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 **ÚSTAV GEOGRAFIE**  
Prírodovedecká fakulta UPJŠ v Košiciach

INTERNATIONAL REMOTE SENSING SUMMER SCHOOL , IV EDITION

Experiencing Remote Sensing on Sardinia inland site: Advanced summer school  
on instruments and methodology for a CAL/VAL site for Optical data

SAN VERO MILIS | SARDINIA, ITALY | 21. - 25. JULY 2025

# Sample UAV HS data classification

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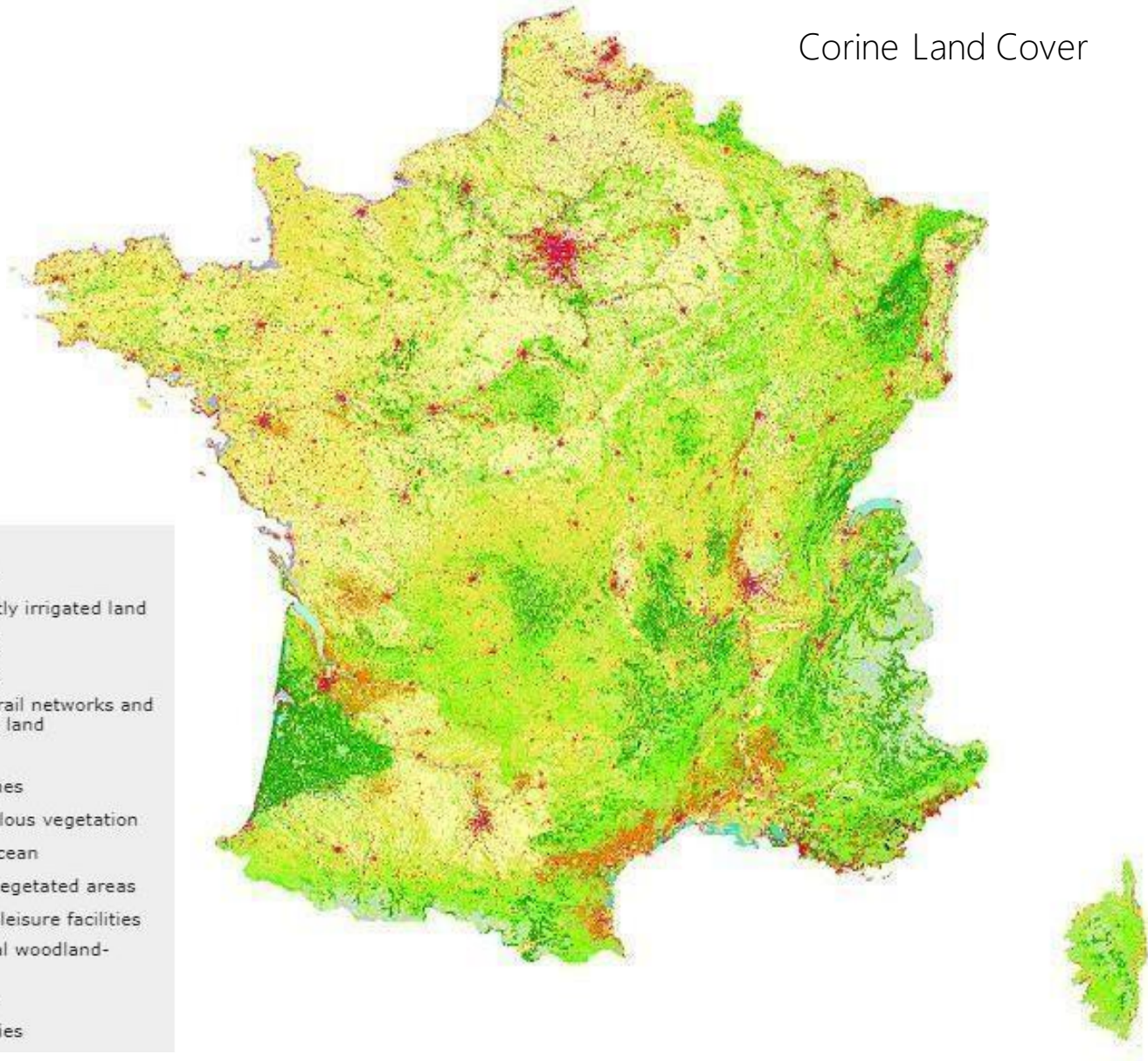
# Image classification

- The process of sorting pixels into a certain number of classes based on their data values
- Finding meaningful patterns in the data (spectral and spatial)
- Simplify/refine the interpretation of the RS record

## Legend:

 Agro-forestry areas	 Fruit trees and berry plantations	 Pastures
 Airports	 Glaciers and perpetual snow	 Peat bogs
 Annual crops associated with permanent crops	 Green urban areas	 Permanently irrigated land
 Bare rocks	 Industrial or commercial units	 Port areas
 Beaches, dunes, sands	 Inland marshes	 Rice fields
 Broad-leaved forest	 Intertidal flats	 Road and rail networks and associated land
 Burnt areas	 Land principally occupied by agriculture, with significant areas of natural vegetation	 Salines
 Coastal lagoons	 Mineral extraction sites	 Salt marshes
 Complex cultivation patterns	 Mixed forest	 Sclerophyllous vegetation
 Coniferous forest	 Moors and heathland	 Sea and ocean
 Construction sites	 Natural grasslands	 Sparsely vegetated areas
 Continuous urban fabric	 Non-irrigated arable land	 Sport and leisure facilities
 Discontinuous urban fabric	 Olive groves	 Transitional woodland-shrub
 Dump sites		 Vineyards
 Estuaries		 Water bodies

Corine Land Cover

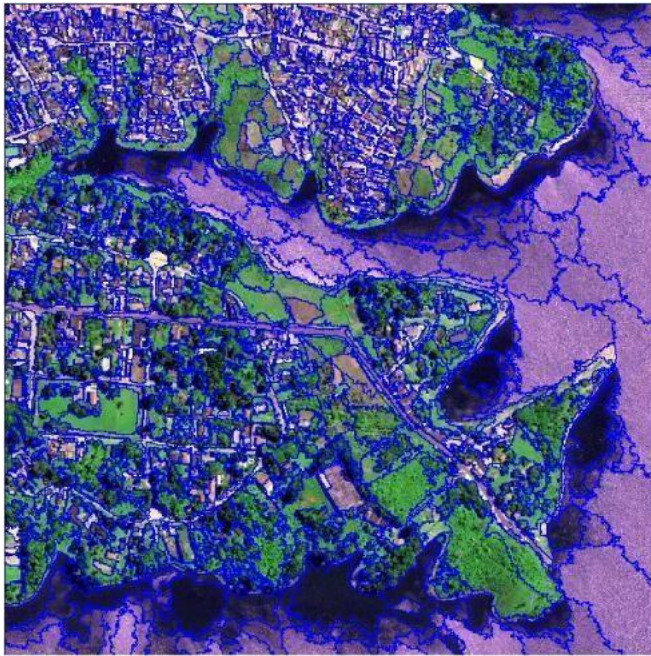




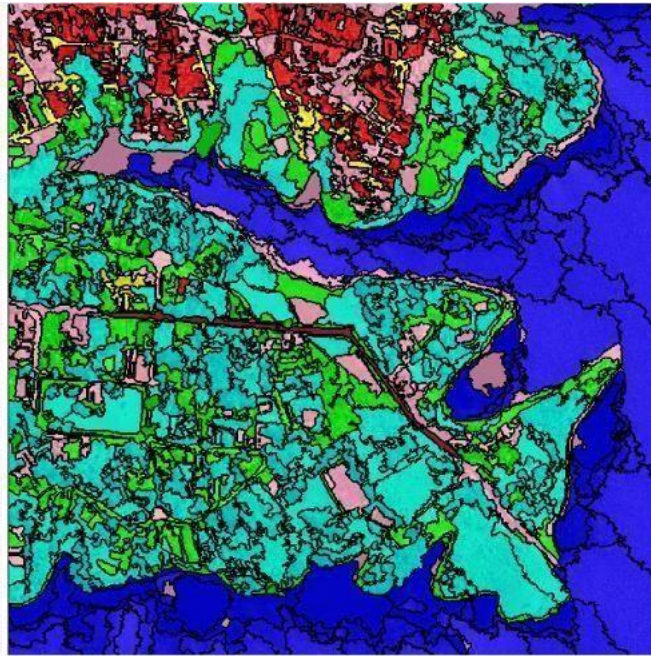
## 2 approaches

### a) Object-oriented (OBIA) (OBIA)

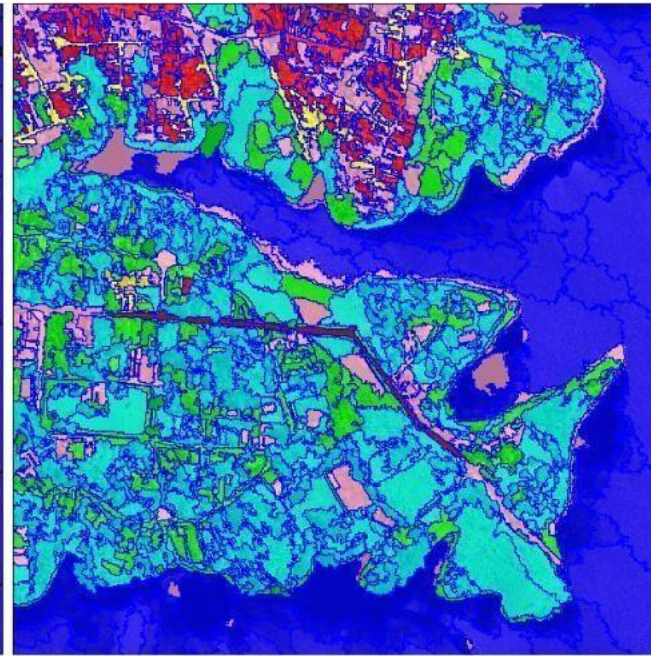
- It uses both spectral information and its spatial distribution



(a) Segmented



(b) Classified



(c) Region merged



## 2 approaches

---

### b) Pixel- based (per-pixel)

- It uses only spectral information
- It does not use spatial distribution and neighborhood relations

#### Types:

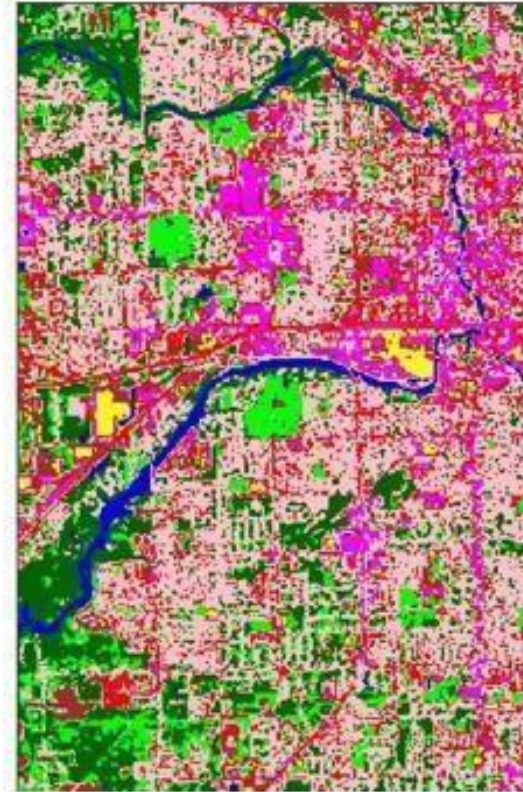
- Supervised classification
- Unsupervised classification
- Based on a different rule



# Unsupervised classification

- The raw spectral data are grouped based on the statistical structure of the data only
- Then the computer assigns each statistical cluster into the appropriate class (if possible)

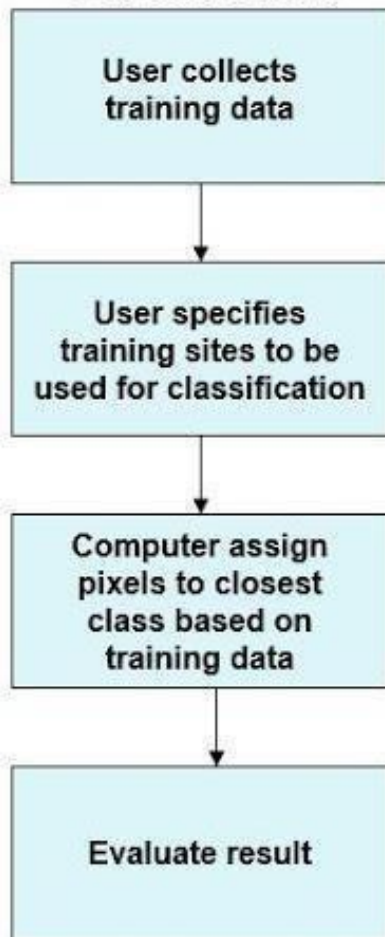
**20 Clusters**  
**6 Iterations**



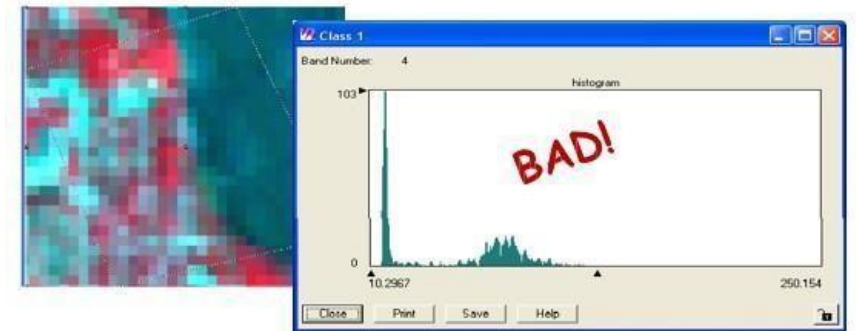
October 2015

# Supervised classification

## Supervised Classification



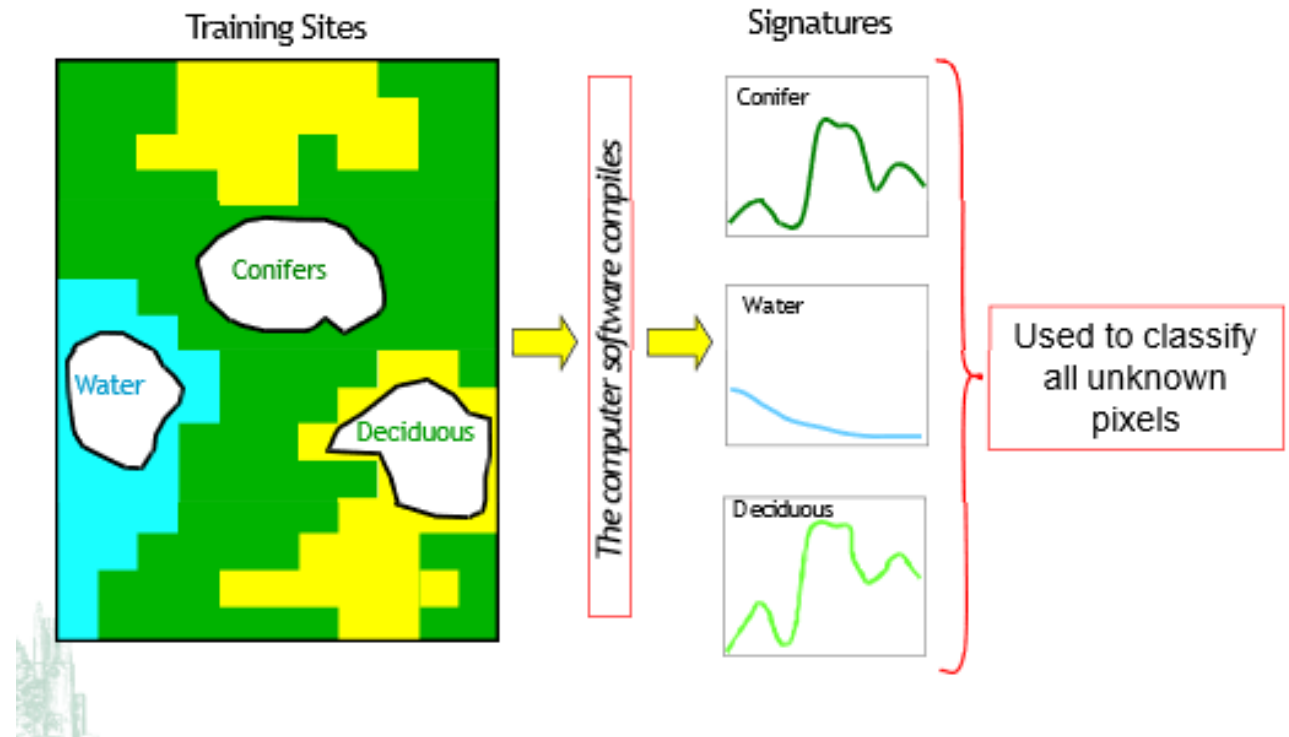
- The user defines homogeneous, representative samples, so-called training samples (areas) of different types of land cover
- Based on the selected algorithm, the computer assigns the pixels to the visually closest class based on the training areas
- Good knowledge of the classified area and good visual interpretation are ideal



# Supervised classification

## Types:

- Minimum Distance-to-Means
  - average DN values
- Maximum Likelihood
  - probability of class membership
- Spectral Angle Mapper
  - the minimum angle from the n-dimensional spectral vector of the class





# CONTENT OF THIS PRACTICAL

1

Spectral signatures

2

Image classification



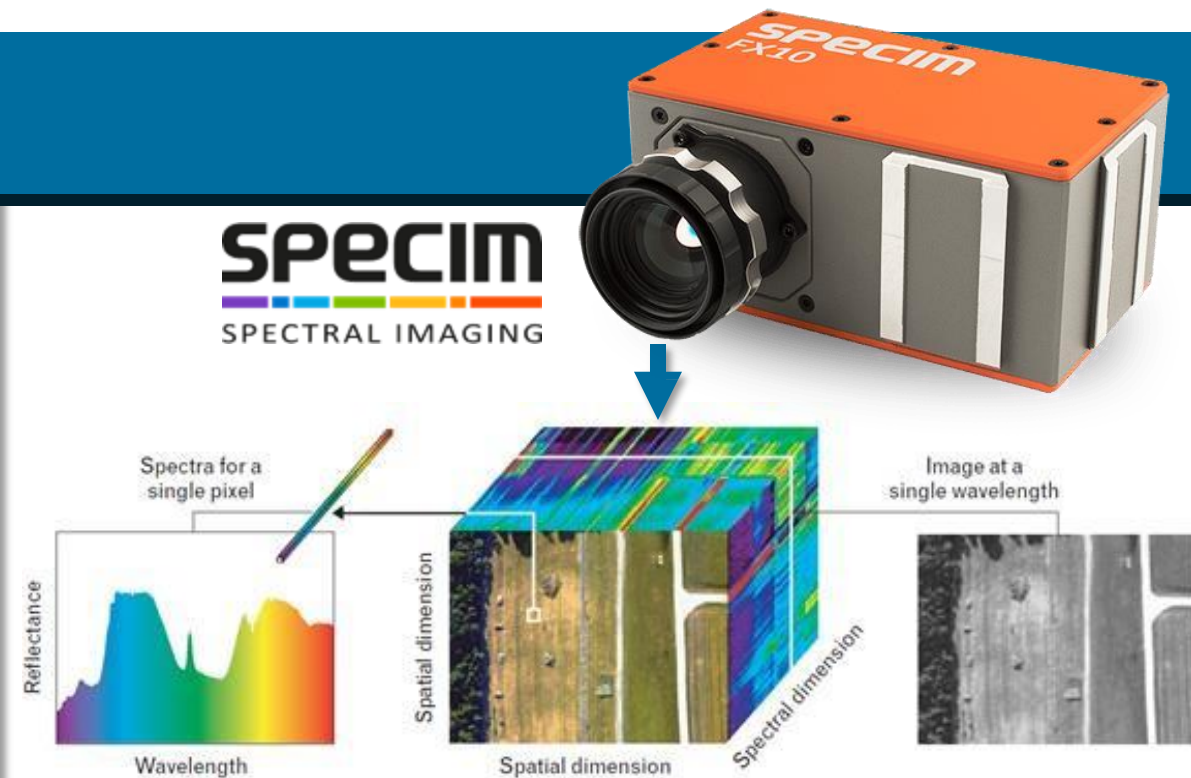
# INPUT HS DATA

## AISA Kestrel 10

- Push-broom camera, 4.75 kg
- Spatial resolution: 1024 or 2048 pix.
- Spectral range: 400 – 1000 nm
- Max. number of spectral bands: 342

## + INPUT LS DATA

- CHM (Canopy Height Model)



- Capture reflected electromagnetic energy in hundreds of contiguous narrow spectral bands
- Combined with UAS:
  - fast, flexible and non-destructive detection of subtle spectral features



MULTISPEC

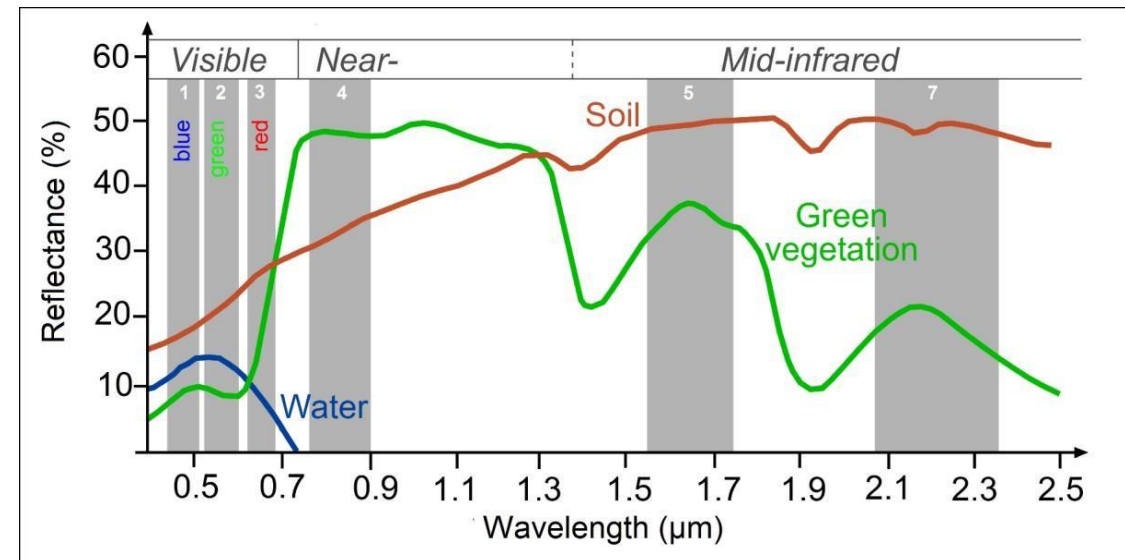
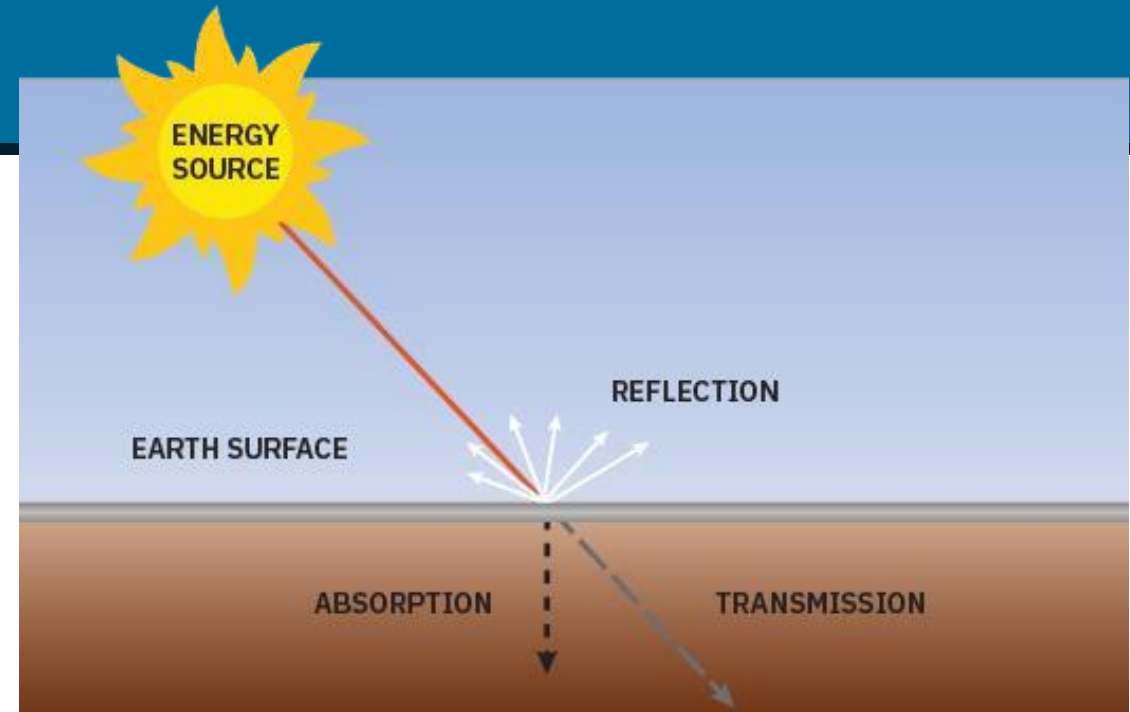
# I. SPECTRAL SIGNATURES



# STATE-OF-THE-ART

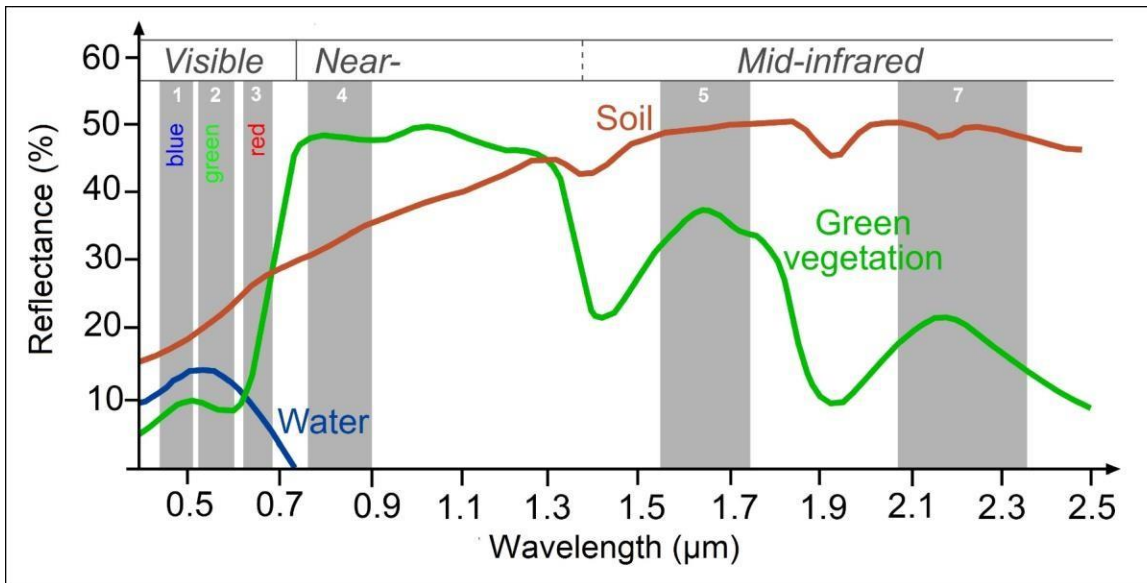
## Spectral signatures and their interpretation

- When EMR from the sun reaches the earth surface, it is:
  - transmitted
  - absorbed
  - reflected
- The nature of how the earth materials transmit, absorb or reflect the solar EMR is called **spectral signature** of an object



# SPECTRA OF EARTH MATERIALS

- Objects/surfaces have different combination of transmittance, absorption and reflectance in different bands of the spectrum



## Vegetation Reflectance

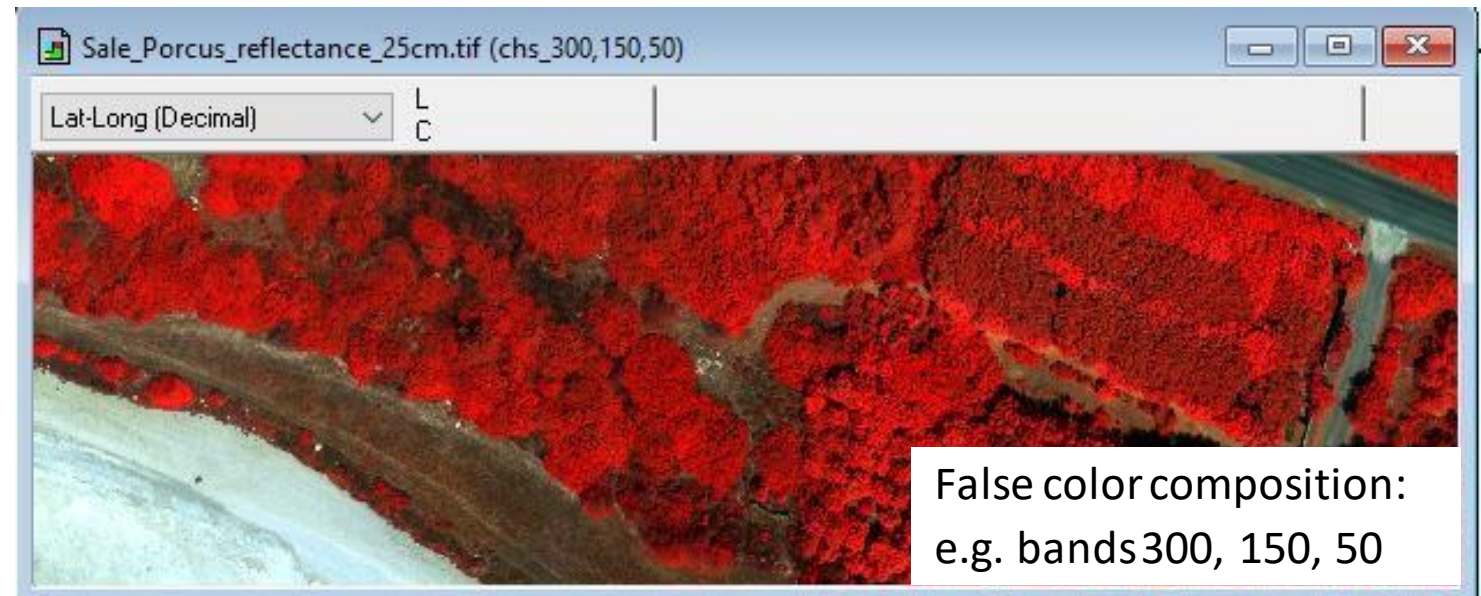
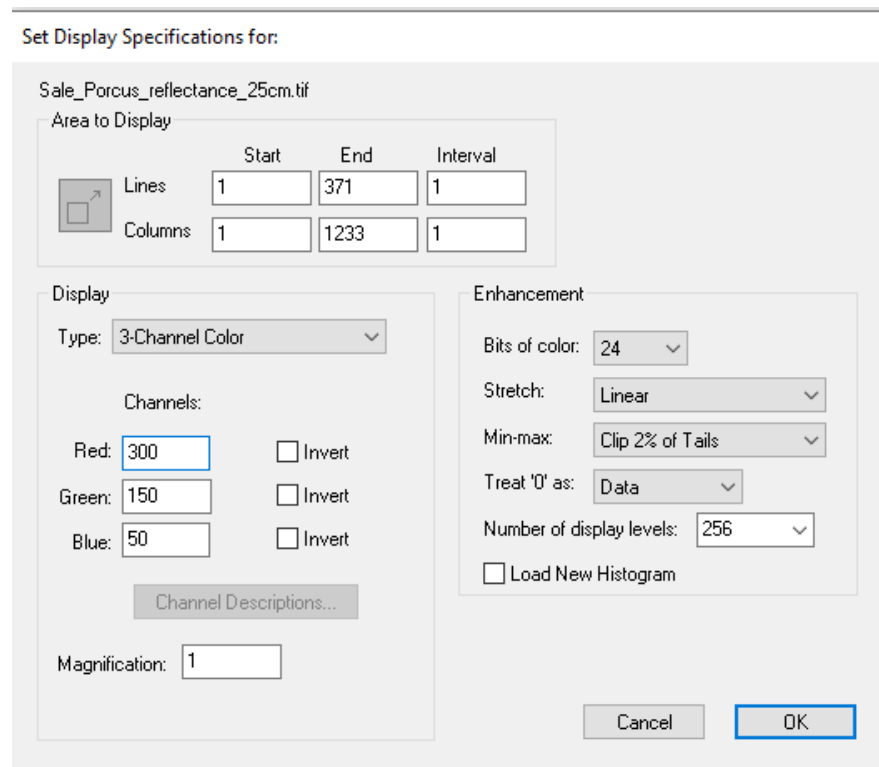




# SPECTRA OF EARTH MATERIALS

## 1.) Data review:

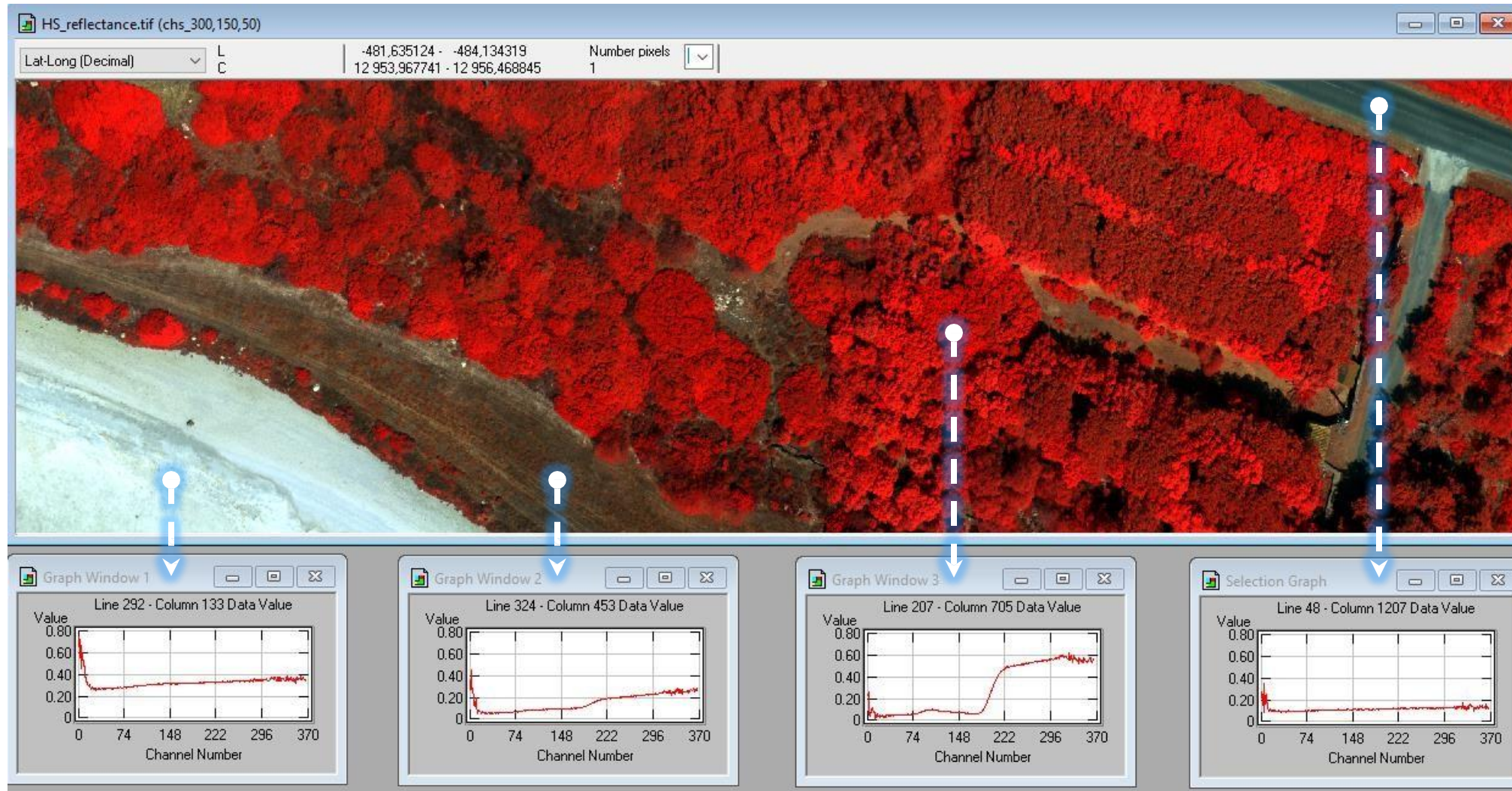
**File - Open Image** - after selecting the file, a window called Set display specifications opens, which is used to set the visualization parameters of the selected file. In the Channels item, three bands can be selected, which will then be displayed in the form of a color composition (synthesis). It is also possible to edit the image by changing the settings in the Enhancement item.



An example of displaying the false color composition using data from the HS scanner AISA KESTREL and the corresponding RGB bands of the scanner.

## 2.) Display of the spectral curves:

### Window – New selection graph

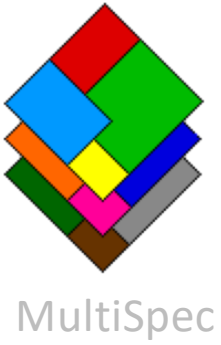






MULTISPEC

## II. IMAGE CLASSIFICATION



# UNSUPERVISED CLASSIFICATION



# 1. Open image

*File - Open Image*

# 2. Write Cluster Report/Map to

*- Cluster mask file*

*- Image Window Overlay*

# 3. Choose unsupervised classification algorithm:

*Processor - Cluster - choose algorithm*

*- ISODATA or Single pass*

Set Cluster Specifications

Algorithm

☐ Single Pass...

☒ ISODATA...

Channel: All Available

Cluster Classification Map Area(s)

☐ No classification map

☐ Training Area(s)

☒ Image Area

Area to Classify

	Start	End	Interval
Line	100	1000	1
Column	100	1000	1

Classification threshold 1024

Symbols: Default set

Cluster Stats: Do Not Save

Write Cluster Report/Map To:

☒ Text Window

☐ Text Disk File

☒ Cluster mask file: GeoTIFF

☒ Image window overlay

Add new overlay

Cancel OK

## 4. Set ISODATA Cluster specifications:

Compared to the Single pass algorithm, you can set the number of clusters (Number clusters) and, similarly to the previous case, the value of the minimum number of pixels forming a cluster (Minimum cluster size). The Convergence (%) parameter affects the number of successive repeated calculations of new cluster centers - iterations. If the number of pixels that do not change their belonging to a certain cluster during the iteration exceeds the specified value, then so-called clusters are created. stable and the calculation is finished.

The method of cluster initialization, which you set in the upper left part of the window (Initialization options), is also important for the classification result. Here you determine how the initial positions of the clusters are to be established in the multidimensional space defined by the individual input bands. The first two options mean that the initial position of the clusters is determined by the principal component analysis method, the third option takes over the result of the single-pass algorithm

Set ISODATA Cluster Specifications

Initialization Options

- ☐ Along first eigenvector
- ☒ Within eigenvector volume
- ☐ Use single-pass clusters

Other options

Number clusters: 6

Convergence (%): 99

Minimum cluster size: 20

Determine clusters from

- ☐ Training Area(s)
- ☒ Image Area

Area to Cluster

	Start	End	Interval
Line	100	1000	1
Column	100	1000	1

Cancel

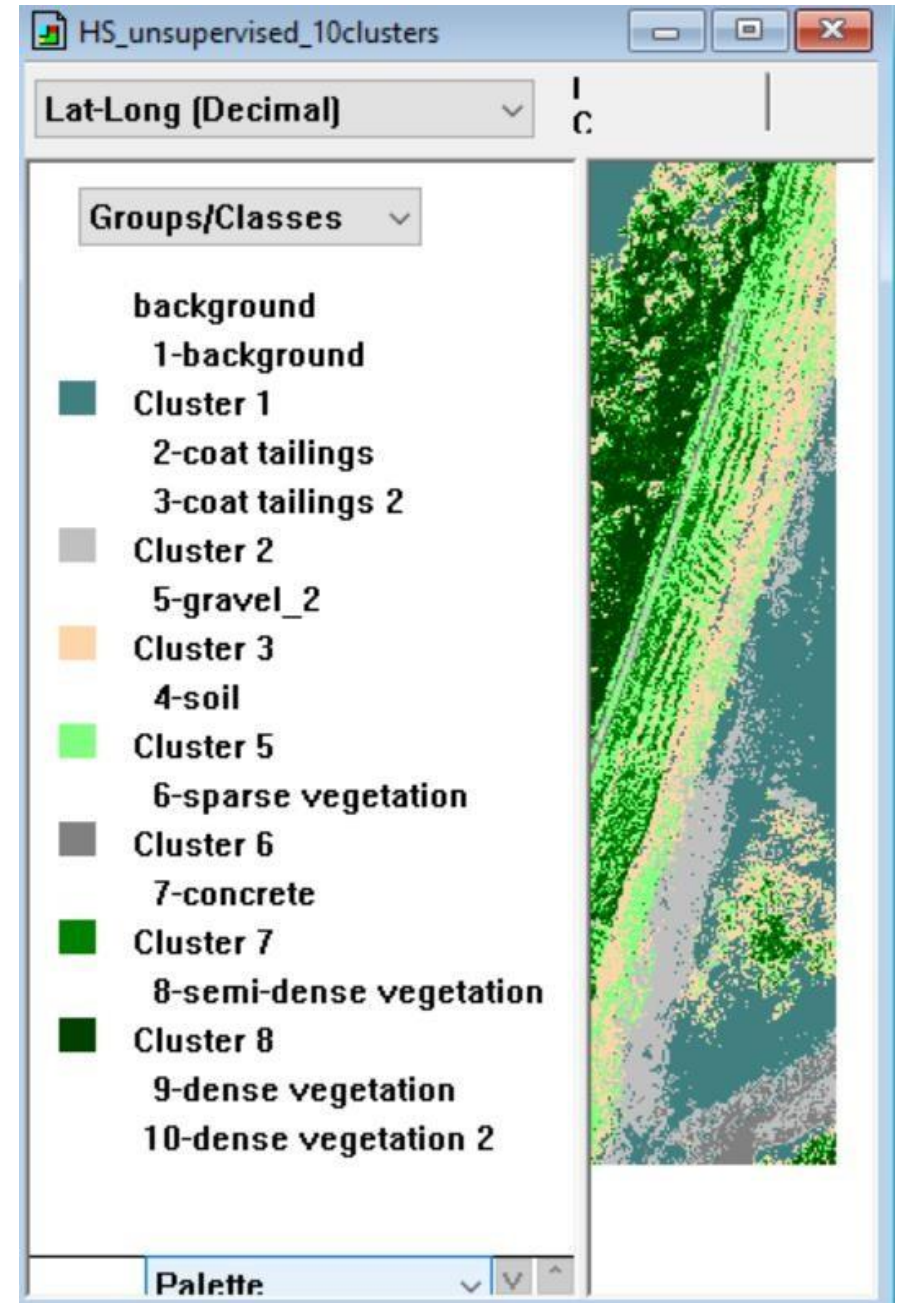
OK

## 5. Editing the result of unsupervised classification

The clustering result is a thematic map stored in the \*.clu file. In the text window of the Multispec program, you will also see the results of the classification in a clear tabular form. Above all, you will find here the resulting number of clusters and the number of pixels included in each of them. Open the saved classification file using the **File – Open Image menu**.

With a larger number of clusters and thus resulting spectral classes, the classified image is difficult to interpret. The colors of individual clusters in the image can be changed by double-clicking on the color icon next to the cluster so that they simulate the color presentation of the selected synthesis. This will make it much easier for you to interpret individual classes, recognize them, or eventually combine (aggregate) several spectral classes (clusters) into categories of basic types of surfaces.

Analogously, you change the name of individual classes by double clicking on the text next to the colored square of the legend.





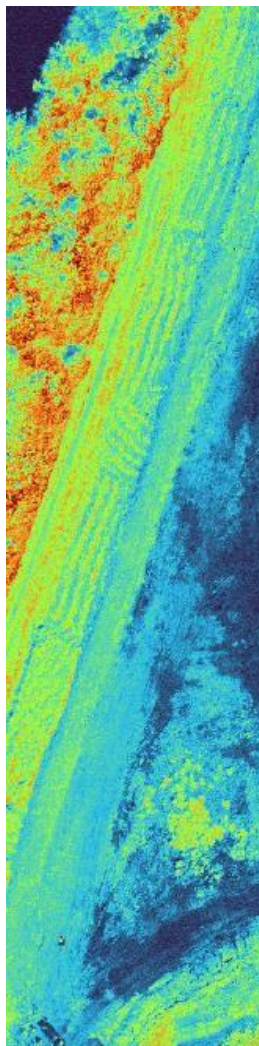
## 6. Repeat the process of unsupervised classification with „stacked data“ – HS + CHM

HS data

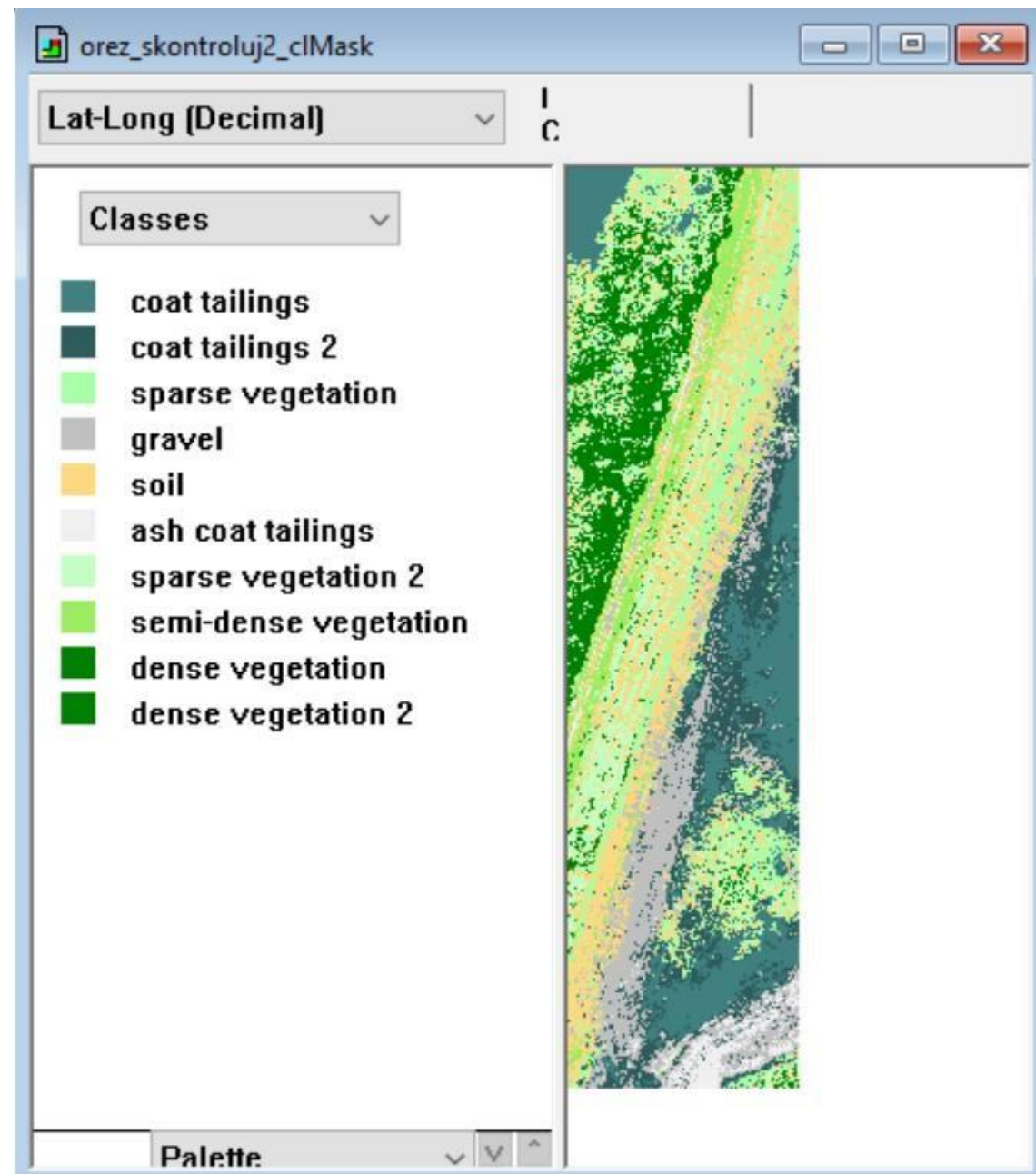


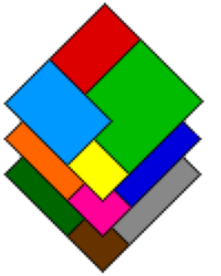
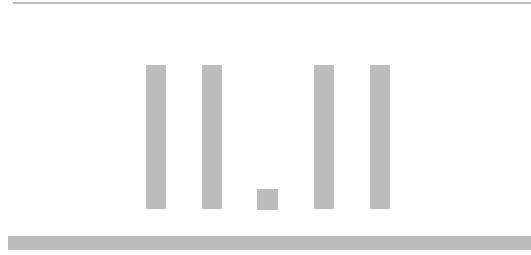
+

LS data – CHM model



=





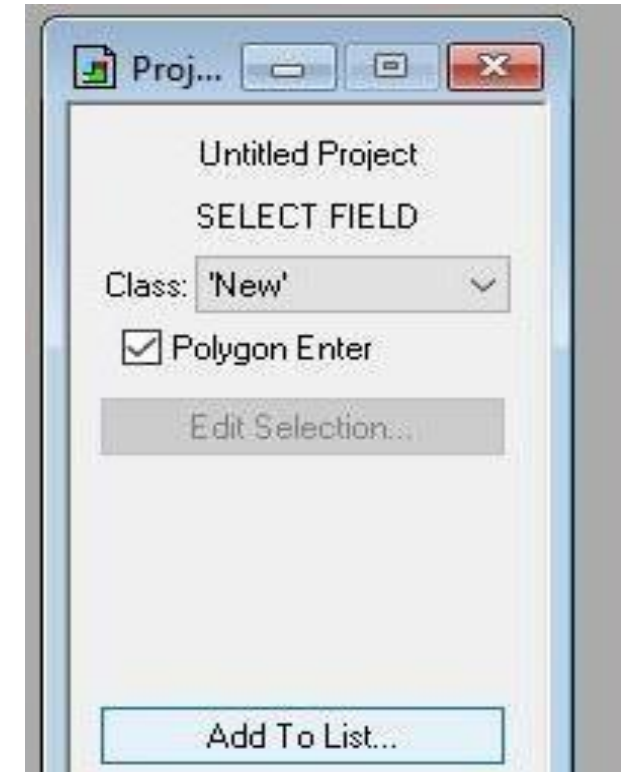
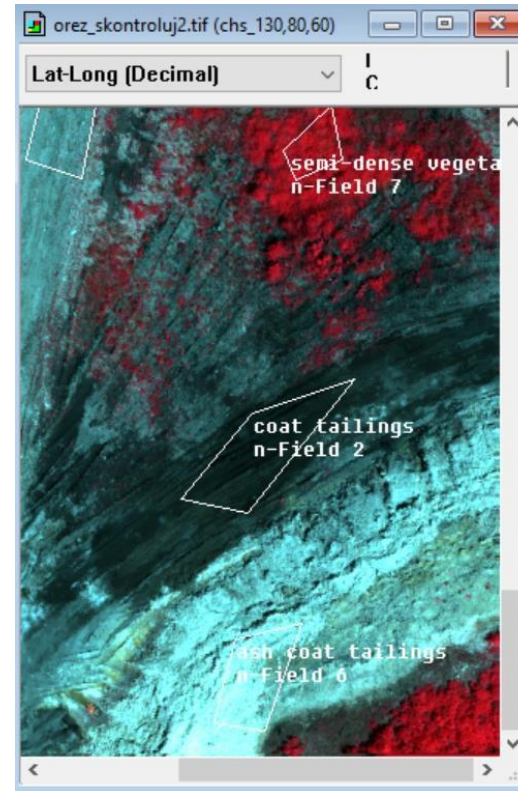
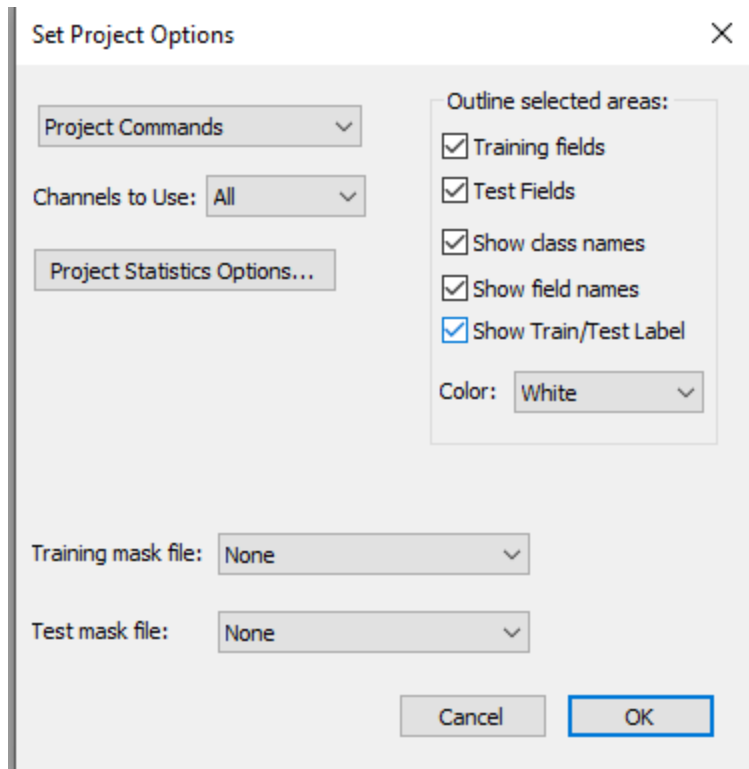
MultiSpec

# SUPERVISED CLASSIFICATION

## 1. File - Open Image

## 2. Create training samples (polygons) - *Processor – Statistics ...* Set Project Options.

In this window, check the item **Show Train/Test Label** and confirm the choice. A new window will open where you can check the **Polygon Enter** option to start creating a training sample for the corresponding land cover type. After creating a training sample (polygon), it is necessary to add the sample to the list via the Add To List option... Via the "New" Class option, we enter the name of the new class, into which other clicked training samples for the same type of land cover will be gradually included. If we want to add a polygon to an already existing class, from the Class drop-down menu we choose the corresponding, already created class, in which we want to include the sample.





- **3. Processor – Classify** opens a window called Set Classification Specifications. In this window, you can choose both the qualifier type (Procedure menu) and the selected input parameters of the selected procedure. Leave the default values of the parameters, but check the Disk file box, which will allow you to save the classification results in a new file of the type e.g. GeoTIFF to disk. You can also check the Image Window Overlay option to directly display the classification result in the MultiSpec window. Confirm the Update project statistics window and save the output.

*Classifiers that can be used for classification:*

- *Maximum likelihood (maximum likelihood classifier - belongs to the most frequently used decision rules in controlled classification of satellite images and gives good results with suitable training areas)*
- *Correlation (SAM) – classification of the so-called spectral angle, a decision rule originally used for hyperspectral image data...*

Set Classification Specifications

Procedure: Gaussian Maximum Likelihood

Channels: All Available

Target: Base Image

Classify:

Class areas: All

☒ Training (resubstitution)

☐ Training (leave-one-out)

☐ Test areas (holdout)

☒ Image selection

Area to Classify

	Start	End	Interval
Lines	100	1000	1
Columns	100	1000	1

Classes: All

Class weights: Equal

Symbols: Default set

Write classification results to:

☒ Disk file: GeoTIFF

☒ Image Window Overlay

Add new overlay

Palette: Default Colors

☐ Threshold results at

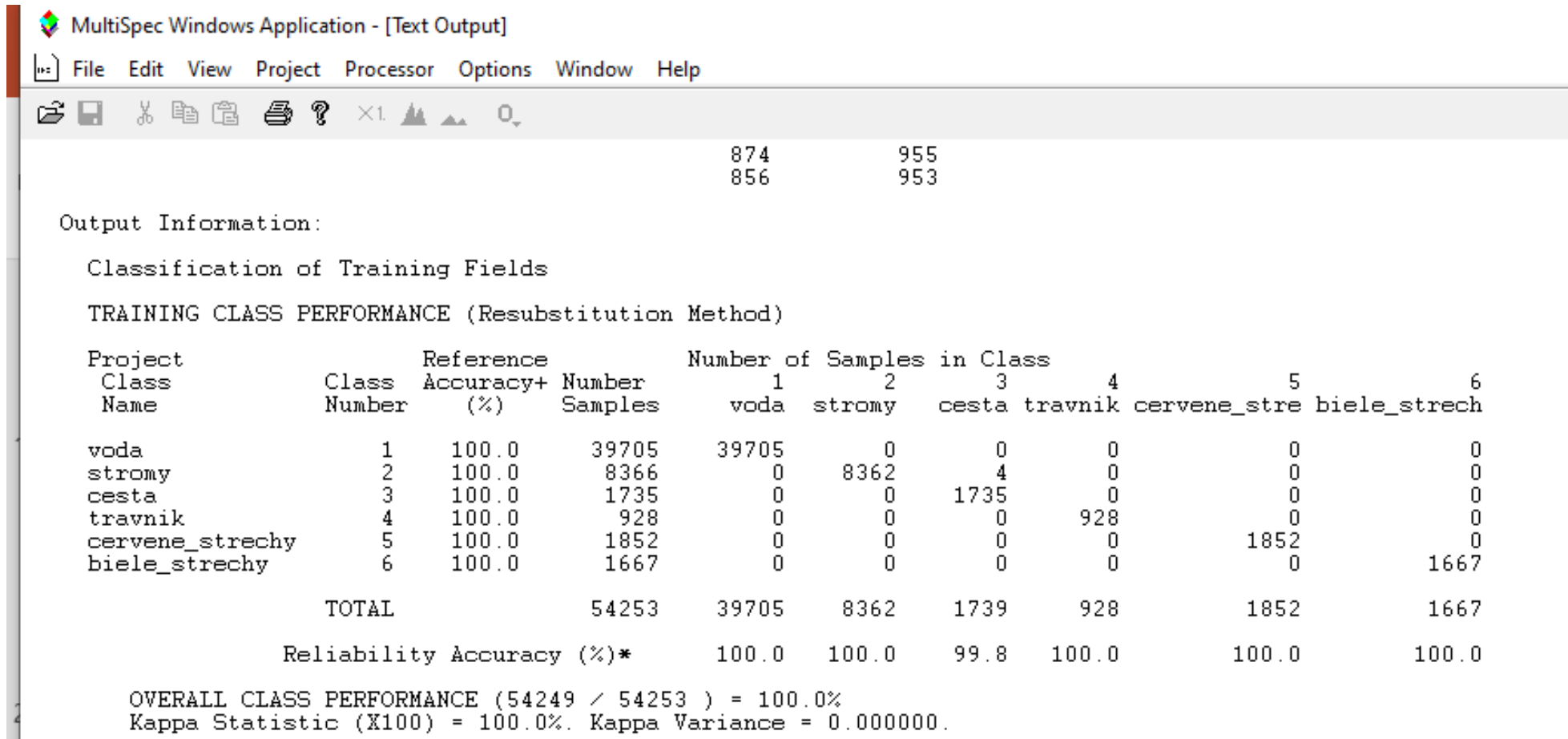
☐ Create Probability Results File

Results List Options...

Cancel OK

## 4. Evaluation of the result of supervised classification

-In addition to the file with classified data, the output of individual algorithms is also directed to the **text window** of the Multispec program. This window can be saved as a text file using the menu File - Save text output as...



The screenshot shows the 'MultiSpec Windows Application - [Text Output]' window. The menu bar includes File, Edit, View, Project, Processor, Options, Window, and Help. The toolbar contains icons for file operations and zooming. The main text area displays the following output:

```
Output Information:

Classification of Training Fields

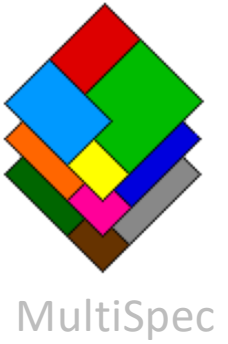
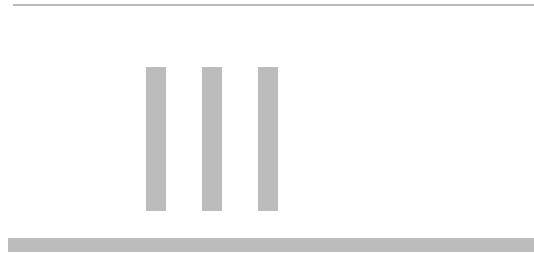
TRAINING CLASS PERFORMANCE (Resubstitution Method)

Project      Class      Reference      Number      Number of Samples in Class
Class        Number      Accuracy+     Samples      1          2          3          4          5          6
Name                                     voda  stromy  cesta  travnik  cervene_stre  biele_strech
voda         1          100.0        39705      39705         0         0         0         0         0
stromy       2          100.0        8366       0          8362         4         0         0         0
cesta        3          100.0        1735       0           0        1735         0         0         0
travnik      4          100.0         928       0           0         0         928         0         0
cervene_strechy 5          100.0        1852       0           0         0         0        1852         0
biele_strechy 6          100.0        1667       0           0         0         0         0        1667

TOTAL                                     54253      39705      8362      1739      928        1852      1667

Reliability Accuracy (%)*      100.0    100.0    99.8    100.0        100.0    100.0

OVERALL CLASS PERFORMANCE (54249 / 54253 ) = 100.0%
Kappa Statistic (X100) = 100.0%. Kappa Variance = 0.000000.
```



# PCA - Principal Component Analysis

- Creating new variables/components that are a linear combination of the original variables without substantial loss of information



### 1.) Open image

*File - Open Image*

**2. Transform the image** using the method of principal components by selecting **Processor – Utilities – Principal Component Analysis**. In the window that opens, you can set parameters that define the range of input data. The analysis can include all or only some of the bands of the hyperspectral image (Subset), the entire range of rows and columns or only a part of them

**3. Save eigenvalues/eigenvectors** - that are used to calculate the so-called main components – mutually uncorrelated data transformed into a new space. Also check the option to save as text output (Note: do not check the option to save to Disk file!). The transformation matrix can also be saved to a file on disk by selecting File – Save Transformation Matrix. It is saved in the directory where the original data is located as a file with the same name as the original data with the ending \*.TRA. The results of all calculations are also displayed in the text window of the program.

Set Principal Component Analysis Specifications

Area(s)

☒ Image Area

Selected Area

Lines

Start

End

Interval

100

1000

1

Columns

100

1000

1

Channel:

All

Options

☐ List eigenvectors

☐ Equalize variances (correlation matrix)

☒ Save eigenvalues/eigenvectors

Output results to

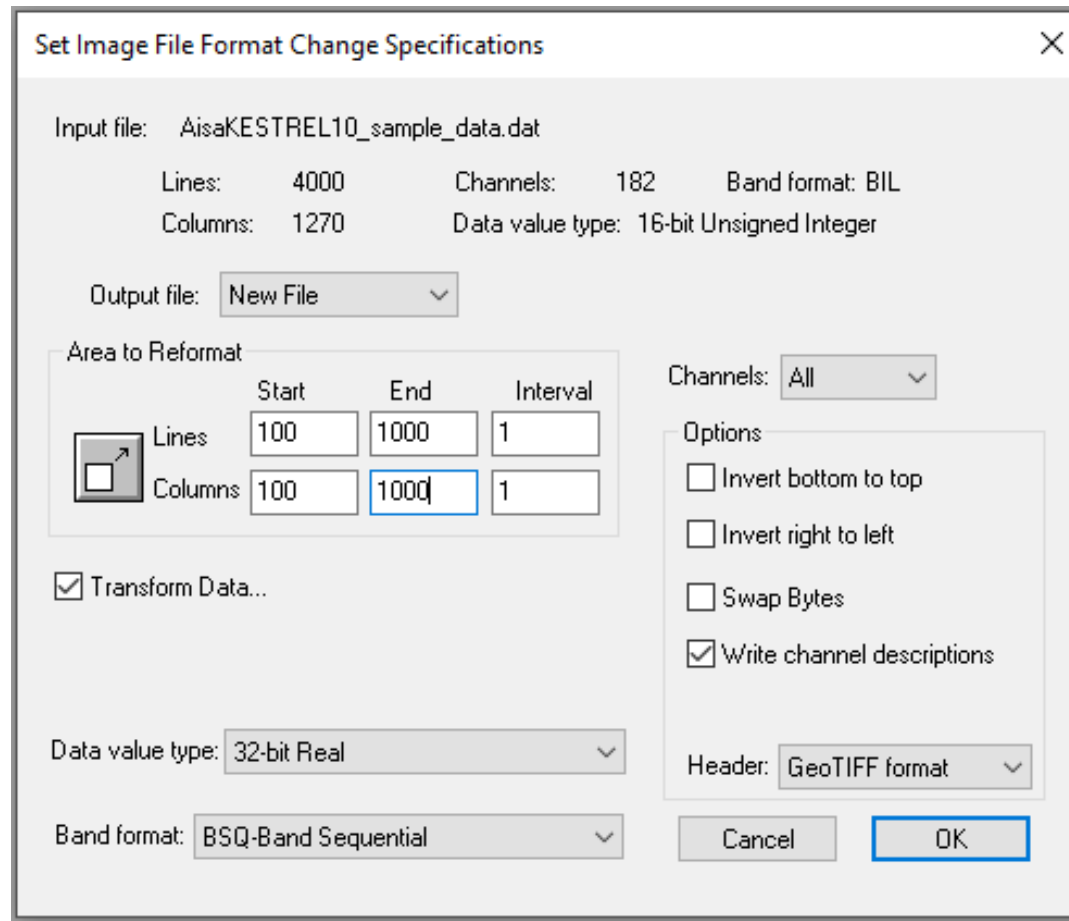
☒ Text window

☐ Disk file

Cancel

OK

4. **Processor – Reformat – Change Image File Format.** In the window that appears, check Transform data and in the new window choose New Channels from PC Eigenvectors. You can select only a subset (if you want to use only certain/significant principal components that e.g. comprise more than 3% - you can find them in the text window) or all bands. Confirm the following two requests with the OK button. Subsequently, you are invited to save the image created by the analysis of the main components in a **\*.LAN file**. Enter a file name and save it.



**Set Image File Format Change Specifications**

Input file: AisaKESTREL10\_sample\_data.dat

Lines: 4000      Channels: 182      Band format: BIL  
Columns: 1270      Data value type: 16-bit Unsigned Integer

Output file: New File

Area to Reformat

	Start	End	Interval
Lines	100	1000	1
Columns	100	1000	1

☒ Transform Data...

Data value type: 32-bit Real

Band format: BSQ-Band Sequential

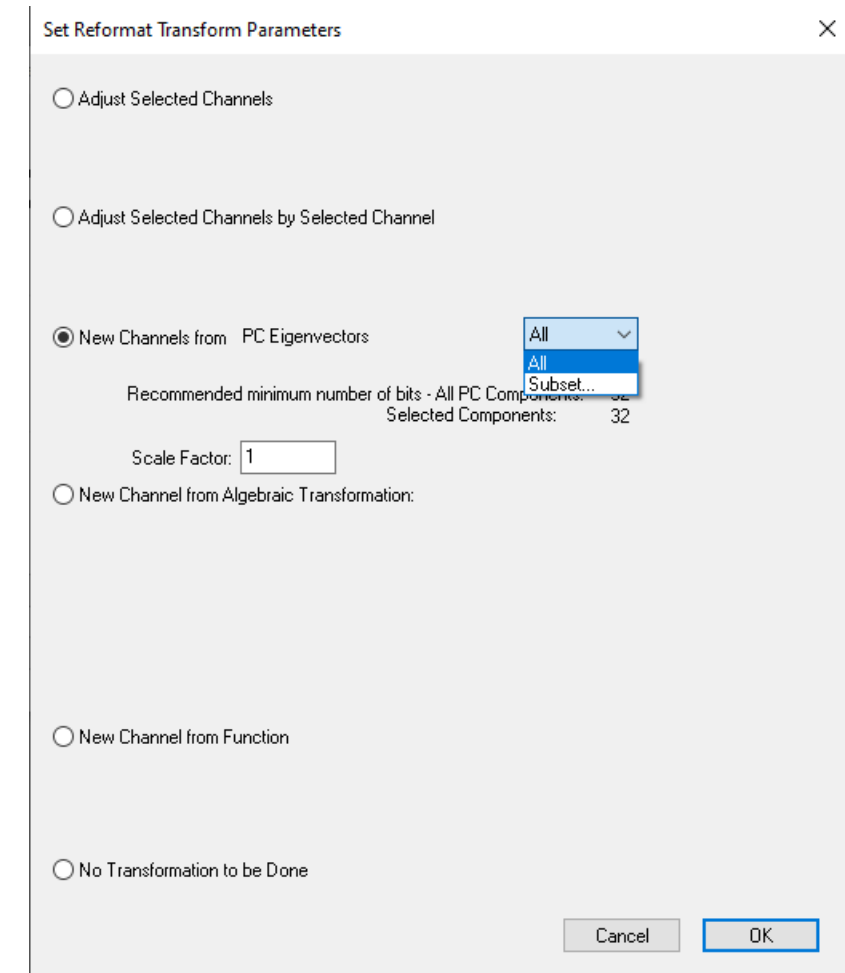
Channels: All

Options

- ☐ Invert bottom to top
- ☐ Invert right to left
- ☐ Swap Bytes
- ☒ Write channel descriptions

Header: GeoTIFF format

Cancel OK



**Set Reformat Transform Parameters**

☐ Adjust Selected Channels

☐ Adjust Selected Channels by Selected Channel

☒ New Channels from PC Eigenvectors

Recommended minimum number of bits - All PC Components: 32  
Selected Components: 32

Scale Factor: 1

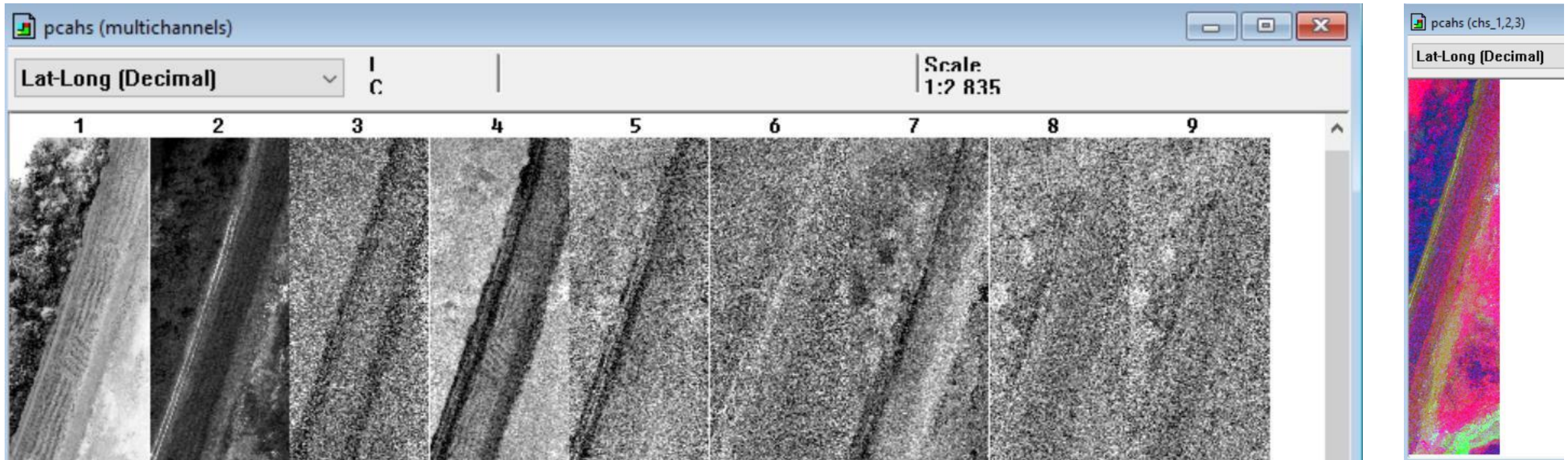
☐ New Channel from Algebraic Transformation:

☐ New Channel from Function

☐ No Transformation to be Done

Cancel OK

5. Next, you can view the transformed image. Choose File - Open Image. Select the resulting file of type \*.LAN. In the Set Display Specifications for ... window, select Side by Side Channels as the Display type. This allows you to view the individual main components side by side in the form of grayscale images, as in the images below.



*A sample of nine images transformed by the principal component analysis method from the AISA KESTREL bands. Notice the gradual loss of useful information, or noise increase in major components with higher numbers. PCA will therefore allow us to use instead of all bands after transformation for further work, such as to create a color composition, only a subset - the first e.g. three components that capture the largest part of the information, and we can neglect the remaining bands, as they include only a negligible part of the information. This will speed up e.g. subsequent creation of image classification.*



# CONCLUSION

- The aim of this practical was to demonstrate how quickly and (relatively) precisely we can classify HS data for e.g. estimation of land cover classes
- Fusion of HS and lidar data
- Spectral information, spatial (geometry) + surface structure (CHM)
- Today, we have even more sensitive and precise algorithms for HS data classification that generate even better results, like machine and deep learning, however, they require more time for processing/ and various input data



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THANK YOU  
FOR  
YOUR ATTENTION

Katarína ONAČILLOVÁ, Michal GALLAY, Ján ŠAŠAK

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