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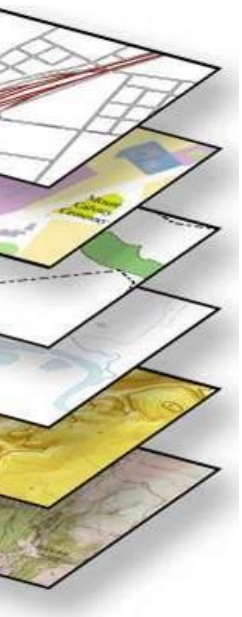
Institute of Applied Ecology



Application of Remote Sensing in Nature Protection and Natural Resource Management

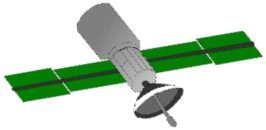
Ivan Tomljenović, PhD

March 11th, 2019

Zagreb

Content of presentation

- About the company



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WITH US DEVELOPMENT IS NATURAL

Remote Sensing applications:

- Sentinel data use - land cover mapping
- Sentinel data use - agriculture
- Sentinel/LiDAR data use - forestry

About company

- ✓ OIKON is a leading licensed and accredited environmental consultancy/research institute in Croatia (research-based SME)
- ✓ 4 departments:
  - Department of Environmental Engineering
  - Department of Nature Protection and Landscape Architecture
  - Department of Natural Resource Management
  - Department of Environmental Law, Policy and Economics
- ✓ 3 laboratories:
  - LADIGIS – Remote Sensing and GIS Laboratory (https://www.researchgate.net/lab/LARESGIS-Remote-Sensing-and-GIS-LAb-Alen-Berta)
  - Laboratory for Research and Monitoring of Large Carnivores
  - Laboratory for Fish and Aquatic Ecosystems

About company

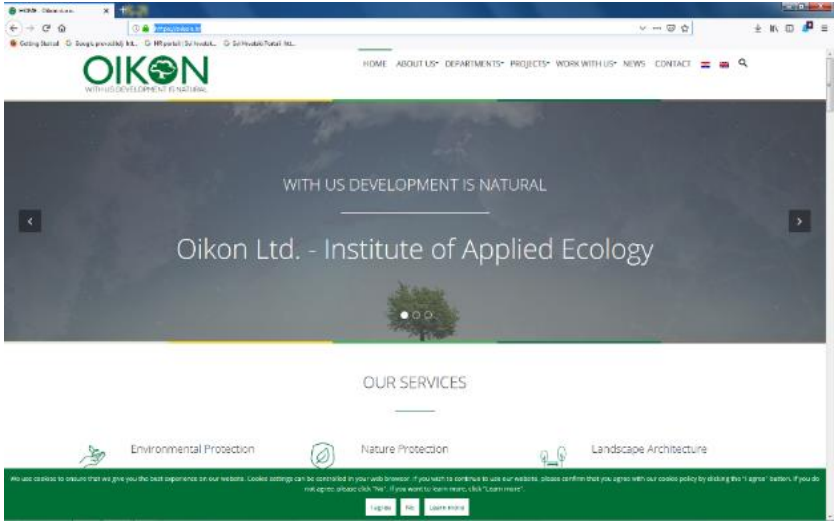
36 employees, 7 PhDs (Forestry, Biology, Ecology, Chemistry, Geoinformatics), 2 PMPs, 5 scientists registered with the Ministry of Science and Education

IUFRO- International council representative for Croatia
(Oikon's employee- Vladimir Kušan, PhD)

Member of EARSEL

Member of Copernicus Academy

Website www.oikon.hr



Laboratory for Remote Sensing and GIS

- Started for better horizontal connectivity between Departments
- For transfer and application of knowledge, and enhanced research and development work related to the use of remote sensing methods on projects (plus lobbying the Investors for using Remote Sensing technics: drone/satellite-LIDAR/imagery)
- Members
  - Alen Berta, **PhD** in forest management and remote sensing (**Head of the Laboratory** and Department for Natural Resources management)
  - Vladimir Kušan, **PhD** in forestry and remote sensing (former professor or RS and GIS on Faculty of forestry, Zagreb, pioneer of RS and GIS in forestry in Croatia)
  - Ivan Tomljenović, **PhD** in applied geoinformatics (Deputy Head of the Laboratory and Coordinator of UniGIS Study Center Zagreb)
  - Zrinka Mesić, **PhD** in biology and remote sensing
  - Ivona Žiža M.Sc. in Agriculture (enrolled in PhD study as of 2018)
  - Nela Jantol, M.Sc. in Biology. (enrolled in PhD study as of 2018)
  - Branimir Radun, M.Sc. in geodesy and geoinformatics (will enroll PhD study in 2019)
  - Željko Čučković, Bachelor's degree in Informatics

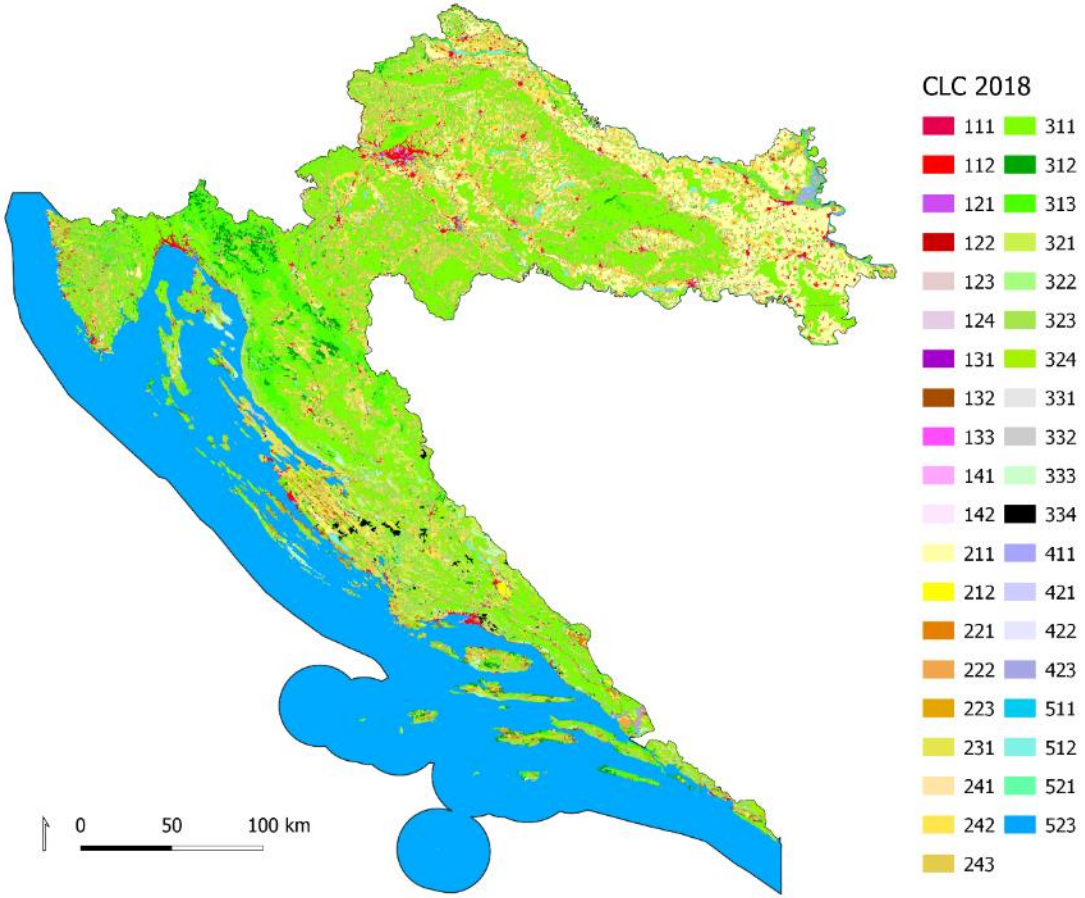
LABORATORY FOR REMOTE SENSING AND GIS – LaDIGIS

Land cover mapping

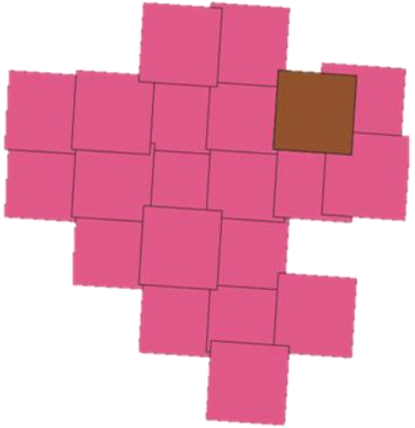
Mapping of land cover by Corine Land Cover (CLC) methodology

We have done all 6 cycles (for referent years 1980, 1990, 2000, 2006, 2012 and 2018)

The last cycle has been done on Sentinel 2 imagery

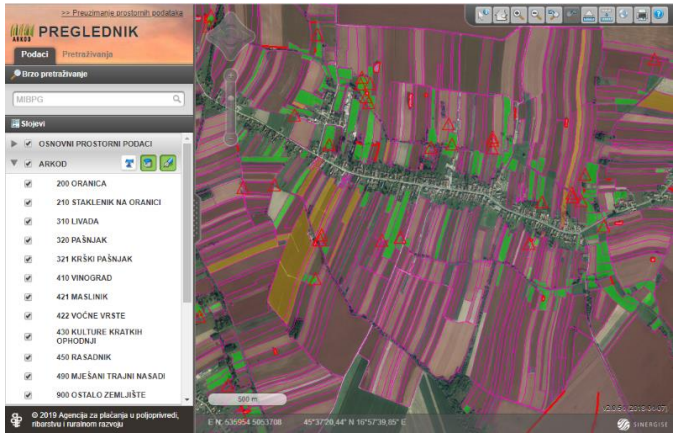


Sentinel data use– agriculture applications



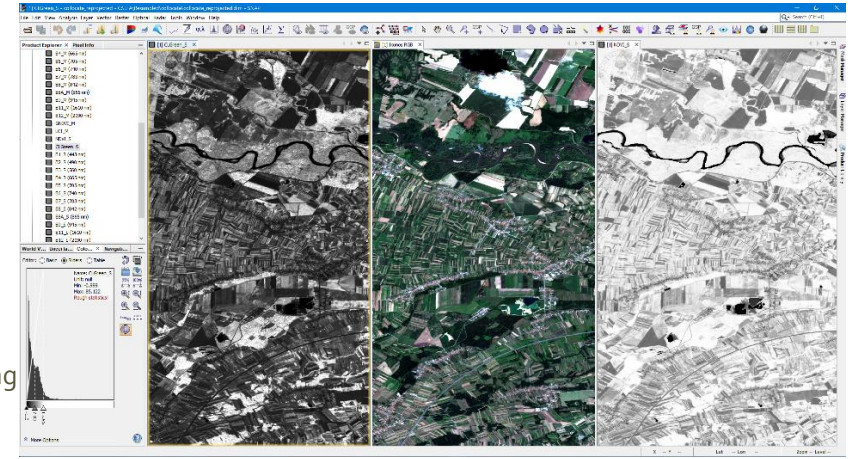
Random Forest Based **Automated Crop Mapping In Small-Scale Farming** Using Stacked Multi-temporal Sentinel 1 And Sentinel 2 Satellite Imagery: A Case Study For Croatia

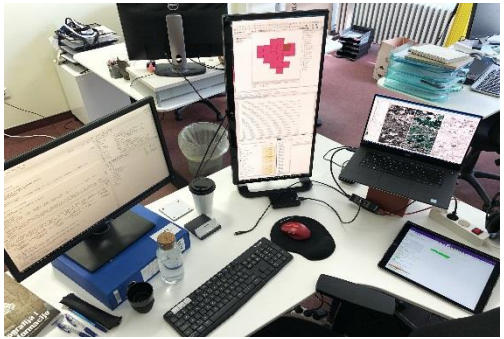
- Such kind of techniques have never been applied in the agricultural field of study in Croatia
- Sentinel 1 and Sentinel 2 data along with machine learning techniques (specifically RandomForest) to map predefined agricultural land cover classes.
- Input data used for classifier training is a set of polygons representing 16 specific crop classes obtained from Croatian database of agricultural parcels (LPIS).
- **70 %** training data- **30%** validation data.
- Total of **3TB** of remotely sensed data was downloaded for the time period of April to November (S1+S2)**+ preprocessing for S1 data**
- The main aims are:
  - use of Random Forest (RF) classifier to classify different agricultural crops,
  - explore best vegetation periods for each crop to get a seasonal pattern
  - to find the most suitable vegetation indices for crop mapping

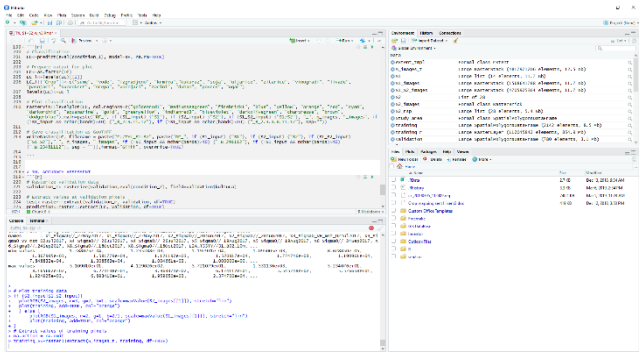


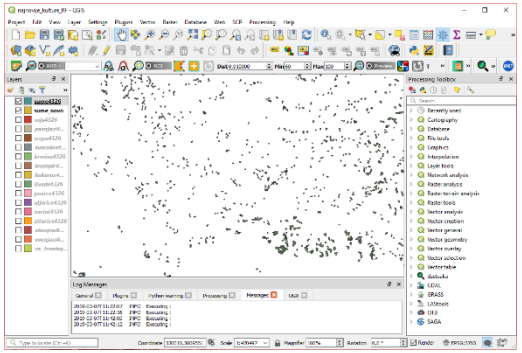
Sentinel data use– agriculture applications

- Tools:
  - Software
    - R - software environment for statistical computing and graphics
    - SNAP – science toolbox exploitation platform
    - QGIS – open source GIS software
  - Hardware
    - Workstations
      - Total of 4 workstations with multi-core processors (8 core), 32GB of RAM, 1 TB SSD storage for processing, 4TB for data archiving
    - Processing server
      - 16 core processor, 64GB of RAM, 12 TB of storage
    - Storage server
      - 30TB of available storage for data archiving



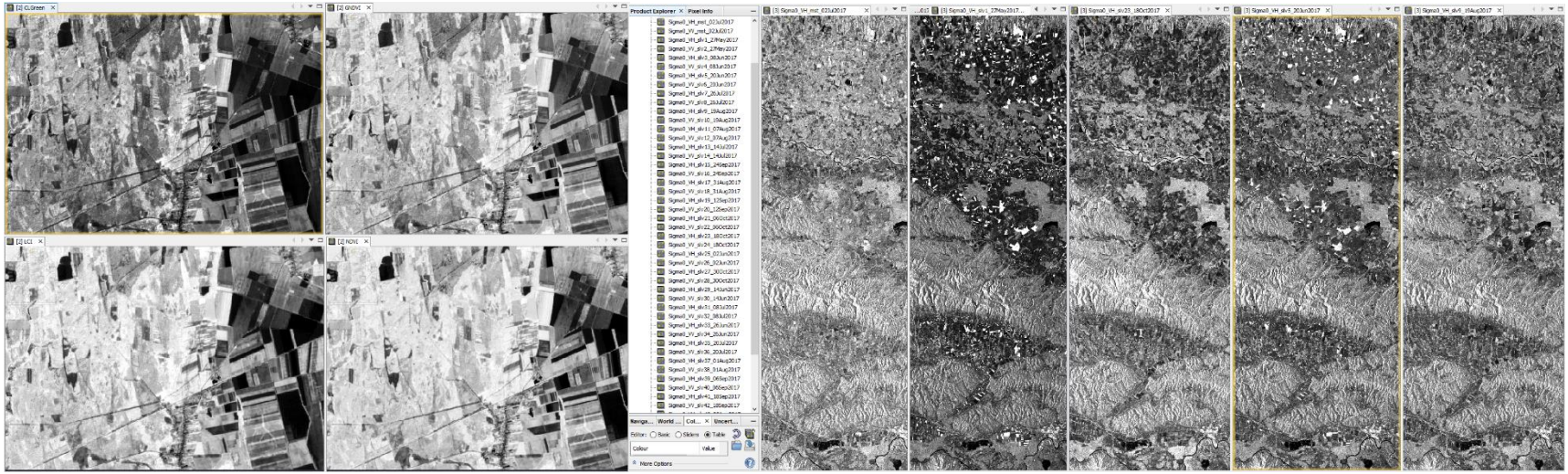




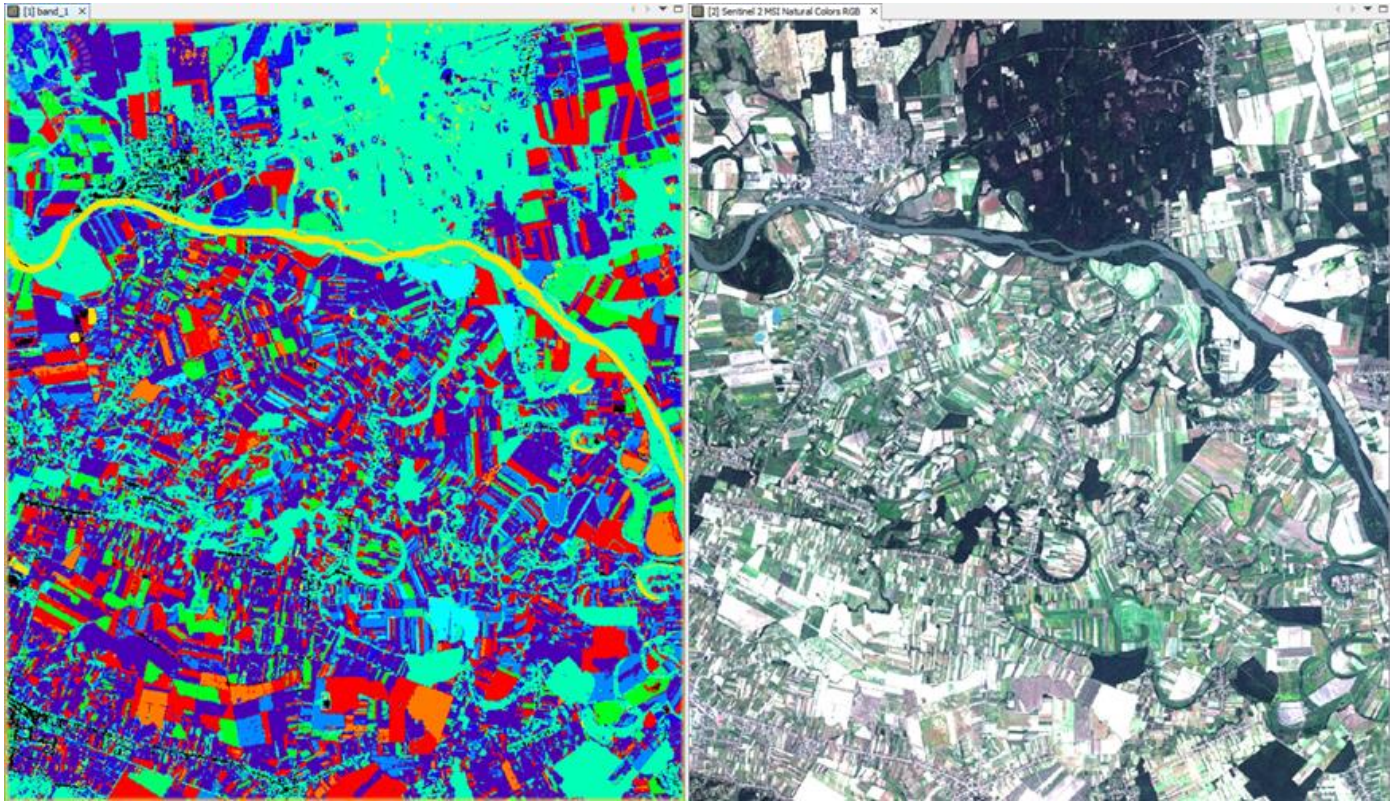


Sentinel data use– agriculture applications

- Test results:
  - 92 % accuracy for the Bjelovarsko-Bilogorska county (2640 km²)
  - Used vegetation indexes: NDVI, GNDVI, LCI and CLGreen
  - Sentinel 1 multitemporal stack April-November
  - Sentinel 2 multitemporal stack April-November

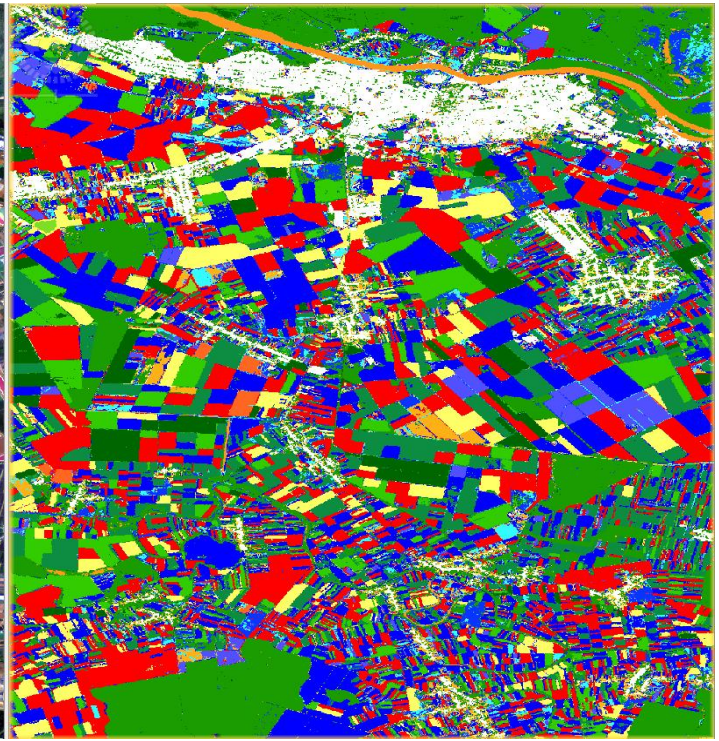


Sentinel data use– agriculture applications



Sentinel data use– agriculture applications

- Initial production results:
  - Požeško-Slavonska county (1.823 km^2) **> 93 % accuracy**

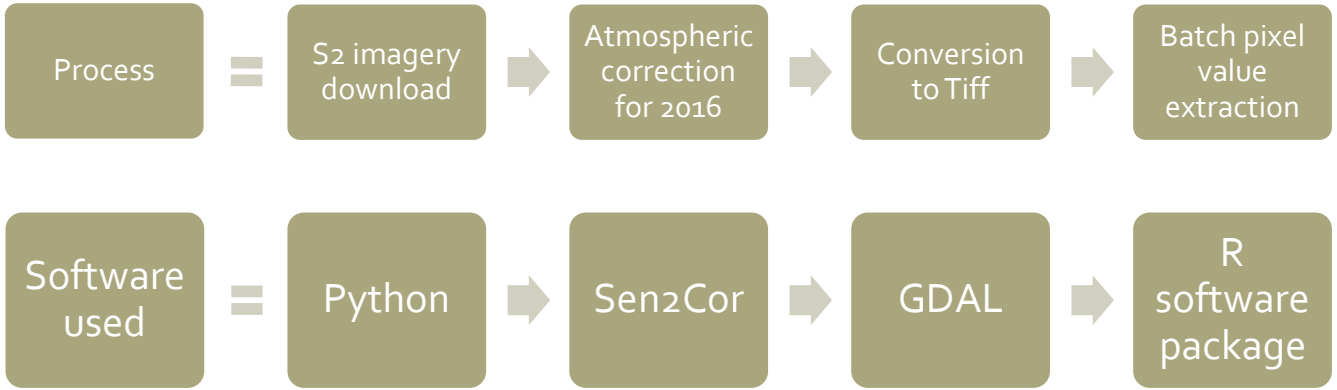


Sentinel data use– forestry applications

- Nationwide data collection projects
  - **Project 1: Biomass assessment regression models** based on Sentinel 2 multitemporal imagery for Thickets, Maquis and first age class stands of pedunculate oak, sessile oak, beech and ash- Investor: CAEN
  - **Project 2:** Use of multispectral satellite images of high resolution in **determining the degree of productivity and age** of uneven-aged stands of private forest owners in the Mediterranean and Submediterranean- Investor: Ministry of Agriculture
  - **Project 3: Forest type classification** using Sentinel 2 data and data mining in forests of Central Croatia (in progress-currently adding multitemporal Sentinel 1 imagery)- Investor: Oikon
- Forest fire mapping in Croatia
- Remote Sensing in Forest Ecosystem Monitoring on the Area of the Planned Danube-Sava Multipurpose Channel

Hardware/software/methodology

- 4 workstations (each with **–only-** 32 GB RAM and **standard** graphics card)
- Plus good organization, a lot of will and a few quirky minds ☺
- For **project 1** Sentinel 2 year long data for Croatia (2016- 5 TB), for **project 2 and 3** 2017 year long data (2 TB)



Hardware/software/methodology

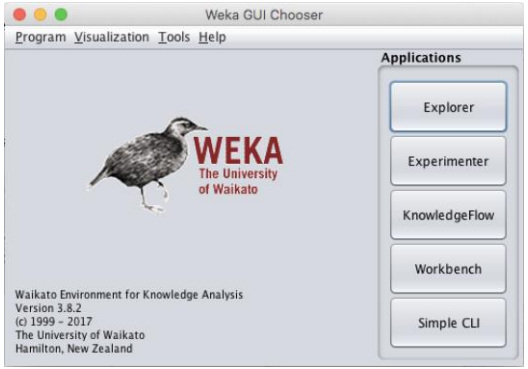
- Pixel data were averaged on a monthly basis
- within the SQL database, all known Vegetation indices were calculated (more than 120) **for every month, for every extracted pixel**
- More than 1500 variables for every pixel
- More than 100.000 pixels per project

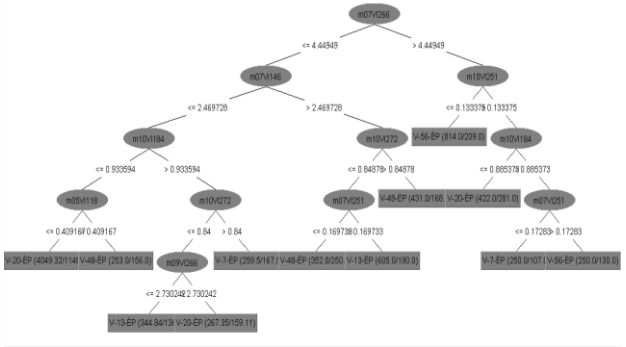
BIG DATA

Bands;VI		2017
Bands 2, 3, 4, 5, 6, 7, 8, 11, 12		I
NDVI		II
PSRI		III
ARI1,2		IV
GRVI1		V
EVI1,2		VI
CRI1,2	X	VII
NDWI		VIII
…		IX
…		X
…		XI
…		XII

Hardware/software/methodology

- Project 1- With RF algorithm (for selecting circa 50 the most corellated variables among ~1000) and stepwise regression analysis (STATA software), we developed biomass assessment models
- Project 2 and 3- WEKA software (for data mining/machine learning), we developed classification trees for site index/forest type determination

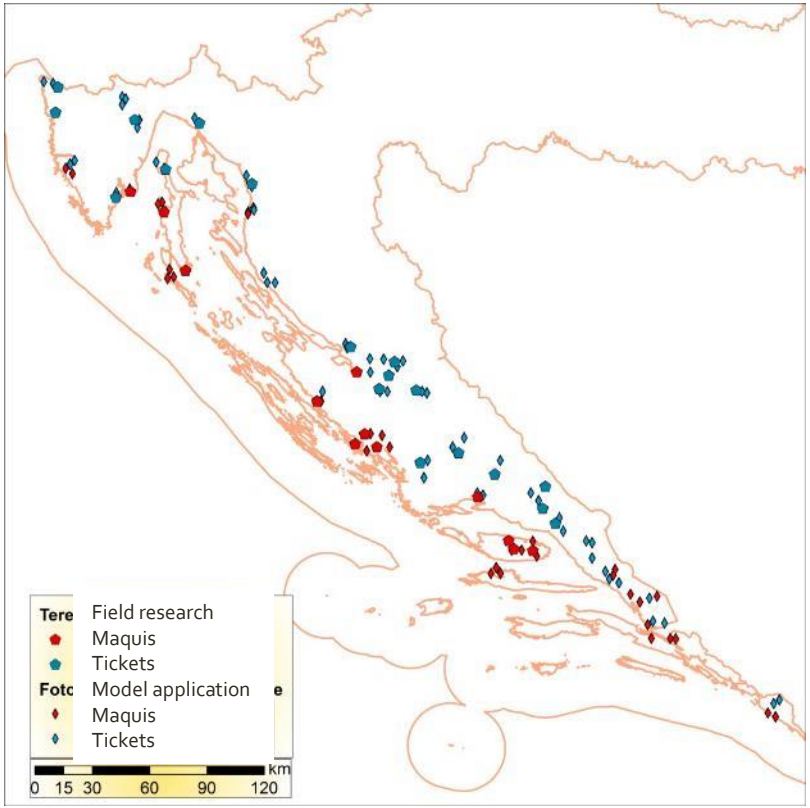


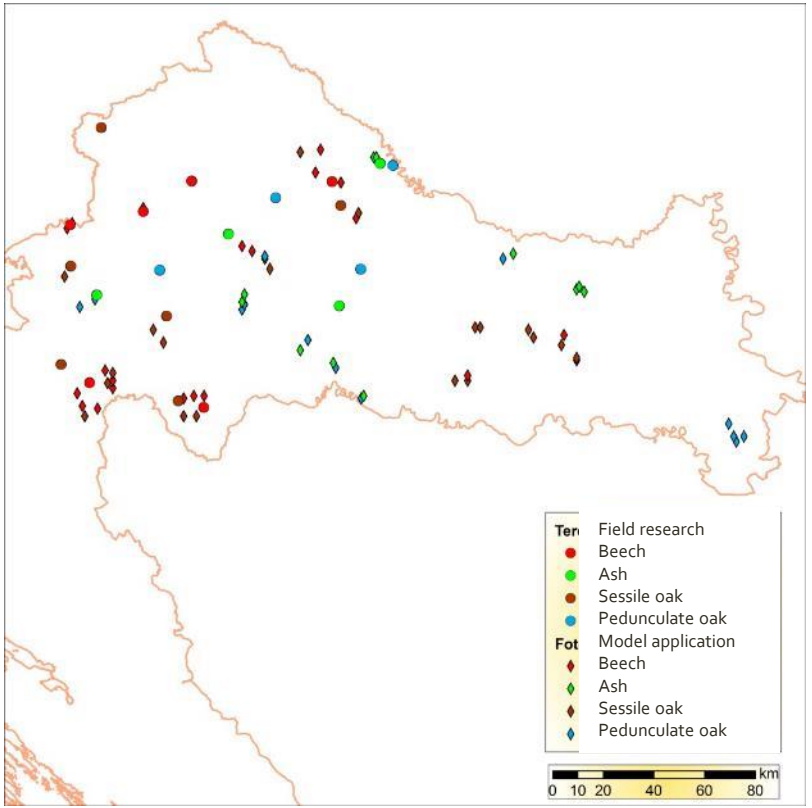


- Models/classification trees can be used for raster calculations within SNAP/ArcGIS/QGIS/ENVI

Forestry project 1

- **Carbon pool assessment** in dead organic matter and average wood stock assessment in maquis, shrubbery and first age class stands in Croatian forests

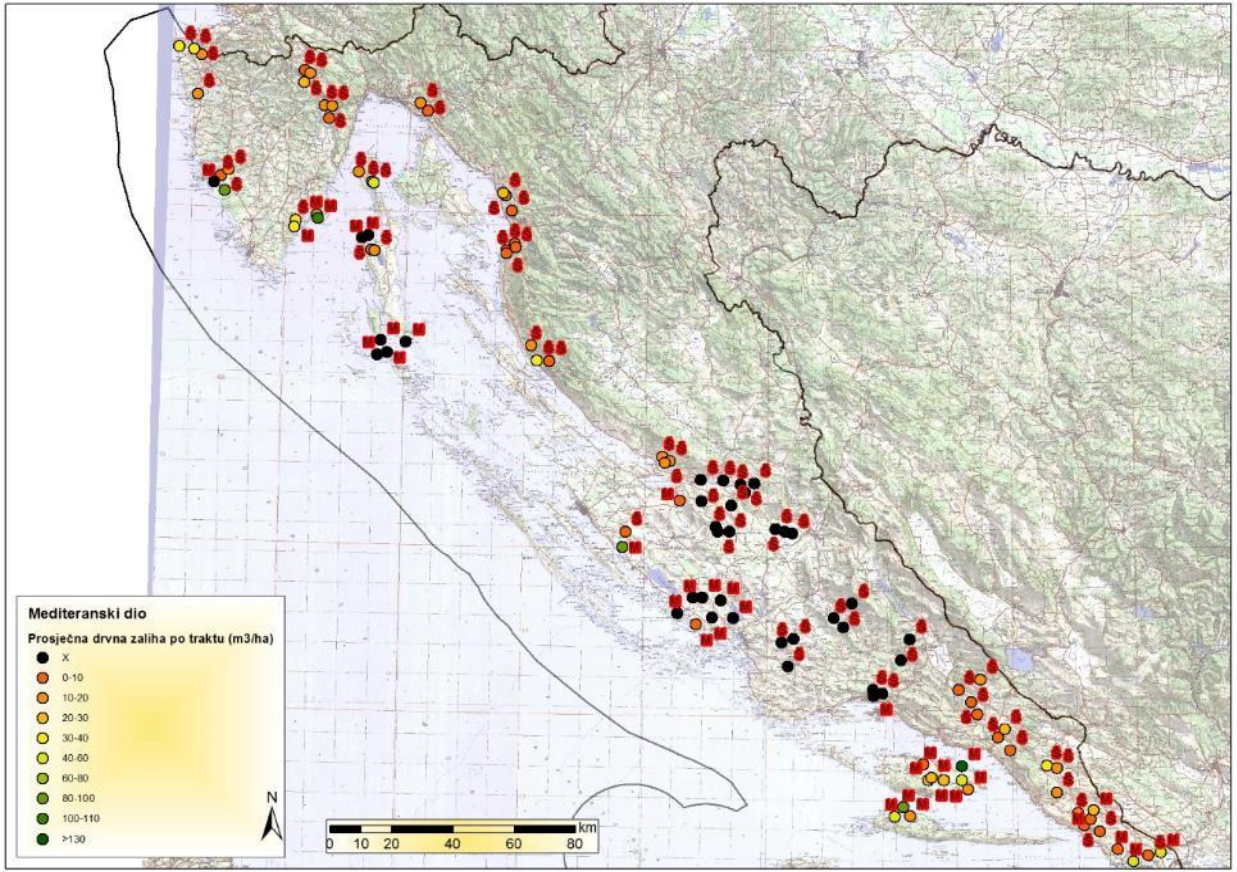


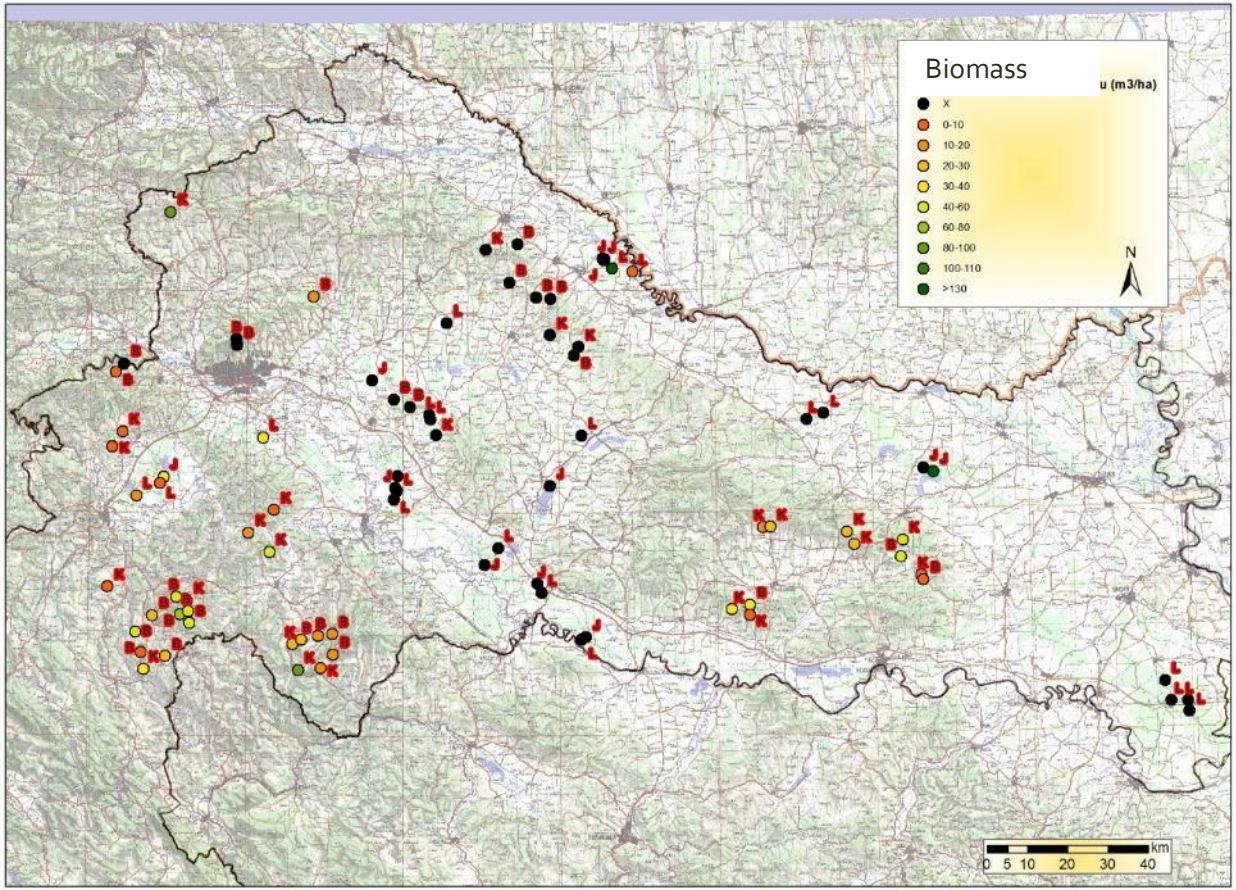


Forestry project 1

Forest stand	Independent variable code	Month/season	Vegetation index	Vegetation indeks formula
Common beech and sessile oak	m7VI266	7	MTCI (MERIS Terrestrial Chlorophyll Index)	(B06 - B05) / (B05 - B04)
	m3VI178	3	Simple Ratio B08/B011	(B08/B011)
	m10VI207	10	Single Band B03	B03
Common oak and narrow-leafed ash	m5VI261	5	NDVI705	(B06 - B05) / (B06 + B05)
	m3VI167	3	Simple Ratio B08/B012	(B08/B012)
Thicket in Istria and Kvarner	m9VI93	9	Normalized Difference B07/B04	(B07-B04)/(B07+B04)
	m5VI285	5	ARI1 (Anthocyanin Reflectance Index)	(1 / B03) - (1 / B05)
Thicket in Dalmatia	m8VI277	8	EVI (Enhanced Vegetation Index)	2.5*(B08 - B04) / (B08 + 6*B04 - 7.5*B02 + 1)
	m8VI246	8	Visible Atmospherically Resistant Index Green	(B03-B04)/(B03+B04-B02)
	m4VI285	4	ARI1 (Anthocyanin Reflectance Index)	(1 / B03) - (1 / B05)
	m8VI225	8	Soil Composition Index	(B011-B08)/(B011+B08)
Maquis	m10VI281	10	CHL-RED-EDGE (Chlorophyll Red-Edge)	(B05 / B08)
	m4VI153	4	Simple Ratio B03/B08	(B03/B08)
	m9VI280	9	CRI1 (Carotenoid Reflectance Index 1)	(1 / B02) - (1 / B03)
	m8VI149	8	Simple Ratio B02/B04	(B02/B04)

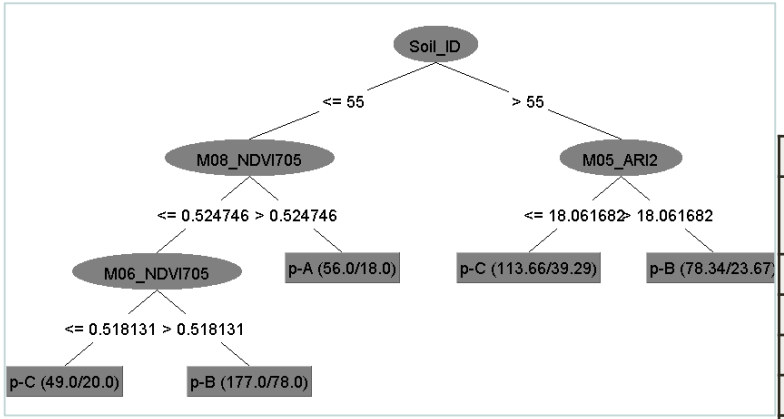
Forestry project 1

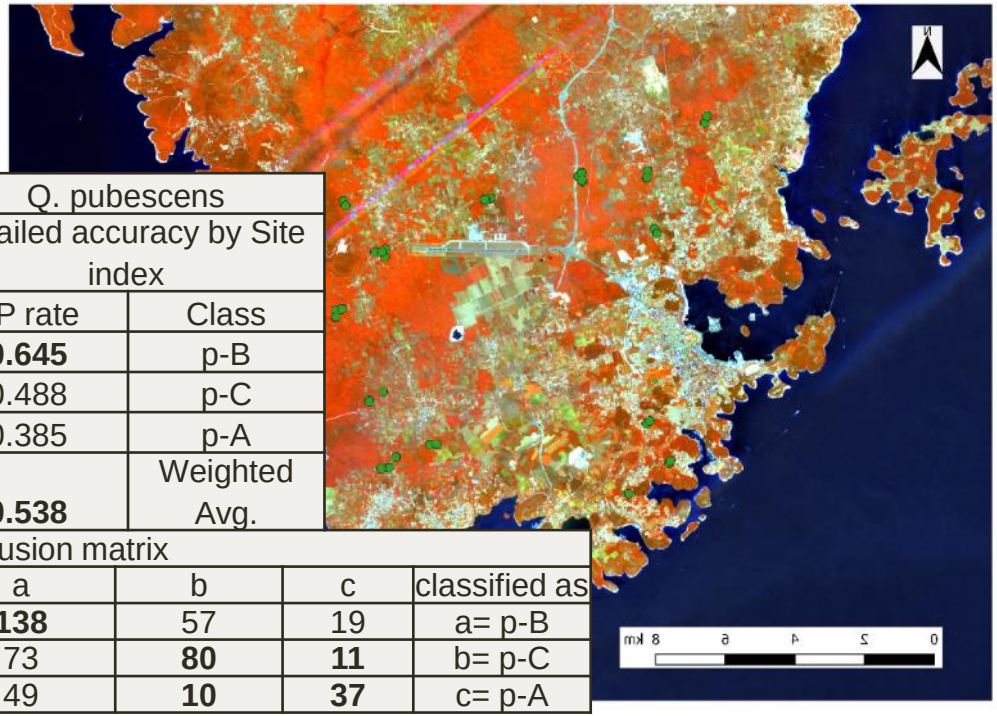



Biomass
u (m3/ha)
X
0-10
10-20
20-30
30-40
40-60
60-80
80-100
100-110
>130
N
km
0 5 10 20 30 40

Forestry project 2

- Use of multispectral satellite images of high resolution in **determining the degree of productivity and age** of uneven-aged stands of private forest owners in the Mediterranean and Submediterranean



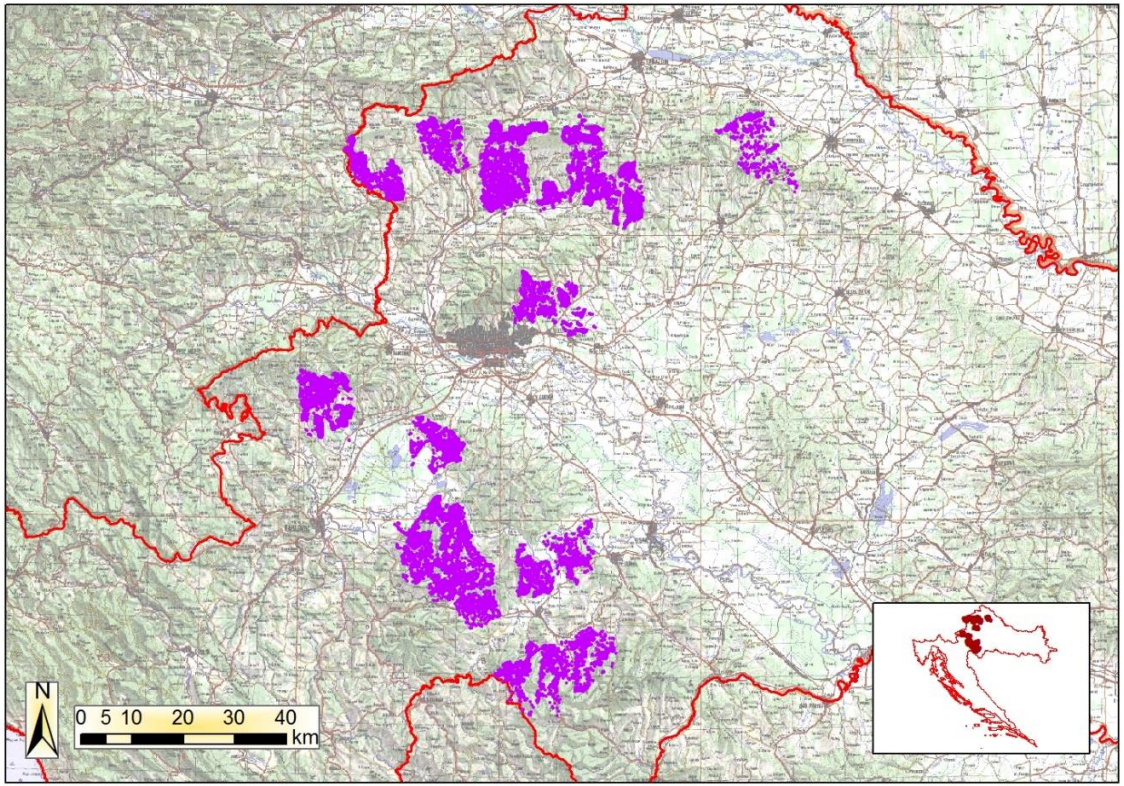


Q. pubescens	
Detailed accuracy by Site index	
TP rate	Class
0.645	p-B
0.488	p-C
0.385	p-A
0.538	Weighted Avg.

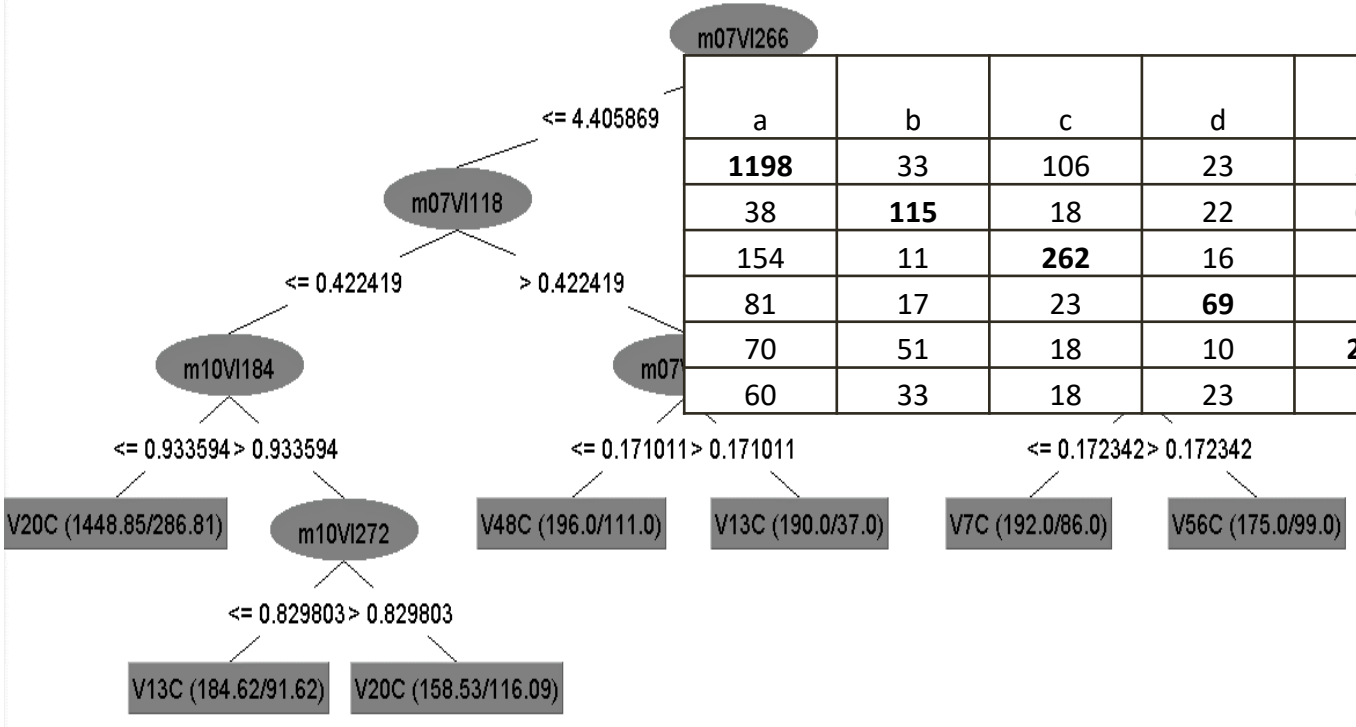
Confusion matrix			
a	b	c	classified as
138	57	19	a= p-B
73	**80**	**11**	b= p-C
49	**10**	**37**	c= p-A

Forestry project 3

- Forest type classification- more than 17.000 field plots



Forestry project 3

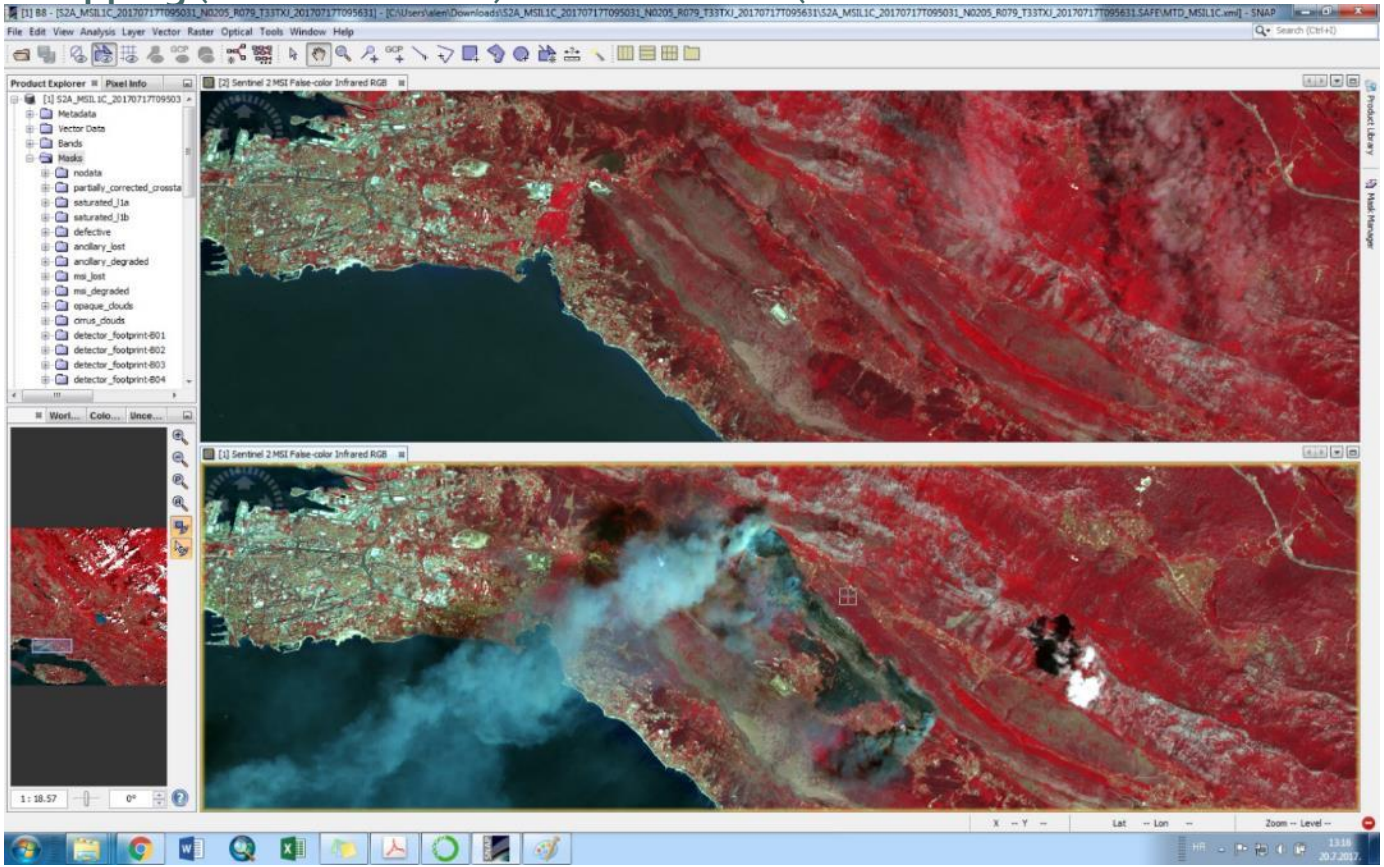


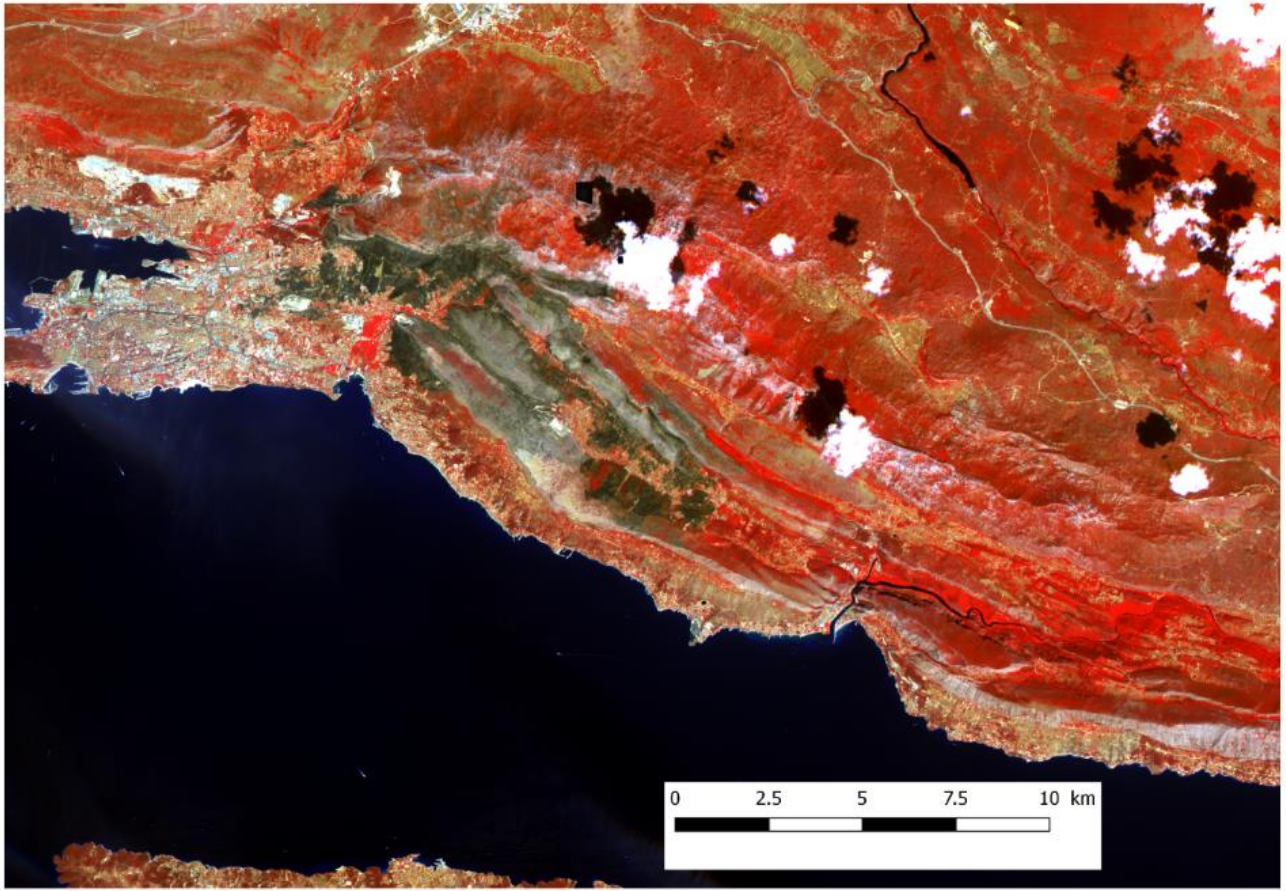
a	b	c	d	e	f	classified as
1198	33	106	23	22	0	a=V20C
38	**115**	18	22	64	0	b=V7C
154	11	**262**	16	5	0	c=V13C
81	17	23	**69**	17	0	d=V48C
70	51	18	10	**297**	0	e=V56C
60	33	18	23	4	**0**	f=V15C

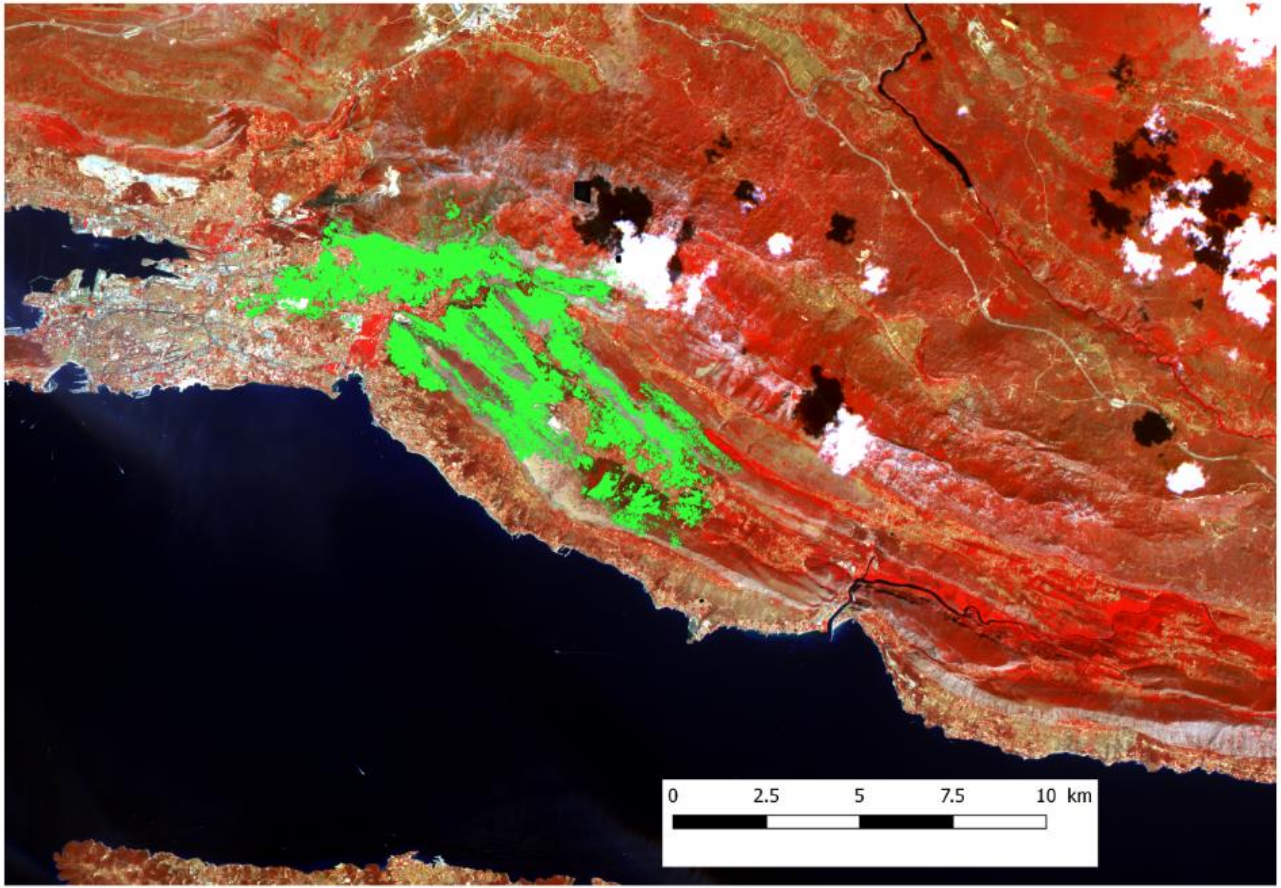
Species	TP rate
V20C	**0.867**
V7C	0.447
V13C	0.585
V48C	0.333
V56C	**0.666**
V15C	0.000
Weighted Avg.	0.674

Remote sensing activities – forestry applications

- **Burnt areas mapping** (from forest fires) with Sentinel 2 (Semi-automatic classification- QGIS/SNAP)




0
2.5
5
7.5
10 km


0
2.5
5
7.5
10 km

Thank you for your attention!

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