + b_1 x + b_2 y + b_3 xy + b_4 x^2 + b_5 y^2 + b_6 x^2 y + b_7 xy^2 + b_8 x^3 + b_9 y^3$$

---------- 1st order polynomial

---------- polynomial 2.order

---------- 3.order

# restoration

Image restoration = correction of radiometric values

resulting

- from instrument calibration
- from changes in radiation exposure at different times of the year, at different times of the day
- from flight geometry - change in angle of irradiation in one line
- from the state of the atmosphere

# Digital Image Processing - Image Highlighting

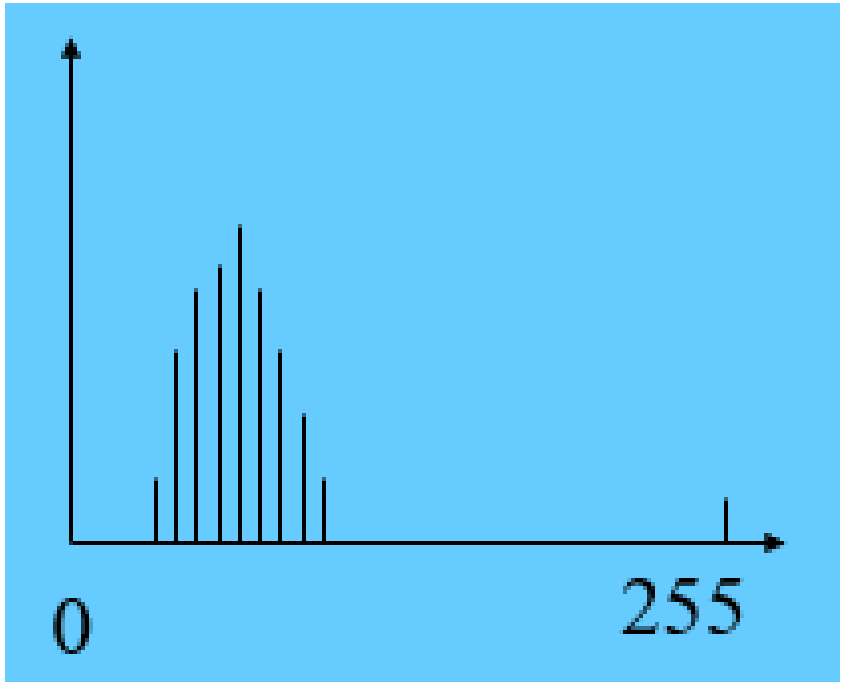
Image highlighting= enhancement to find the most information contained in the data

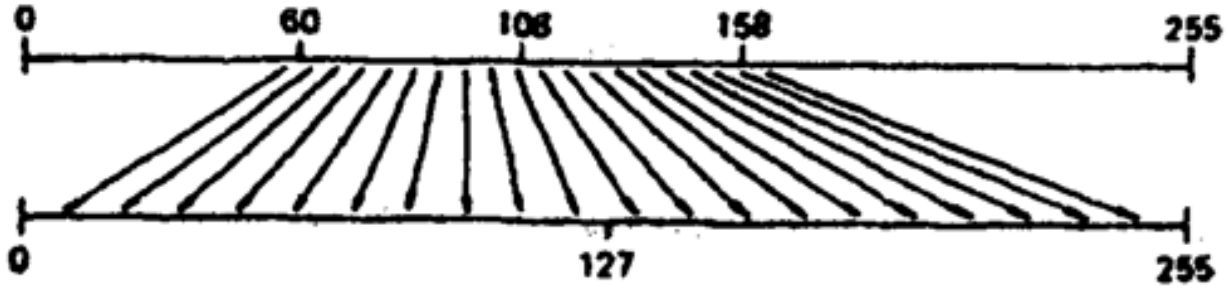
important because the sensitivity of vision is less than the range of most measured data

Point highlight methods = methods that do not consider values around pixels

1. histogram expansion - linear, non-linear

# Histogram—a bar chart showing the frequency of digital values in an image file

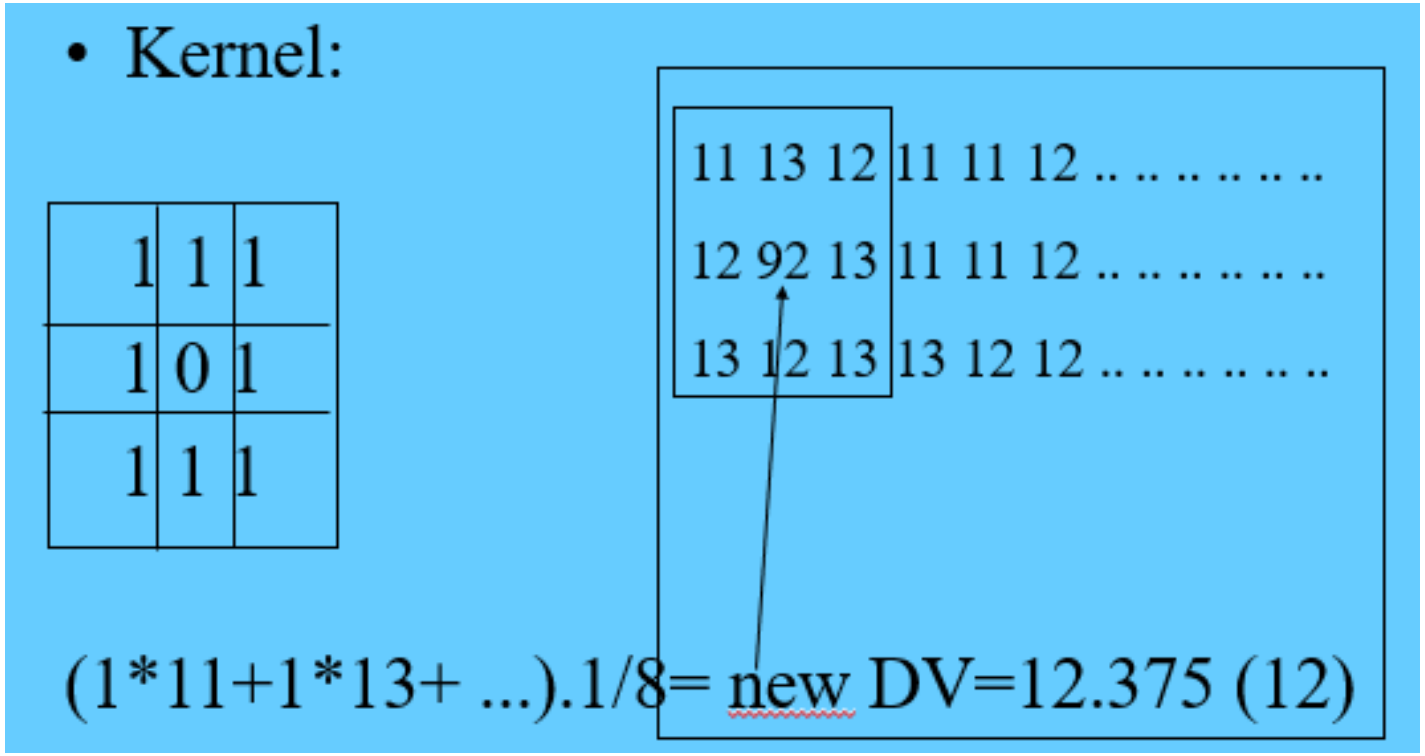



Histogram: frequency occurrence of DH in the image

# Filtering

- 2. Image filtering - a method of local highlighting, i.e. highlighting that is performed sequentially for each value of the image file based on its DH and DH pixels in its surroundings
- The environment is defined by a submatrix - kernel = moving window (moving window)



# Digital Image Processing - filtering

- Purpose of filtration:
  - Suppress small differences between DH - and highlight large differences - high-pass filters - highlight edges and lines
  - Smooth image - low pass filters - average (all values in kernel = 1)

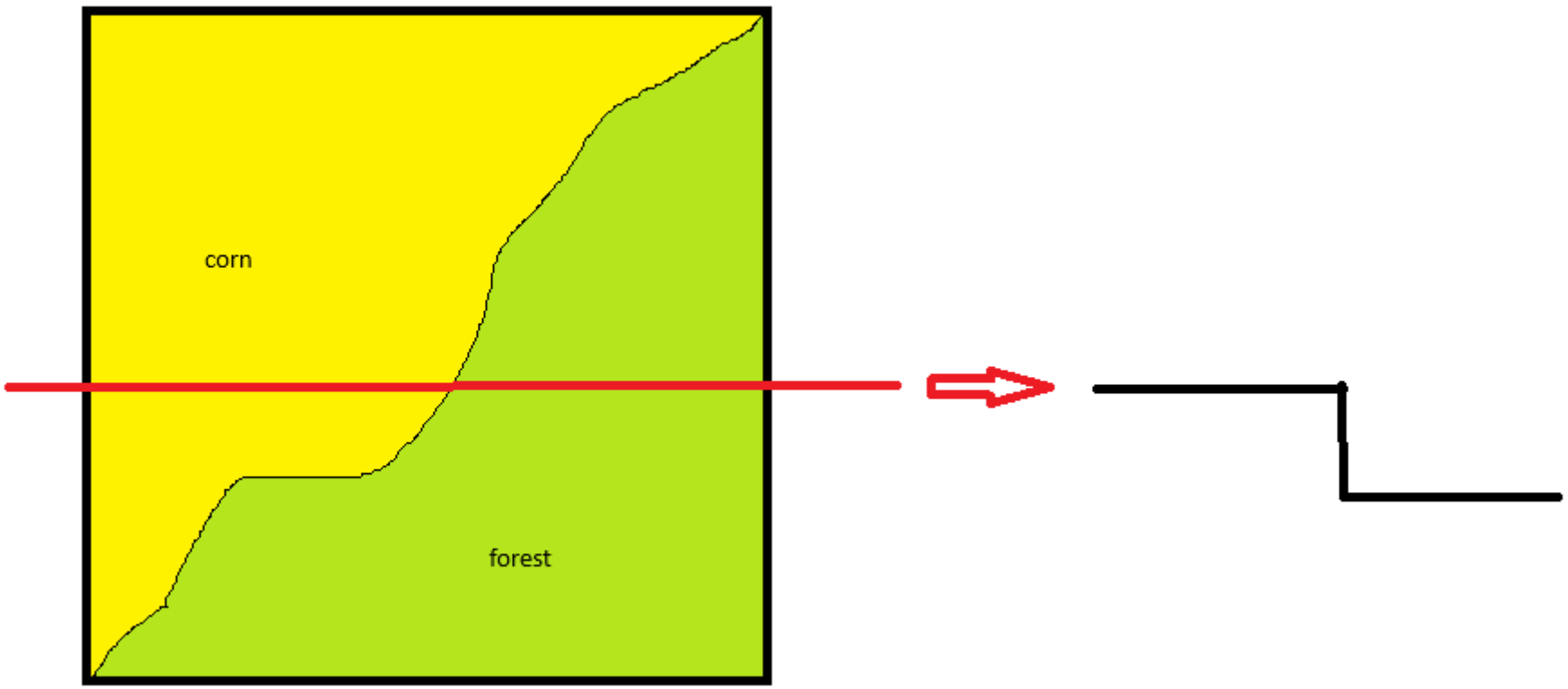
# Edge filters - carriers of positional data

- **An edge in a grayscale image** is called a discontinuity in the image function, or an area in the image where the grayscale value changes significantly or in steps. Edges are an important component of an image and are often the information sought.

- The edges can be divided into 3 types:
- **- roof edge** is a lighter linear formation on a darker background, e.g. dirt road, concrete road,
- **- a trench edge** is a darker linear formation on a lighter background, e.g. a watercourse,
- **- a step edge** is an interface between a lighter and a darker object, e.g. field-forest interface, boundary between cultures.

For example: Prewitt operator (also Sobel, Laplace-sharpening, Robinson, gradient, etc.)

# Step edge



# Edge operators

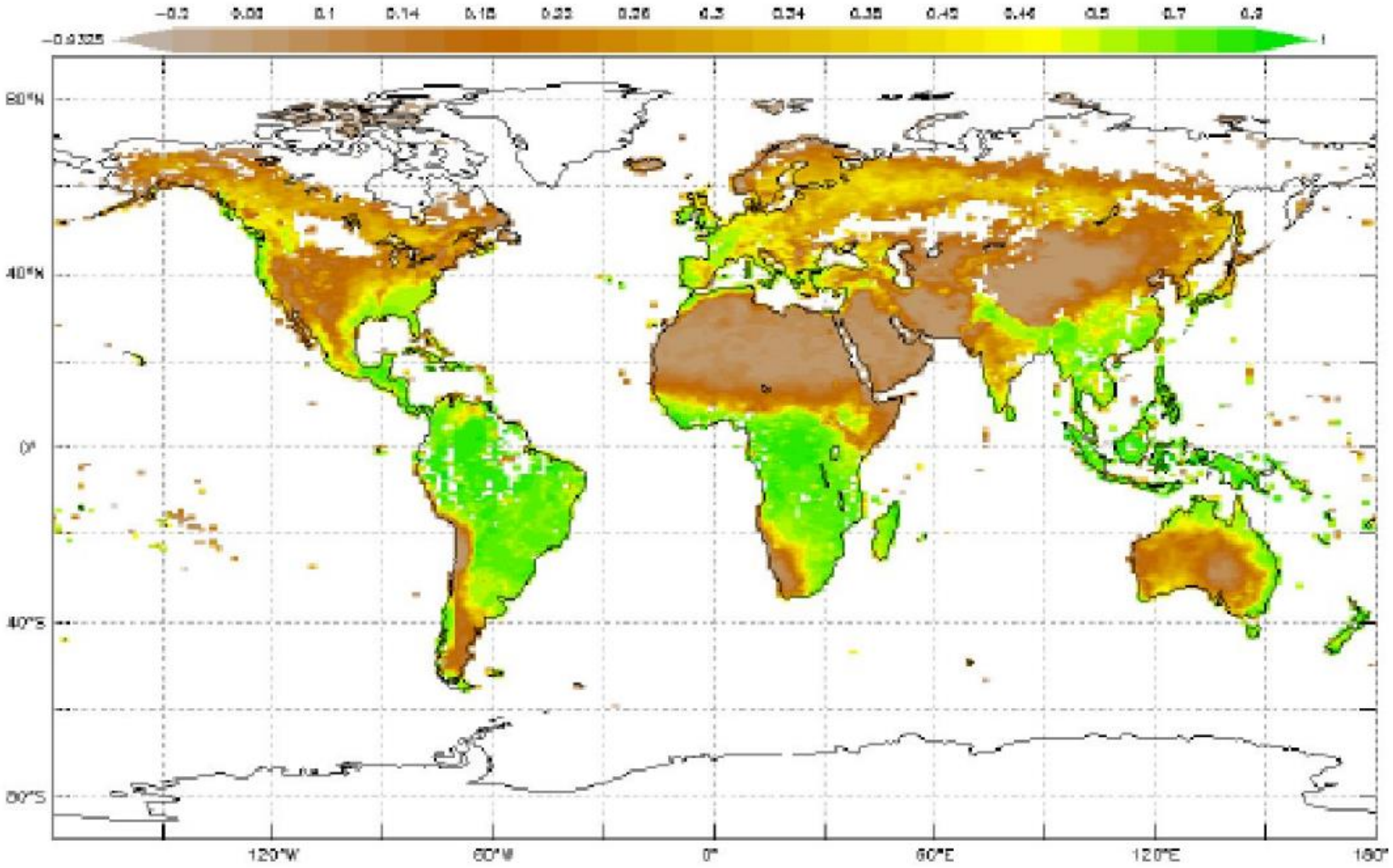
- The normal edge operator calculates the average from the differences in the image window and fits it behind the center pixel. In homogeneous regions the differentials will be zero, non-zero numbers will indicate the degree of probable presence of an edge.

$$p(i,j) = \frac{1}{8}\sum_{k=1}^{3}\sum_{l=1}^{3}\left|f(i,j) - f(k,l)\right|$$

# Vegetation indices

Vegetation indices – characterize the increase in reflectance between the R and NIR bands – most commonly used – NDVI (normalized difference vegetation index) (newly calculated channel):NDVI = (NIR – R)/ (NIR + R), where IR is the infrared band, R is red; Vegetation indices indicate the presence (quantity) and quality of green matter.

# Global vegetation monitoring




https://land.copernicus.eu/en/products/vegetation/normalised-difference-vegetation-index-v2-0-300m

# Other indices

https://www.indexdatabase.de/db/i.php

- VI
- NDVI
- Soil-Adjusted Vegetation Index (SAVI)

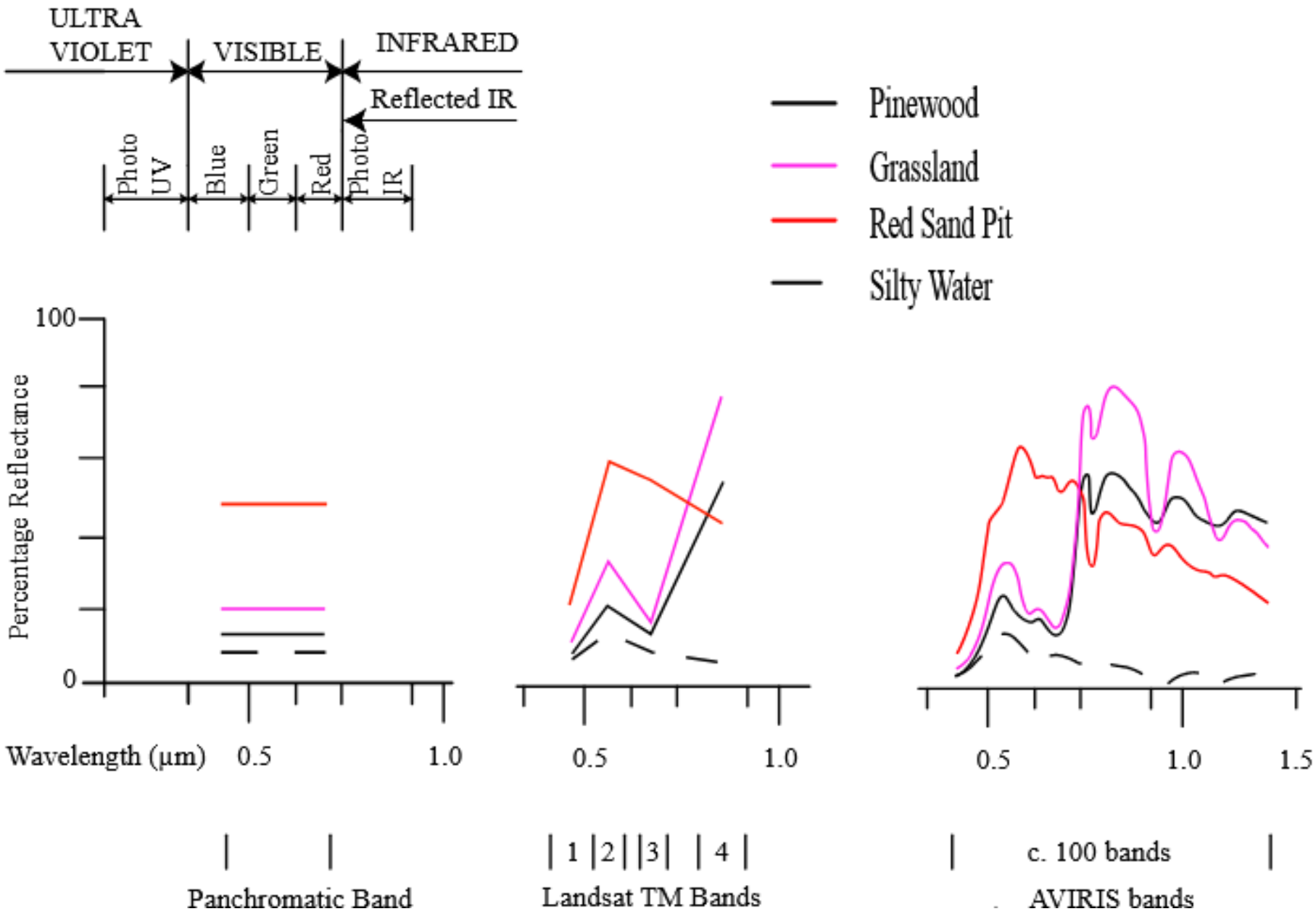
$$EVI = 2.5 * \frac{(NIR - Red)}{(NIR + 6 * Red - 7.5 * Blue + 1)}$$

$$\mathrm{SAVI} = \frac{(1 + \mathrm{L})(\mathrm{NIR} - \mathrm{Red})}{(\mathrm{NIR} + \mathrm{Red} + \mathrm{L})}$$

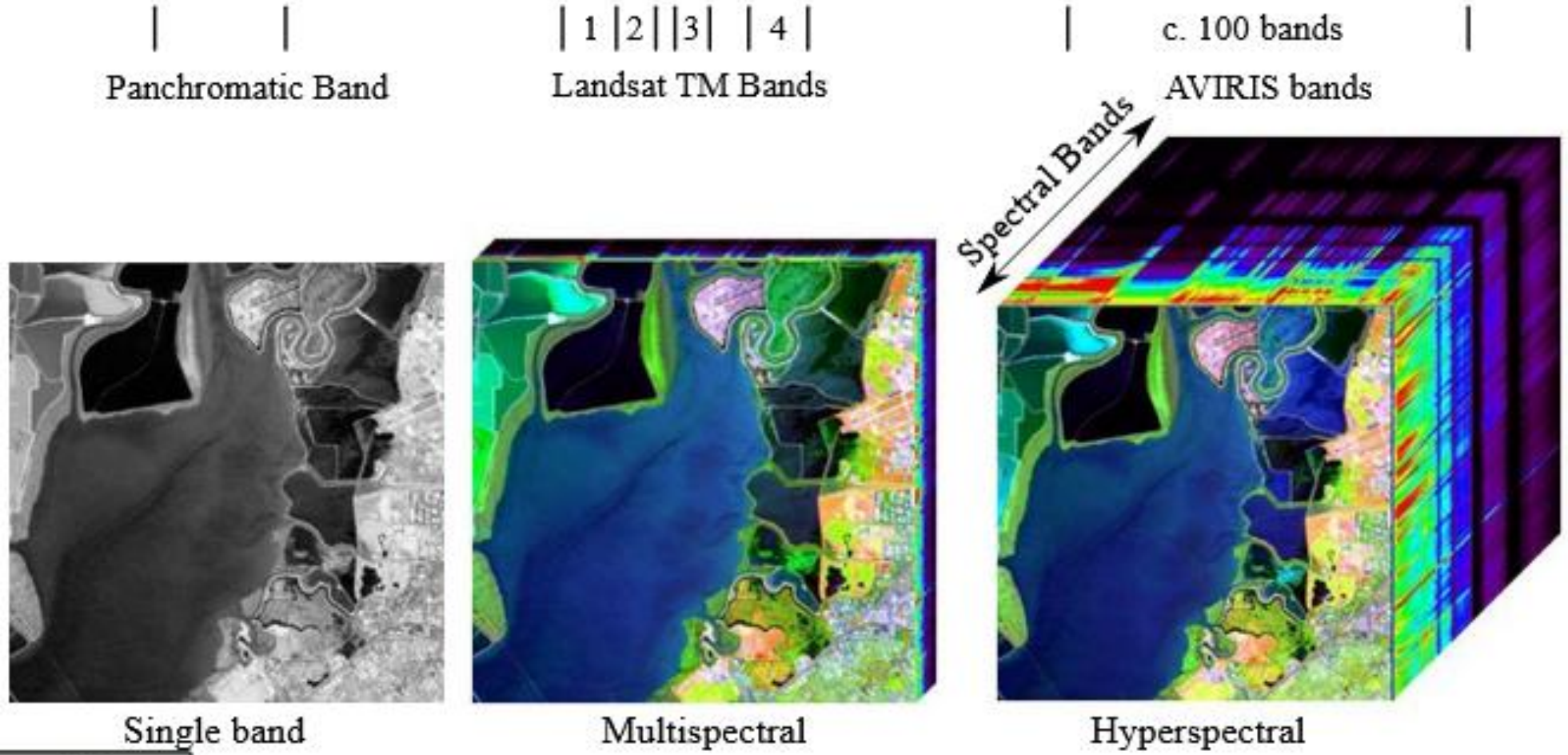
$$GNDVI = \frac{(NIR - Green)}{(NIR + Green)}$$

# Classification

- Types of classifications:
- Classification:
  - pixel-by-pixel
    - Controlled  (based on training sets)
    - uncontrolled  (iterration process by computer)
    - Hybrid
    - neural networks
  - other methods - textural classification

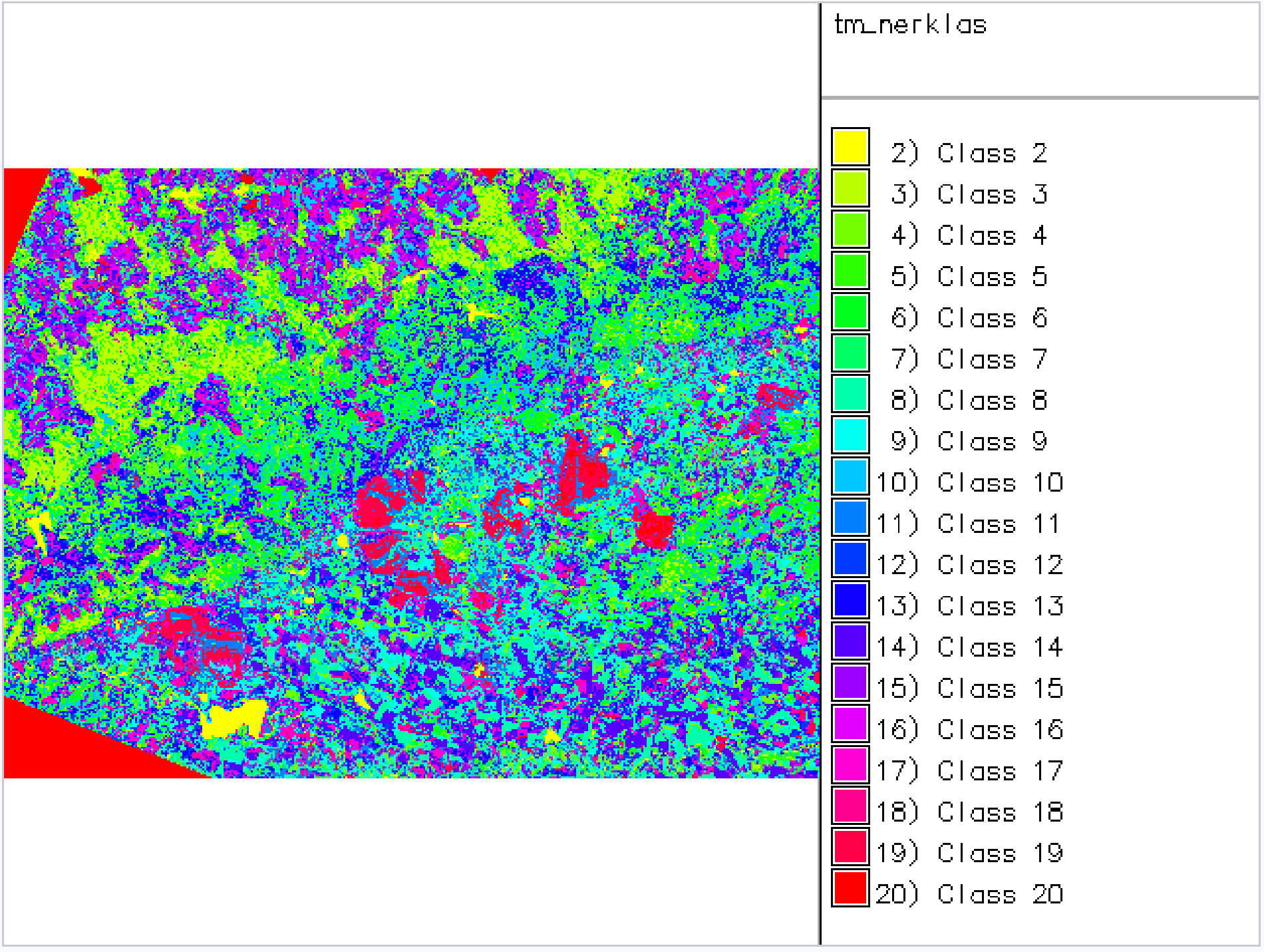

ULTRA VIOLET
VISIBLE
INFRARED
Reflected IR
Photo UV
Blue
Green
Red
Photo IR
Pinewood
Grassland
Red Sand Pit
Silty Water
100
0
Percentage Reflectance
Wavelength (μm)
0.5
1.0
0.5
1.0
0.5
1.0
1.5
1
2
3
4
c. 100 bands
Panchromatic Band
Landsat TM Bands
AVIRIS bands

# Panchromatic, multispectral and hyperspectral data

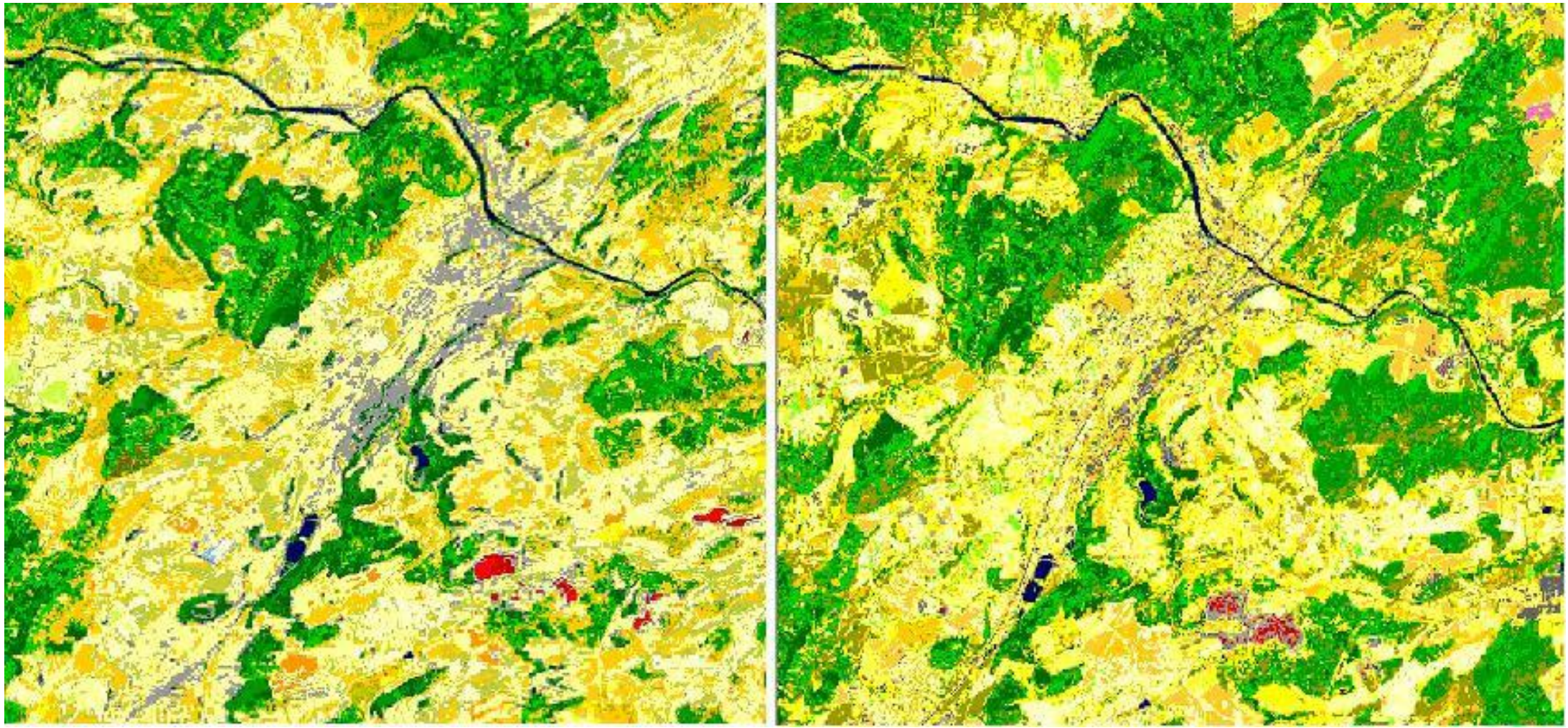


# Classification

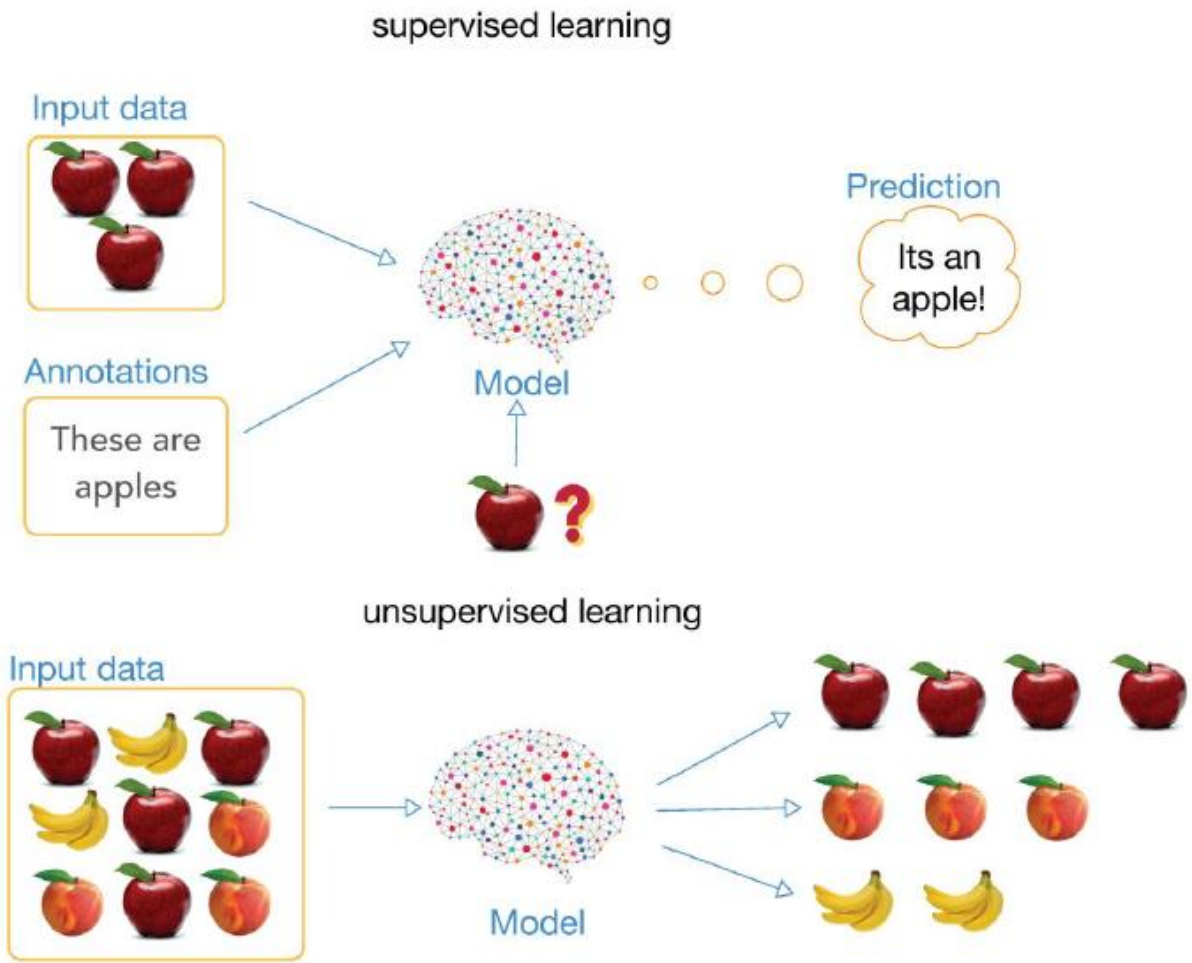
- Data classification means sorting data into defined groups; the basis of thematic maps.
- Multispectral classifications are supervised or unsupervised.
- Unsupervised classification is the classification of data according to a multidimensional histogram, performed geometrically (**Isoclus**).
- For supervised classification, we need training sets on which the system learns classification and creates features according to which we classify individual pixels of the image into a class. It is based on statistics (**Maximum likelihood**).


tm_nerklas
2) Class 2
3) Class 3
4) Class 4
5) Class 5
6) Class 6
7) Class 7
8) Class 8
9) Class 9
10) Class 10
11) Class 11
12) Class 12
13) Class 13
14) Class 14
15) Class 15
16) Class 16
17) Class 17
18) Class 18
19) Class 19
20) Class 20

# Classification results (isocluss): TM 2,3,4,5,7 (left) and Aster 1,2,3N,4,1/4(5+6+7+8)



# Image classification with machine learning




Ma et al., 2018

| Learning Principle | Exemplary Classifiers |
|---|---|
| *Instance-based learning* | *-Nearest Neighbor (NN) classifier*<br>*-k-Nearest Neighbor (k-NN) classifier* |
| *Probabilistic learning* | *- Naïve Bayesian (NB) classifier*<br>*- Linear Discriminant Analysis (LDA)*<br>*- Quadratic Discriminant Analysis (QDA)* |
| *Max-margin learning* | *- Support Vector Machine (SVM)* |
| *Rule-based learning* | *- Decision Tree (DT)* |
| *Ensemble learning* | *- Random Forest (RF)*<br>*- Random Fern (RFe)*<br>*- AdaBoost (AB)* |
| *Deep learning* | *- Multi-Layer Perceptron (MLP)* |

**Thank you for your attention.**

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