Grupo de Gráficos
y Geomática de Jaén

EPS
Escuela Politécnica
Superior de Jaén

IARIA

Aerial Hyperspectral Analysis:

DISTINGUISHING OLIVE VARIETIES FOR PRECISION AGRICULTURE

Ruth M. Córdoba Ortega
Alba Gómez Liébana
M.Isabel Rramos
Lidia M. Ortega
Juan M.Jurado

Universidad de Jaén

INDEX

EPS Escuela Politécnica Superior de Jaén

Objectives

General goal

Develop a precision agriculture **methodology based on hyperspectral analysis** for the **differentiation of olive varieties.**

Optimize agricultural management through **accurate variety identification** across large areas of land.

- Differenciate olive varieties
- Drone flight
- Automated process
- Optimize agricultural management

Importance of the Study

Accurate identification of olive tree varieties is essential to ensure product quality and to **optimize agricultural management** by adjusting inputs and irrigation practices according to the specific characteristics of each variety.

MANUAL AND RUDIMENTARY PROCESSES

Agricultural technicians rely on manual or imprecise methods to identify olive varieties.

MEDIUM-SCALE COVERAGE

Drones provide an intermediate resolution—higher than satellite imagery but lower than laboratory analysis.

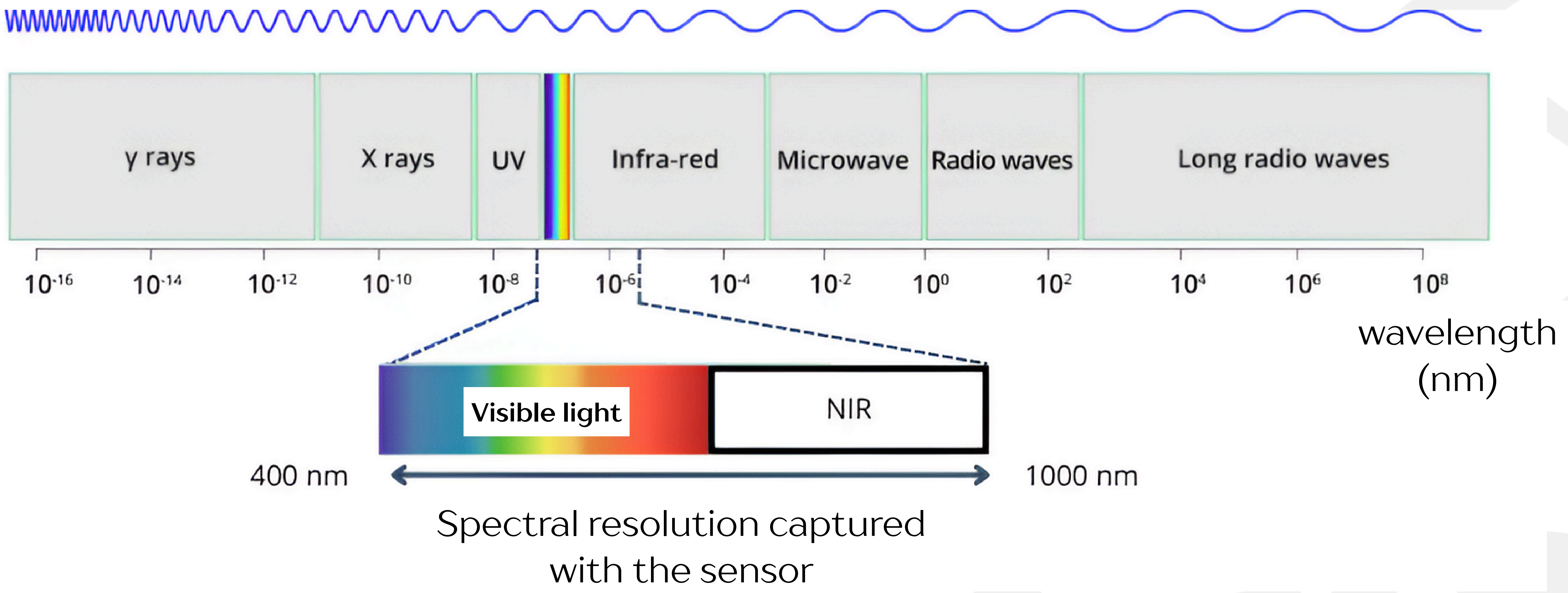
FRAGMENTED MANAGEMENT

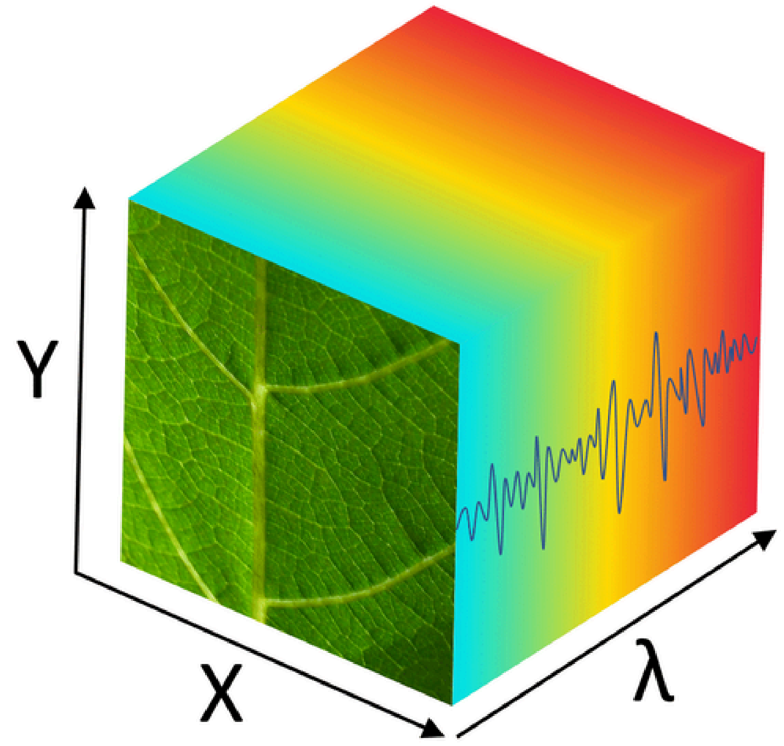
Olive grove management must be tailored to each variety to optimize productivity.

- IRRIGATION MANAGEMENT
- HERBICIDE APLLICATION
- HARVESTING SCHEDULES

HYPERSPECTRAL TECHNOLOGIES

HYPERSPECTRAL IMAGING (HSI) AS A FUNDAMENTAL TECHNOLOGY IN PRECISION AGRICULTURE





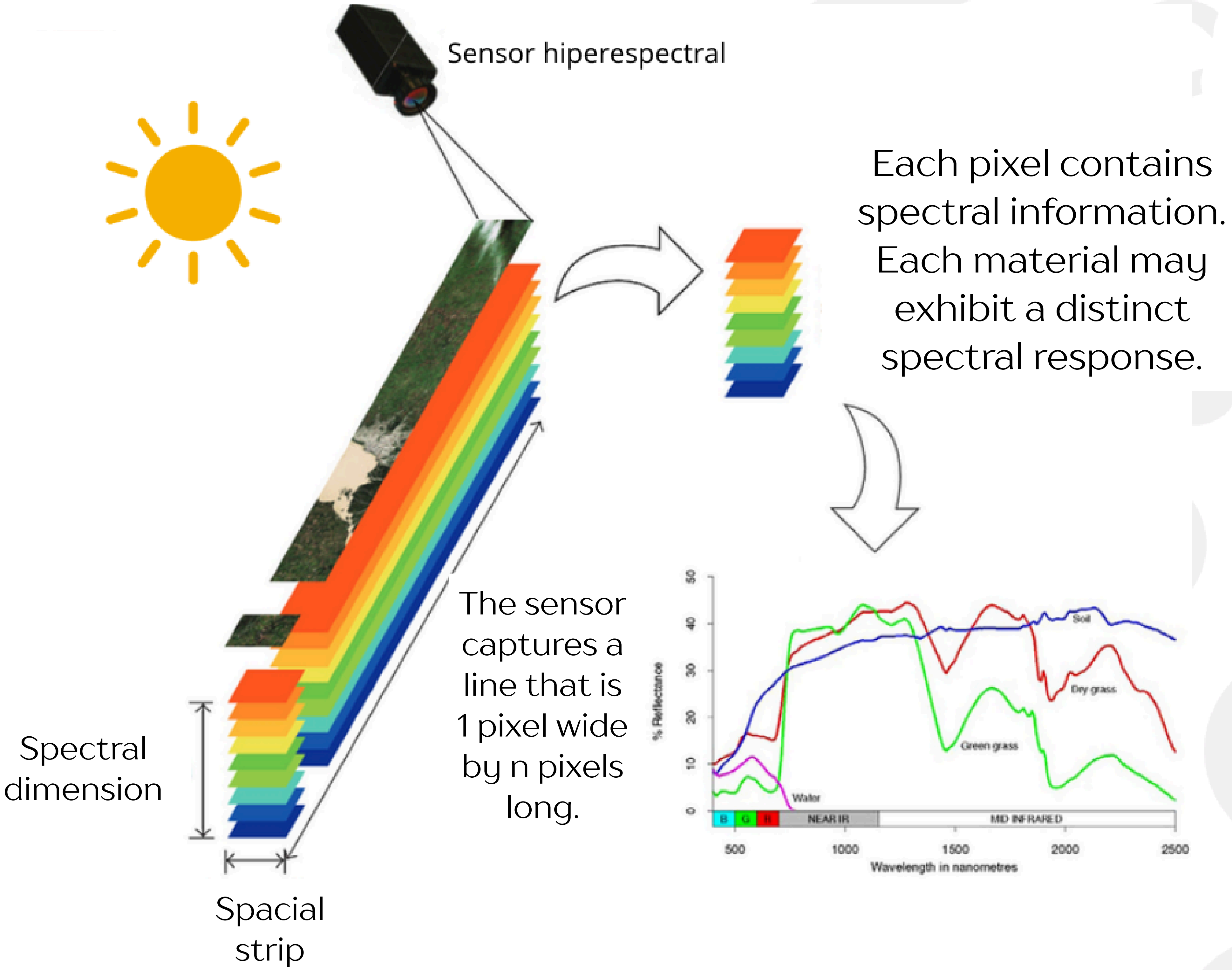
This ability to detect subtle differences across the full spectrum is highly valuable for identifying **slight variations in the biophysical or biochemical properties**.

HYPERSPECTRAL TECHNOLOGIES

HYPERSPECTRAL IMAGING (HSI) AS A FUNDAMENTAL TECHNOLOGY IN PRECISION AGRICULTURE

Hyperspectral Data Acquisition Methods:

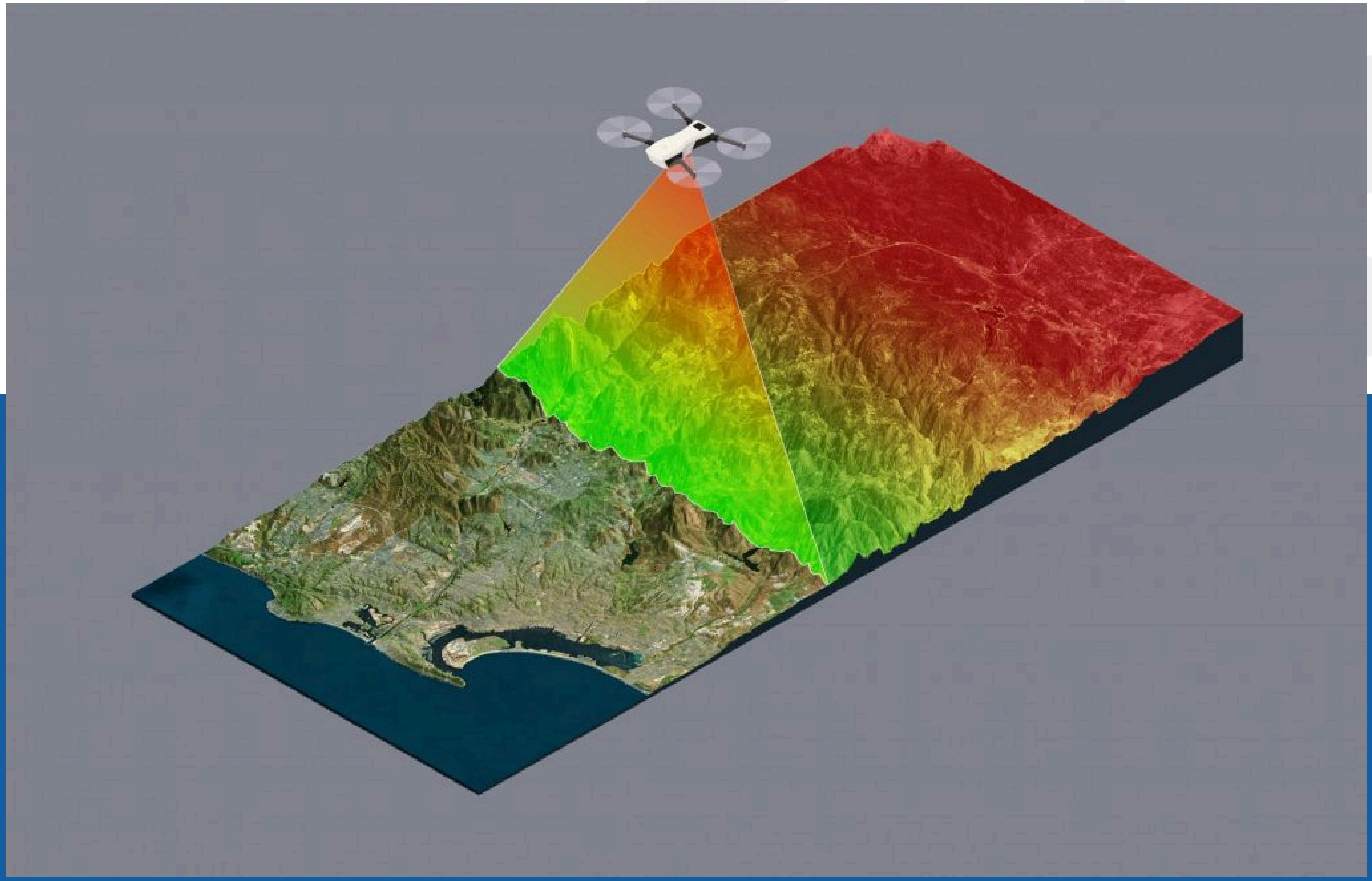
- Point Scanning
- **Line Scanning**
- Snapshot Scanning



LiDAR TECHNOLOGY

NECESSARY FOR THE CORRECTION OF HYPERSPECTRAL DATA

LiDAR is an **active remote sensing** technology that uses laser light pulses to measure distances and generate detailed three-dimensional representations of objects and environments.



Generated products:

- **High-precision point clouds**
- **Digital Elevation Models (DEM)**
- **Digital Surface Models (DSM)**

Materials and equipment

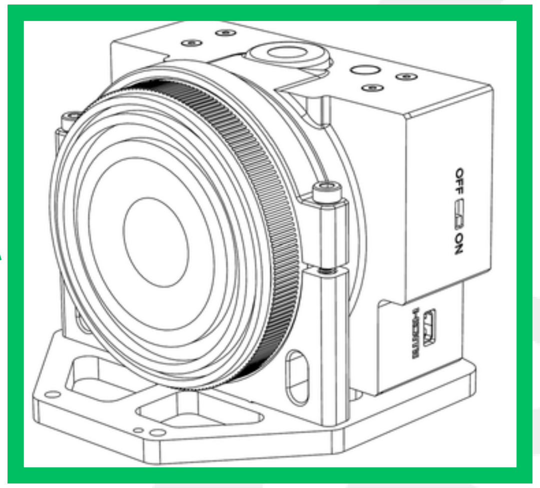
The following sensors are incorporated into a single UAV platform:

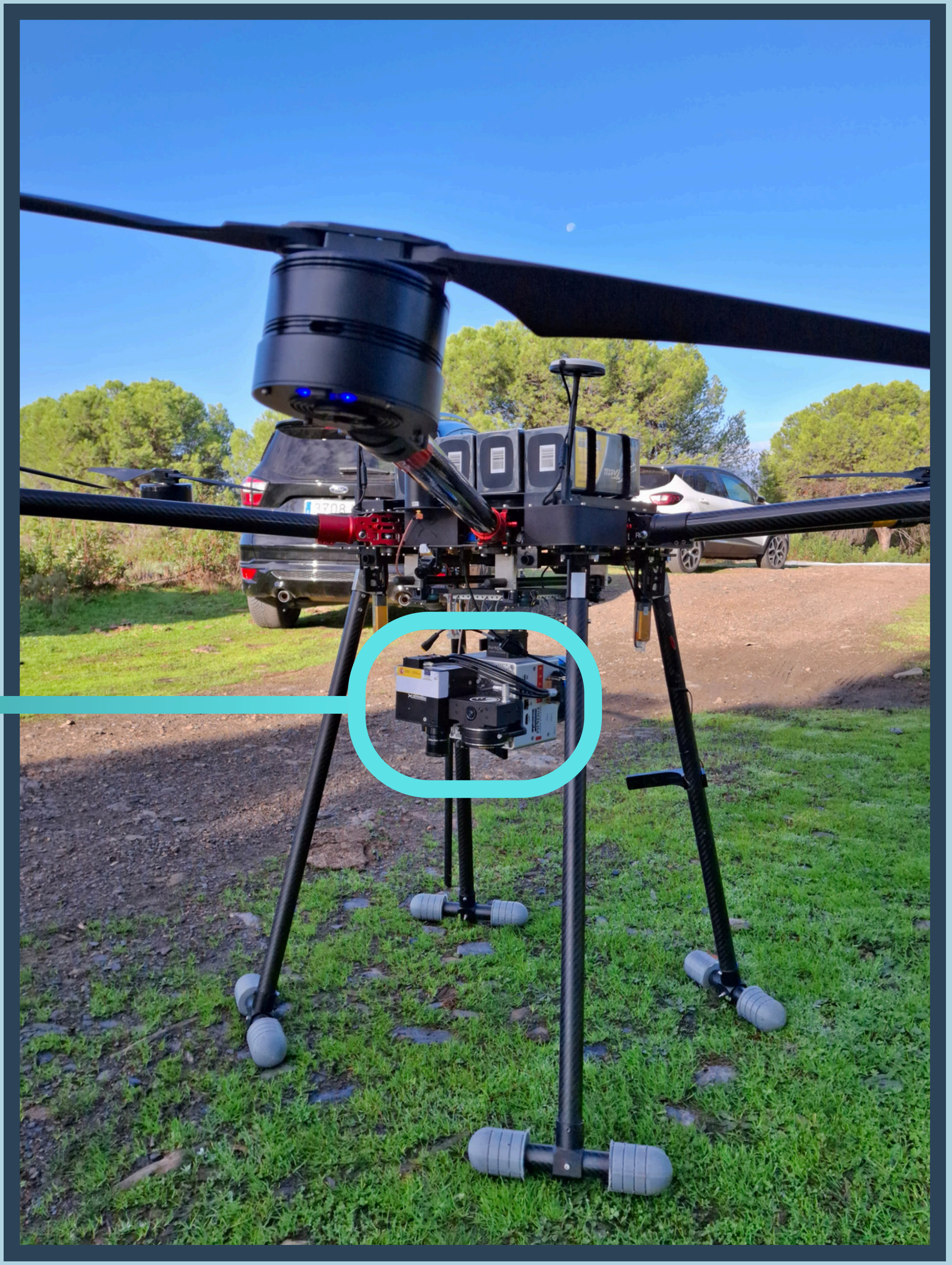
- **Hiperespectral**
- **LiDAR**
- **RGB camera**

Phoenix LiDAR scout-Ultra

Nano Hyperspec VNIR

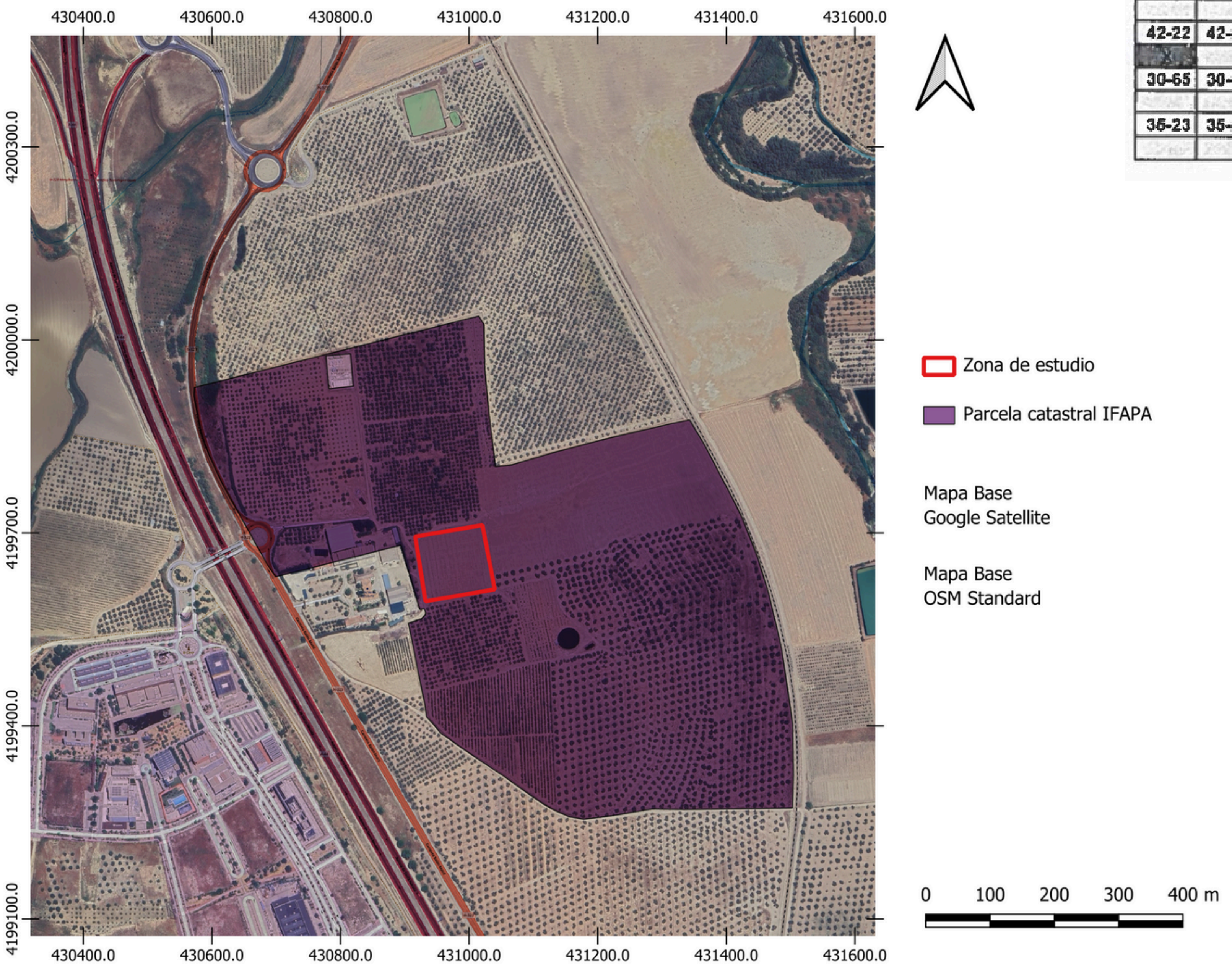
Phoenix LiDAR A6K-Lite



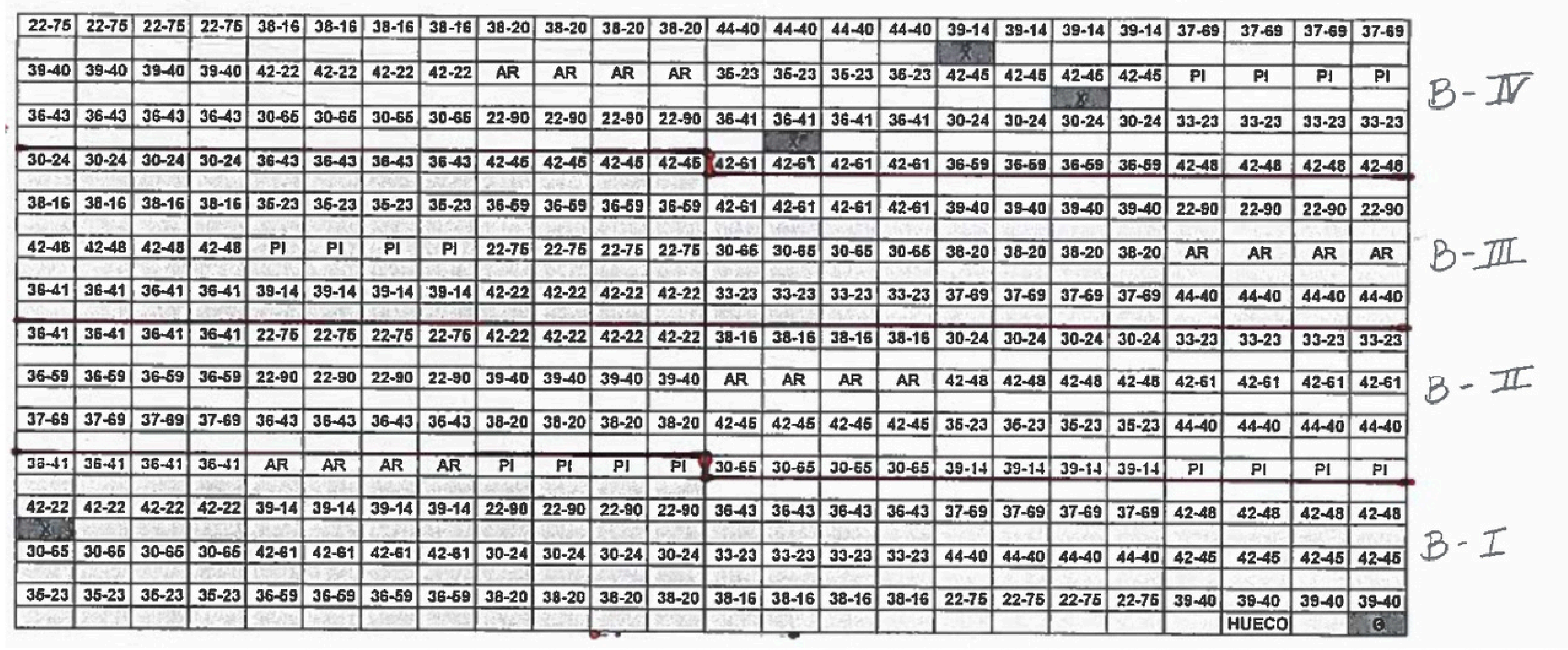


Study area

Instituto de Investigación y Formación Agraria y Pesquera de Andalucía (**IFAPA**)

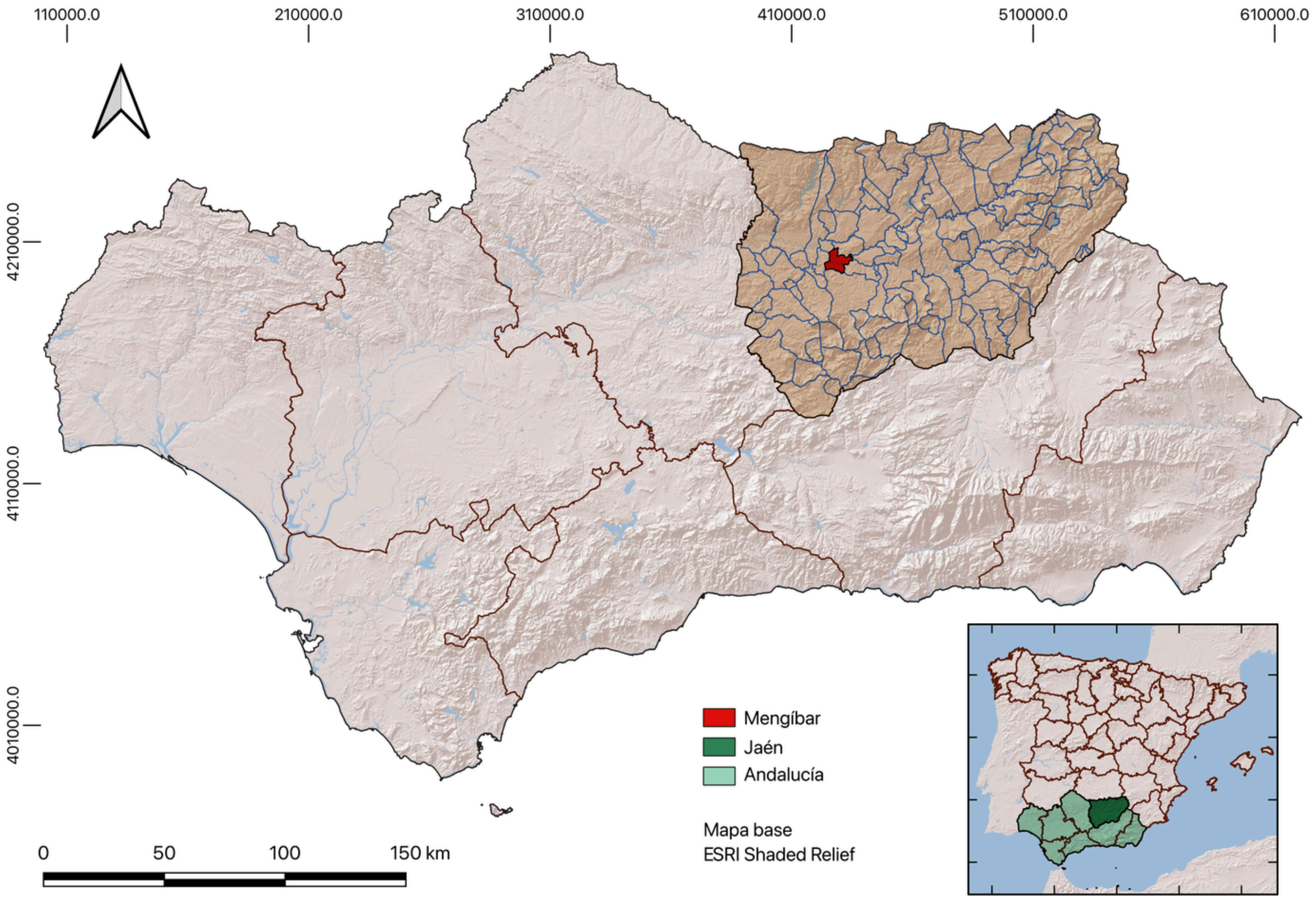


Map of the varieties present in the experimental farm:



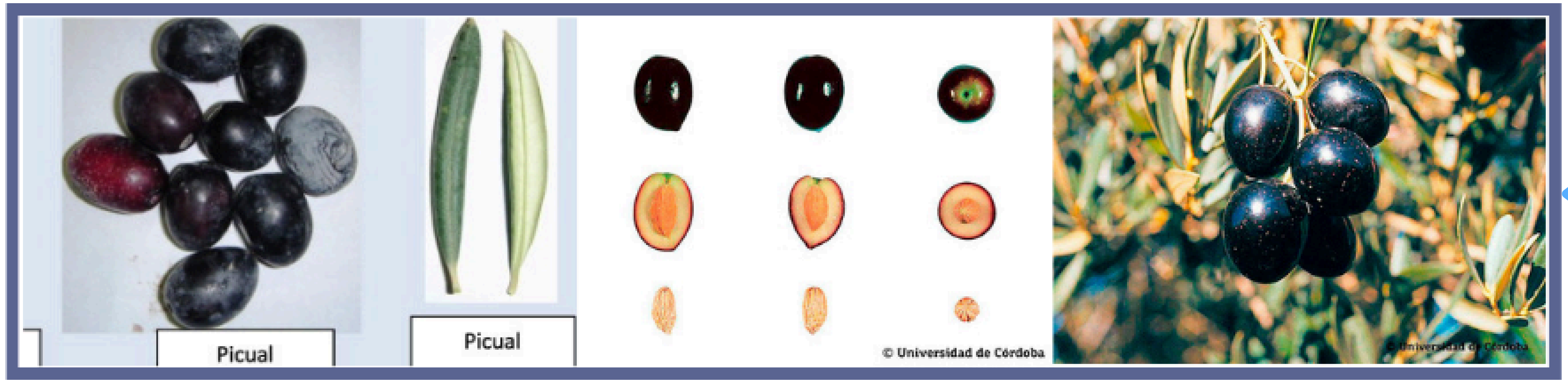
22-75	22-75	22-75	22-75	38-16	38-16	38-16	38-16	38-20	38-20	38-20	38-20	44-40	44-40	44-40	44-40	39-14	39-14	39-14	39-14	37-69	37-69	37-69	37-69
39-40	39-40	39-40	39-40	42-22	42-22	42-22	42-22	AR	AR	AR	AR	35-23	35-23	35-23	35-23	42-45	42-45	42-45	42-45	PI	PI	PI	PI
36-43	36-43	36-43	36-43	30-65	30-65	30-65	30-65	22-90	22-90	22-90	22-90	36-41	36-41	36-41	36-41	30-24	30-24	30-24	30-24	33-23	33-23	33-23	33-23
30-24	30-24	30-24	30-24	36-43	36-43	36-43	36-43	42-45	42-45	42-45	42-45	42-61	42-61	42-61	42-61	36-59	36-59	36-59	36-59	42-48	42-48	42-48	42-48
38-16	38-16	38-16	38-16	35-23	35-23	35-23	35-23	36-59	36-59	36-59	36-59	42-61	42-61	42-61	42-61	39-40	39-40	39-40	39-40	22-90	22-90	22-90	22-90
42-48	42-48	42-48	42-48	PI	PI	PI	PI	22-75	22-75	22-75	22-75	30-65	30-65	30-65	30-65	38-20	38-20	38-20	38-20	AR	AR	AR	AR
36-41	36-41	36-41	36-41	39-14	39-14	39-14	39-14	42-22	42-22	42-22	42-22	33-23	33-23	33-23	33-23	37-69	37-69	37-69	37-69	44-40	44-40	44-40	44-40
36-41	36-41	36-41	36-41	22-75	22-75	22-75	22-75	42-22	42-22	42-22	42-22	38-16	38-16	38-16	38-16	30-24	30-24	30-24	30-24	33-23	33-23	33-23	33-23
36-59	36-59	36-59	36-59	22-90	22-90	22-90	22-90	39-40	39-40	39-40	39-40	AR	AR	AR	AR	42-48	42-48	42-48	42-48	42-61	42-61	42-61	42-61
37-69	37-69	37-69	37-69	36-43	36-43	36-43	36-43	38-20	38-20	38-20	38-20	42-45	42-45	42-45	42-45	35-23	35-23	35-23	35-23	44-40	44-40	44-40	44-40
36-41	36-41	36-41	36-41	AR	AR	AR	AR	PI	PI	PI	PI	30-65	30-65	30-65	30-65	39-14	39-14	39-14	39-14	PI	PI	PI	PI
42-22	42-22	42-22	42-22	39-14	39-14	39-14	39-14	22-90	22-90	22-90	22-90	36-43	36-43	36-43	36-43	37-69	37-69	37-69	37-69	42-48	42-48	42-48	42-48
30-65	30-65	30-65	30-65	42-61	42-61	42-61	42-61	30-24	30-24	30-24	30-24	33-23	33-23	33-23	33-23	44-40	44-40	44-40	44-40	42-45	42-45	42-45	42-45
35-23	35-23	35-23	35-23	36-59	36-59	36-59	36-59	38-20	38-20	38-20	38-20	38-16	38-16	38-16	38-16	22-75	22-75	22-75	22-75	39-40	39-40	39-40	39-40
																					HUECO		6

B-IV
B-III
B-II
B-I

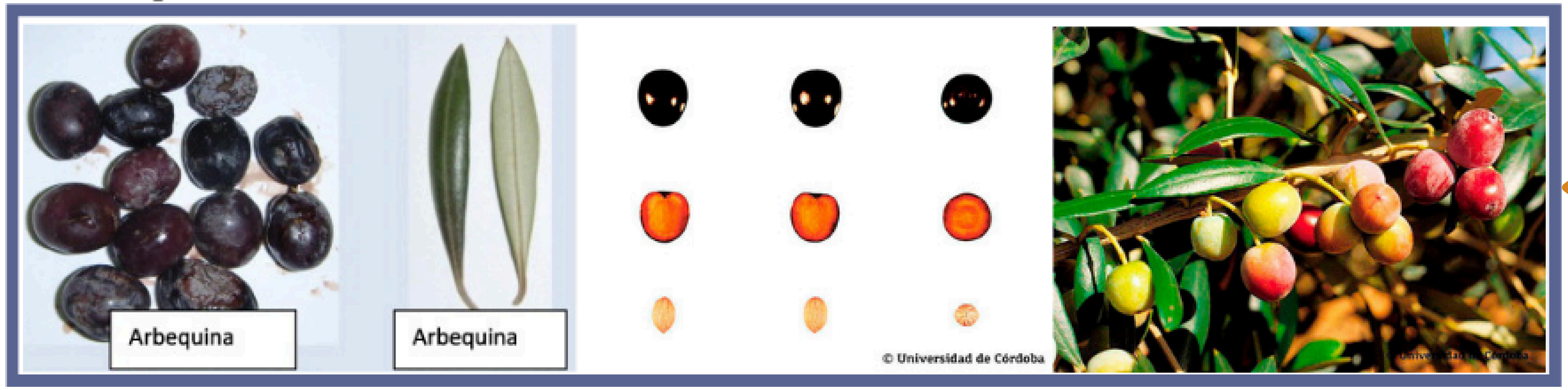


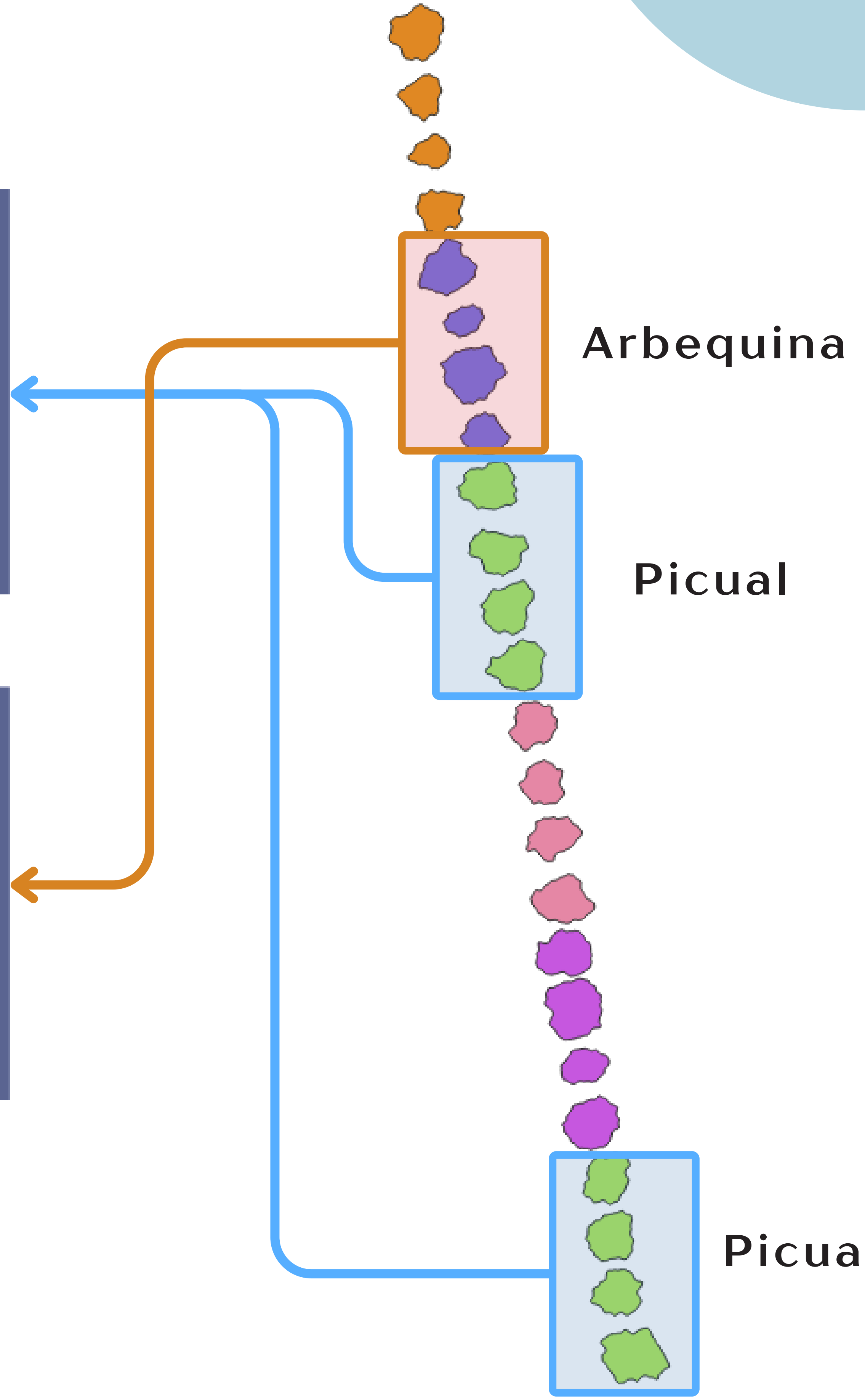
Properties of varieties

PICUAL

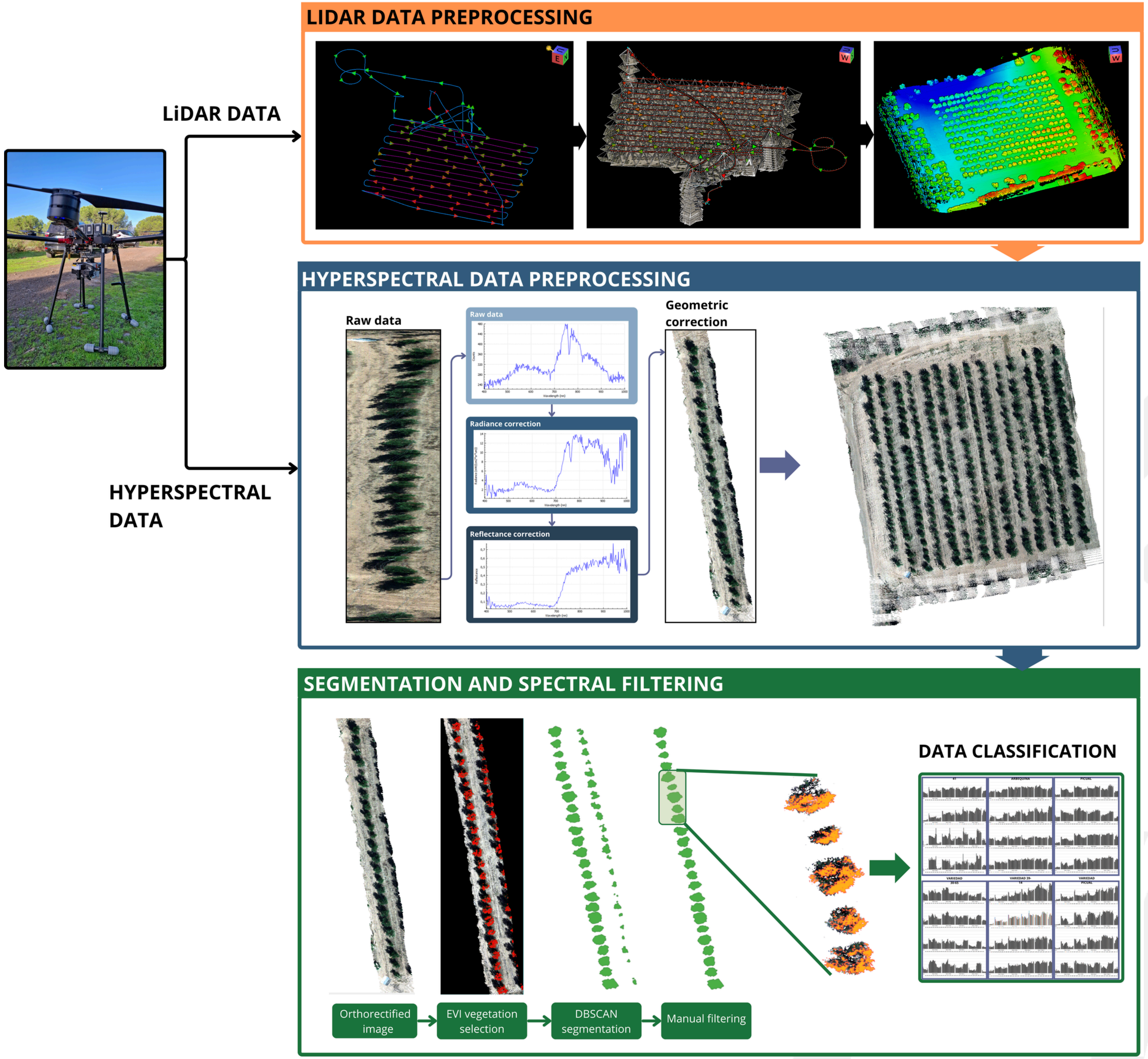


ARBEQUINA





METHODOLOGY



LiDAR DATA

↓

Hyperspectral image pre-processing

↓

Vegetation index calculation

↓

Segmentation of olive trees

↓

Shadow pixel filtering

↓

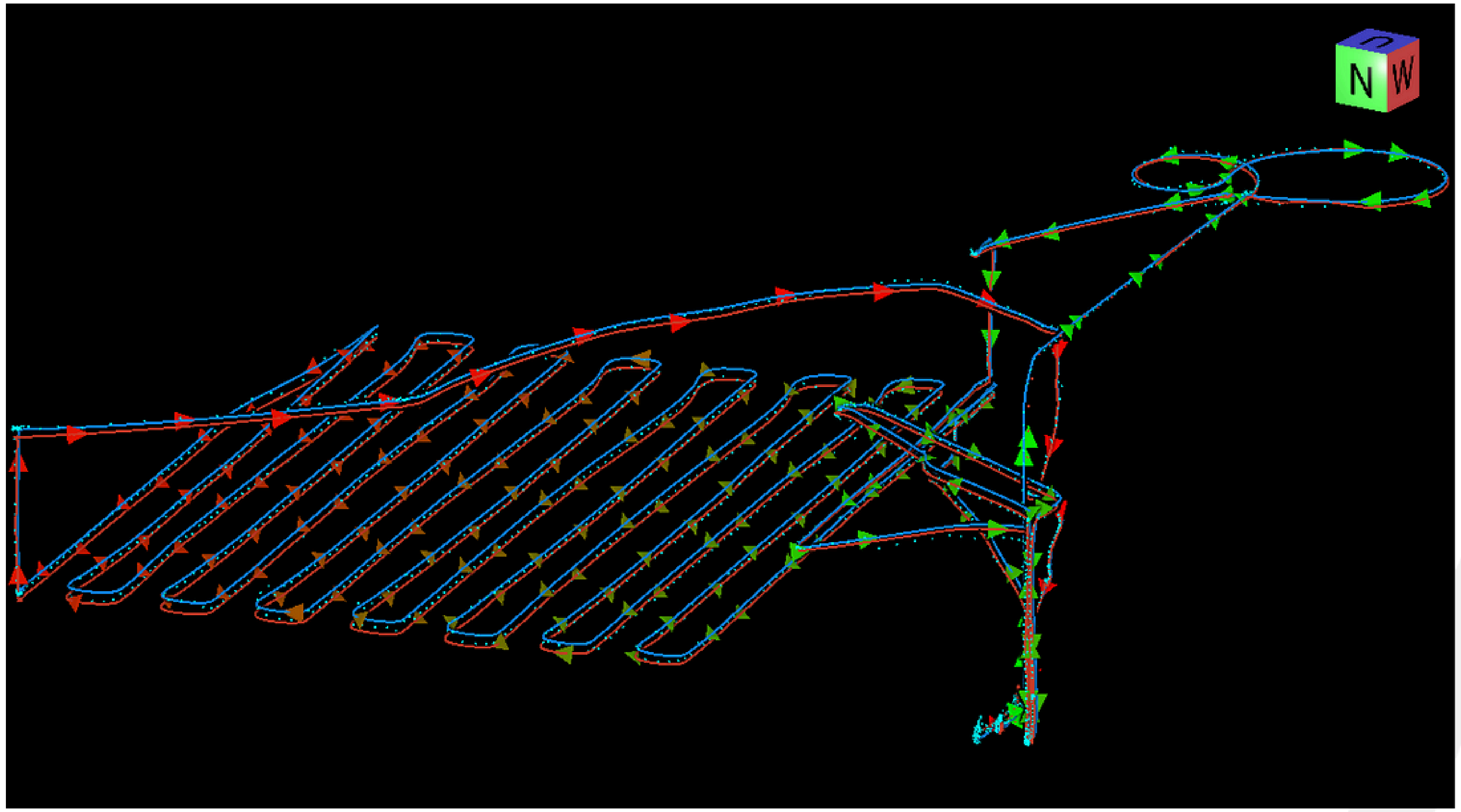
Hyperspectral pixel classification method

METHODOLOGY

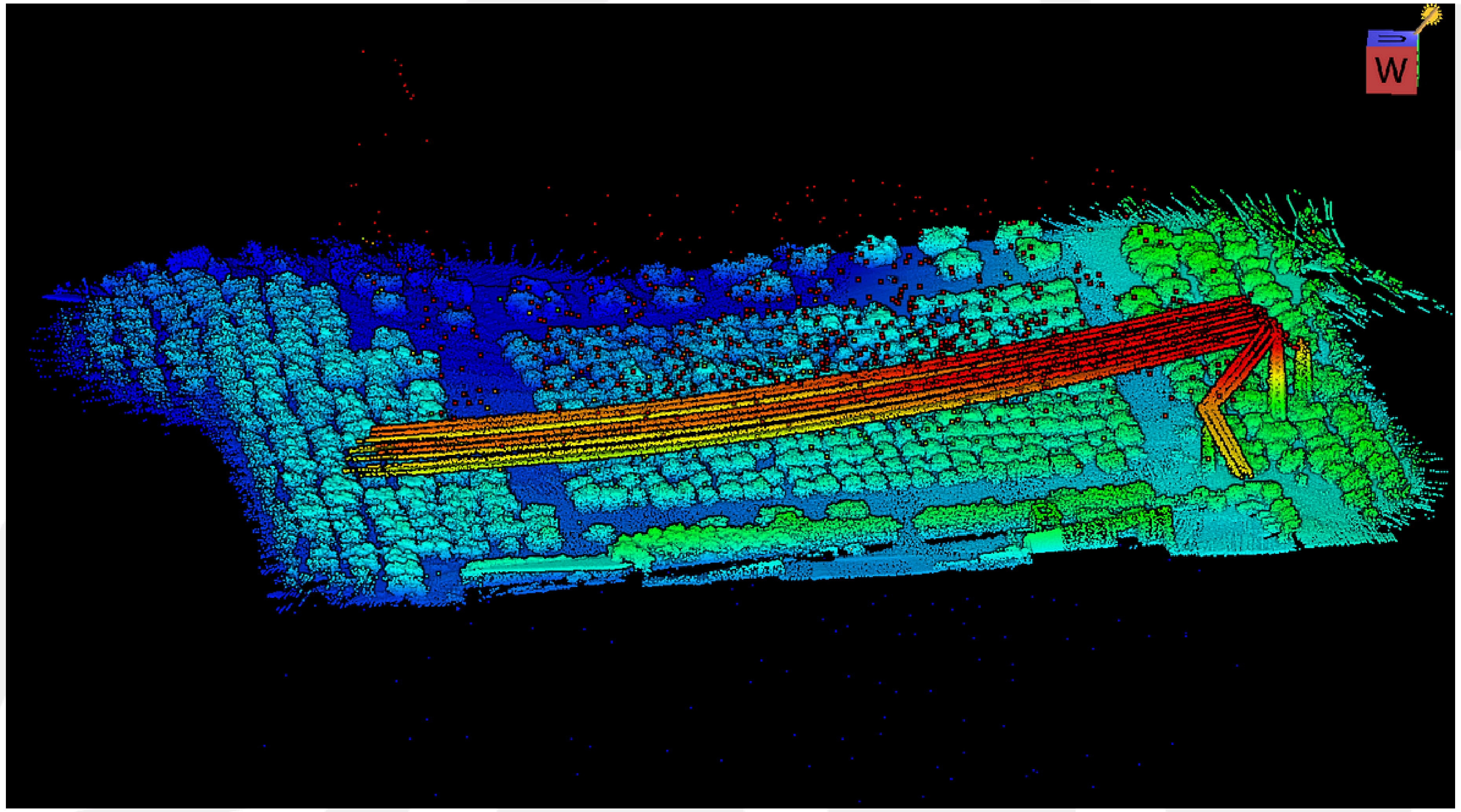
LiDAR DATA

Hyperspectral image pre-processing

LiDAR data preprocessing



Flight path



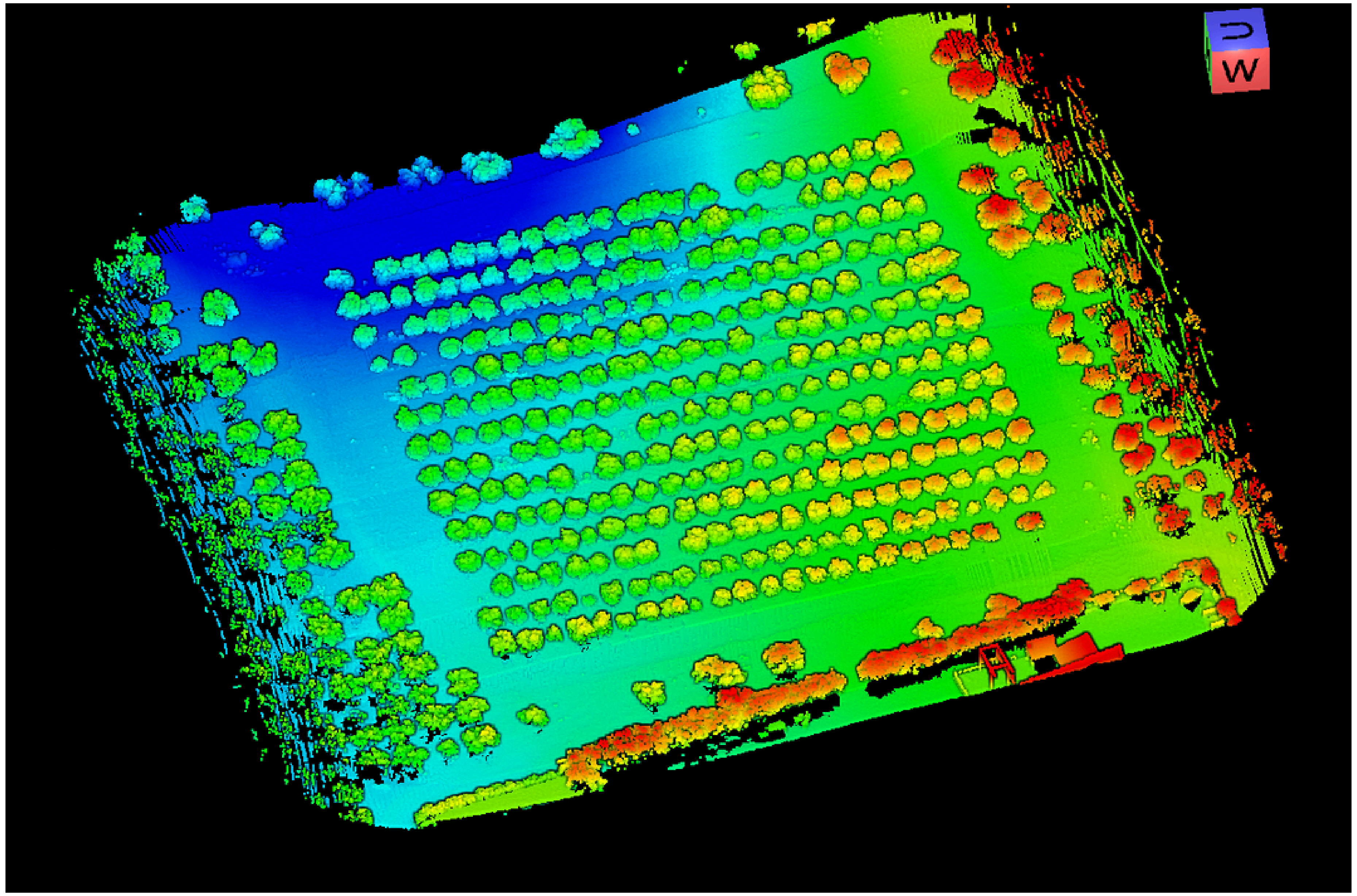
Unfiltered point cloud

METHODOLOGY

LiDAR DATA

Hyperspectral image pre-processing

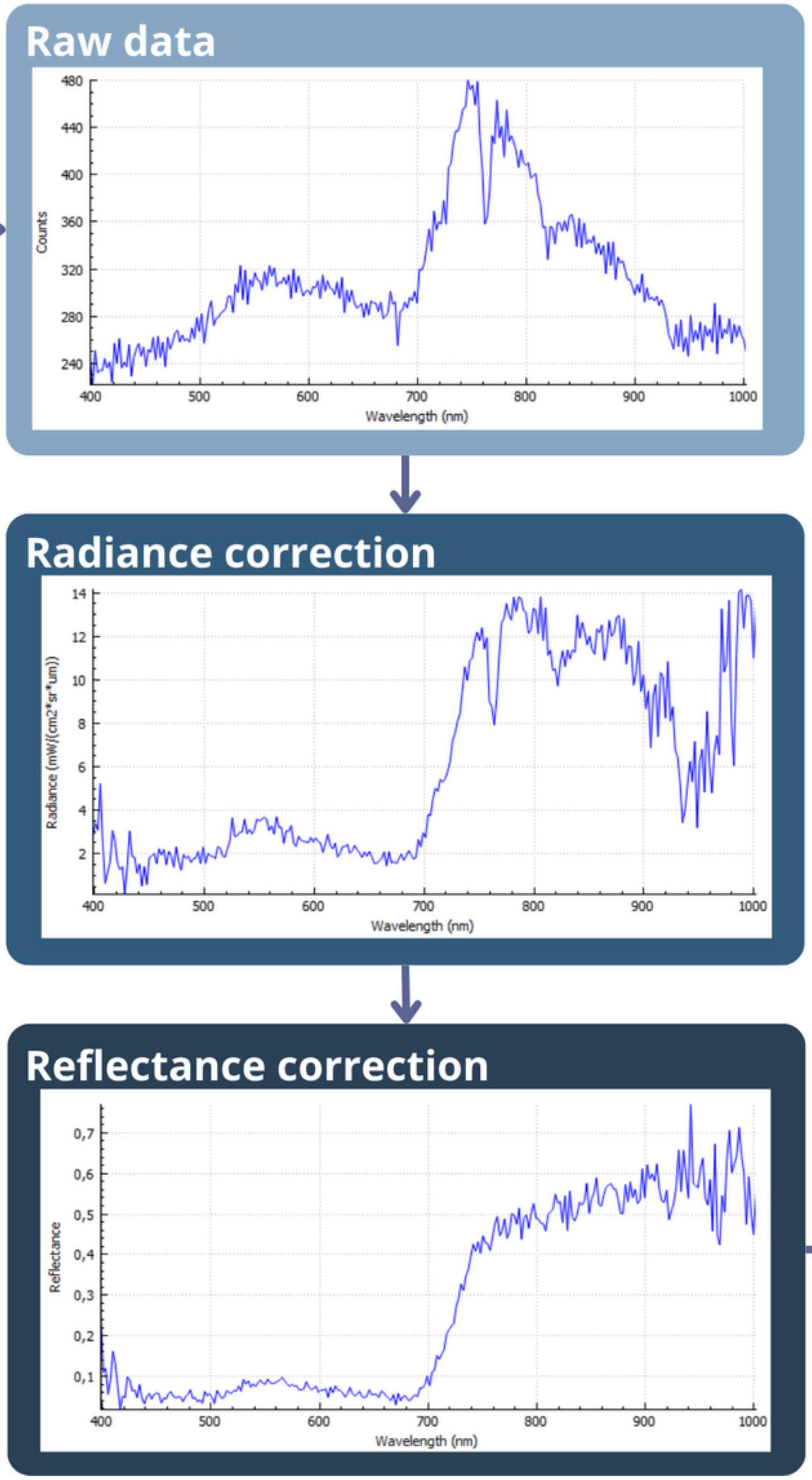
LiDAR data preprocessing



Digital Surface Model (DSM)

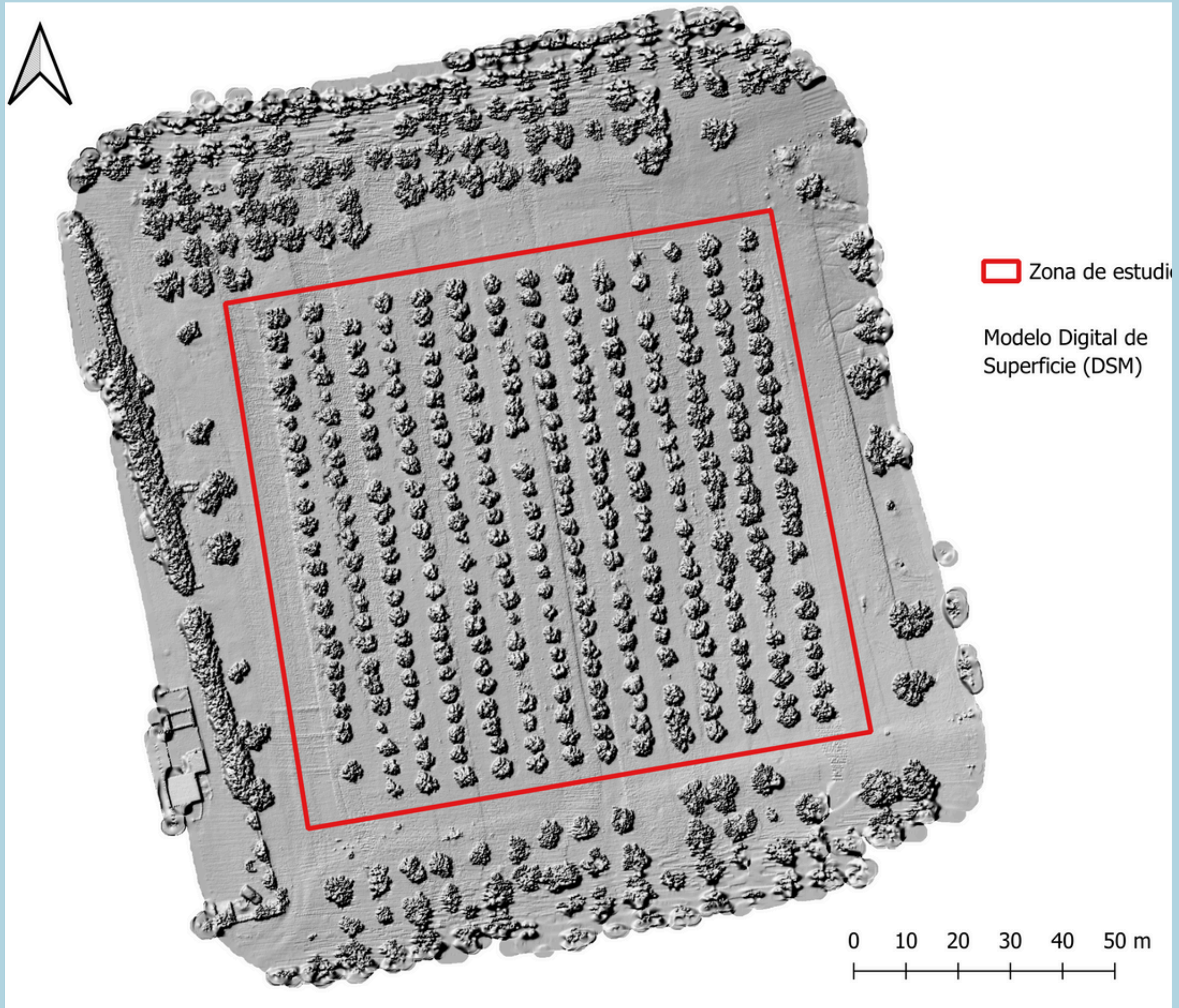
Hyperspectral data preprocessing

Raw data



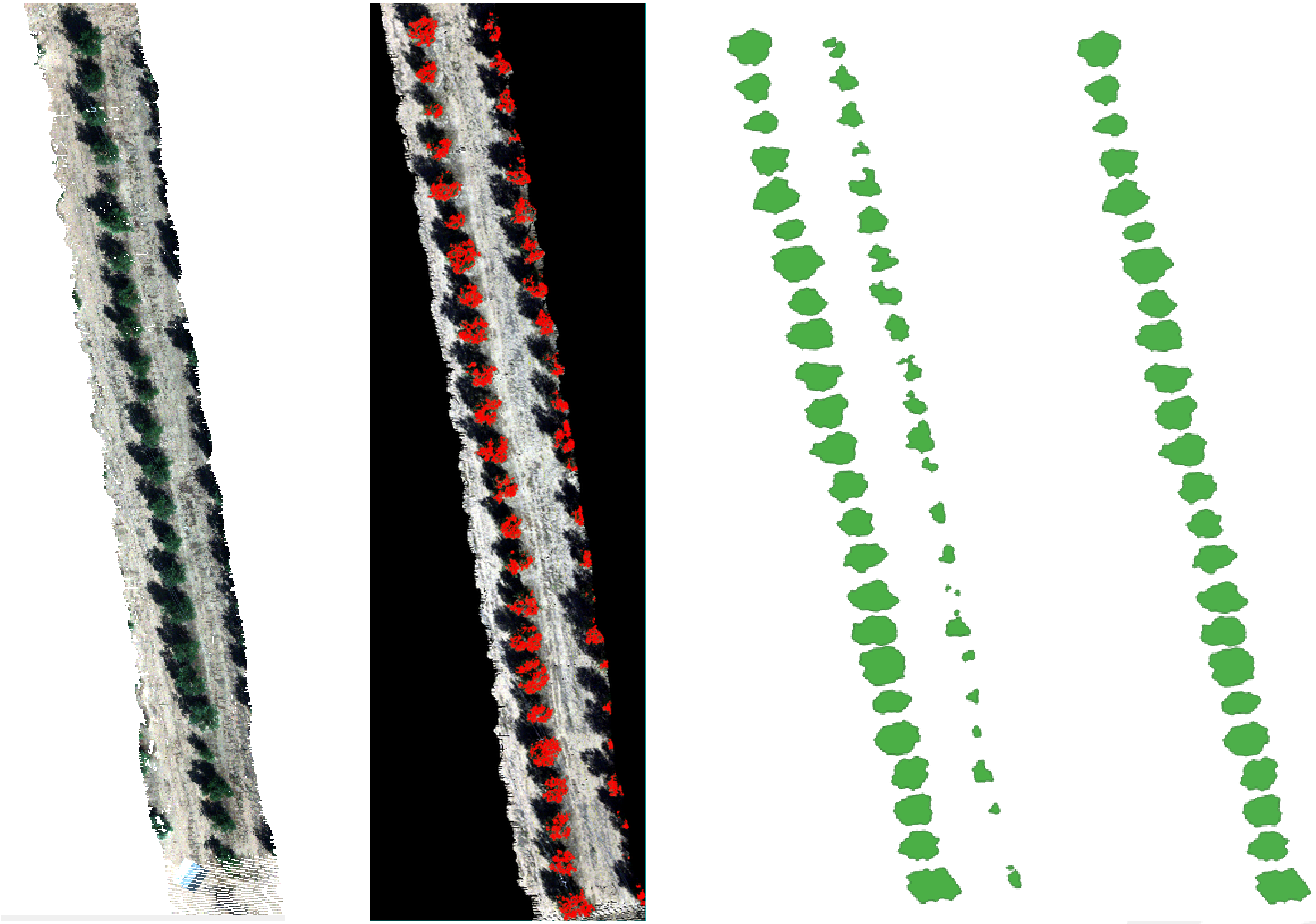
Geometric correction

Digital Surface Model (DSM)



METHODOLOGY

Olive tree segmentation



Orthorectified image → EVI vegetation selection → DBSCAN segmentation → Manual filtering

LiDAR DATA

Hyperspectral image pre-processing

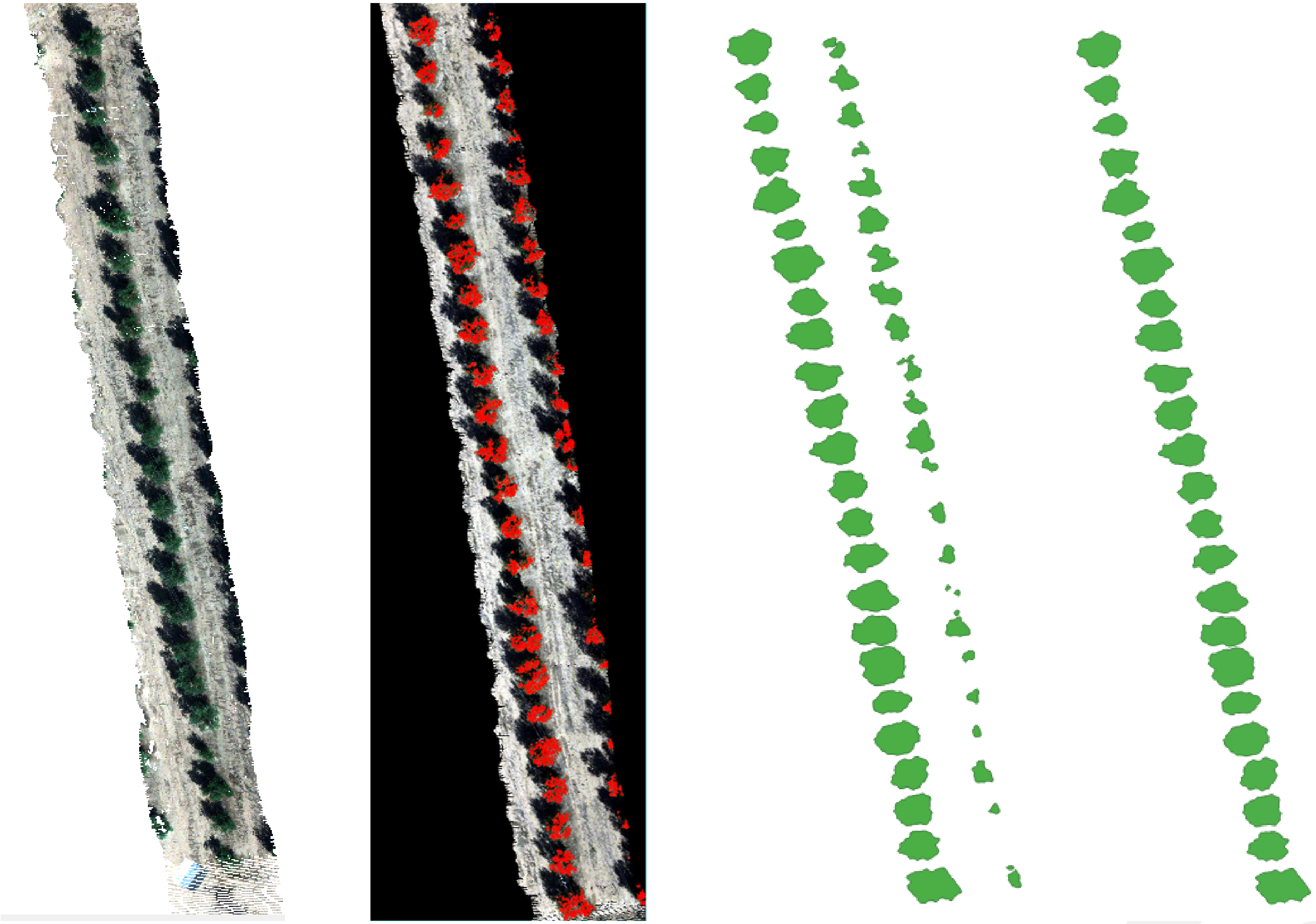
Vegetation index calculation

Segmentation of olive trees

$$\text{EVI} = G \cdot \frac{\text{NIR} - \text{Rojo}}{\text{NIR} + C_1 \cdot \text{Rojo} - C_2 \cdot \text{Azul} + L},$$

METHODOLOGY

Olive tree segmentation



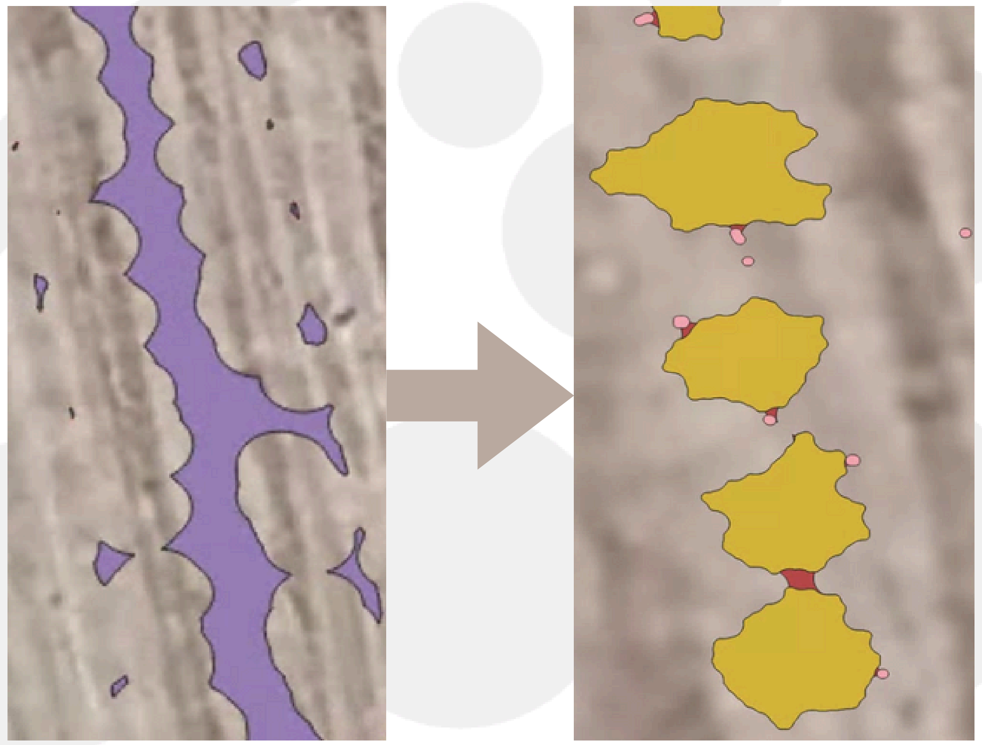
Orthorectified image → EVI vegetation selection → DBSCAN segmentation → Manual filtering

LiDAR DATA

Hyperspectral image pre-processing

Vegetation index calculation

Segmentation of olive trees



METHODOLOGY

Olive tree segmentation

ID_TREE	AREA (m2)	VARIETY
401	10,024	36-41
402	5,978	36-41
403	4,514	36-41
404	7,274	36-41
405	9,702	AR
406	4,045	AR
407	11,784	AR
408	6,600	AR
409	9,763	PI
410	8,543	PI
411	9,056	PI
412	9,484	PI
413	7,565	30-65
414	6,554	30-65
415	7,447	30-65
416	9,617	30-65
417	9,380	39-14
418	12,412	39-14
419	5,958	39-14
420	10,126	39-14
421	8,187	PI
422	8,433	PI
423	7,857	PI
424	12,282	PI

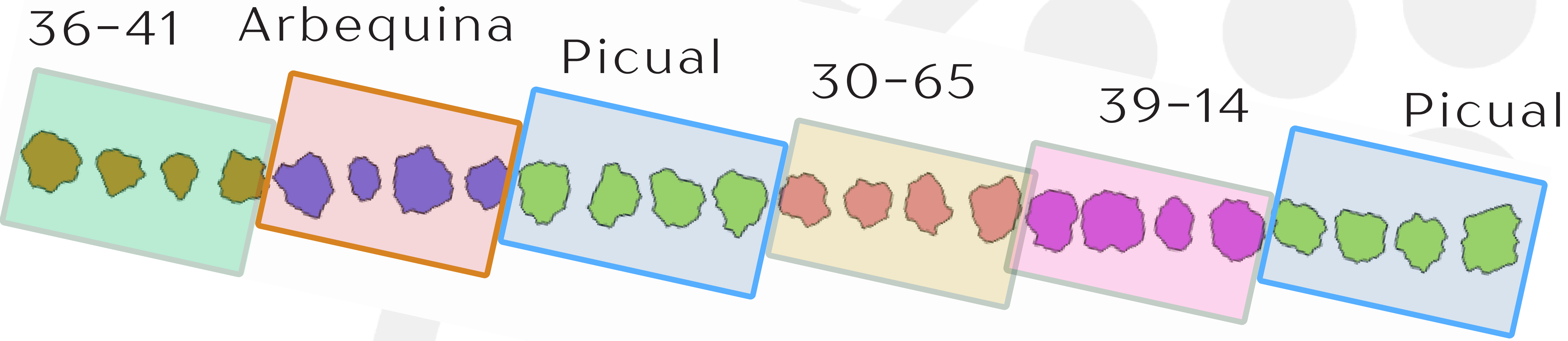
In this process, in addition to **isolating the geometry** of each olive tree, data such as the area and variety of each tree are also **correlated**.

LiDAR DATA

Hyperspectral image pre-processing

Vegetation index calculation

Segmentation of olive trees



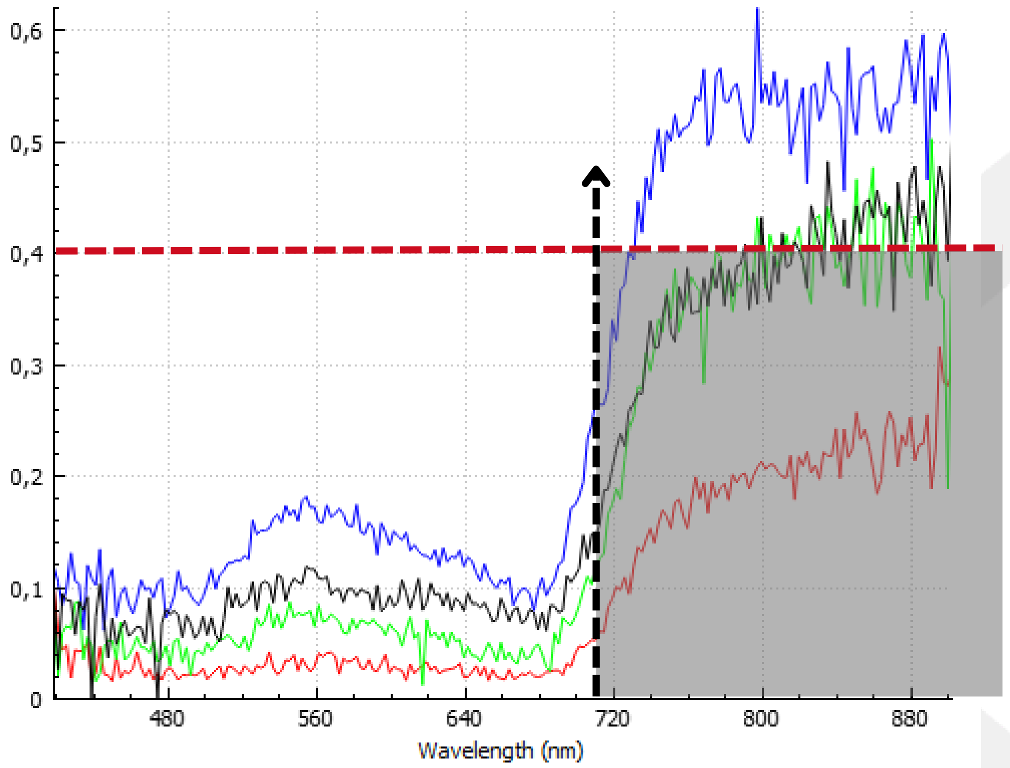
METHODOLOGY

Pixel filtering according to reflectance

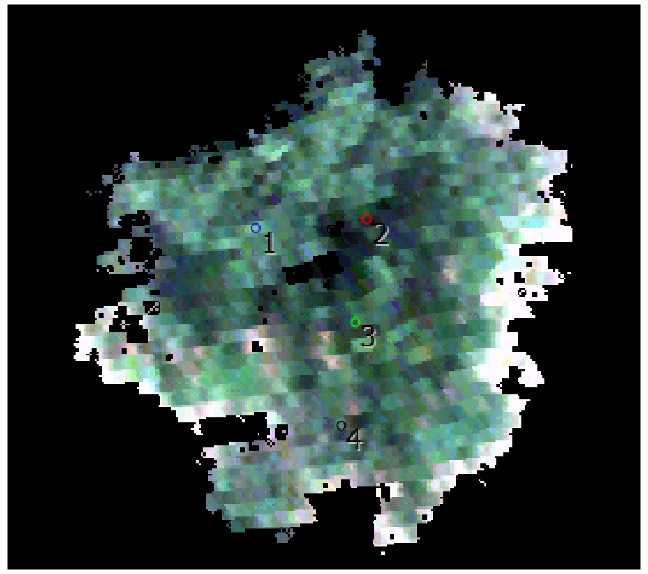
Two methods are used for filtering low reflectance pixels

- **Filtering according to NIR reflectance**

Filters out pixels with high reflectance in a specific band (NIR)



- **Filtered by standard deviation**



The spectral mean and standard deviation are calculated for each olive tree.

Each pixel in the tree is compared to the spectral mean and standard deviation, thus eliminating the most dispersed data.

LiDAR DATA

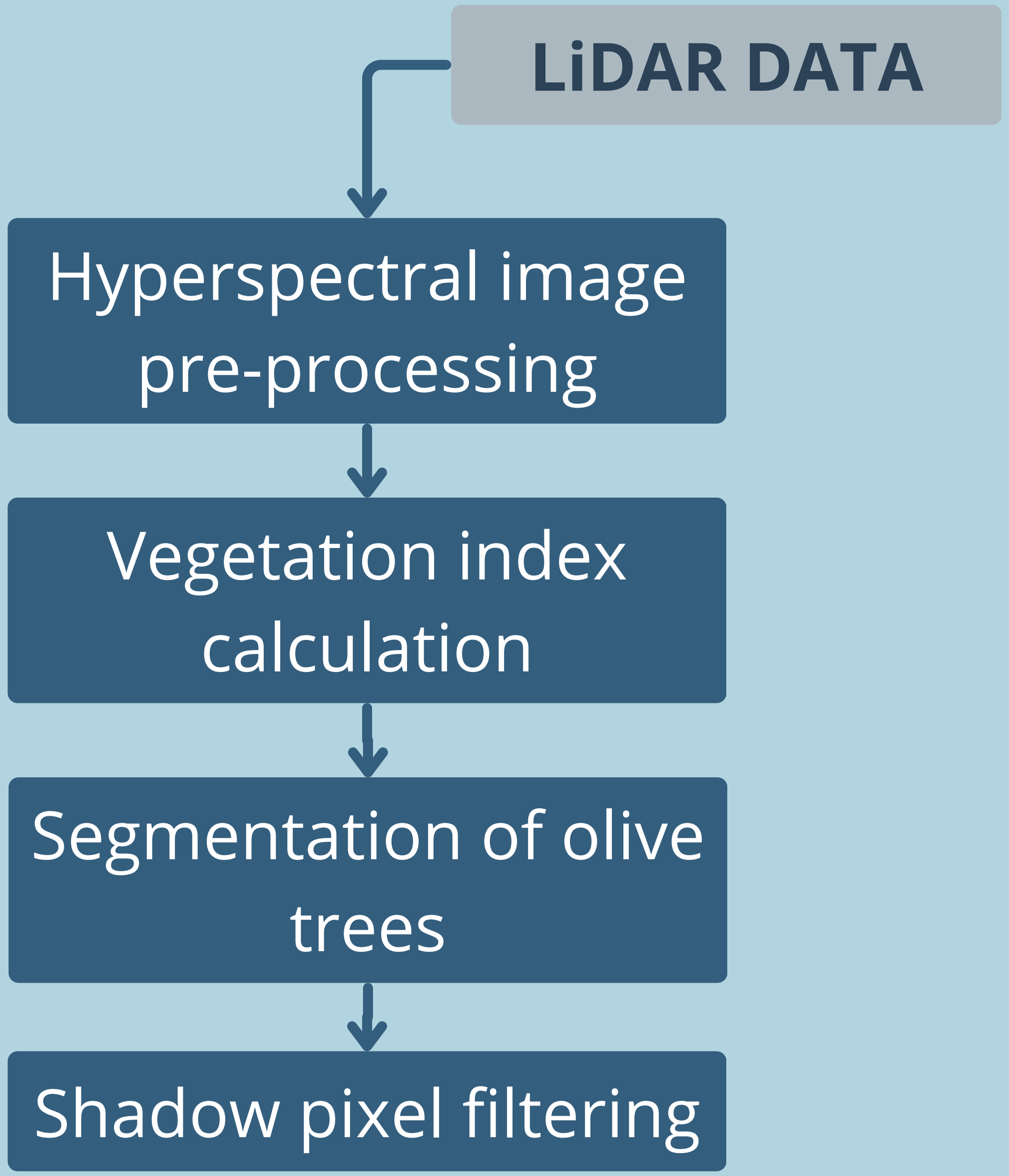
Hyperspectral image pre-processing

Vegetation index calculation

Segmentation of olive trees

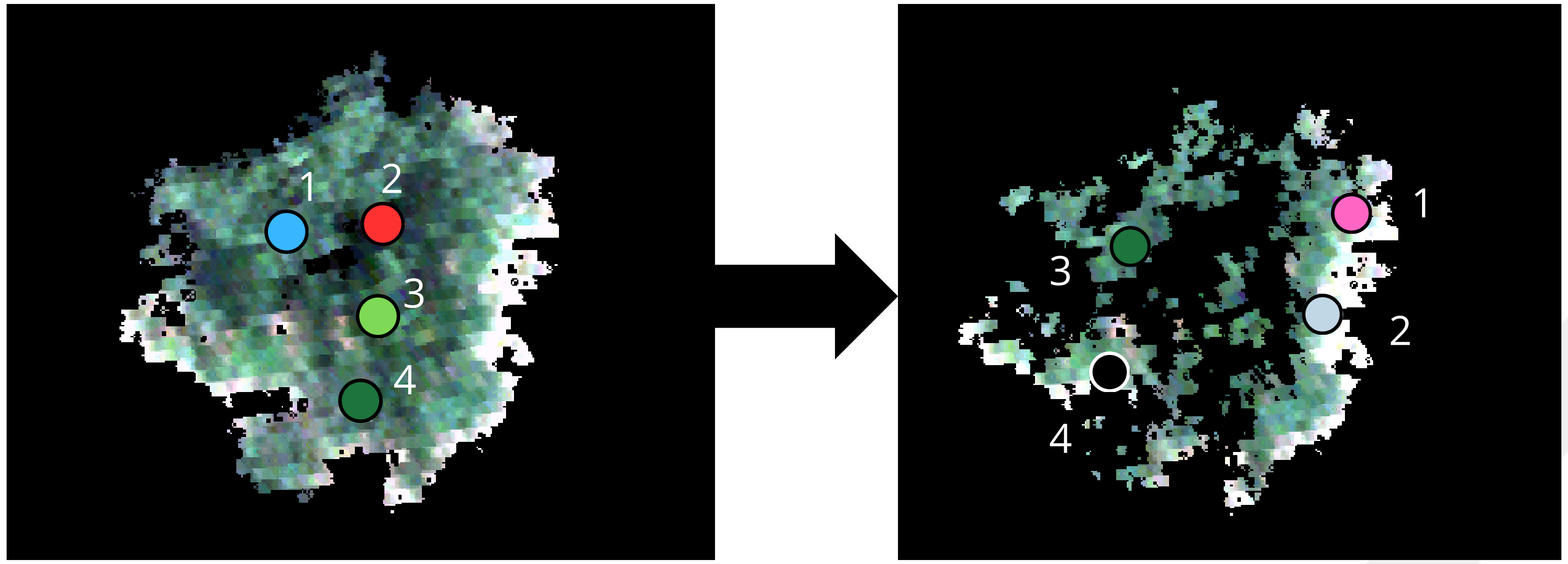
Shadow pixel filtering

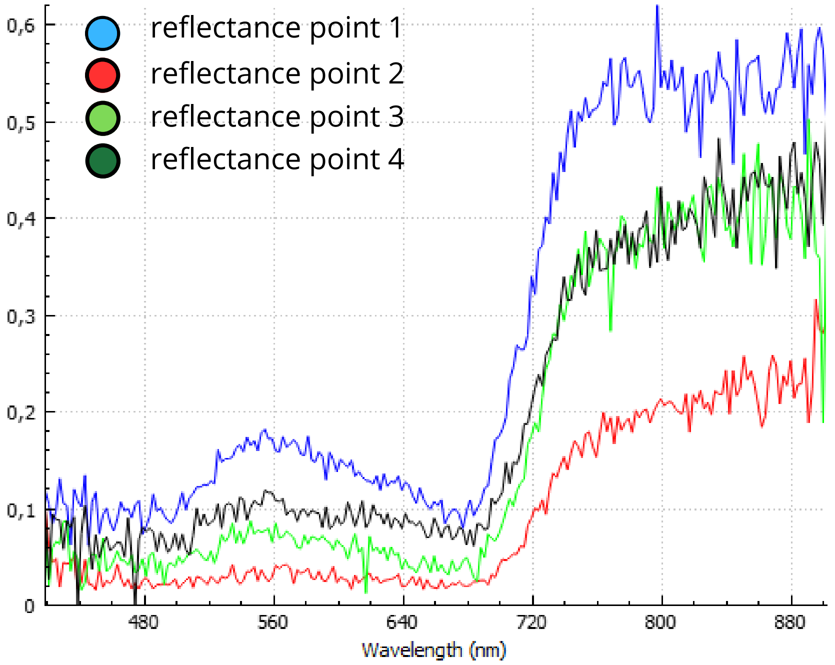
METHODOLOGY

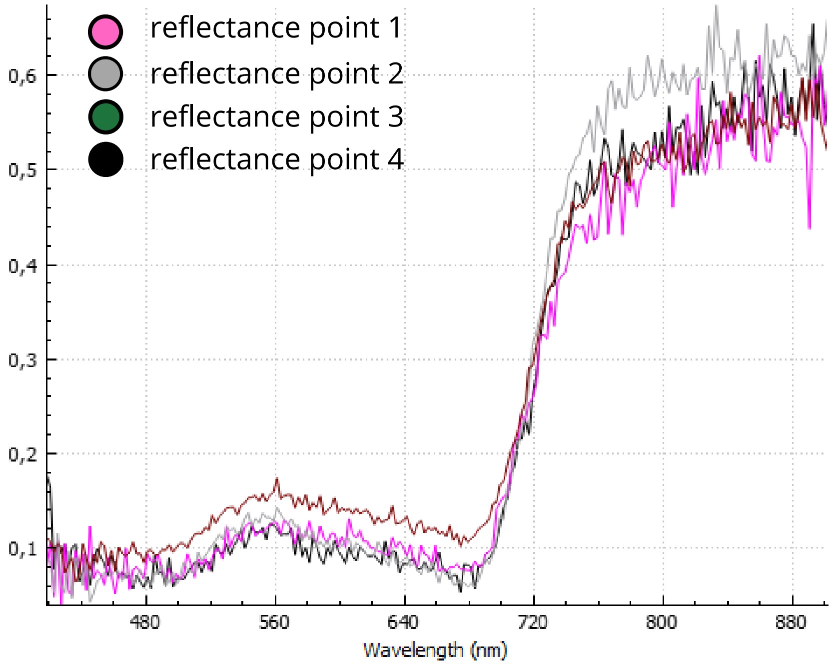


Pixel filtering according to reflectance

- Filtering according to NIR reflectance



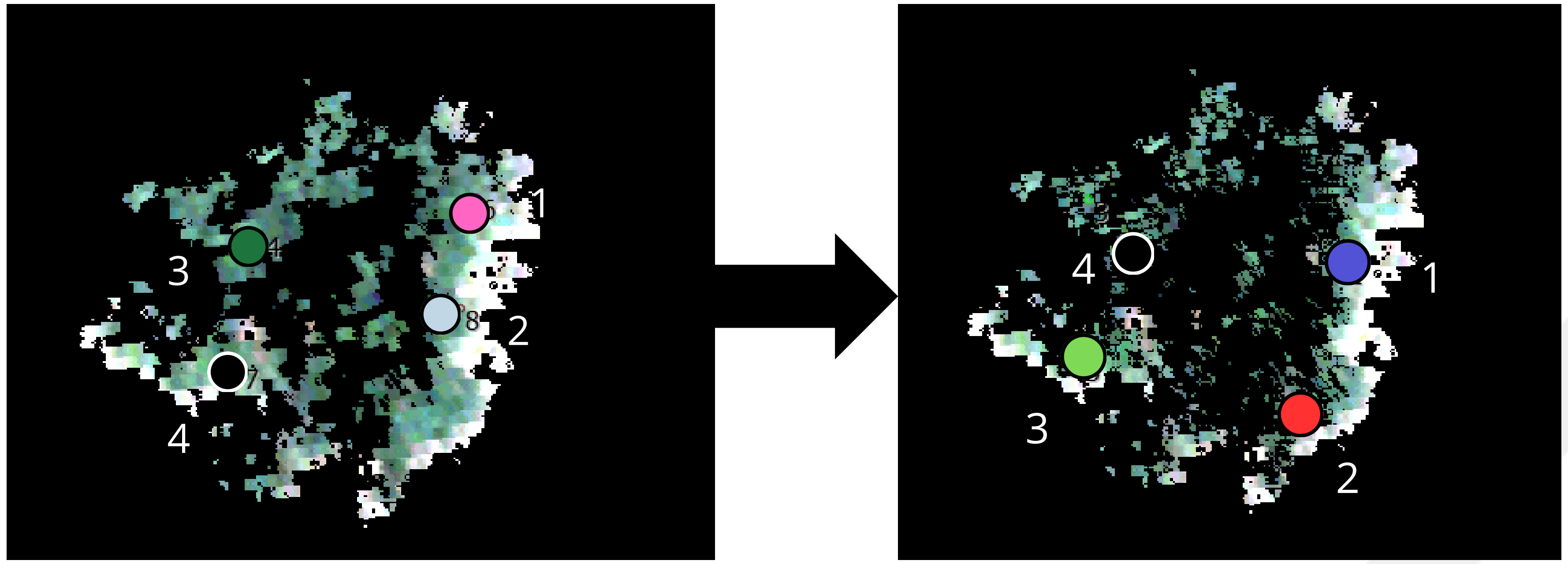


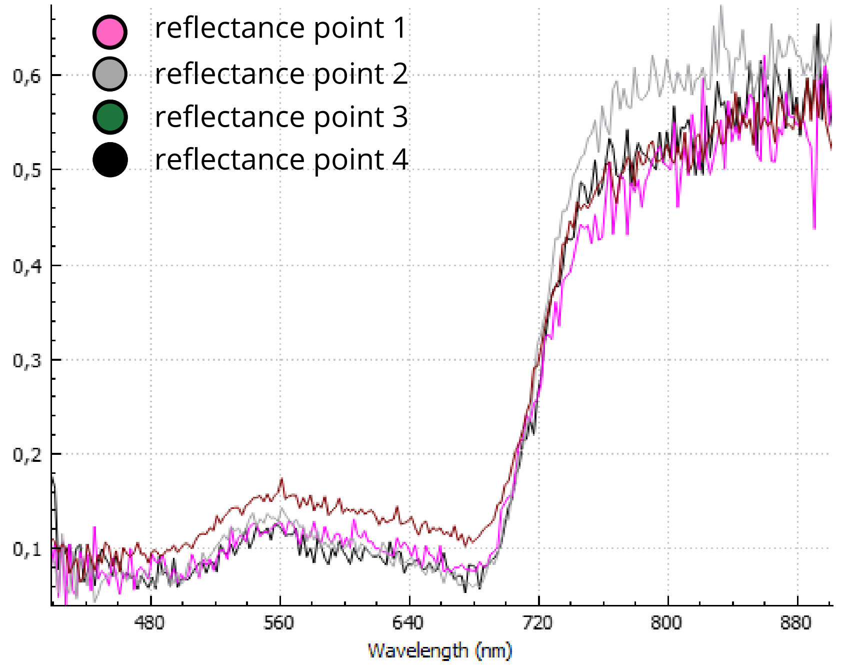


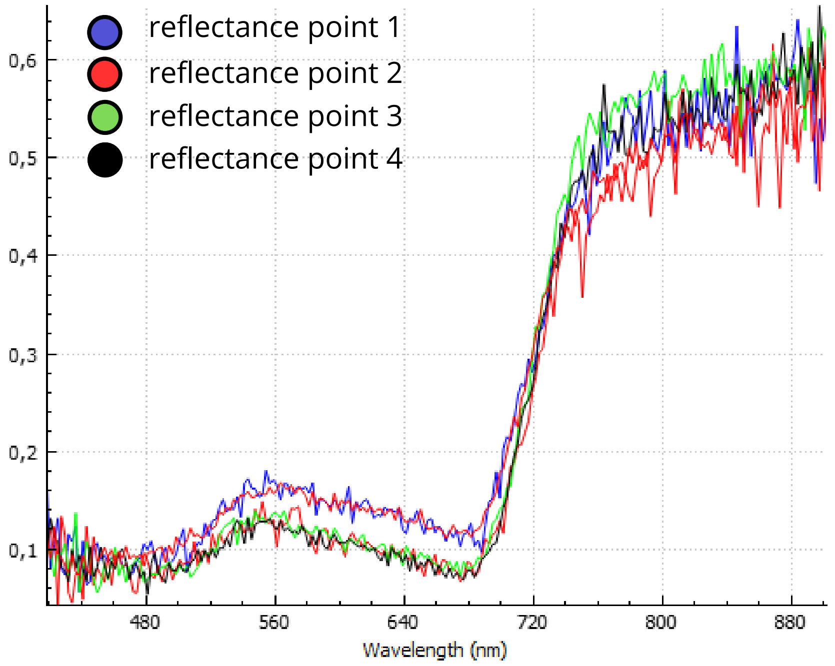
METHODOLOGY

Pixel filtering according to reflectance

- Filtered by standard deviation







LiDAR DATA

Hyperspectral image pre-processing

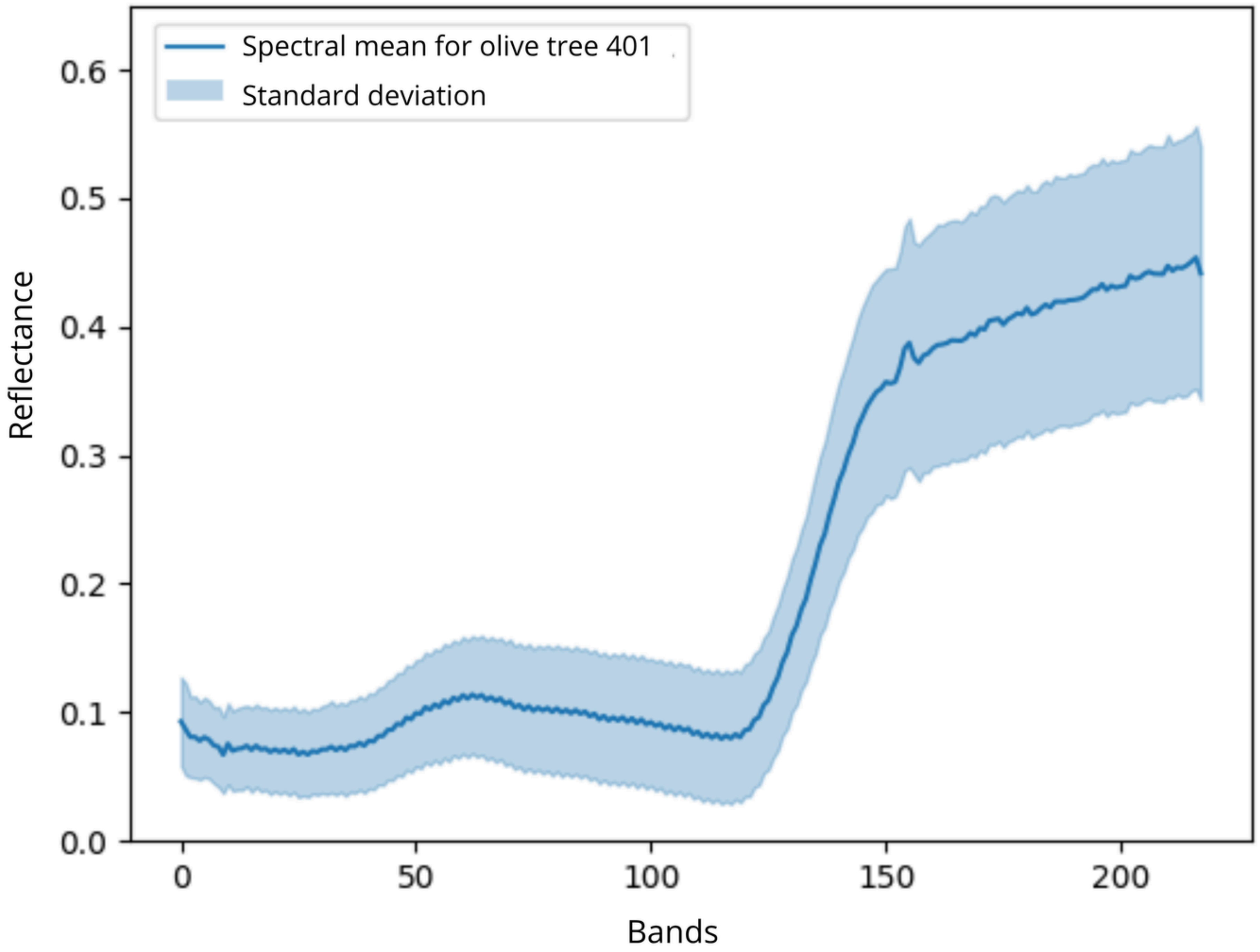
Vegetation index calculation

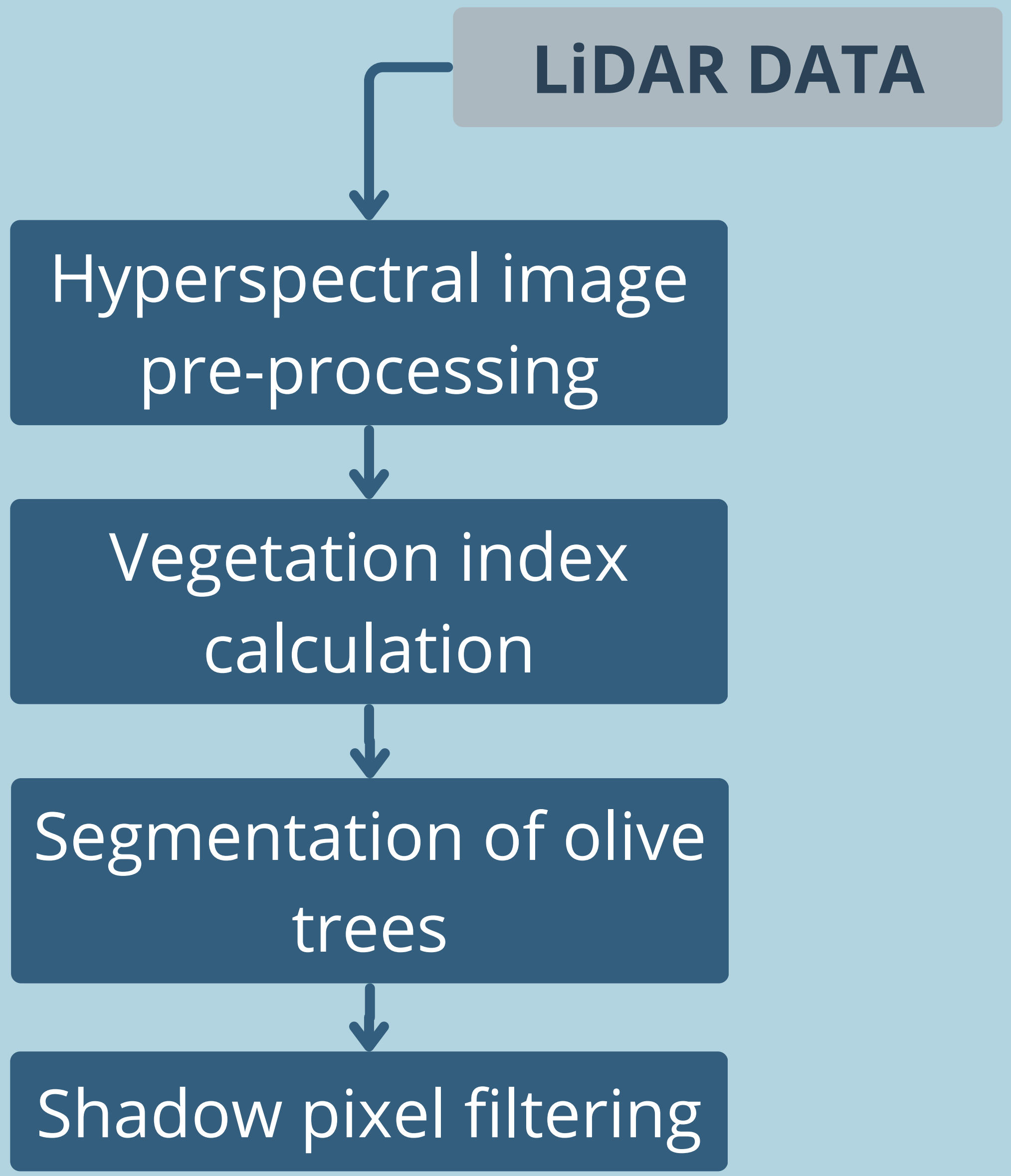
Segmentation of olive trees

Shadow pixel filtering

METHODOLOGY

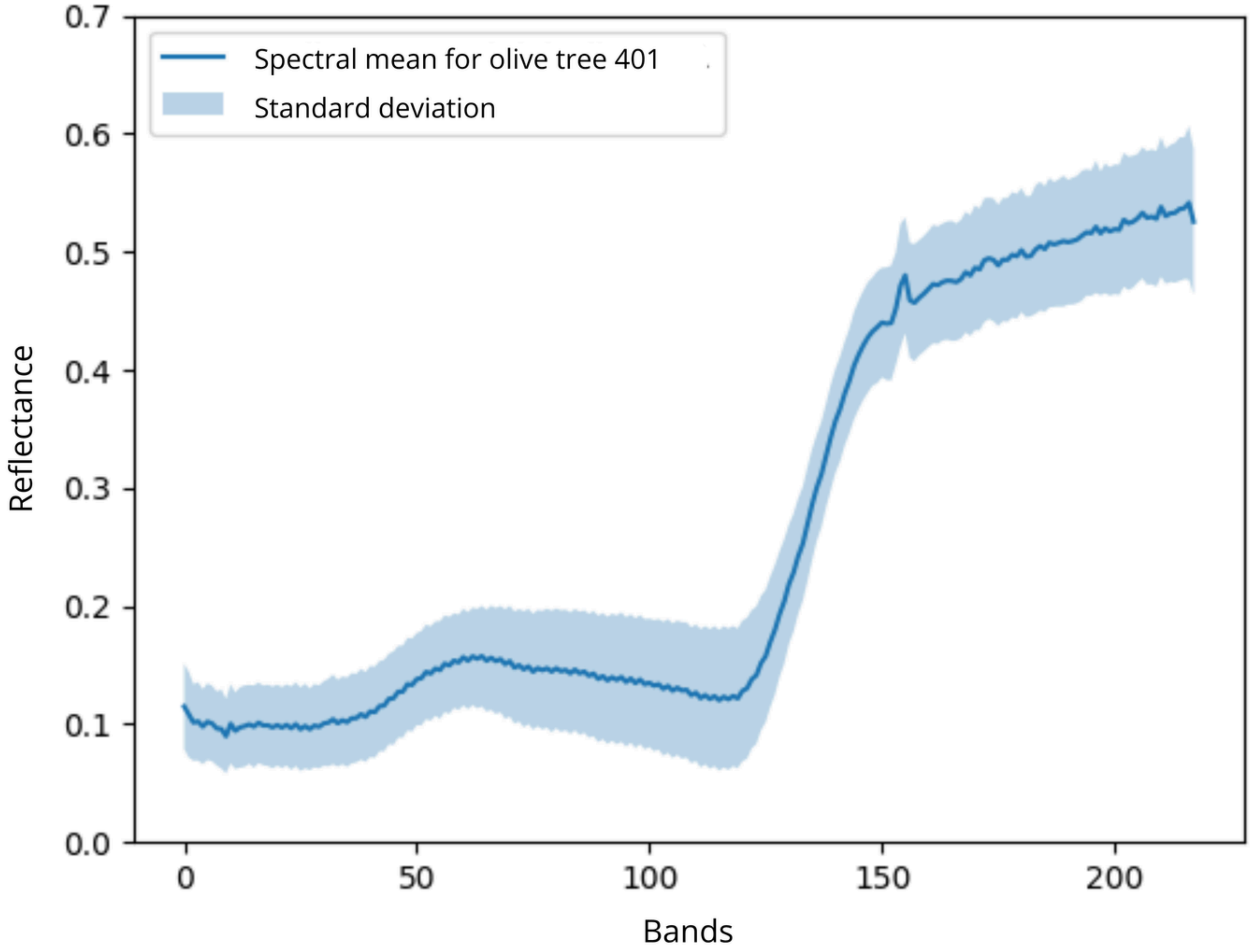
Pixel filtering according to reflectance

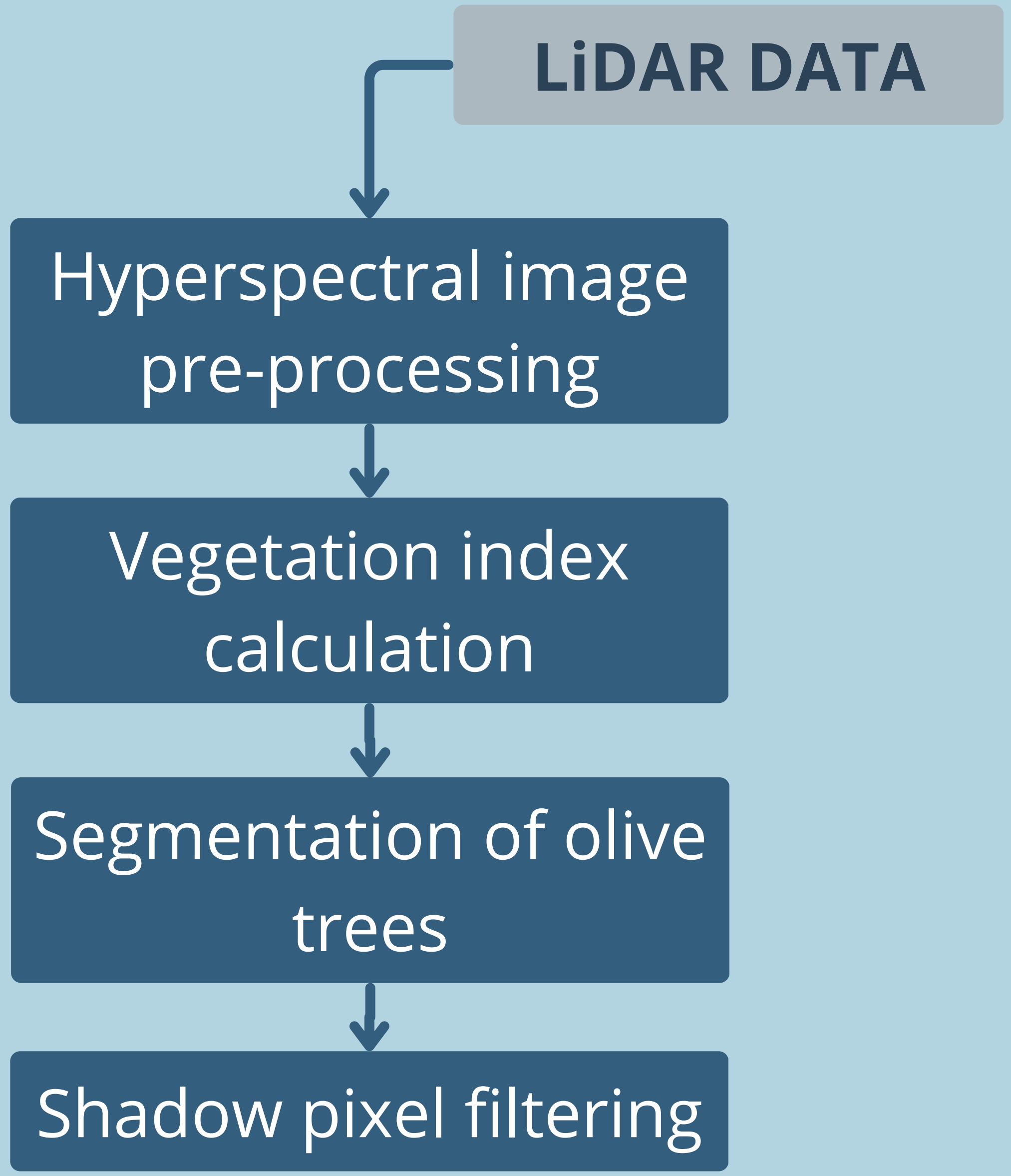




METHODOLOGY

Pixel filtering according to reflectance

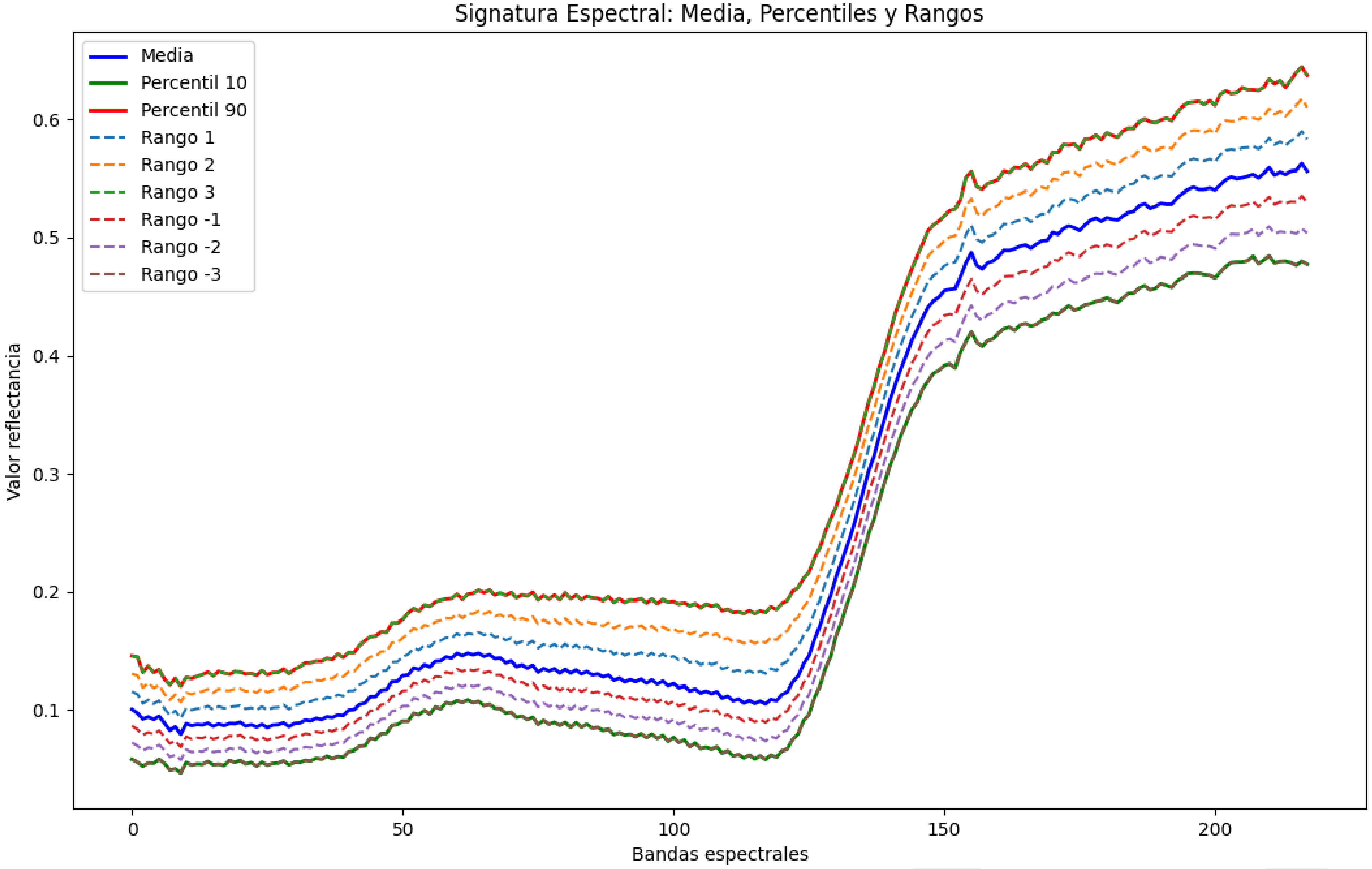




METHODOLOGY

Pixel classification method

To enable the comparison of data from different olive trees and determine whether they exhibit similar behavior, a **range-based classification** system is proposed.



LiDAR DATA

Hyperspectral image pre-processing

Vegetation index calculation

Segmentation of olive trees

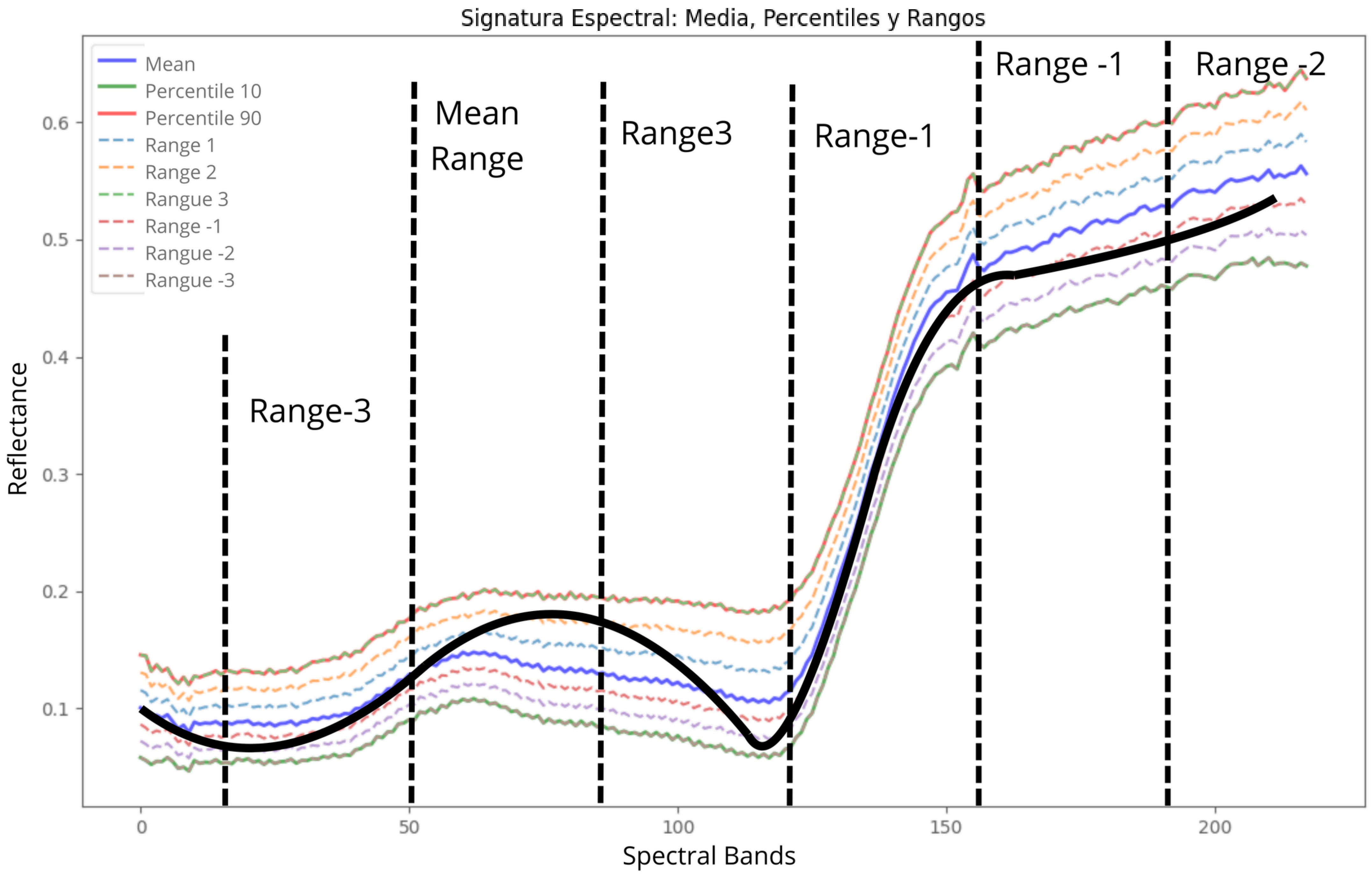
Shadow pixel filtering

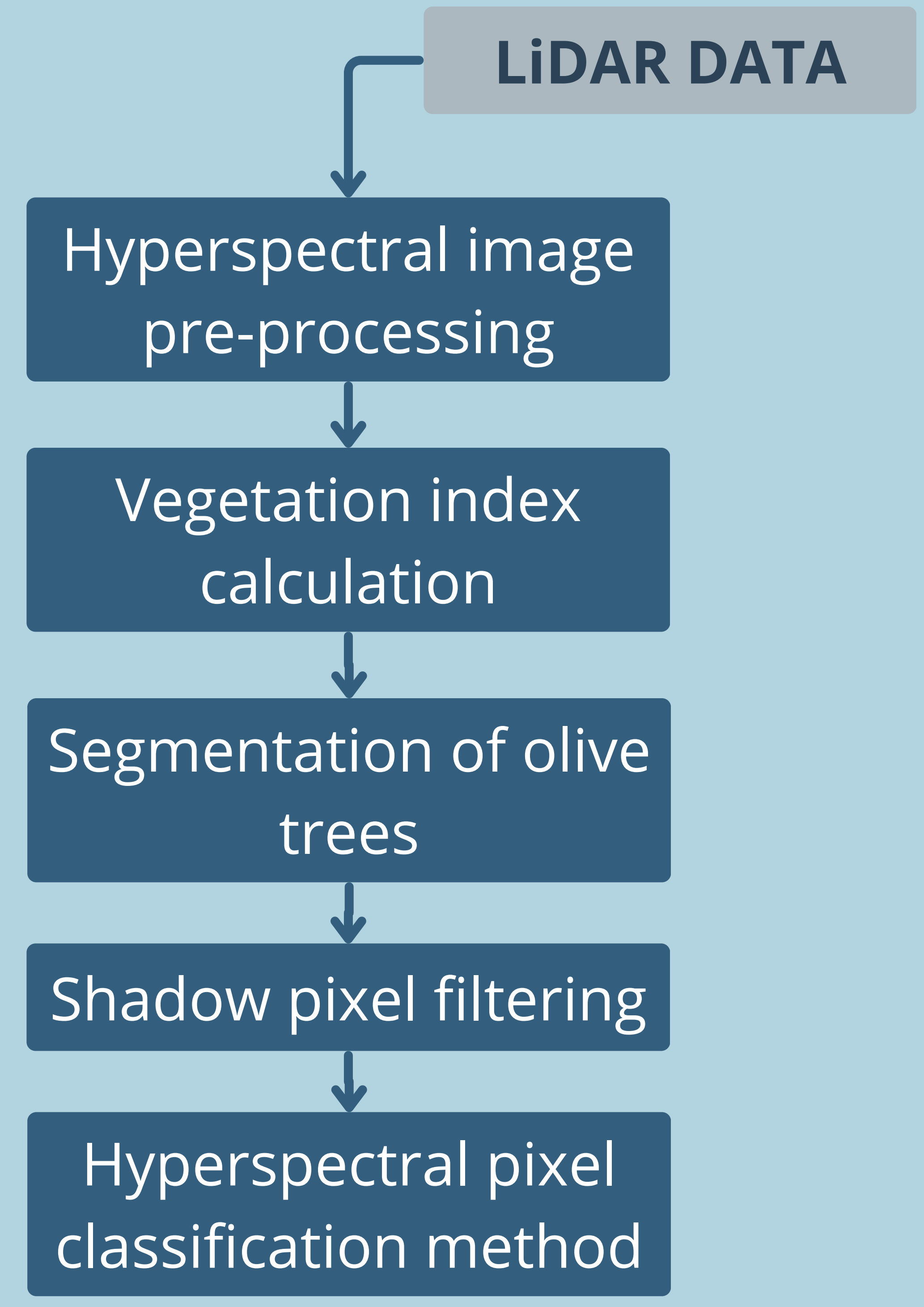
Hyperspectral pixel classification method

METHODOLOGY

Pixel classification method

To enable the comparison of data from different olive trees and determine whether they exhibit similar behavior, a **range-based classification** system is proposed.



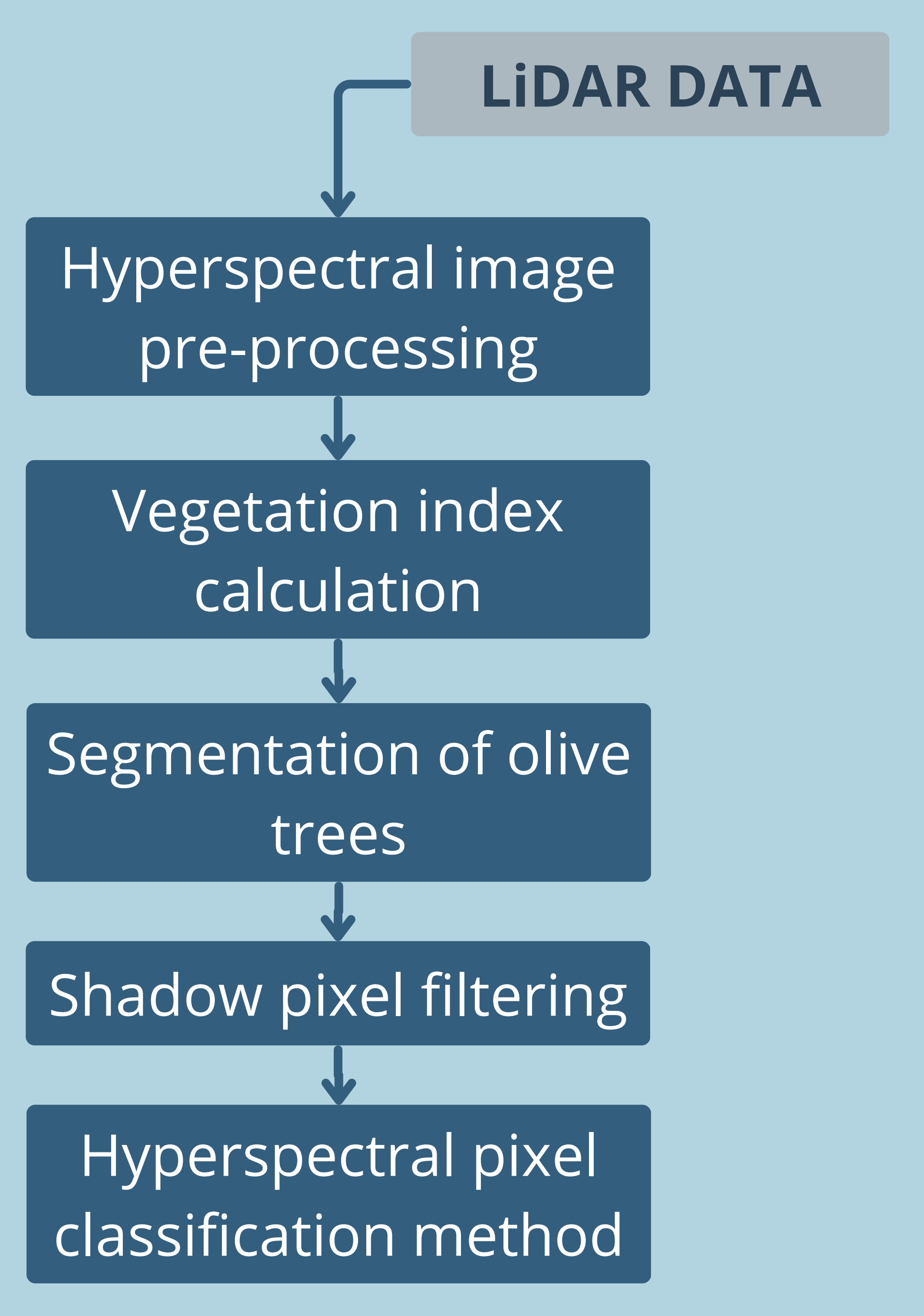


METHODOLOGY

Pixel classification method

In order to compare data from different olive trees and assess whether they exhibit similar behavior, a classification system **based on value ranges is proposed.**

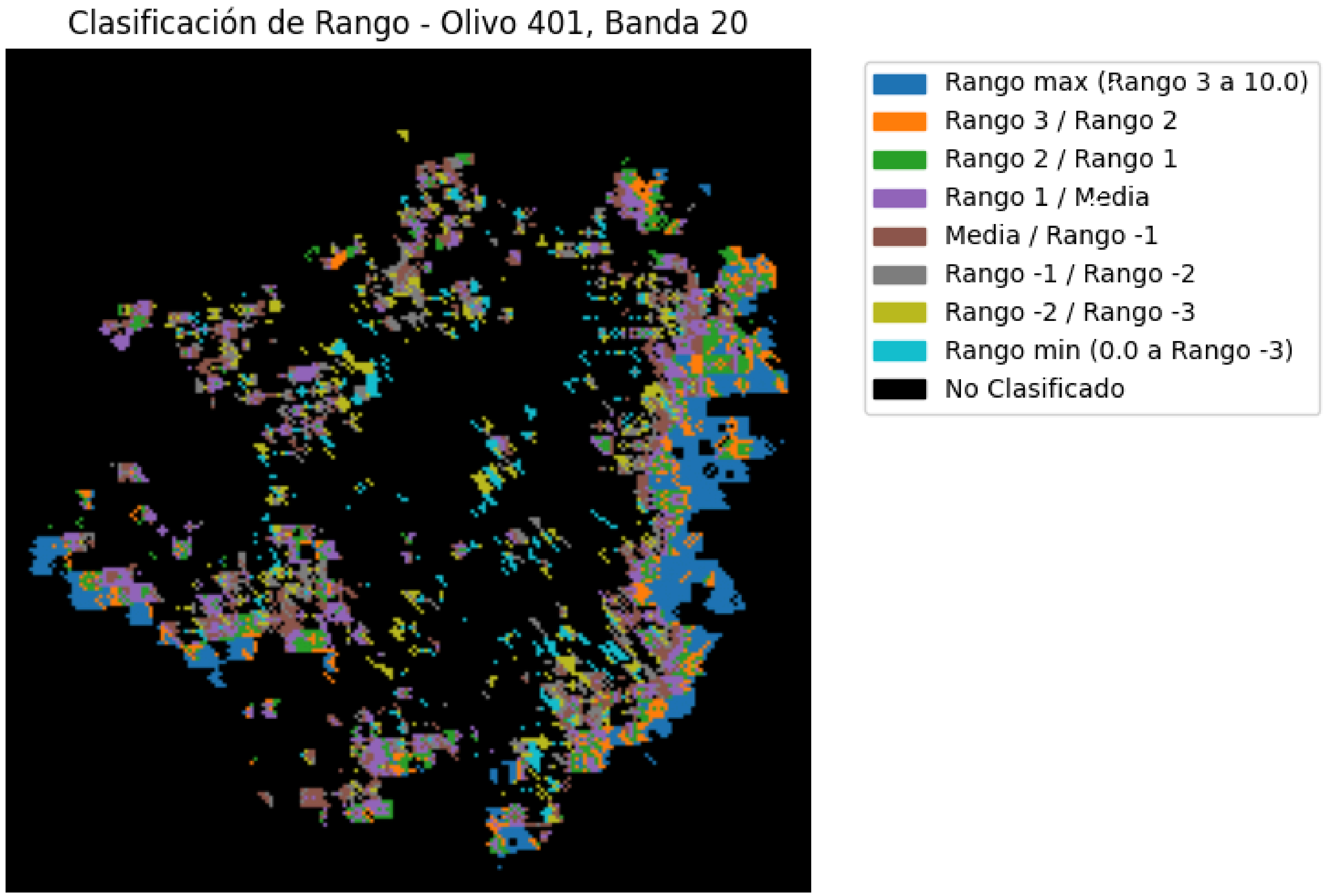
ID_OLIVO	Variedad	Rango	0	10	20	30	40	50	60	70	80	90	100	...	217
401	36-41	Rango max (Rango 3 a 10.0)	19.23	19.86	18.29	18.92	18.29	18.56	17.70	18.86	17.95	18.66	18.03	...	3.10
401	36-41	Rango 3 / Rango 2	13.56	9.60	7.93	9.56	8.06	7.90	8.81	8.02	7.46	6.73	7.54	...	4.44
401	36-41	Rango 2 / Rango 1	16.87	13.31	10.50	10.14	10.46	10.37	10.62	10.96	10.97	11.00	8.87	...	8.91
401	36-41	Rango 1 / Media	15.55	16.25	16.19	15.32	15.00	13.95	14.28	12.10	12.82	12.42	12.88	...	14.06
401	36-41	Media / Rango -1	13.05	15.07	16.11	15.14	13.80	16.60	13.73	14.71	13.63	13.28	11.79	...	16.82
401	36-41	Rango -1 / Rango -2	10.50	12.12	13.34	14.71	15.85	14.02	15.25	15.57	16.85	16.85	17.56	...	17.41
401	36-41	Rango -2 / Rango -3	6.04	7.65	10.36	10.17	10.90	10.14	10.85	11.29	12.35	13.18	14.39	...	15.01
401	36-41	Rango min (0.0 a Rango -3)	5.20	6.13	7.29	6.04	7.63	8.46	8.75	8.49	7.98	7.89	8.96	...	20.27



METHODOLOGY

Pixel classification method

In order to compare data from different olive trees and assess whether they exhibit similar behavior, a classification system **based on value ranges is proposed.**



LiDAR DATA

Hyperspectral image pre-processing

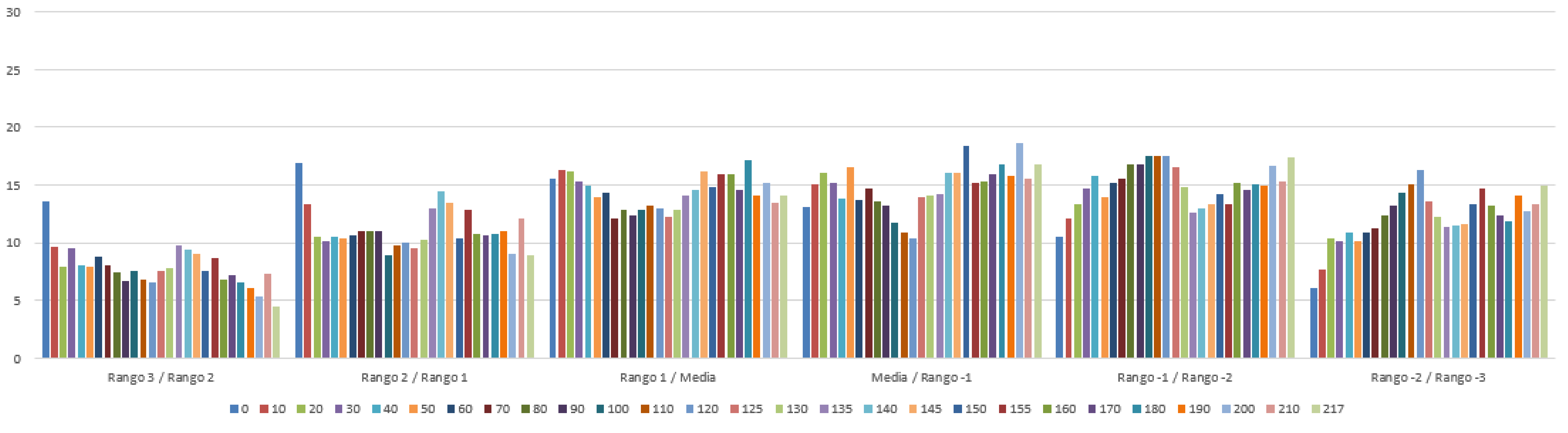
Vegetation index calculation

Segmentation of olive trees

Shadow pixel filtering

Hyperspectral pixel classification method

Classification of proportions with ranges



Number of pixels within an olive tree that fall into each defined range.

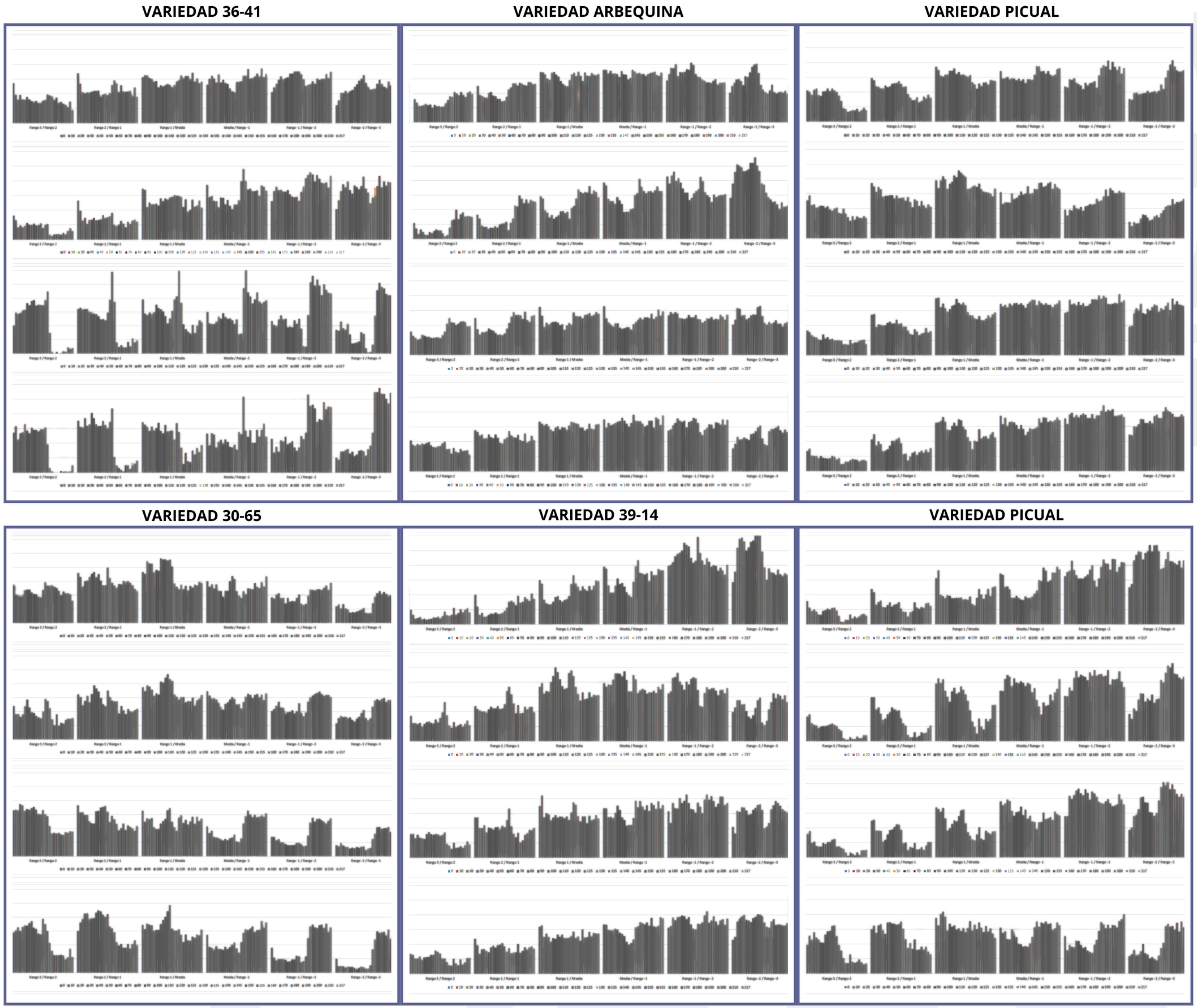
The proportions of pixels per spectral band for each created range are represented in column format.

The sum of all ranges per band represents 100% of the proportion.

RESULTS

Classification of proportions with ranges

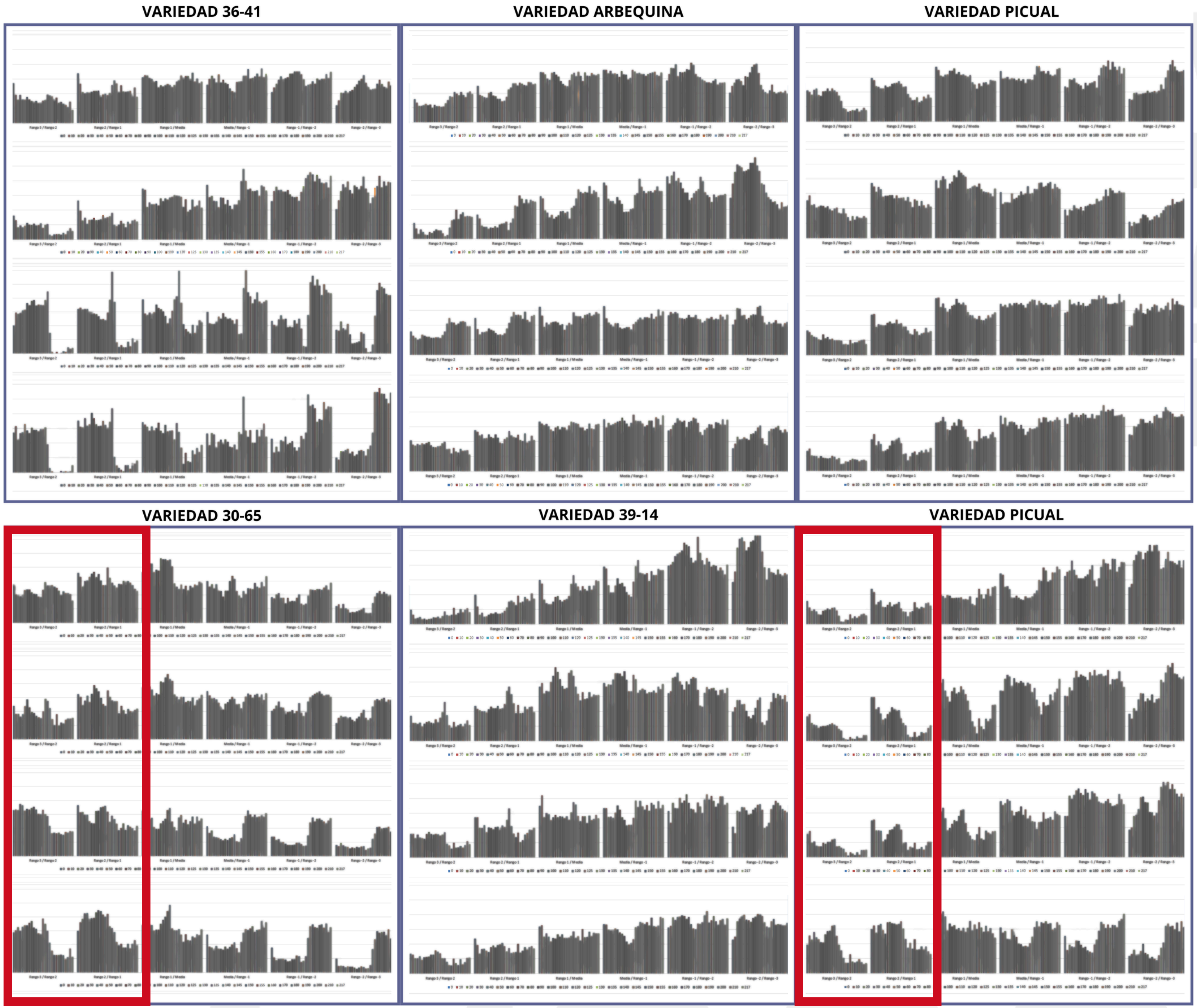
Within each group of the same variety, the graphs exhibit **similar trends and behaviors** in their spectral distribution.



RESULTS

Classification of proportions with ranges

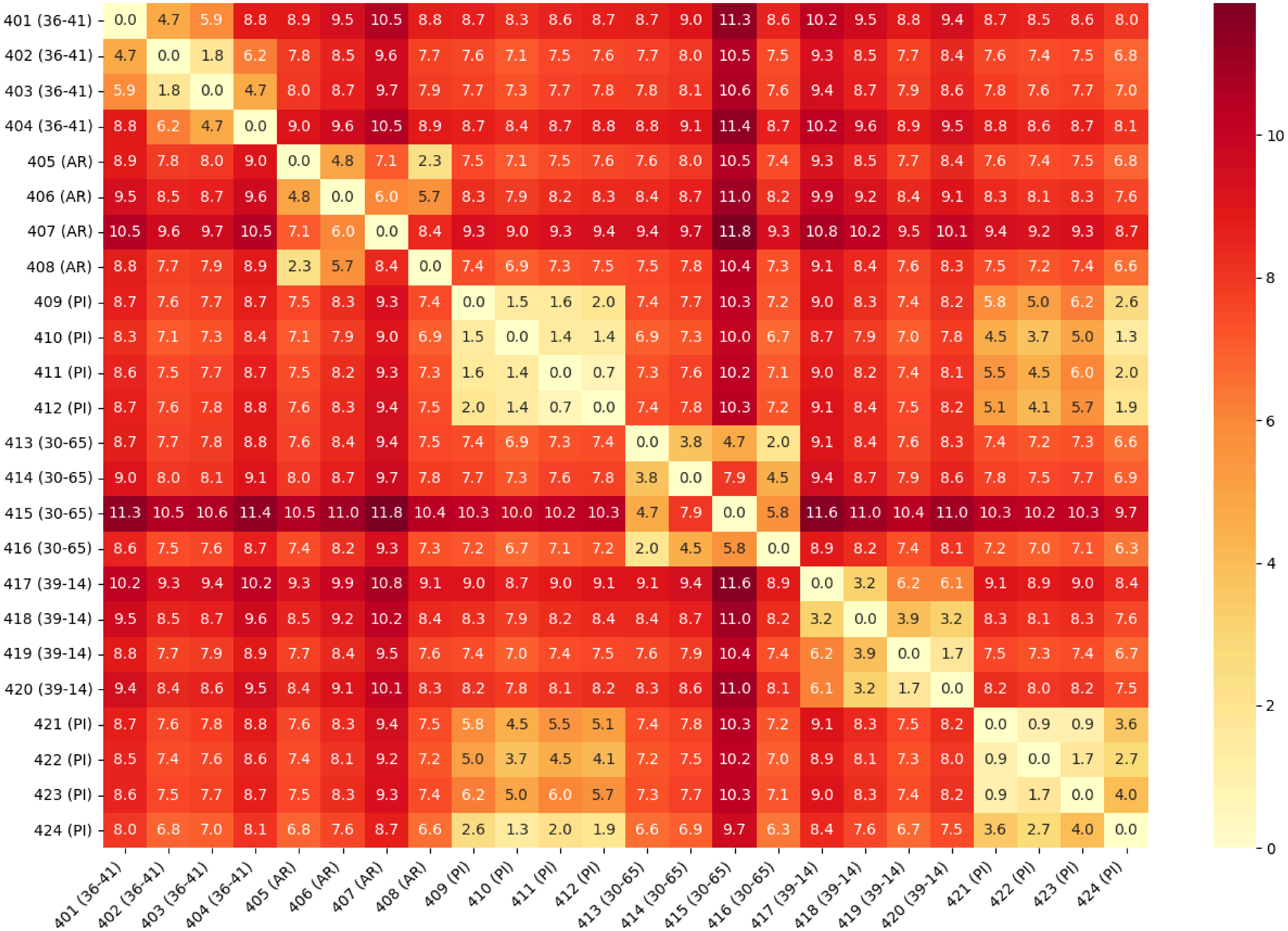
Within each group of the same variety, the graphs exhibit **similar trends and behaviors** in their spectral distribution.



RESULTS

Classification of proportions with ranges

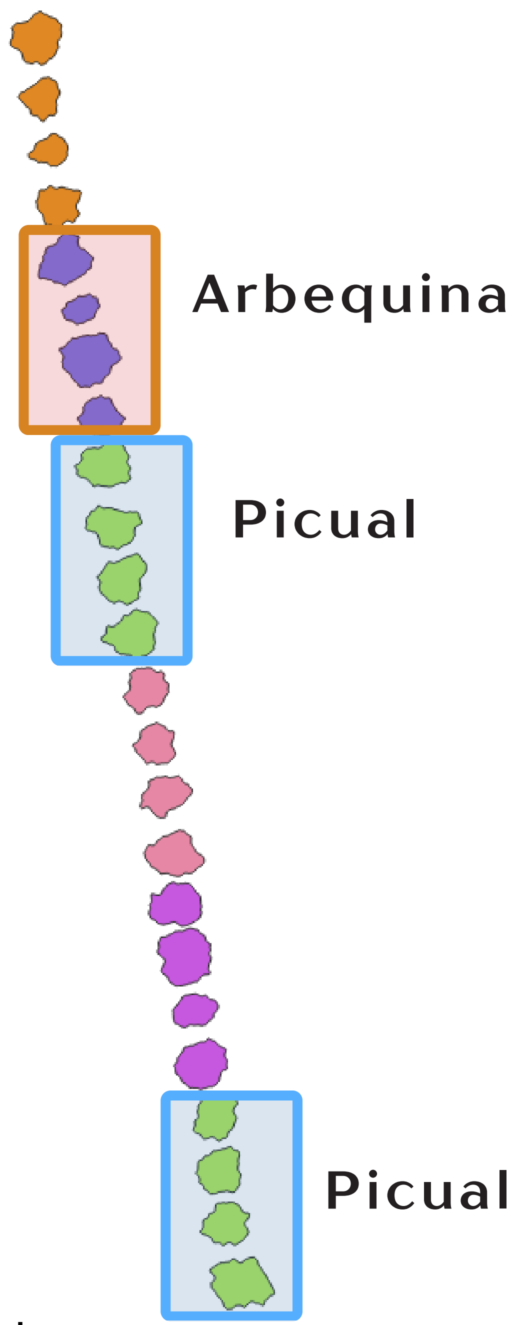
Heatmap of **Euclidean distances** between olive trees.



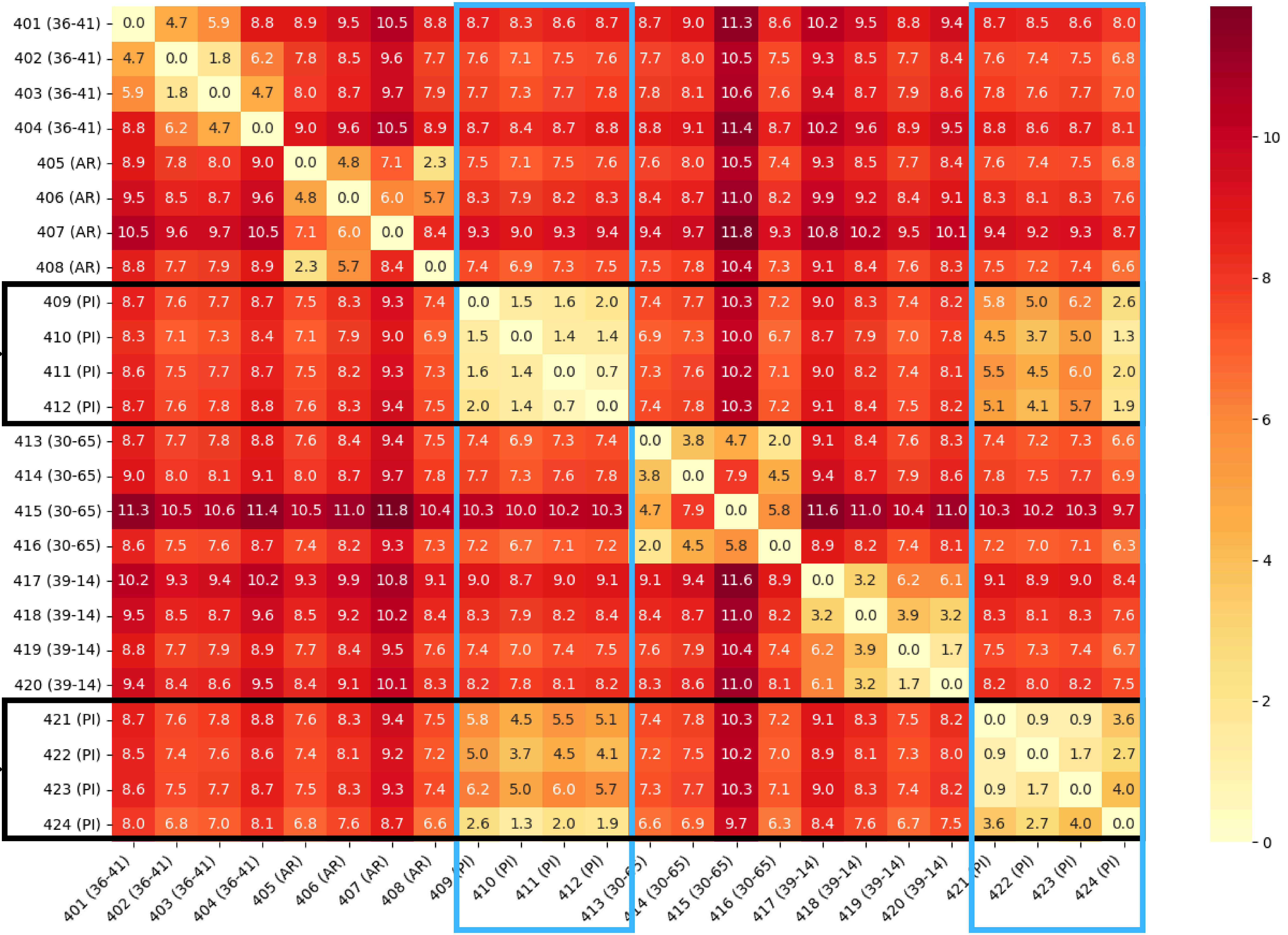
- **Extract statistical characteristics** (mean, deviation, etc.) from each olive tree.
- Train a classifier (**Random Forest**) to distinguish varieties.
- **Calculate the distance** between olive trees based on these characteristics.

RESULTS

Classification of proportions with ranges



PICUAL
VARIET
IES



	401 (36-41)	402 (36-41)	403 (36-41)	404 (36-41)	405 (AR)	406 (AR)	407 (AR)	408 (AR)	409 (PI)	410 (PI)	411 (PI)	412 (PI)	413 (30-65)	414 (30-65)	415 (30-65)	416 (30-65)	417 (39-14)	418 (39-14)	419 (39-14)	420 (39-14)	421 (PI)	422 (PI)	423 (PI)	424 (PI)
401 (36-41)	0.0	4.7	5.9	8.8	8.9	9.5	10.5	8.8	8.7	8.3	8.6	8.7	8.7	9.0	11.3	8.6	10.2	9.5	8.8	9.4	8.7	8.5	8.6	8.0
402 (36-41)	4.7	0.0	1.8	6.2	7.8	8.5	9.6	7.7	7.6	7.1	7.5	7.6	7.7	8.0	10.5	7.5	9.3	8.5	7.7	8.4	7.6	7.4	7.5	6.8
403 (36-41)	5.9	1.8	0.0	4.7	8.0	8.7	9.7	7.9	7.7	7.3	7.7	7.8	7.8	8.1	10.6	7.6	9.4	8.7	7.9	8.6	7.8	7.6	7.7	7.0
404 (36-41)	8.8	6.2	4.7	0.0	9.0	9.6	10.5	8.9	8.7	8.4	8.7	8.8	8.8	9.1	11.4	8.7	10.2	9.6	8.9	9.5	8.8	8.6	8.7	8.1
405 (AR)	8.9	7.8	8.0	9.0	0.0	4.8	7.1	2.3	7.5	7.1	7.5	7.6	7.6	8.0	10.5	7.4	9.3	8.5	7.7	8.4	7.6	7.4	7.5	6.8
406 (AR)	9.5	8.5	8.7	9.6	4.8	0.0	6.0	5.7	8.3	7.9	8.2	8.3	8.4	8.7	11.0	8.2	9.9	9.2	8.4	9.1	8.3	8.1	8.3	7.6
407 (AR)	10.5	9.6	9.7	10.5	7.1	6.0	0.0	8.4	9.3	9.0	9.3	9.4	9.4	9.7	11.8	9.3	10.8	10.2	9.5	10.1	9.4	9.2	9.3	8.7
408 (AR)	8.8	7.7	7.9	8.9	2.3	5.7	8.4	0.0	7.4	6.9	7.3	7.5	7.5	7.8	10.4	7.3	9.1	8.4	7.6	8.3	7.5	7.2	7.4	6.6
409 (PI)	8.7	7.6	7.7	8.7	7.5	8.3	9.3	7.4	0.0	1.5	1.6	2.0	7.4	7.7	10.3	7.2	9.0	8.3	7.4	8.2	5.8	5.0	6.2	2.6
410 (PI)	8.3	7.1	7.3	8.4	7.1	7.9	9.0	6.9	1.5	0.0	1.4	1.4	6.9	7.3	10.0	6.7	8.7	7.9	7.0	7.8	4.5	3.7	5.0	1.3
411 (PI)	8.6	7.5	7.7	8.7	7.5	8.2	9.3	7.3	1.6	1.4	0.0	0.7	7.3	7.6	10.2	7.1	9.0	8.2	7.4	8.1	5.5	4.5	6.0	2.0
412 (PI)	8.7	7.6	7.8	8.8	7.6	8.3	9.4	7.5	2.0	1.4	0.7	0.0	7.4	7.8	10.3	7.2	9.1	8.4	7.5	8.2	5.1	4.1	5.7	1.9
413 (30-65)	8.7	7.7	7.8	8.8	7.6	8.4	9.4	7.5	7.4	6.9	7.3	7.4	0.0	3.8	4.7	2.0	9.1	8.4	7.6	8.3	7.4	7.2	7.3	6.6
414 (30-65)	9.0	8.0	8.1	9.1	8.0	8.7	9.7	7.8	7.7	7.3	7.6	7.8	3.8	0.0	7.9	4.5	9.4	8.7	7.9	8.6	7.8	7.5	7.7	6.9
415 (30-65)	11.3	10.5	10.6	11.4	10.5	11.0	11.8	10.4	10.3	10.0	10.2	10.3	4.7	7.9	0.0	5.8	11.6	11.0	10.4	11.0	10.3	10.2	10.3	9.7
416 (30-65)	8.6	7.5	7.6	8.7	7.4	8.2	9.3	7.3	7.2	6.7	7.1	7.2	2.0	4.5	5.8	0.0	8.9	8.2	7.4	8.1	7.2	7.0	7.1	6.3
417 (39-14)	10.2	9.3	9.4	10.2	9.3	9.9	10.8	9.1	9.0	8.7	9.0	9.1	9.1	9.4	11.6	8.9	0.0	3.2	6.2	6.1	9.1	8.9	9.0	8.4
418 (39-14)	9.5	8.5	8.7	9.6	8.5	9.2	10.2	8.4	8.3	7.9	8.2	8.4	8.4	8.7	11.0	8.2	3.2	0.0	3.9	3.2	8.3	8.1	8.3	7.6
419 (39-14)	8.8	7.7	7.9	8.9	7.7	8.4	9.5	7.6	7.4	7.0	7.4	7.5	7.6	7.9	10.4	7.4	6.2	3.9	0.0	1.7	7.5	7.3	7.4	6.7
420 (39-14)	9.4	8.4	8.6	9.5	8.4	9.1	10.1	8.3	8.2	7.8	8.1	8.2	8.3	8.6	11.0	8.1	6.1	3.2	1.7	0.0	8.2	8.0	8.2	7.5
421 (PI)	8.7	7.6	7.8	8.8	7.6	8.3	9.4	7.5	5.8	4.5	5.5	5.1	7.4	7.8	10.3	7.2	9.1	8.3	7.5	8.2	0.0	0.9	0.9	3.6
422 (PI)	8.5	7.4	7.6	8.6	7.4	8.1	9.2	7.2	5.0	3.7	4.5	4.1	7.2	7.5	10.2	7.0	8.9	8.1	7.3	8.0	0.9	0.0	1.7	2.7
423 (PI)	8.6	7.5	7.7	8.7	7.5	8.3	9.3	7.4	6.2	5.0	6.0	5.7	7.3	7.7	10.3	7.1	9.0	8.3	7.4	8.2	0.9	1.7	0.0	4.0
424 (PI)	8.0	6.8	7.0	8.1	6.8	7.6	8.7	6.6	2.6	1.3	2.0	1.9	6.6	6.9	9.7	6.3	8.4	7.6	6.7	7.5	3.6	2.7	4.0	0.0

CONCLUSIONS

HSI TECHNOLOGY IN PRECISION AGRICULTURE

- **Allows the detection of subtle differences** in crops and olive varieties classification.

USE OF UAV PLATFORMS AND PROCESS AUTOMATION

- UAVs with hyperspectral cameras **optimize resources** and improve the accuracy of agricultural monitoring.
- By capturing all the information at once, it is possible to **automate** much of the process, **eliminating fieldwork.**

POTENTIAL OF ARTIFICIAL INTELLIGENCE AND FUTURE CHALLENGES

- It is possible to improve accuracy through advanced techniques such as **Deep Learning .**

THANK YOU