
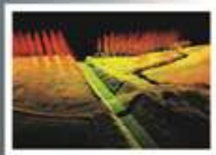



envirosense

Envirosense Hungary Ltd.

Eszterházy Károly University
Research Institute of Remote Sensing and Rural Development

Airborne Remote Sensing Technologies

Dezső Mikus - Envirosense Hungary Ltd.
László Bekő - Eszterházy Károly University

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Overview

- Introduction
- Technical background
  - Airborne sensors
  - Field measurments
  - Data processing
- Case studies

Introduction
Envirosense Hungary Ltd

Envirosense Hungary Ltd. ⟶ spin off established in 2009.

- specialist of remote sensing, **production and processing** of images by **aerial** sensors
- Remote sensing **devices**:
  - aerial hyperspectral
  - airborne LiDAR technologies
  - digital imagery +processing of UAV and satellite images.
- **Fields of activities**:
  - Environmental protection / Nature conservation
  - Forestry
  - Agriculture
  - Urban development
  - Mining
  - etc.

Introduction

Eszterházy Károly University

Research **I**nstitute of **R**emote **S**ensing and **R**ural **D**evelopment

- The mission of the **EKU RIRSRD** is to conduct basic and applied remote sensing research for the advancement of scientific knowledge about the environment.
- Our team is responsible for conducting all phases of remote sensing operations, including ***flight/mission planning***, ***sensor maintenance***, ***data acquisition***, ***data processing***, ***data analysis*** *and* ***modelling***
- 10+ years experience:
  - R+D projects
  - Hyperspectral imagery
  - LIDAR and orthophoto
  - Image processing

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Introduction

Eszterházy Károly University
Research Institute of Remote Sensing and Rural Development

INSTITUTIONAL SUPPORT OF THE DISASTER AND EMERGENCY RESPONSE PROGRAM OF THE UNITED NATIONS – UN SPIDER

United Nations Office for Outer Space affairs (UNOOSA) I.

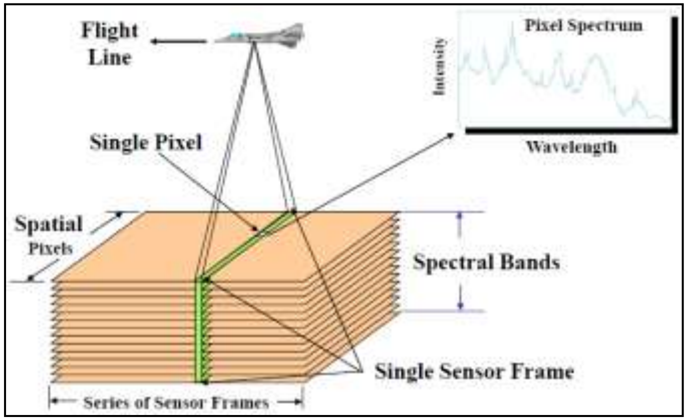
UNOOSA is the United Nations office responsible for promoting international cooperation in the peaceful uses of outer space.

UNOOSA conducts international workshops, training courses and pilot projects on topics that **include remote sensing, satellite navigation, satellite meteorology, tele-education and basic space sciences** for the benefit of developing nations. It also maintains a 24-hour hotline as the United Nations focal point for satellite imagery requests during disasters and manages the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER).

UNITED NATIONS | UNOOSA | UN-SPIDER

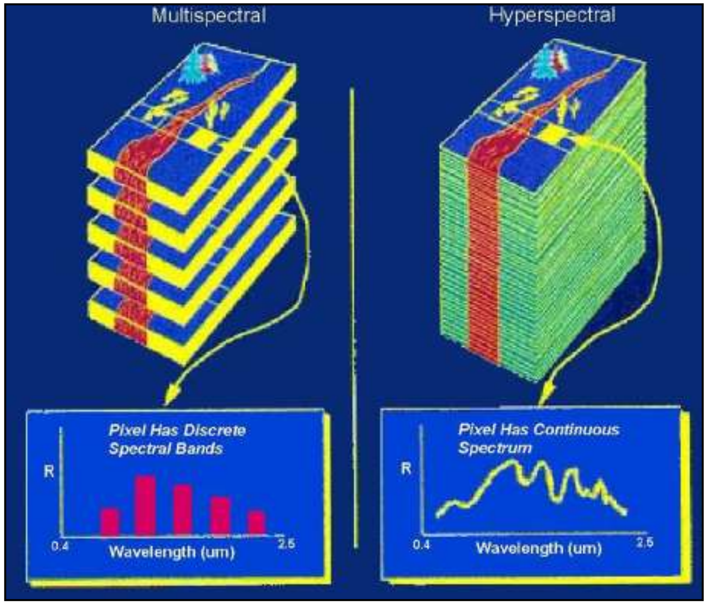
United Nations Platform for Space-based Information for Disaster Management and Emergency Response

Airborne remote sensing
Hyperspectral imagery



What is spectral imaging?
(hyperspectral imaging,
imaging spectroscopy)

Each pixel is associated with simultaneous high resolution spectral information produced by a spectral camera



Airborne remote sensing
Hyperspectral imagery

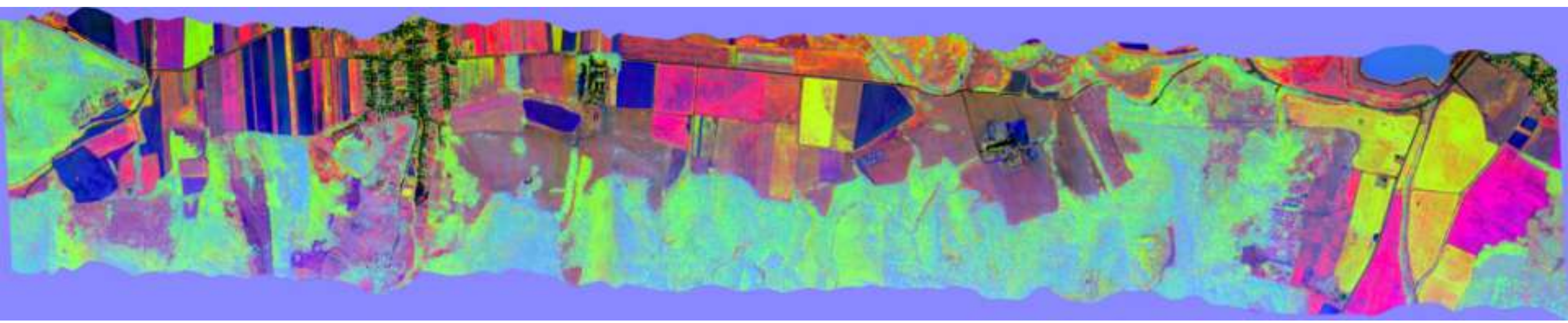
An ***Aisa FENIX 1K*** the top-of-the-range full spectrum (380 – 2500 nm spectral range) sensor with 1024 spatial pixels used for airborne collection operations.

This sensor is capable to record more than 600 bands up to 0.5 m ground resolution

Airborne remote sensing
Hyperspectral imagery

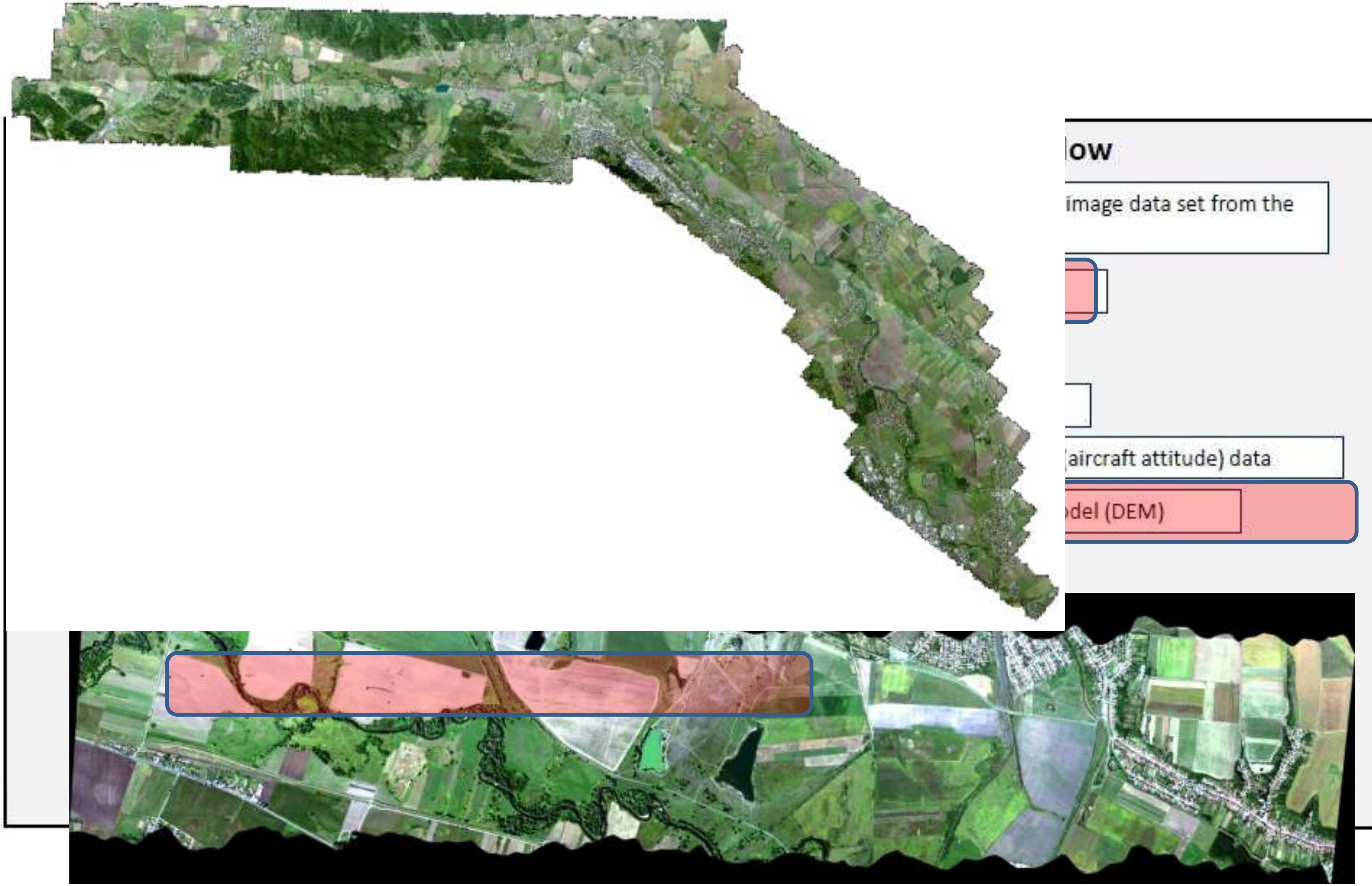
Hyperspectral image in different displays (Sajó valley, Hungary)

MNF (m … d bands



Data processing

AISA data processing chain



Airborne remote sensing
Hyperspectral imagery

Drenthe province of the Netherlands
AOI area: **2698,15 km²**

	A01	A02	A03	B04	B05	B06	C07	C08
Area (km^2)	402.22	412.29	419.30	382.22	412.95	216.39	209.28	260.26
Planned flight lines	26	26	30	30	25	28	28	22

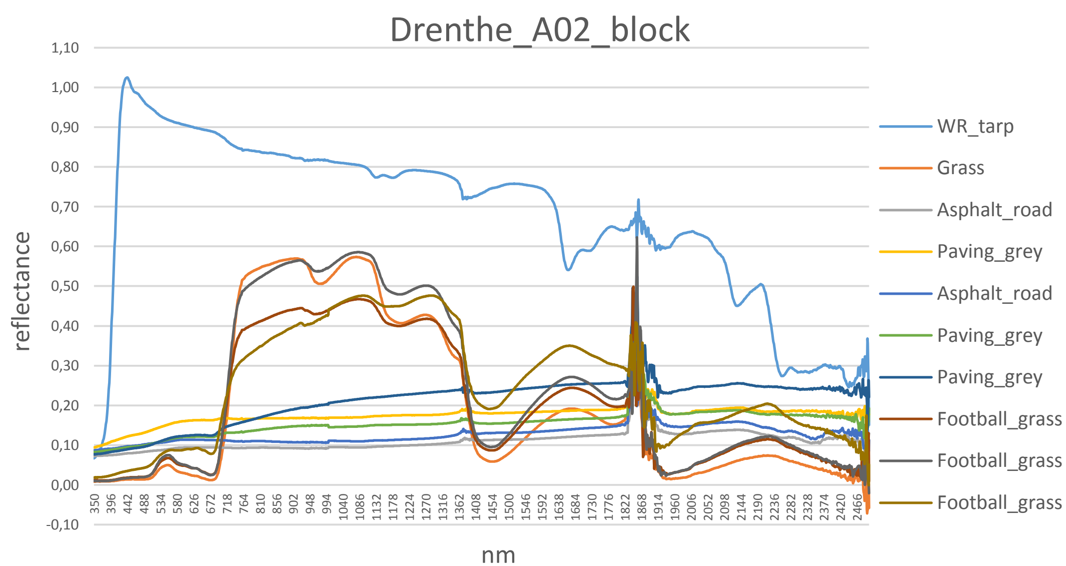
Flight line (to cover the AOI): **217**

Raw data size: **4.17 TB**

Flight days: 4-12 May 2016.

Airborne remote sensing
Hyperspectral imagery

Airborne remote sensing Hyperspectral imagery

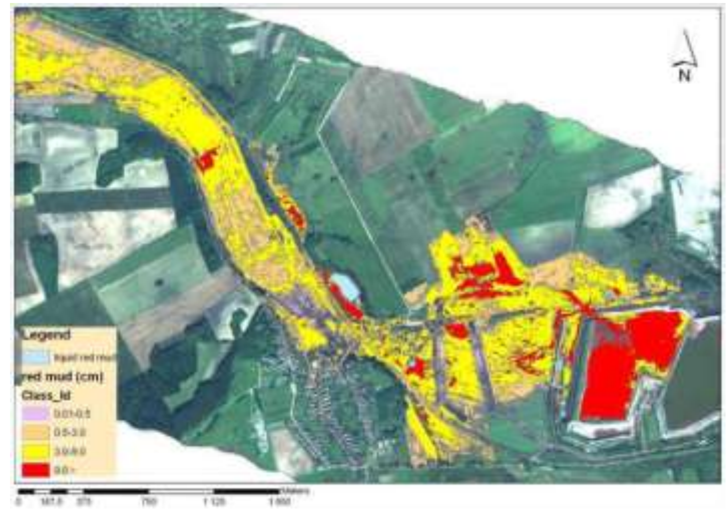


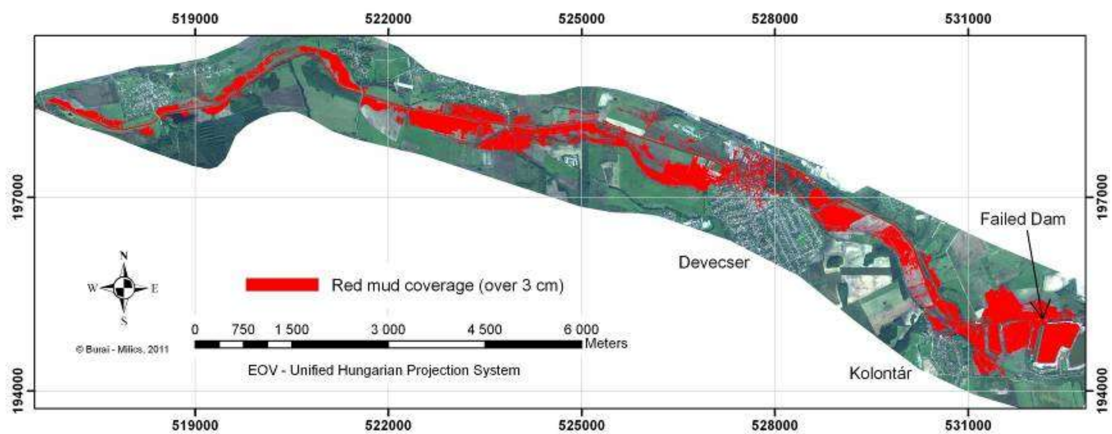

WR tarp


Grass


Concrete

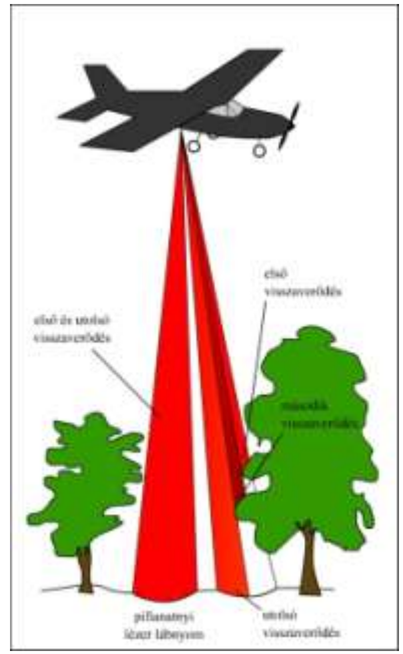
Airborne remote sensing
Hyperspectral imagery



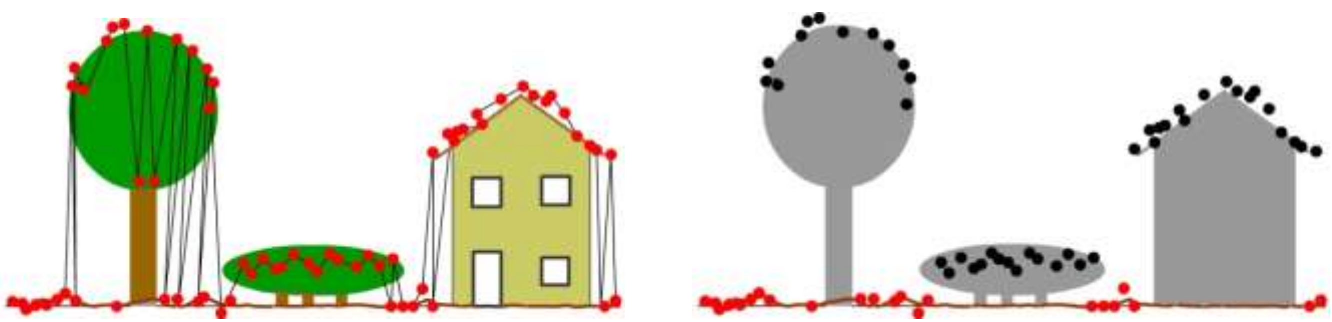


Berke J., Bíró T., Burai P., Kováts L.D., Kozma-Bognár V., Nagy T., Tomor T., Németh T. (2013): Application of remote sensing in the red mud environmental disiaster in Hungary, *Carpathian Journal of Earth and Environmental Sciences*, Vol. 3, 2, pp. 49-54., http://www.ubm.ro/sites/CJEES/viewTopic.php?topicId=318

Airborne remote sensing
Airborne laser scanning (LiDAR)



Multiple returnes



Point cloud classification

Airborne remote sensing

Airborne laser scanning (LiDAR) and digital orthophoto

Leica ALS-70 HP sensor with high accuracy GPS/INS **and Leica RCD 30 RGBN 60 MP** digital medium format camera

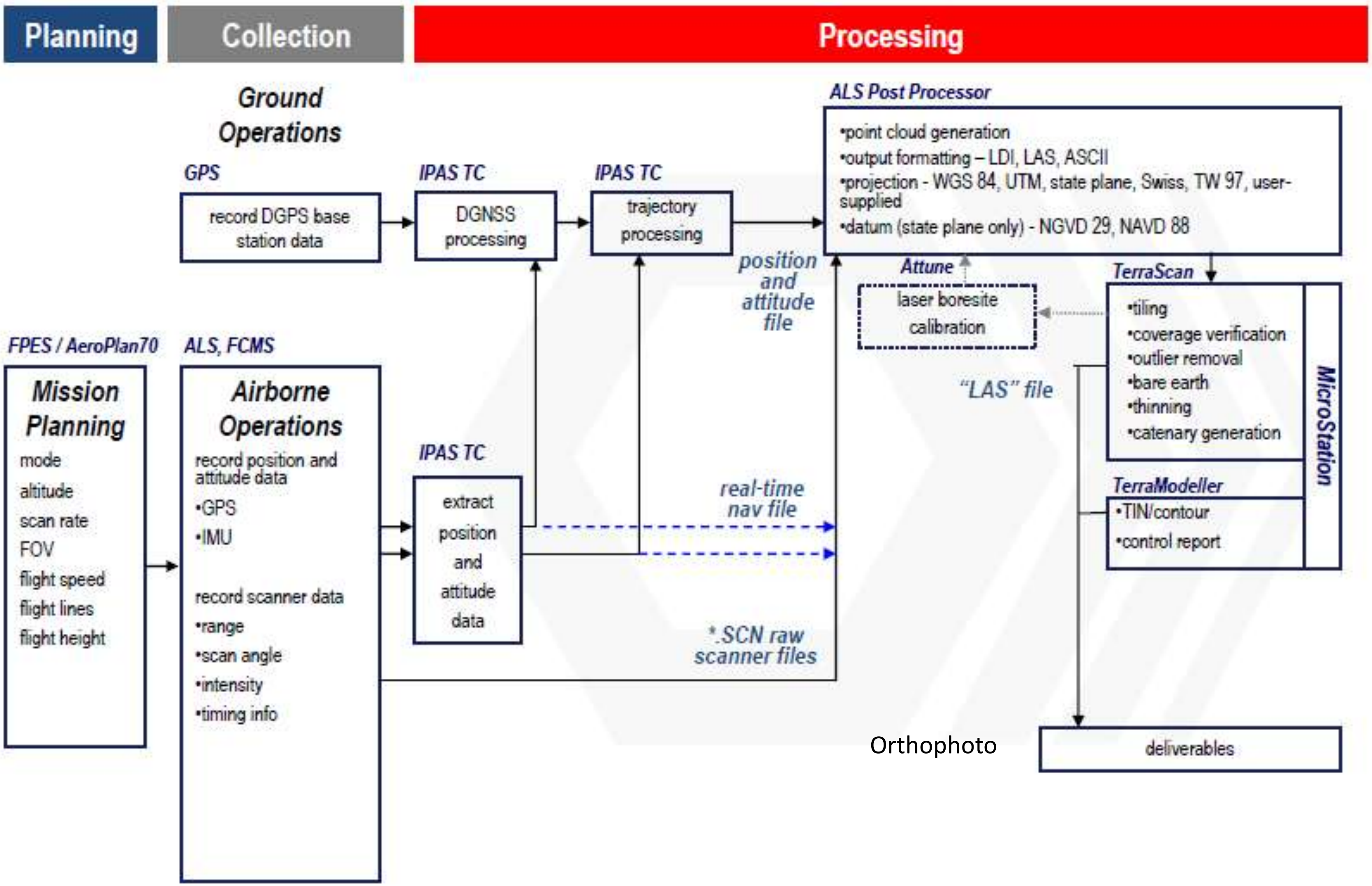
Maximum Flying Height (m AGL)	3500	
Maximum Measurement Rate (kHz)	500	
Field of view (degrees)	0–75 (full angle, user adjustable)	
Roll stabilization (automatic adaptive, degrees)	75–active FOV	
Scan patterns (user selectable) Maximum Scan Rate (Hz)	single	200
	triangle	158
	raster	120
Numbers of returns	unlimited	
Number of intensity measurements	3 (first, second, third)	
Accuracy	see graph	
Storage media	removable 500 GB SSD	
Storage capacity (hours @ max measurement rate)	6	

Piper PA-23-250 "Aztec" aircraft

60 megapixels resolution (8956 x 6708 pixel)
Geometric resolution (max) : 4 cm
Spectral range: RGB és NIR (780 – 900 nm)
50 mm focal lenght objective

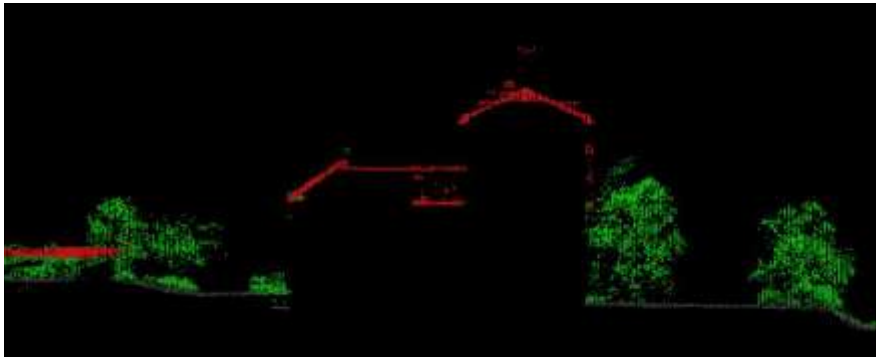
Data processing

Processing of LIDAR data and aerial digital images

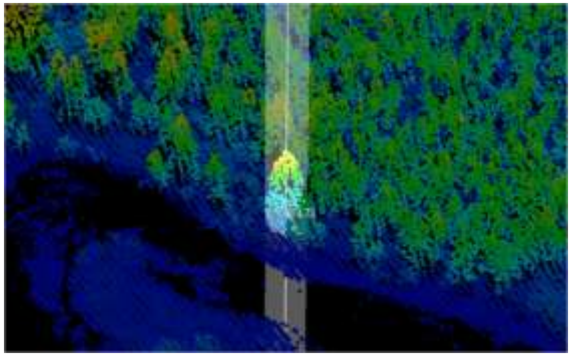


Airborne remote sensing
Advantage of LIDAR and aerial digital imagery

- Producing **DSM** and **DTM**, especially in **forested areas**
- **High accuracy** and very **dense measurement** applications, e.g., DTM generation and **volume calculation** in open pit mines, waste deposits, forest parameters



- DTM and DSM generation in **urban areas**, generation of **3D city models**
- Mapping of **corridors**, e.g., roads, railway tracks, pipelines, waterway landscapes



- Mapping of **electrical power lines** and **towers** including tree clearance
- Mapping **large area** (500-1000 km^2/day)

Ground based measurements

Airborne laser scanning (LIDAR) and aerial digital imagery :

- Ground survey with DGPS and base station for calibrating
- Reference points surveys with high accuracy DGPS
- Collecting GNSS data with base station (during airborne acquisition and post-process)

Airborne hyperspectral imagery :

- Reference surveys with field spectrometer
- Study and controll sites surveys with DGPS
- Collecting ground samples (ASD FieldSpec3, etc)
- In situ measurments (WALZ Mini-Pam, etc.)

Data processing
Techniques and devices

- **SGI supercomputer** SGI UV 2000 (24 db 2,4GHz Intel Xeon E5-4610 type CPU-144 core, total:1536 GB RAM)
- **SGI Octane III** high-performance graphics workstations
- **SGI C2108-TY11 server**
- **SGI C1104-2TY9 dual-node server**
- **RAID storage**

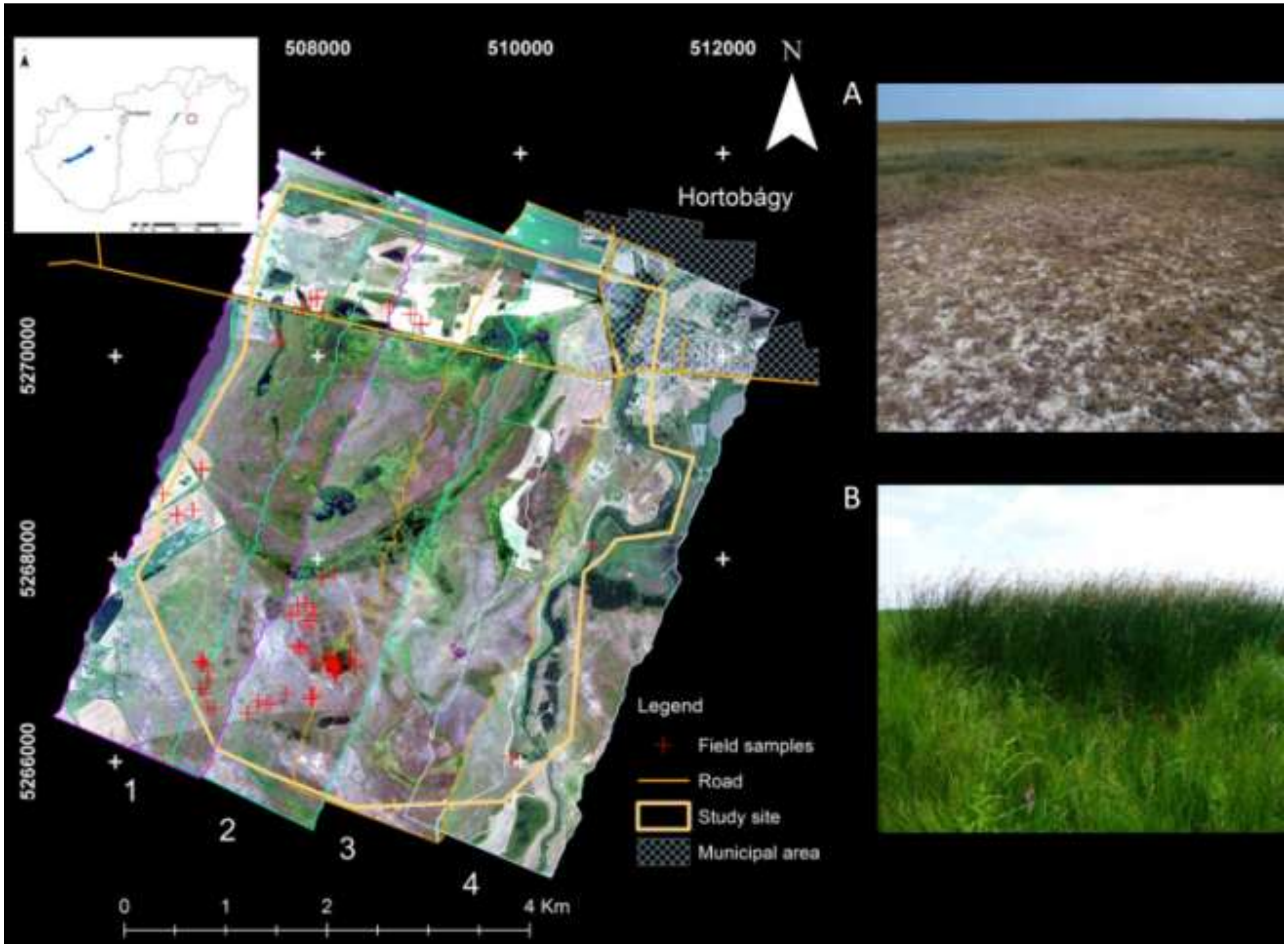
Case studies

1. Mapping of grassland (natural conversation)
2. Integration of hyperspectral and Lidar dataset to analyse tree species (forestry, railway)
3. Mapping of invasive tree species

Vegetation mapping using hyperspectral imagery

Study site: Pentezug-puszta (Hortobágy National Park), size: 23.5 km^2

Partners: National Park of Hortobágy, University of Debrecen



Hyperspectral imagery can be a suitable method for a **detailed vegetation classification** based on the **dominant** or **subdominant genera** or **species**

Hyperspectral acquisition and data sampling

Sensor: AISA Eagle +
Spectral resolution: 400-1000nm
Spectral resolution: 5nm
Number of bands: 128
Ground resolution: 1m
Acquisition: 07/07/2013

The sensor was mounted to a Piper Aztec aircraft.

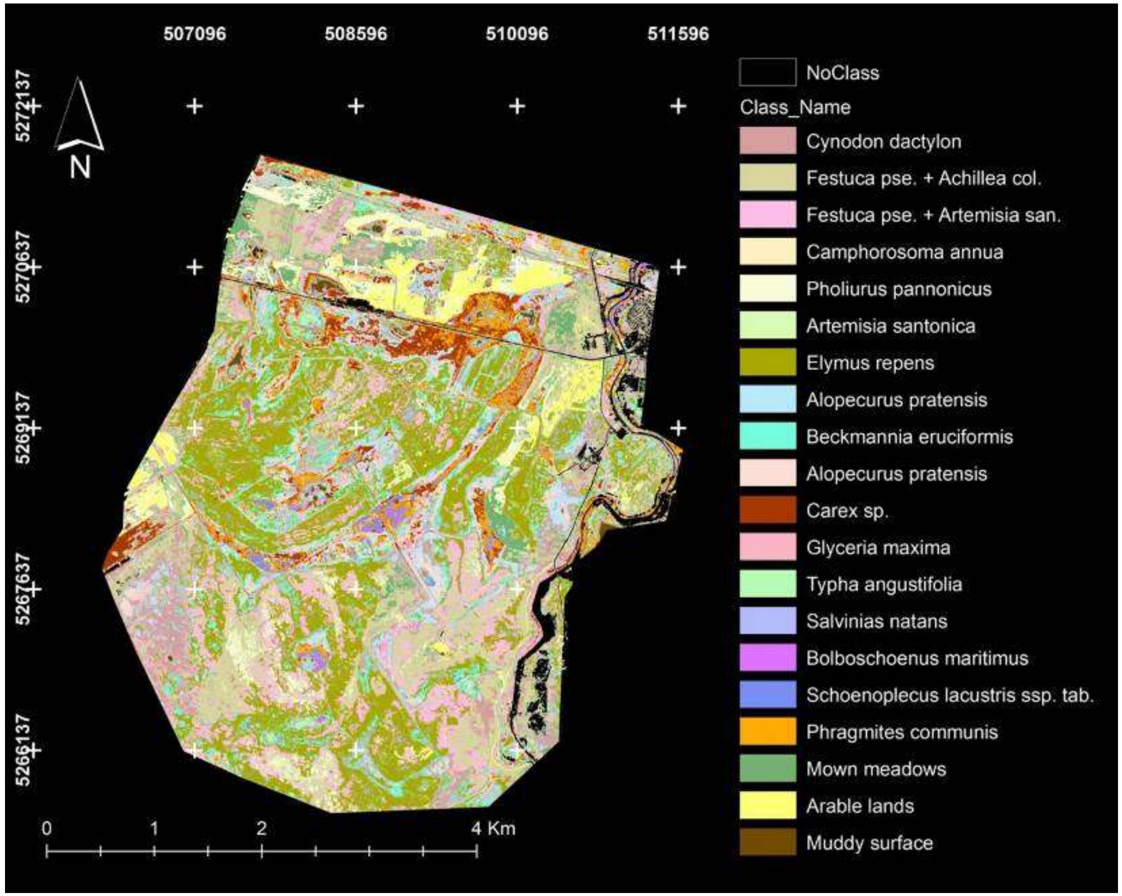
Hyperspectral acquisition and data sampling

For the calculations we classified the species as dominant (>50%) and subdominant species (10%–50%) based on their relative cover.

Abbreviation	Dominant Species	Subdominant Species	Canopy Height (cm)	Total Coverage of Vegetation (%)	Measured Area (m^2)
CYN	Cynodon dactylon	Achillea collina	21.2	96.2	211
FAC	Festuca pseudovina	Achillea collina	3.0	80.0	141
FAR	Festuca pseudovina	Artemisia santonica	28.3	80.8	96
CAM	Camphorosma annua	-	4.4	28.0	118
PHO	Pholiurus pannonicus	-	18.6	47.0	142
ART	Artemisia santonica	Pholiurus pannonicus	13.7	43.7	64
ELY	Elymus repens	-	96.0	64.0	402
ALO	Alopecurus pratensis	Agrostis stolonifera	48.3	93.3	531
BEC	Beckmannia eruciformis	Agrostis stolonifera, Cirsium brachycephalum	87.5	91.2	552
ACI	Alopecurus pratensis	Cirsium arvense Elymus repens	140.0	85.0	82
CAR	Carex spp.	-	100.0	90.0	253
GLY	Glyceria maxima	-	40.0	90.0	229
TYP	Typha angustifolia	Salvinia natans	200.0	70.0	63
SAL	Salvinia natans	Typha angustifolia, Utricularia vulgaris	133.0	70.0	65
BOL	Bolboschoenus maritimus	-	76.2	78.8	179
SCH	Schoenoplectus lacustris ssp. tabernaemontani	-	166.0	87.0	121
PHR	Phragmites communis	-	250.0	100.0	297
FMM *	Alopecurus pratensis	-	10.0	80.0	351
ARA *	Gypsophyla muralis, Polygonum aviculare	-	8.0	80.0	123
MUD **	not relevant	-	10.0	8.0	158

random sampling method → **training** and **validation** dataset

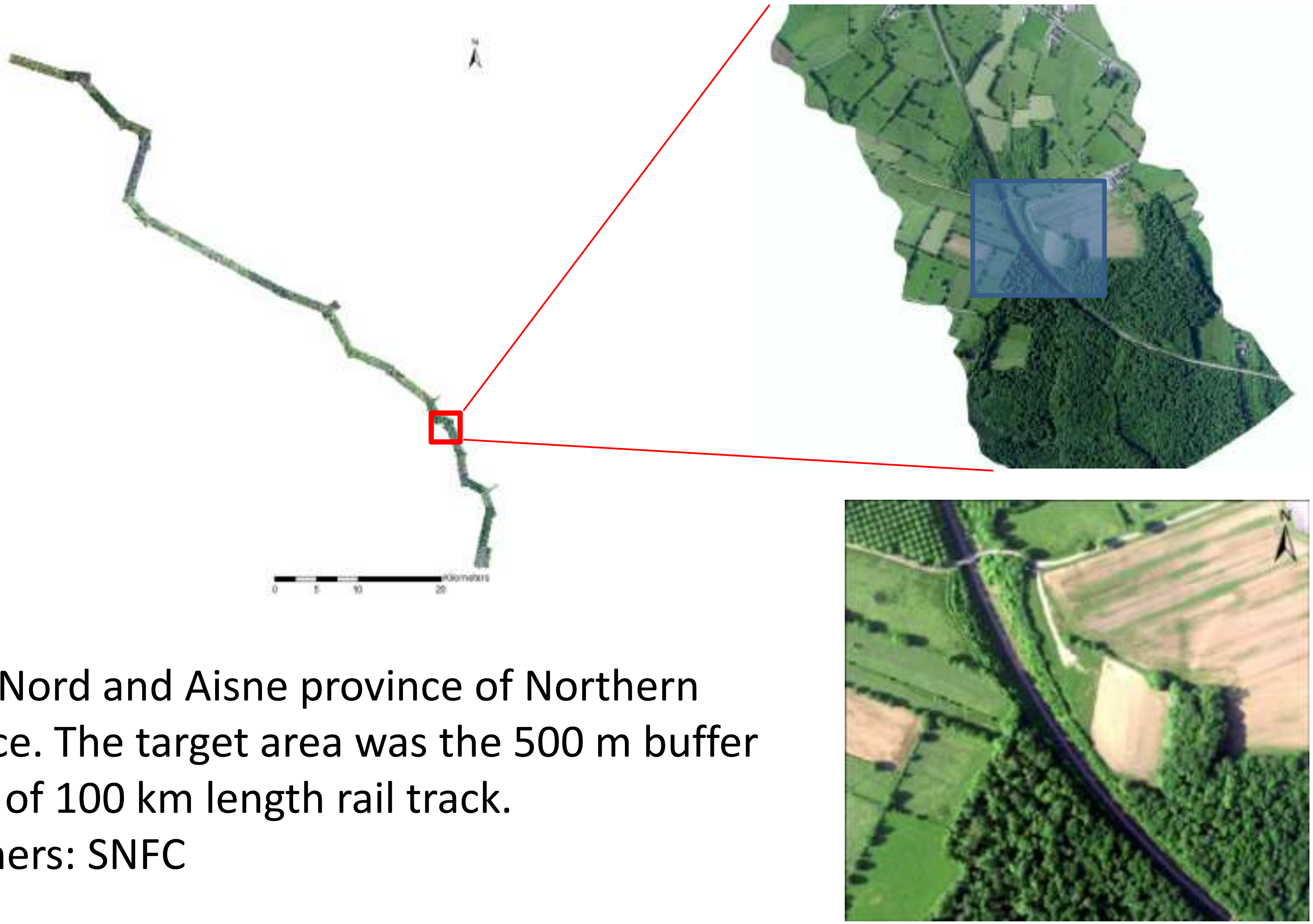
Vegetation mapping using hyperspectral imagery



Open vegetation was characterized by grasslands and wetlands with three classifiers and we could **separate 20 vegetation classes** with a **OA of 82.06%** (using SVM with MNF-transformed bands).

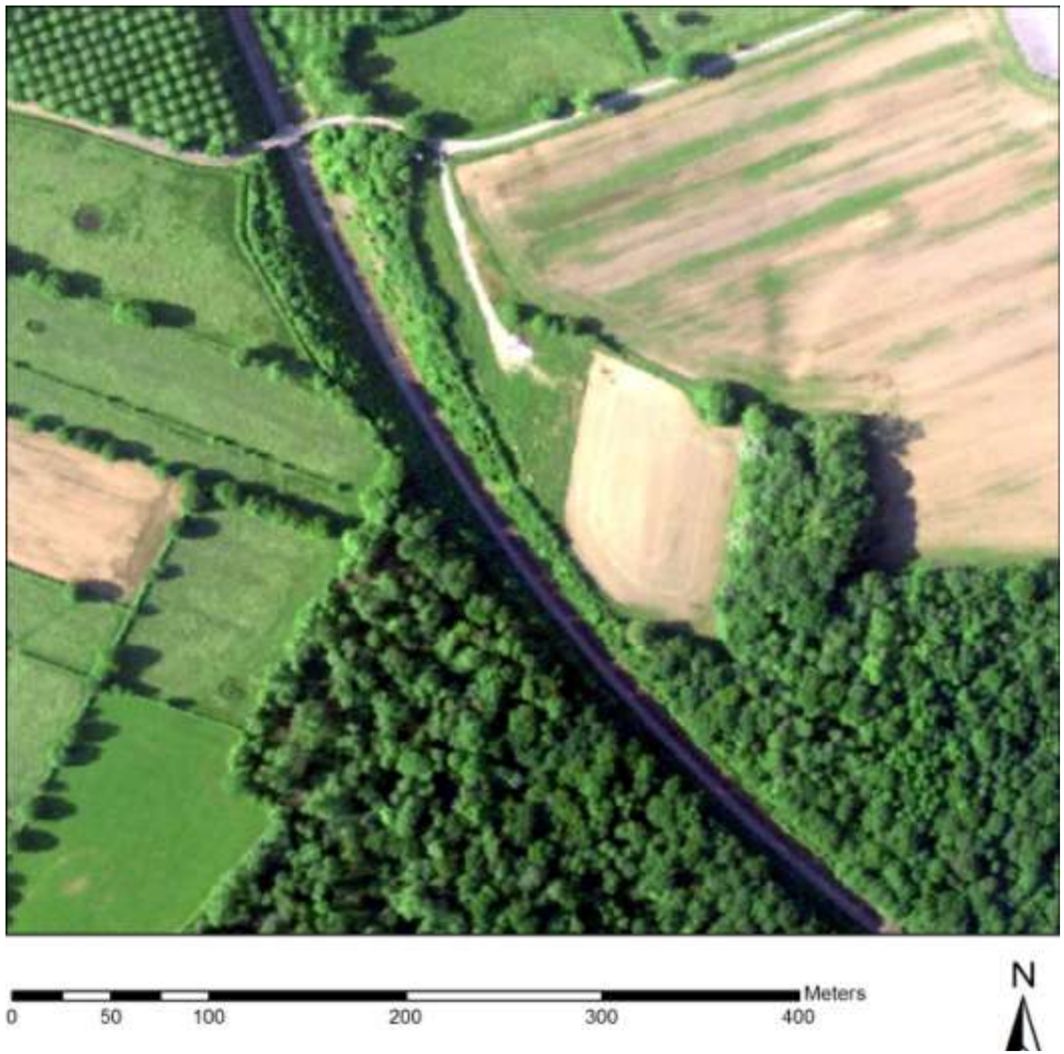
BURAI, P.–DEÁK, B.–VALKÓ, O.–TOMOR, T. (2015): Classification of herbaceous vegetation using airborne hyperspectral imagery. ***Remote Sensing****, Vol. 7 (2), pp. 2046-2066.*

Integration of hyperspectral and Lidar dataset to analyse tree species



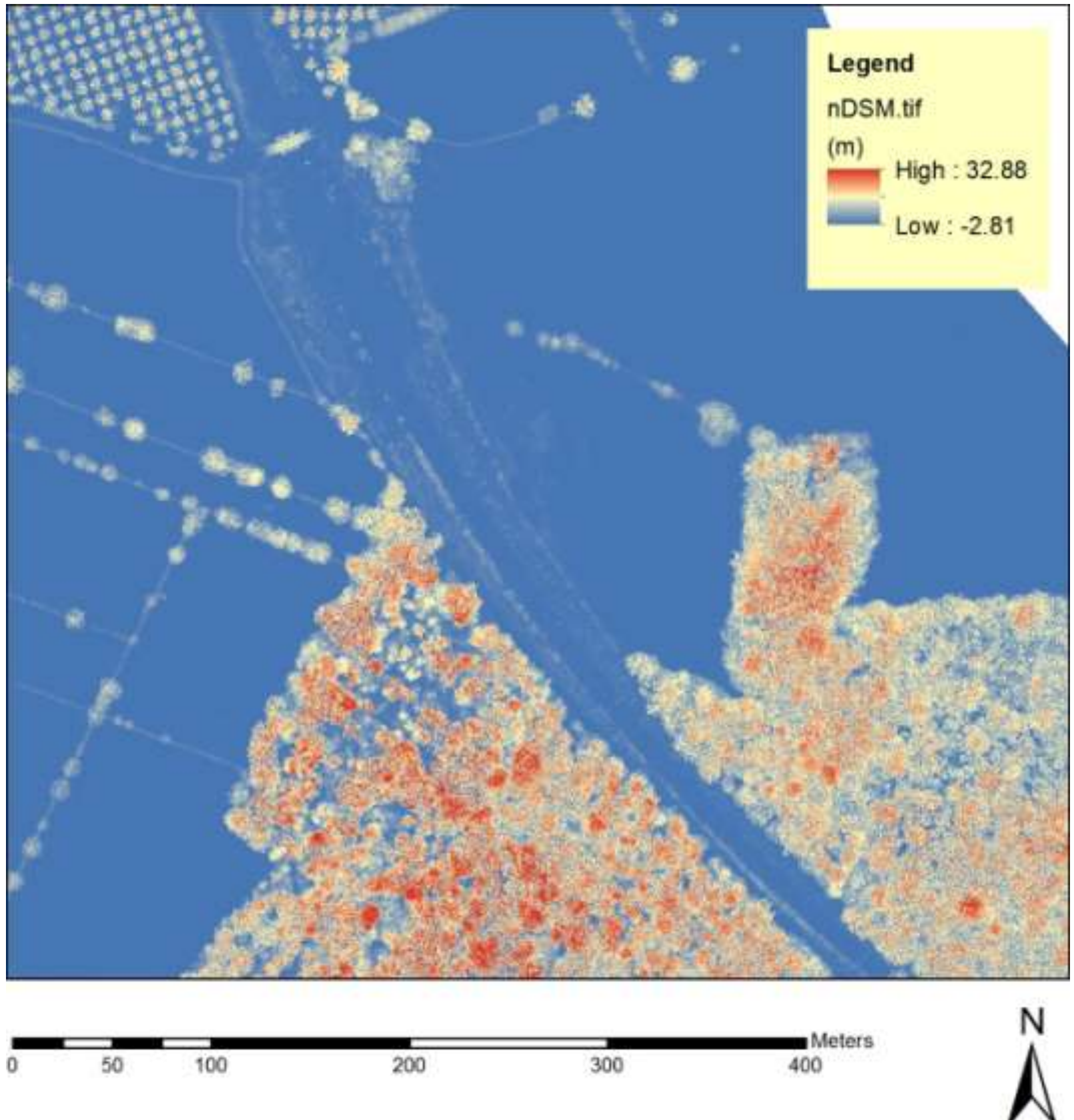
AOI: Nord and Aisne province of Northern France. The target area was the 500 m buffer zone of 100 km length rail track.
Partners: SNFC

Integration of hyperspectral and Lidar dataset to analyse tree species



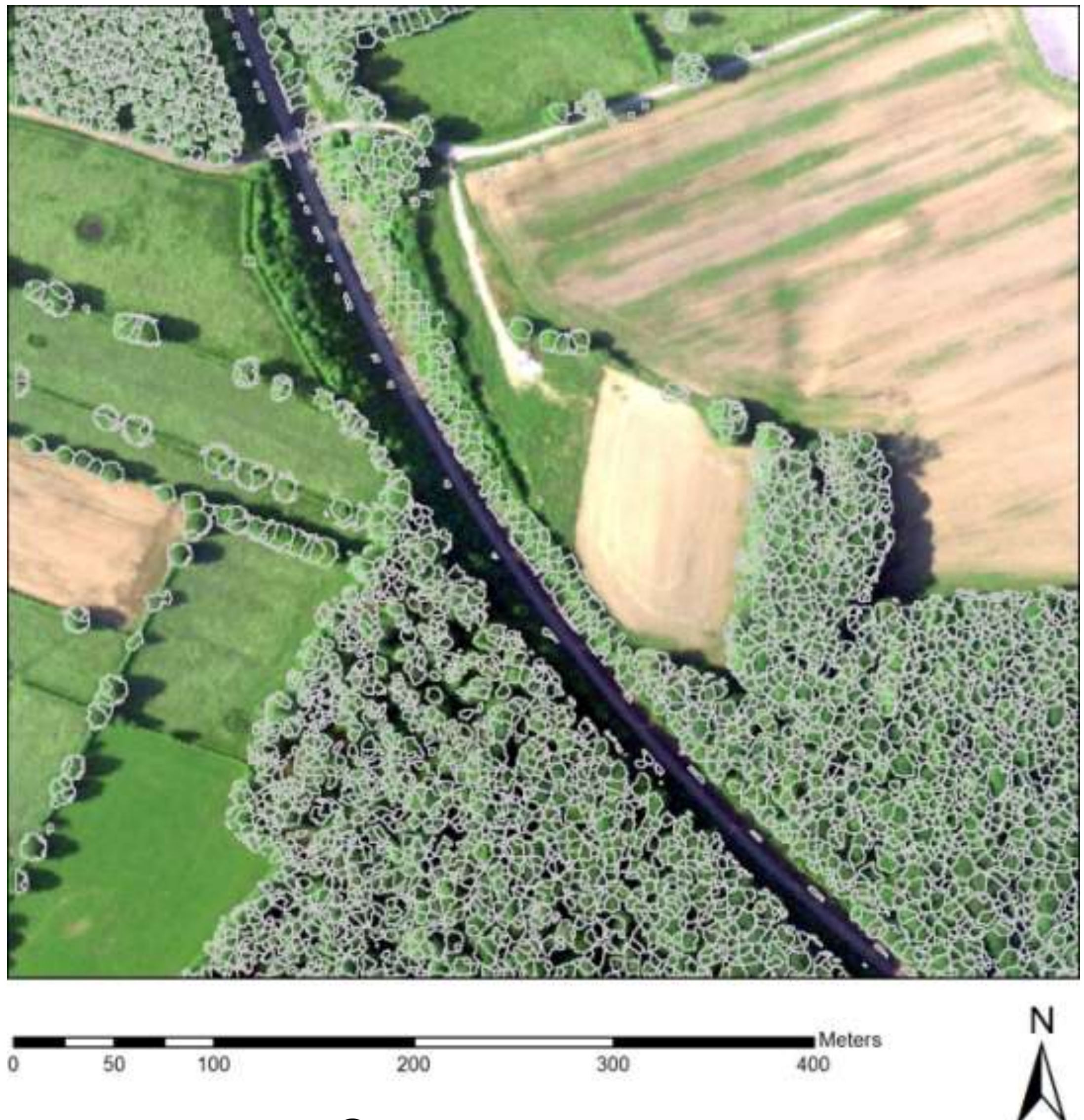
Spatial subset of hyperspectral image (RGB)

Integration of hyperspectral and Lidar dataset to analyse tree species



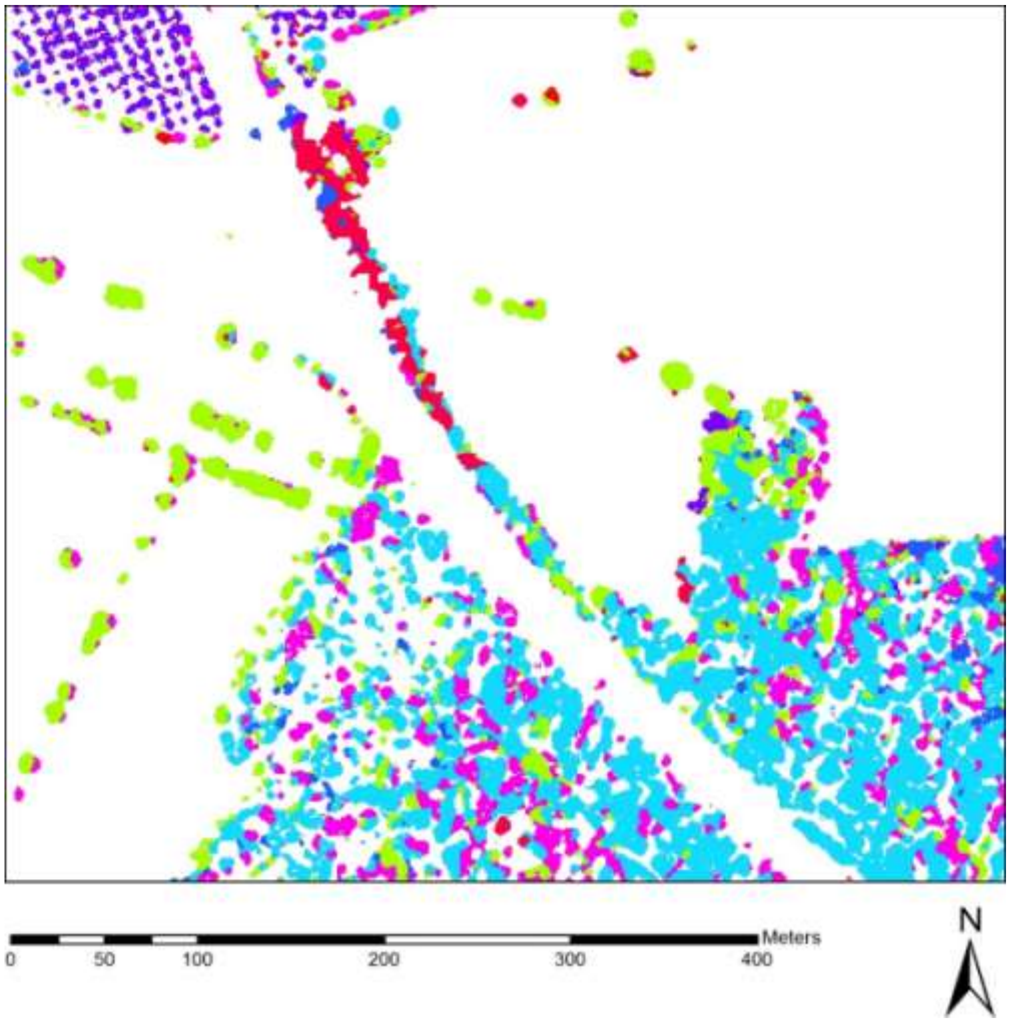
Classified nDSM

Integration of hyperspectral and Lidar dataset to analyse tree species



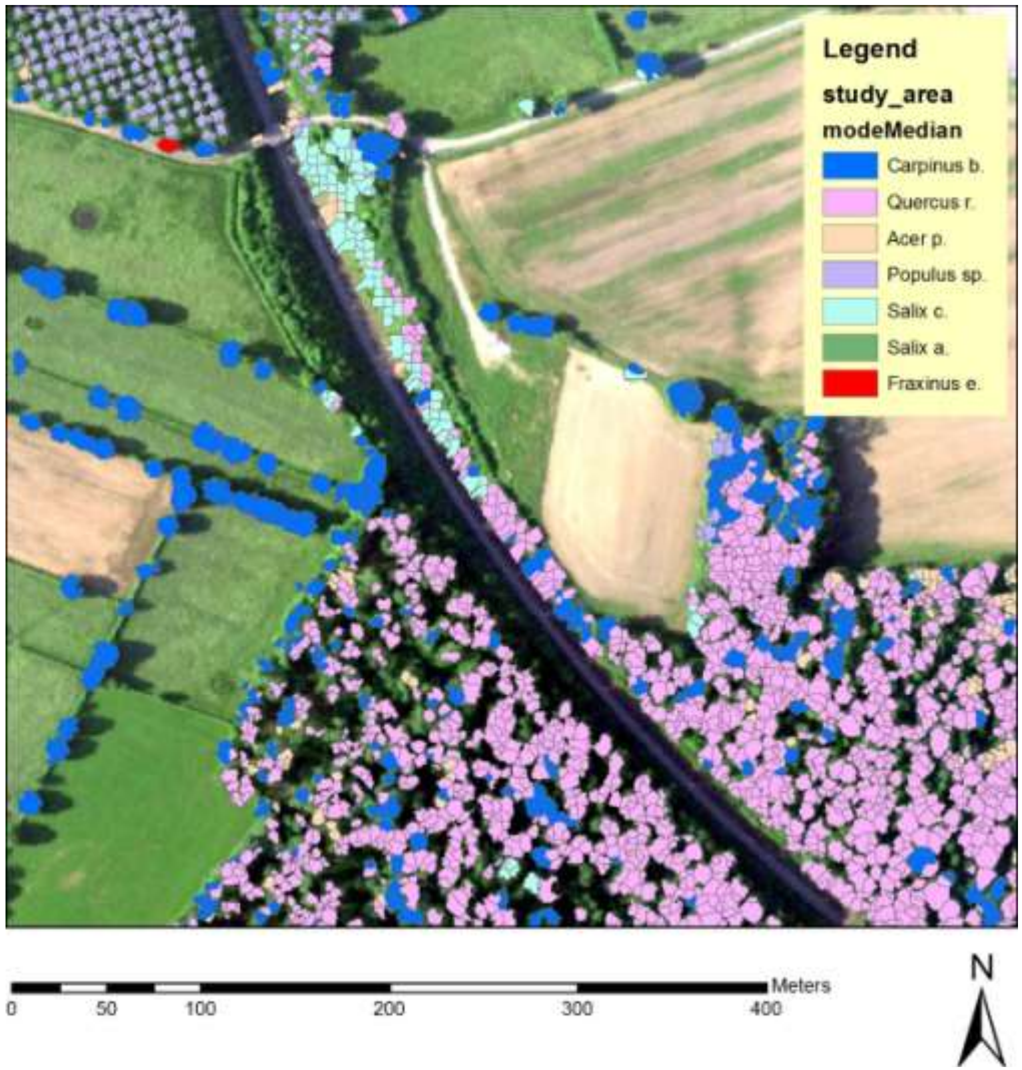
Crown segments

Integration of hyperspectral and Lidar dataset to analyse tree species



24 tree species were collected on the field measurements – **12 classes** were labeled for image classification

Integration of hyperspectral and Lidar dataset to analyse tree species



Classified trees

Mapping invasive trees using hyperspectral and LiDAR data

Sensor and flight parameters

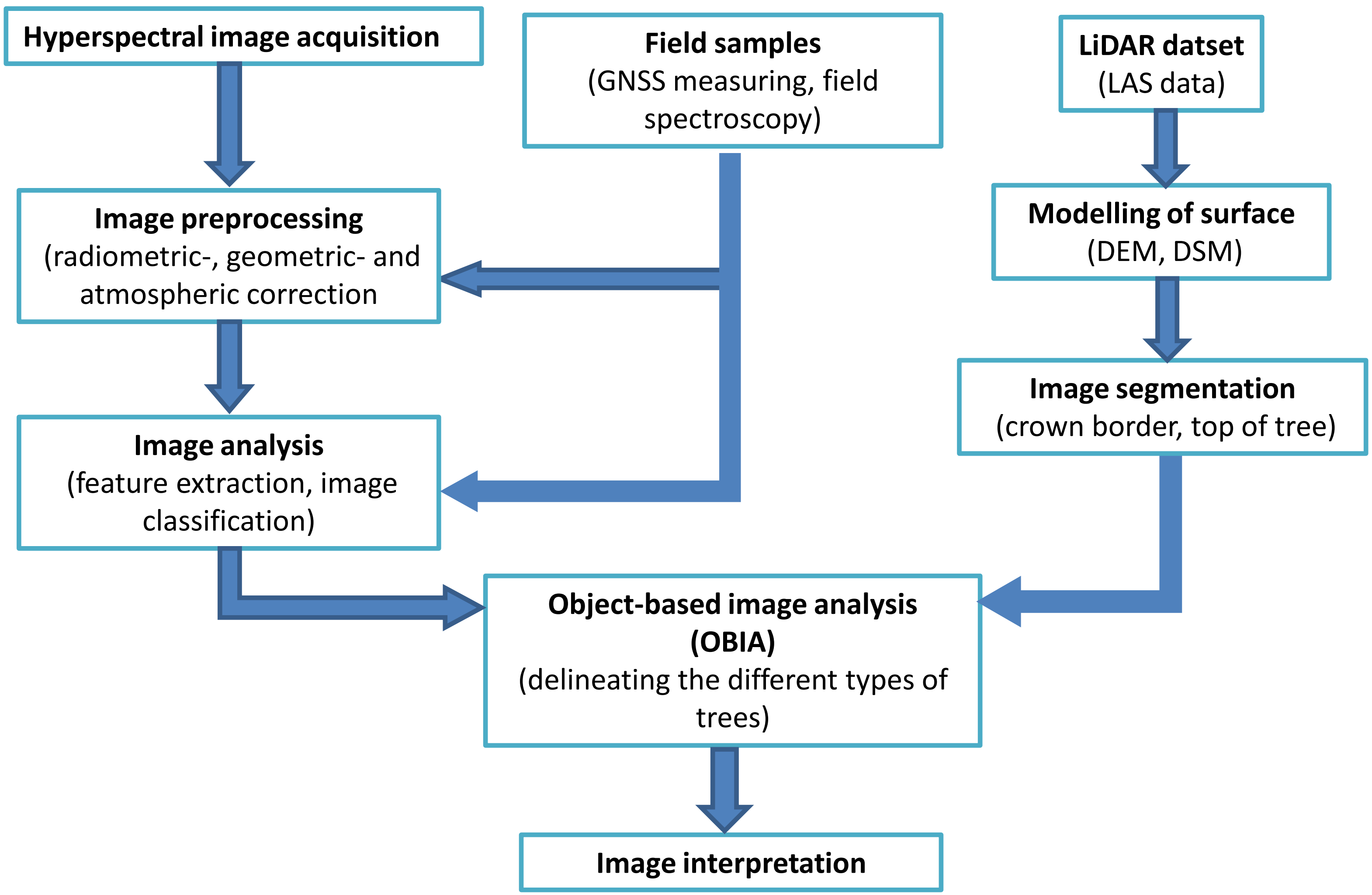
- Flight altitude: 1415 m (AGL) / 4642 ft (AGL)
- Swath width: 1024 m
- Flight speed (GS): 100 kts (185.2 km/h)
- Spectral res.: 3.5 nm (VNIR) / 6.3 nm (SWIR)
- Spectral range: 380-2450 nm
- Number of spectral bands: 420
- Spatial resolution: 1 m
- Overlapping: 20%
- Flight day: 29th June 2016 (08:07 – 08:49 UTC)
- Flight line (to cover the AOI): 21
- Raw data size: 195 GB

Visible colour (RGB) mosaic of hyperspectral lines

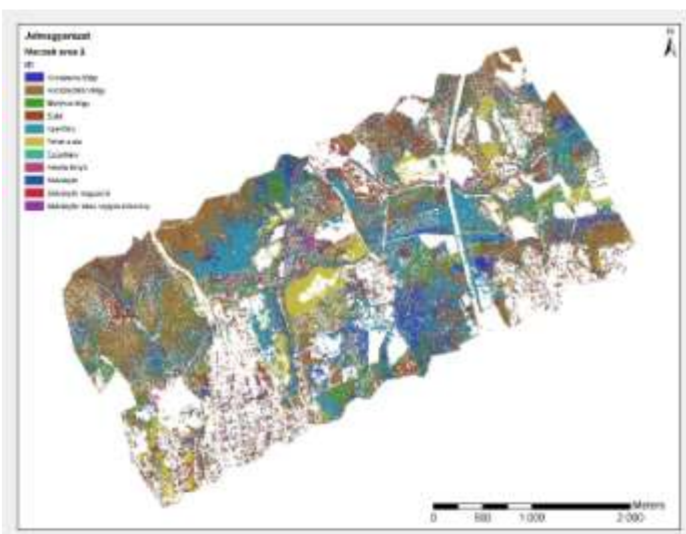
Mapping invasive trees using hyperspectral and LiDAR data

Workflow of image processing

15 tree species were collected on the field measurements – **18 classes** were labeled for image classification



Classified hyperspectral image



15 tree species were collected on the field measurements – **18 classes** were labeled for image classification

Classes	Species	Latin name	Training (pixel)	Controll (pixel)	Overall (pixel)
1	Pedunculate oak	Quercus robur	234	112	346
2	Sessile oak	Quercus petraea	1942	676	2618
3	Downy oak	Quercus pubescens	296	124	420
4	Common beech	Fagus sylvatica	153	67	220
5	Common hornbeam	Carpinus betulus	460	243	703
6	Black locust	Robinia pseudoacacia	1589	828	2417
7	Sycamore	Acer pseudoplatanus	91	27	118
8	Field maple	Acer campestre	120	49	169
9	Common ash	Fraxinus excelsior	82	26	108
10	Manna ash	Fraxinus ornus	166	74	240
11	Silver lime	Tilia tomentosa	176	73	249
12	Cherries	Cerasus	369	175	544
13	Spruce	Picea	77	17	94
14	Black pine	Pinus nigra	234	128	362
15	Ailanthus	Ailanthus	932	387	1319
16	Ailanthus (spreading seeds)	---	237	94	331
17	Black locust, Ailanthus mixed population	---	271	115	386
18	Ailanthus (re-growth after clear-cut)	---	83	49	132

Mapping invasive trees using hyperspectral and LiDAR data

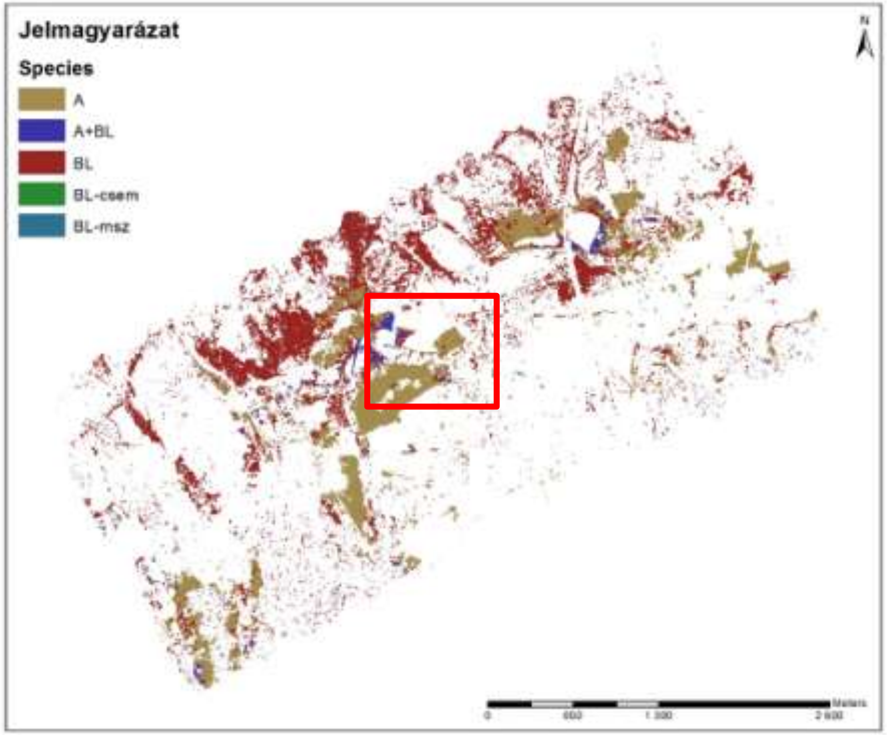
Result of image classification (MNF bands + SVM)

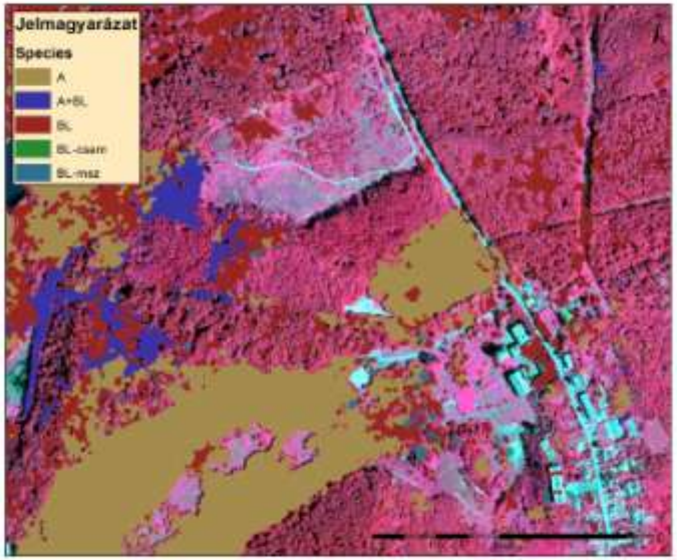
	Ground Truth (Percent)																		
Class	BL	CS	KTT	GY	A	B	A+BL	HJ	EH	KST	BL-msz	LF	BL-csem	MK	MOT	VK	MJ	FF	Total
BL	**76,61**	0,81	0,31	0,00	1,20	1,31	2,95	0,00	0,57	0,00	1,27	0,00	0,00	0,00	1,35	0,00	0,00	0,43	10,13
CS	6,97	**86,18**	4,69	0,87	0,63	1,31	0,00	0,00	0,00	0,00	1,27	0,00	0,00	1,22	1,35	0,00	0,83	0,00	6,64
KTT	0,86	2,98	**69,26**	4,13	0,06	0,65	0,00	0,00	0,00	0,00	4,22	0,00	0,00	2,44	5,07	3,01	0,00	0,00	18,86
GY	0,54	2,44	3,96	**67,39**	0,00	6,54	0,00	0,00	0,00	0,00	1,69	0,00	0,00	0,00	3,04	1,81	0,00	0,00	5,68
A	4,61	1,08	0,21	1,09	**89,93**	0,00	2,58	0,00	0,00	0,00	0,84	0,00	0,00	0,00	0,34	0,00	0,00	0,00	19,89
B	0,21	1,90	1,39	4,78	0,06	**88,89**	0,00	0,00	1,14	0,00	0,00	0,00	0,00	0,00	2,03	0,60	0,00	0,00	2,71
A+BL	3,00	0,00	0,31	0,43	5,85	0,00	**93,73**	0,00	0,00	0,00	0,42	0,00	0,00	0,00	0,00	1,20	0,00	0,00	5,14
HJ	0,00	1,08	0,05	0,22	0,13	0,00	0,00	**98,94**	0,00	2,14	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,41
EH	0,21	0,54	0,82	0,43	1,45	0,00	0,00	0,00	**96,02**	0,00	0,00	0,00	0,00	0,00	0,00	1,20	0,00	0,00	2,87
KST	0,00	0,27	1,39	0,00	0,19	0,00	0,00	1,06	0,57	**97,86**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,49
BL-msz	6,01	0,00	0,82	0,87	0,06	0,00	0,00	0,00	0,00	0,00	**87,34**	0,00	0,00	1,22	0,00	0,60	0,00	0,00	3,81
LF	0,11	0,00	0,00	0,00	0,13	0,00	0,00	0,00	0,00	0,00	0,00	**100,00**	0,00	0,00	0,00	0,00	0,00	0,00	1,06
BL-csem	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,57	0,00	0,00	0,00	**100,00**	0,00	0,00	0,00	0,00	0,00	1,12
MK	0,00	2,44	7,36	0,00	0,25	0,00	0,00	0,00	0,00	0,00	0,42	0,00	0,00	**91,46**	1,35	0,60	0,00	0,00	3,15
MOT	0,00	0,27	5,87	17,83	0,06	1,31	0,00	0,00	0,00	0,00	0,84	0,00	0,00	3,66	**82,09**	0,60	0,00	1,28	6,01
VK	0,21	0,00	2,94	1,52	0,00	0,00	0,00	0,00	0,57	0,00	0,84	0,00	0,00	0,00	2,03	**90,36**	0,00	0,43	3,01
MJ	0,32	0,00	0,62	0,43	0,00	0,00	0,00	0,00	0,57	0,00	0,84	0,00	0,00	0,00	0,34	0,00	**99,17**	0,00	1,86
FF	0,32	0,00	0,00	0,00	0,00	0,00	0,74	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,01	0,00	0,00	**97,86**	3,15
Total	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00

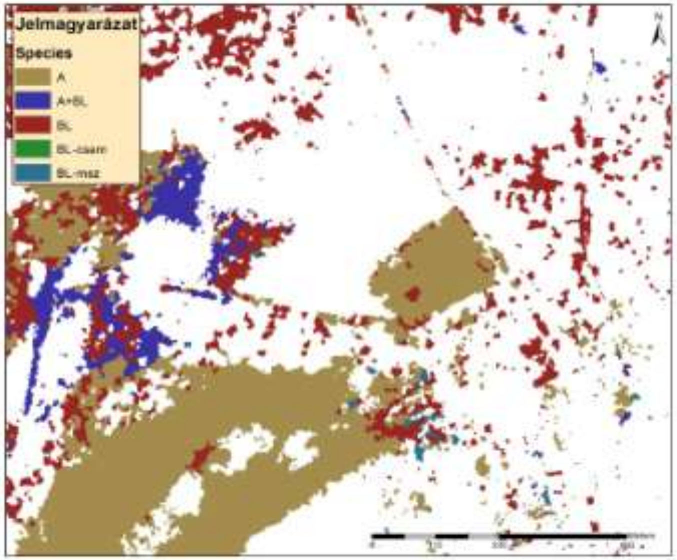
Overall accuracy: 82.24%

Kappa: 0.798

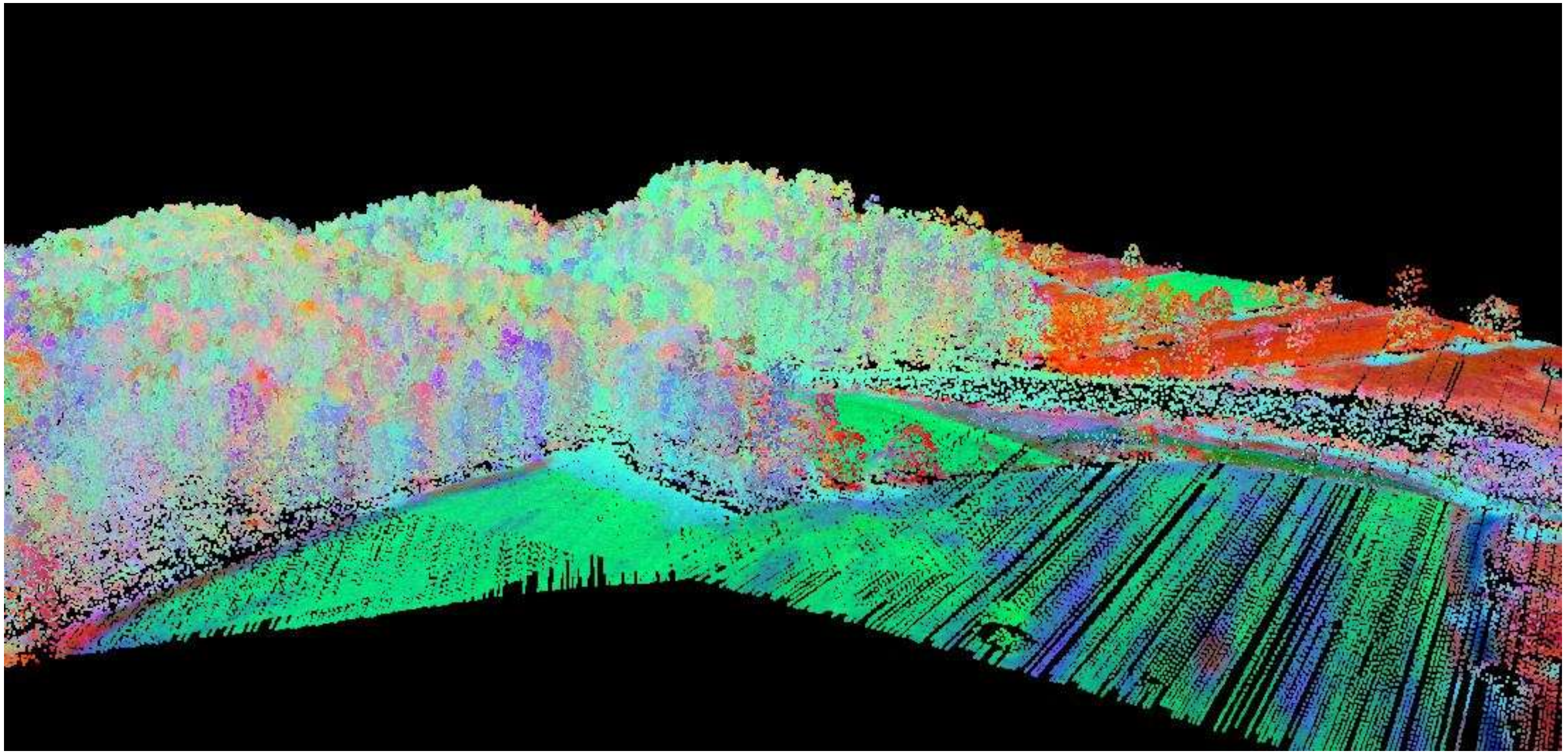
Mapping of invasive trees







Thank you for your attention!



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László Bekő