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9 Raster Analysis

c) Land Cover Classification



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Institute of Applied Sciences



Learning objectives



Understand the importance of land cover classification

Learn the differences between supervised and unsupervised classification

Explore common classification algorithms used in remote sensing

Identify the advantages and limitations of each method

Land cover classification



Definition

The process of categorizing and mapping the Earth's surface into distinct land cover types using remote sensing imagery and classification algorithms, which analyze the spectral, temporal, and spatial characteristics of different surfaces

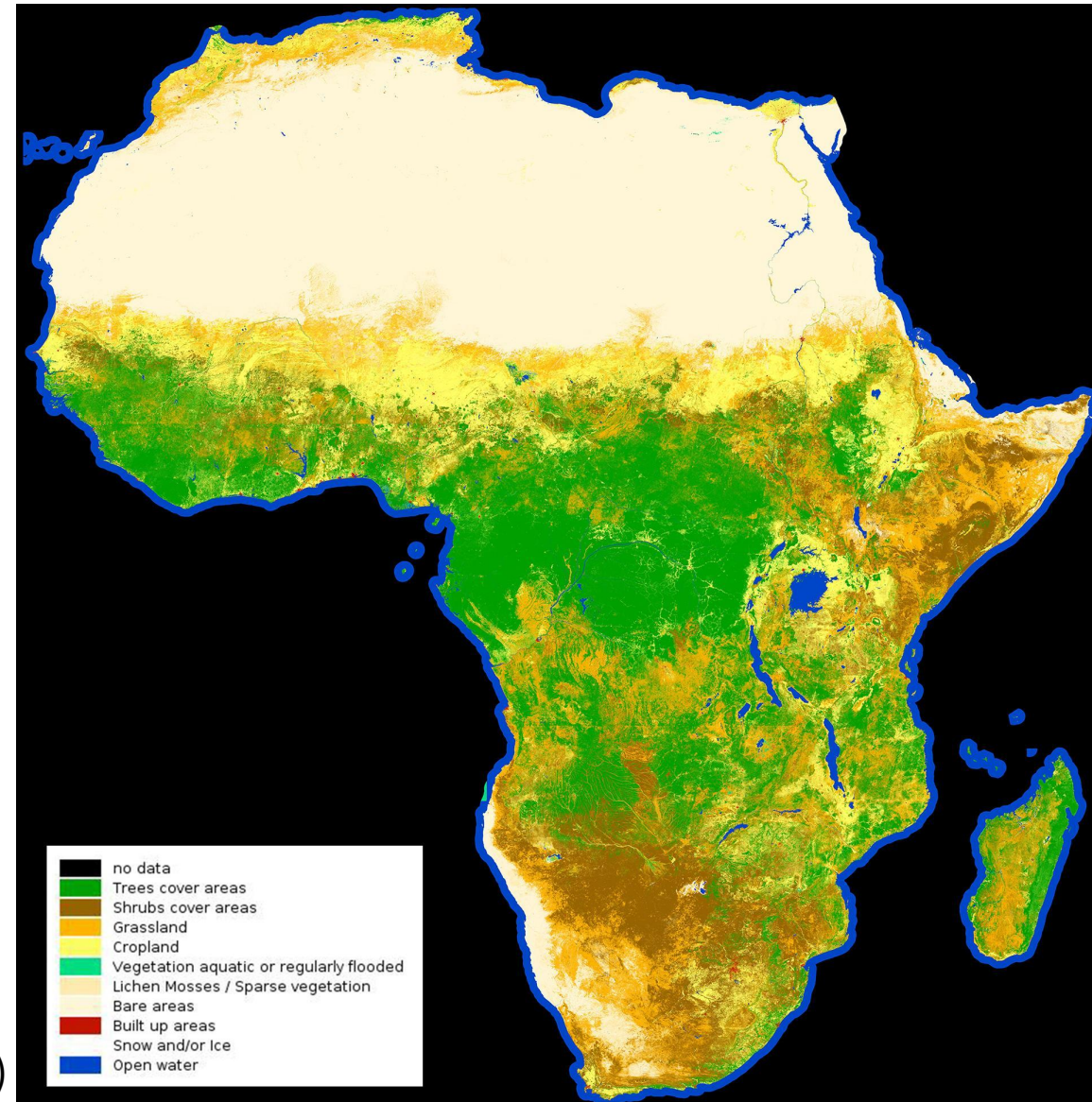
Land cover classification



Usage

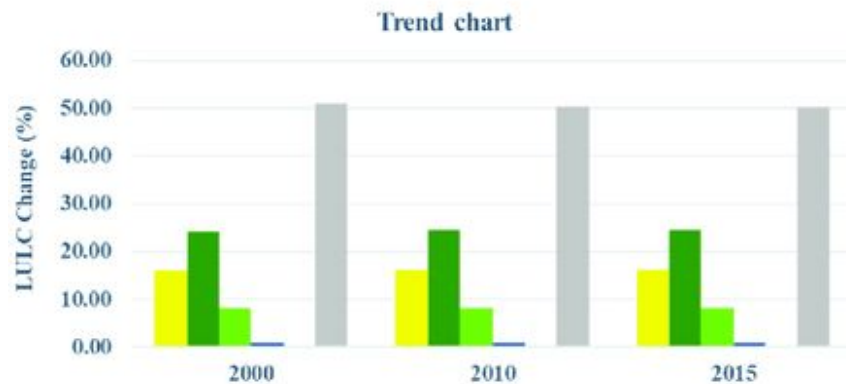
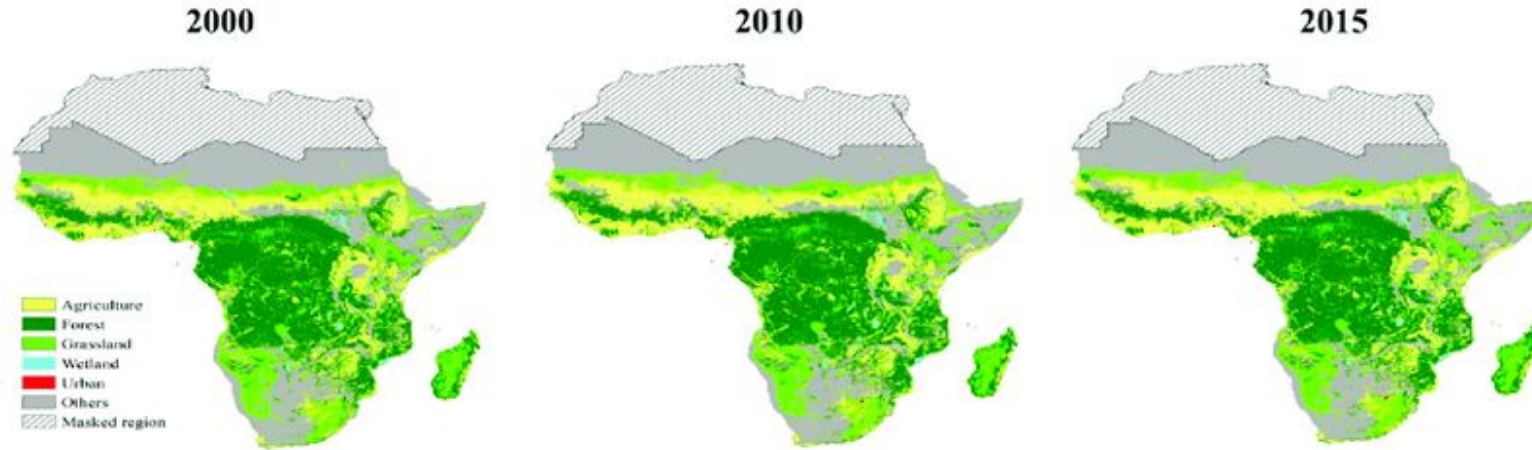
- Environmental monitoring
- Urban planning
- Agriculture and forestry
- Disaster management

(ESA 2017)





Land cover classification - Time series



Can you think of other use cases of LCC time series analysis?

(Chiaka/Zhen 2021)



Land cover classification methods

Supervised classification

Requires training data
(user-defined)

Unsupervised classification

Clusters pixels based on statistical
patterns



Supervised classification

- User provides labeled training data (e.g., selecting known land cover types).
- Algorithm learns from these samples to classify the entire image.

Examples

- Maximum Likelihood Classification (MLC)
- Support Vector Machines (SVM)
- Random Forest (RF)
- Artificial Neural Networks (ANN)

Supervised classification



Advantages

- High accuracy if good training data is available
- Suitable for complex land cover types
- Can incorporate expert knowledge

Disadvantages

- Bad accuracy if training data is not sufficient
- time consuming (training data)

Supervised classification – Maximum likelihood

Definition

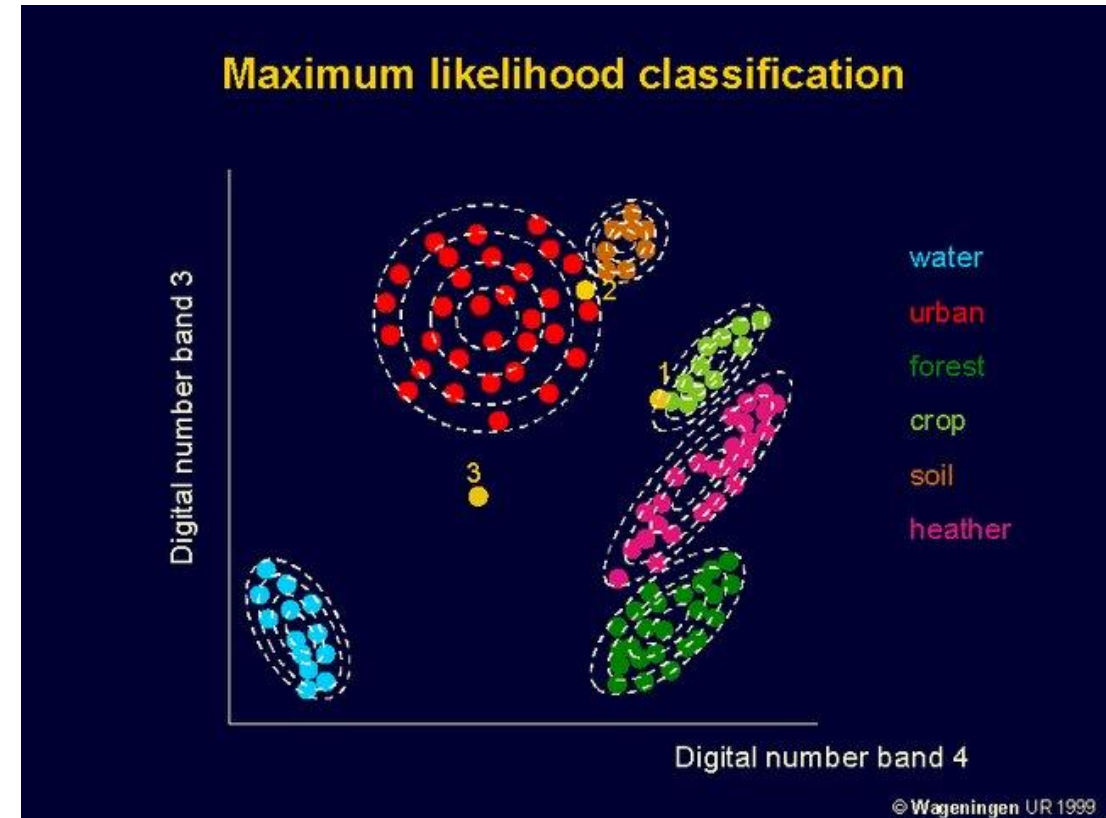
- A **probabilistic classifier** that assigns each pixel to the class with the highest probability
- Assumes that the **data follows a normal (Gaussian) distribution**
- Uses statistical parameters from training data (mean, variance, covariance)

Supervised classification – Maximum likelihood



How MLC Works

- Estimates probability density functions for each class
- Assigns pixels to the class with the highest probability
- Uses a Bayesian decision rule to minimize classification errors



(Vahidi et al. 2023)

Supervised classification – Maximum likelihood

Advantages

- Well-established, widely used in remote sensing
- Provides probabilistic confidence levels
- Works well if data follows a normal distribution

Disadvantages

- Assumes normality, which may not always be true
- Performance depends on the quality of training data
- Struggles with highly heterogeneous land cover types

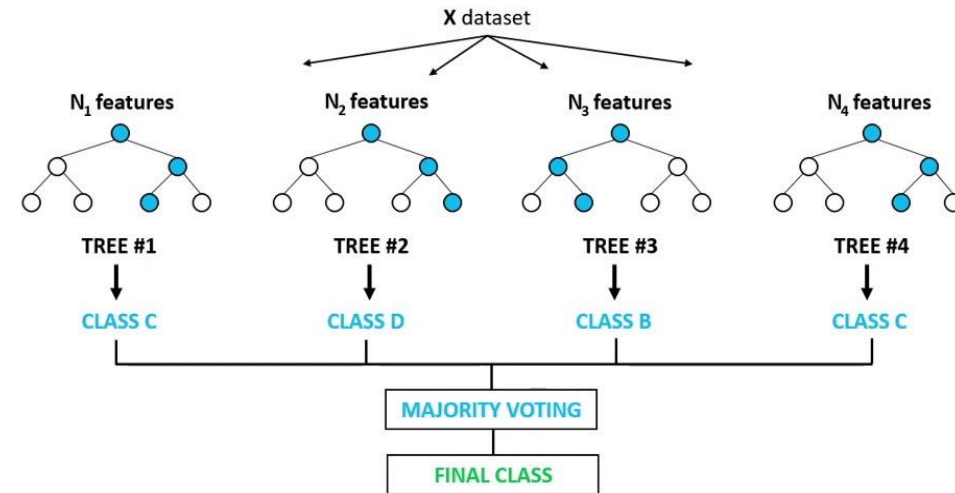
Supervised classification – Random forest



How RF Works

1. Creates multiple decision trees from random subsets of training data
2. Each tree classifies pixels independently
3. The final classification is determined by a majority vote

Random Forest Classifier



(Khushvaktov 2023)

Supervised classification – Random forest

Advantages

- Handles large datasets with high accuracy
- Does not assume a normal distribution
- Resistant to overfitting due to ensemble averaging

Disadvantages

- Computationally intensive, especially for large images
- Requires fine-tuning (e.g., number of trees, depth of trees)
- Can be slower than simpler classifiers



Unsupervised classification

- No prior training data required
- Algorithm automatically groups pixels into spectral clusters
- User assigns classes to clusters after classification

Examples

- K-Means Clustering
- ISODATA (Iterative Self-Organizing Data Analysis)

Unsupervised classification



Advantages

- No need for pre-labeled data
- Faster and more automated process
- Useful for exploratory analysis

Disadvantages

- Results may not match real-world categories well
- User must interpret clusters manually
- Less control over classification rules

Unsupervised classification – K-Means

Definition

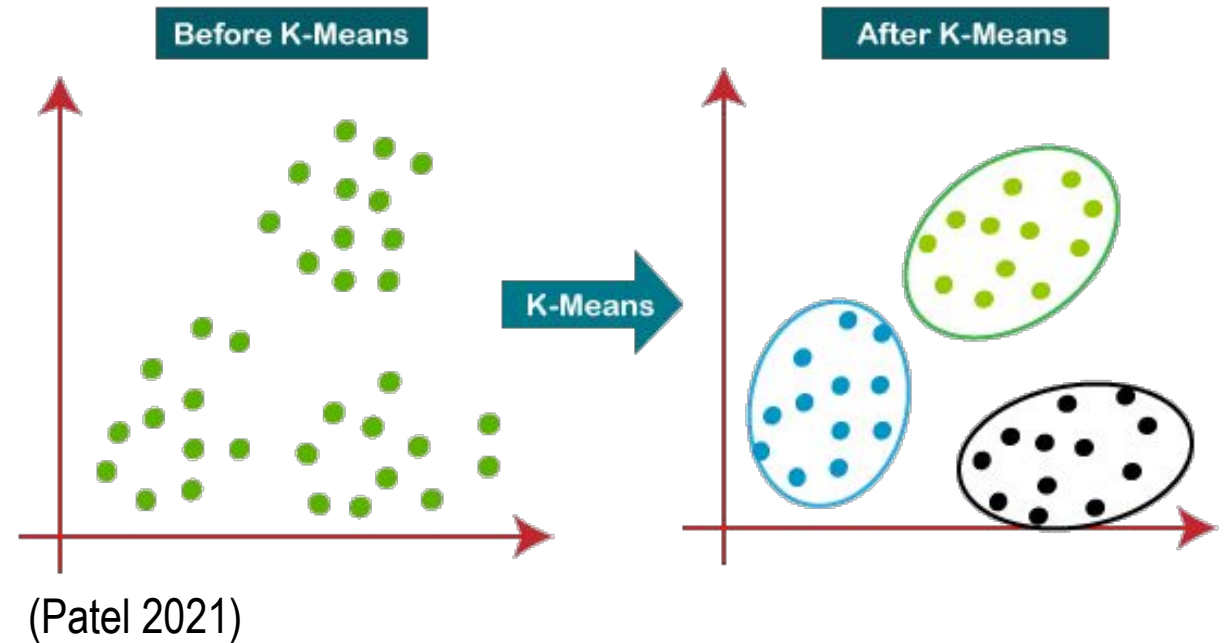
- An **unsupervised classification method** that partitions pixels into clusters based on similarity
- The number of clusters (**K**) is defined by the user

Unsupervised classification – K-Means



How K-Means Works

1. Select K cluster centers (centroids) randomly
2. Assign each pixel to the nearest centroid based on spectral distance
3. Compute new centroid positions as the average of assigned pixels
4. Repeat the process until clusters stabilize





Unsupervised classification – K-Means

Advantages

- Fast and efficient for large datasets
- No need for labeled training data
- Works well for initial land cover exploration

Disadvantages

- Requires predefined number of clusters (K)
- May assign similar land cover types to different clusters
- Sensitive to outliers and spectral variability



Supervised vs unsupervised classification

Aspect	Supervised classification	Unsupervised classification
Training data	Required	Not required
User involvement	High (training data & validation)	Lower (post-classification interpretation)
Accuracy	Typically higher	Can be lower due to spectral mixing
Best for	Thematic mapping, detailed studies	Quick analysis, unknown land cover
Example Methods	Maximum Likelihood, Random Forest, SVM	K-Means, ISODATA



Summary & key takeaways

Land cover classification is essential for remote sensing analysis

Supervised Classification requires training data and is more accurate

Unsupervised Classification is fully automated but requires interpretation

Choosing the right method depends on **data availability and project goals**

Sources



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Thank you for your attention!

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