Correlation between vegetation indices and ant populations – spectral measurements from UAV

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COST OPTIMISE
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Problem: How vegetation state (described by vegetation index) is related with local ant populations

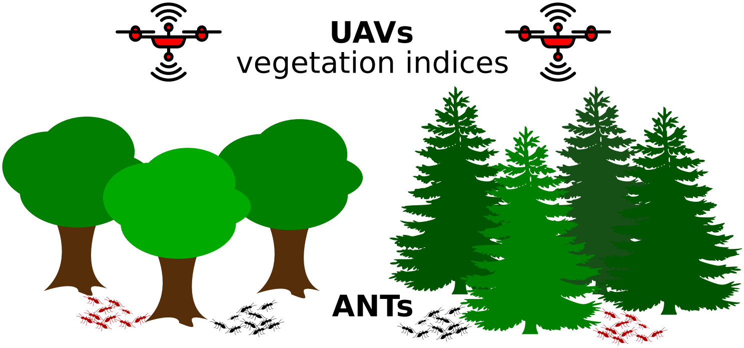

Figure 1 : Experiment overview

Myrmecology point of view

- Investigation of relation between ants and plants on canopy level
- Utilization of data from automatic sensors on LAI/monitoring towers
- Is it possible to aid myrmecological surveying with remote sensing products?

Remote sensing point of view

- Selection of ,,the best" vegetation index for differentation of ants habitats
- Verification of high resolution measurement scheme with BRDF modelling/verification
- Utilization of spectral measurement payload developed during STSM in 2016

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Spectral measurement payload based on COST-STSM-ES1309-050916-079512 outcome

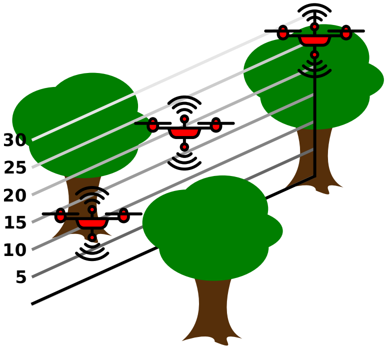

Figure 2 : Light absorption measurement within a tree canopy

Wigry National Park

- since 1989
- area 150.9 km^2
- – forests 94.5 km^2
- – waters 29.1 km^2
- – other 27.3 km^2
- Masurian Lake District

Most popular phytocenosis

- Carpinion betuli
  - European hornbeam/Silver birch
- Dicrano-Pinion
  - Scots pine/Silver fir

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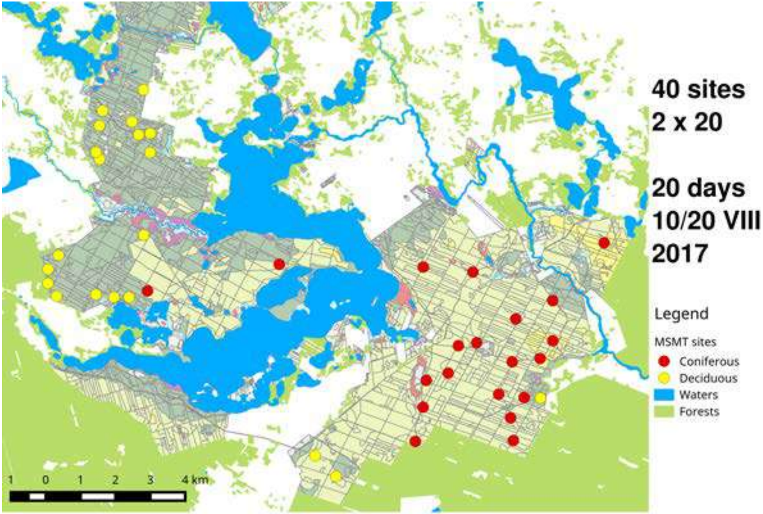

Figure 4 : Plan of measurement sites

Normalized Difference Vegetation Index

$$NDVI = \frac{R_{800} - R_{670}}{R_{800} + R_{670}} \quad (1)$$

Modified Simple Ratio

$$MSR = \frac{\frac{R_{800}}{R_{670}} - 1}{\sqrt{\frac{R_{800}}{R_{670}} + 1}} \quad (2)$$

Modified Chlorophyll Absorption Ratio Index 2

$$MCARI2 = \frac{1.5[2.5(R_{800} - R_{670}) - 1.3(R_{800} - R_{550})]}{\sqrt{(2R_{800} + 1)^2 - (6R_{800} + 5\sqrt{R_{670}}) - 0.5}} \quad (3)$$

Set of indices in VIS-NIR. Selection based on Haboudane et. al 2004

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Ocean Optics Spectrometer STS

Parameter	Specification
Dimensions	40 mm x 42 mm x 24 mm
Weight	60 grams
Detector	ELIS 1024
FoV	30^O bare optics
Wavelengths	335 – 824nm (VIS)
	633 – 1123nm (NIR)
Resolution	3.0 nm (optical)
	0.47 nm (digital)
Interface	USB

Table 1 : Ocean Optics STS specification

Figure 5 : Ocean Optics STS-NIR

2 sensors VIS/NIR (both downside)

Methods
Sensors:RGB camera

Figure 6 : GoPro Hero Black3+

- 12Mpix (4000x3000px)
- FOV (diagonal)
  - 149.2^o
  - 115.7^o
  - 79.7^o
- intervalometer

Figure 7 : Versa X6 Research

Size	850 x 850 x 340-450 [mm]
Motors	6
Weight	5000 [g]
Payload mass	2500 / 5000 [g]
Speed	16H [m/s], 6V [m/s]
Flight time	10 - 15 [min]

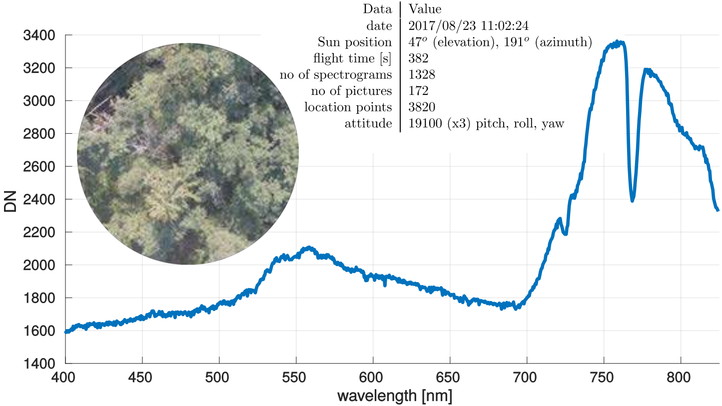
Table 2 : Versa X6 Research specification

Figure 8 : Integrated platform during flight

parameter	value
Flight altitude	50m above canopy level
Support size	1300m^2
No of spectra	500 - 1500 (per site)
White target calibration	before and after flight
No of RGB pictures	200 - 800 (per site)
GPS time res.	10Hz
Atitude time res.	50Hz
Flight time	7 min (per site)
Operation mode	manual + waypoint
Ground measurements	Sunphotometer

Field campaign
demanding locations

Figure 9 : Limited space for drones operation



Data	Value
date	2017/08/23 11:02:24
Sun position	47^o (elevation), 191^o (azimuth)
flight time [s]	382
no of spectrograms	1328
no of pictures	172
location points	3820
attitude	19100 (x3) pitch, roll, yaw

Figure 10 : quicklook of selected dataset [G6]

Data processing
Workflow

Figure 11 : Workflow od vegetation indices estimation

Data processing
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Spectroradiometers

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Data processing
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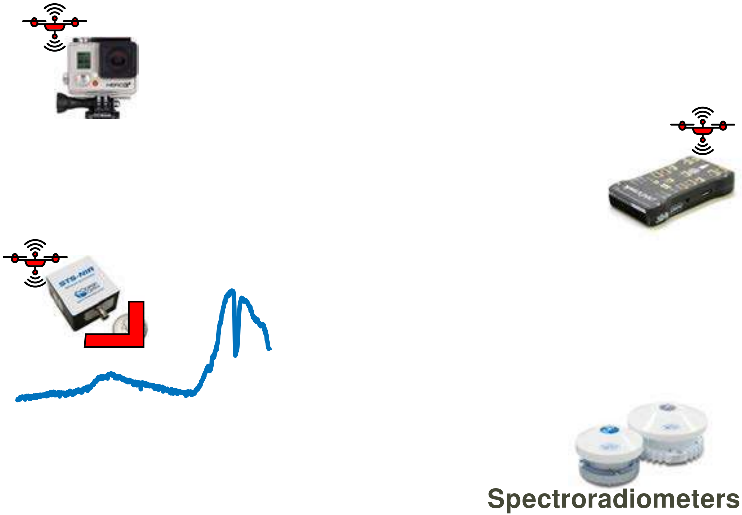

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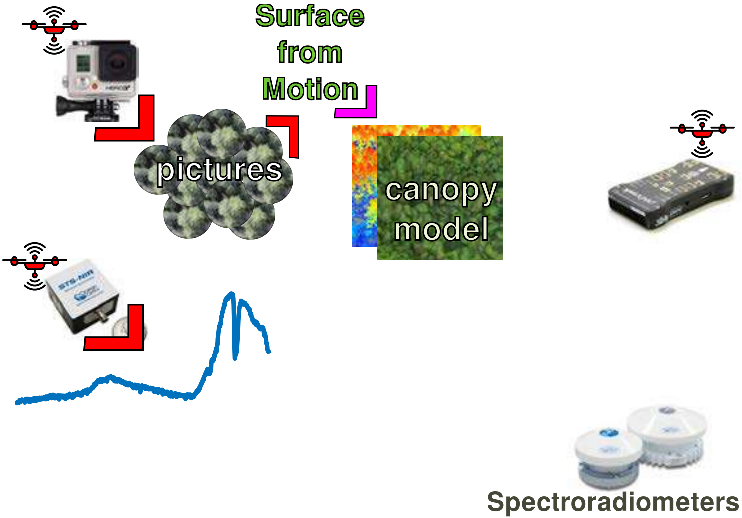

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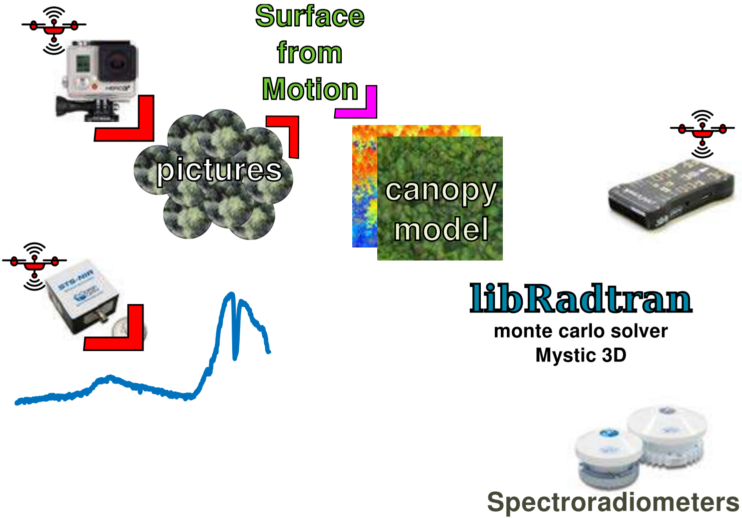

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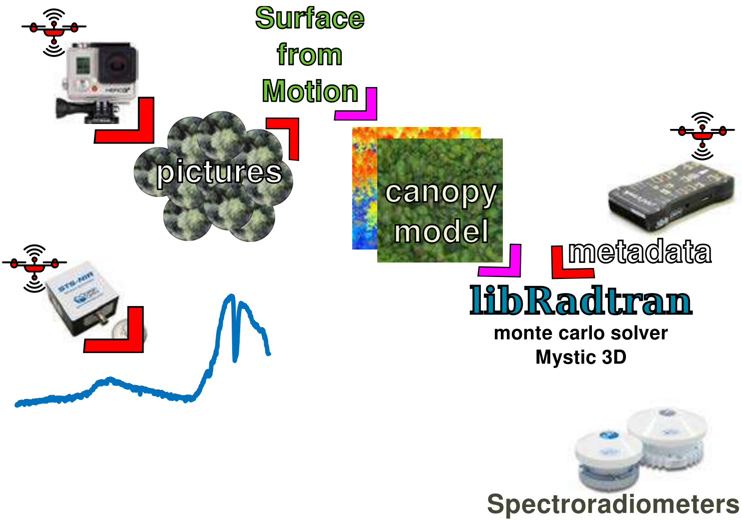

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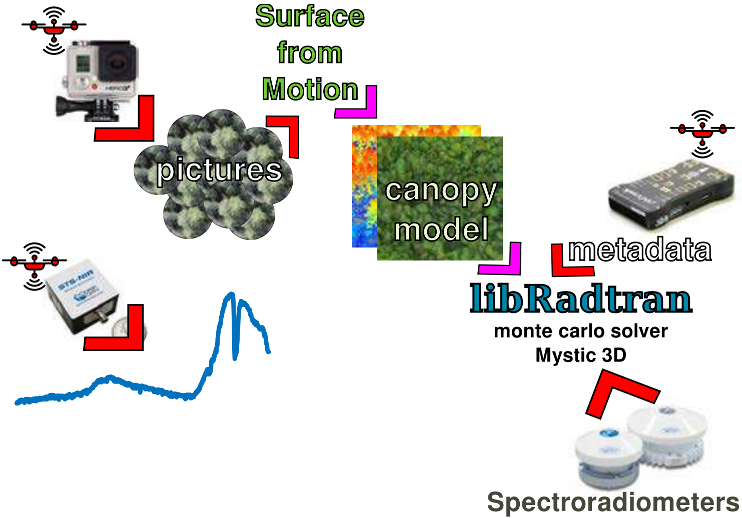

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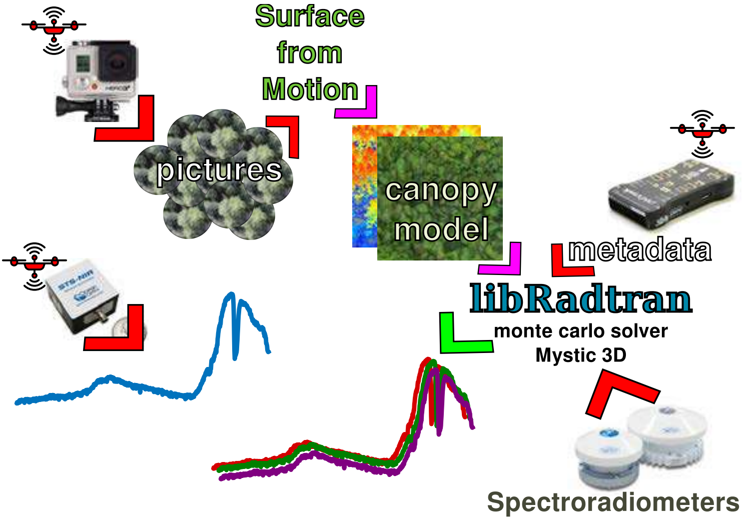

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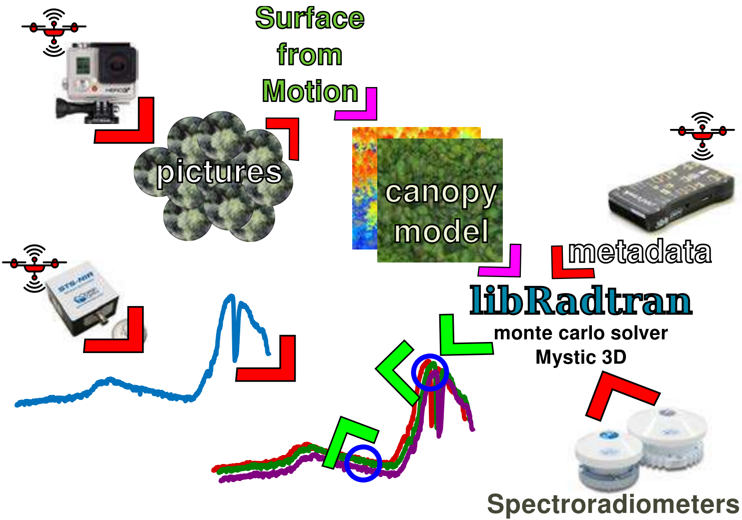

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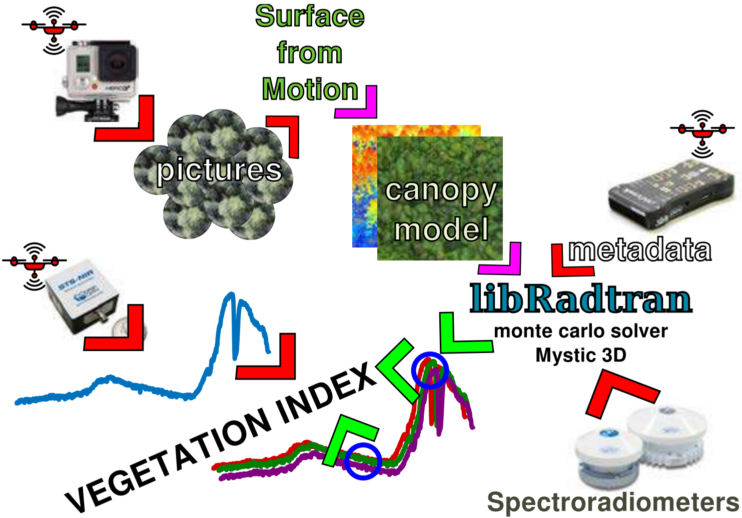

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Vegetation indices

- mean values from every site (very small confidence intervals x high number of input spectra)
- comparision between two different forest types (t-test for mean)
- variability inside groups (standard measurements, changes reflects changes in ecosystem)

Ants populations

In every location number of ants, number of different species and number of ants looking for food was checked

- Spearman's rank correlation coefficient
- Separate datasets for both forest types
- Significance of results for $\alpha = 0.95$

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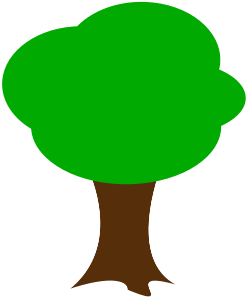

+25% NDVI

+44% MSR

+50% MCARI2

p-value <0.0001
confint: +/- 4%

Figure 12 : Mean difference in vegetation indices between deciduous and coniferous forest

Deciduous forest:Carpinion betuli

Figure 13 : Carpinion betuli

Number of species x VI: No significant correlation

			NDVI	MSR	MCARI2
Number of nests	Myrmica ruginodis	ρ Spearmana	-0,209	-0,209	-0,254
		p-value	0,406	0,406	0,308
	Myrmica rubra	ρ Spearmana	-0,325	-0,325	-0,339
		p-value	0,175	0,175	0,156
	Lasius platythorax	ρ Spearmana	0,322	0,322	0,442
		p-value	0,18	0,18	0,058
	TOTAL	ρ Spearmana	-0,184	-0,184	-0,092
		p-value	0,45	0,450	0,708
Number of species with nest		ρ Spearmana	0,006	0,006	0,023
		p-value	0,979	0,979	0,925

Figure 14 : Correlation between species diversity and vegetation indices [Deciduous]

Number of ants prowling x VI

		NDVI	MSR	MCARI2
Myrmica ruginodis	ρ Spearman	-0,044	-0,044	0,125
	p-value	0,857	0,857	0,610
Myrmica rubra	ρ Spearman	-0,119	-0,119	-0,055
	p-value	0,628	0,628	0,822
Lasius platythorax	ρ Spearman	0,178	0,178	0,284
	p-value	0,466	0,466	0,239
Formica rufa / Formica polyctena	ρ Spearman	0,533	0,533	0,378
	p-value	0,019	0,019	0,110
TOTAL	ρ Spearman	0,126	0,126	0,268
	p-value	0,608	0,608	0,268

Figure 15 : Correlation between number of prowling ants and vegetation indices [Deciduous]

Appendix:Formica nest

Figure 16 : Dome-shaped nest of Formica sp. species (fot. Tomasz Kuran)

Number of dome-shaped nests (+barber traps) x VI

		NDVI	MSR	MCARI2
Barber traps – number of species	ρ Spearman	0,632	0,632	0,632
	p-value	0,252	0,252	0,252
Barber traps – number of species	ρ Spearman	0,100	0,100	0,100
	p-value	0,873	0,873	0,873
Number of dome-shaped nests	ρ Spearman	0,598	0,598	0,533
	p-value	0,007	0,007	0,019

Figure 17 : Correlation between number dome-shaped (+barber traps) nests and vegetation indices [Deciduous]

Figure 18 : Coniferous forest (Dicrano-Pinion)

Number of species x VI

			NDVI	MSR	MCARI2
Number of nests	Myrmica ruginodis	ρ Spearman	-0,675	-0,675	-0,628
		p-value	0,011	0,011	0,022
	Myrmica rubra	ρ Spearman	-0,019	-0,019	0,07
		p-value	0,951	0,951	0,821
	Lasius platythorax	ρ Spearman	-0,513	-0,513	-0,513
		p-value	0,073	0,073	0,073
	TOTAL	ρ Spearman	-0,676	-0,676	-0,696
		p-value	0,011	0,011	0,008
Number of species with nest		ρ Spearman	-0,474	-0,474	-0,364
		p-value	0,102	0,102	0,222

Figure 19 : Correlation between species diversity and vegetation indices [Coniferous]

Number of ants prowling x VI: No significant correlation

		NDVI	MSR	MCARI2
Myrmica ruginodis	ρ Spearman	-0,06	-0,06	-0,233
	p-value	0,846	0,846	0,443
Myrmica rubra	ρ Spearman	0,171	0,171	0,285
	p-value	0,577	0,577	0,345
Lasius platythorax	ρ Spearman	-0,057	-0,057	0
	p-value	0,853	0,853	1
Formica rufa / Formica polyctena	ρ Spearman	0,154	0,154	0
	p-value	0,615	0,615	1
TOTAL	ρ Spearman	0,028	0,028	-0,036
	p-value	0,928	0,928	0,906

Figure 20 : Correlation between number of prowling ants and vegetation indices [Coniferous]

Number of dome-shaped nests (+barber traps) x VI

		NDVI	MSR	MCARI2
Barber traps – number of species	ρ Spearman	0,316	0,316	0,316
	p-value	0,684	0,684	0,684
Barber traps – number of species	ρ Spearman	0,400	0,400	0,400
	p-value	0,600	0,600	0,600
Number of dome-shaped nests	ρ Spearman	0,516	0,516	0,637
	p-value	0,021	0,021	0,019

Figure 21 : Correlation between number dome-shaped (+barber traps) nests and vegetation indices [Coniferous]

Conslusions

- Number of ants species was corellated (-) with VI only in coniferous forest
- Number of dome-shaped nests was correlated (+) in both ecosystems
- Correlation coefficient (significant) was in range 0.5-0.7
- **No significant differences between vegetation indices**

Plans for 2018

- Spatial analysis of NDVI distribution
- Switch from spectrometers to NDVI micro-cameras (Mapir)
- Change of large UAV system to small of-the-shelf solution 3DR Solo, DJI Phantom?
- Parallel measurements (two / three teams)

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