

Seminario:

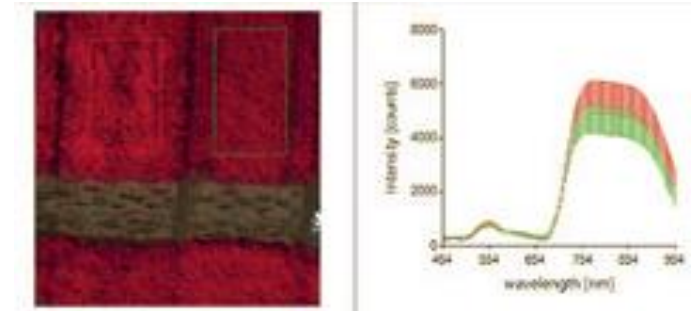
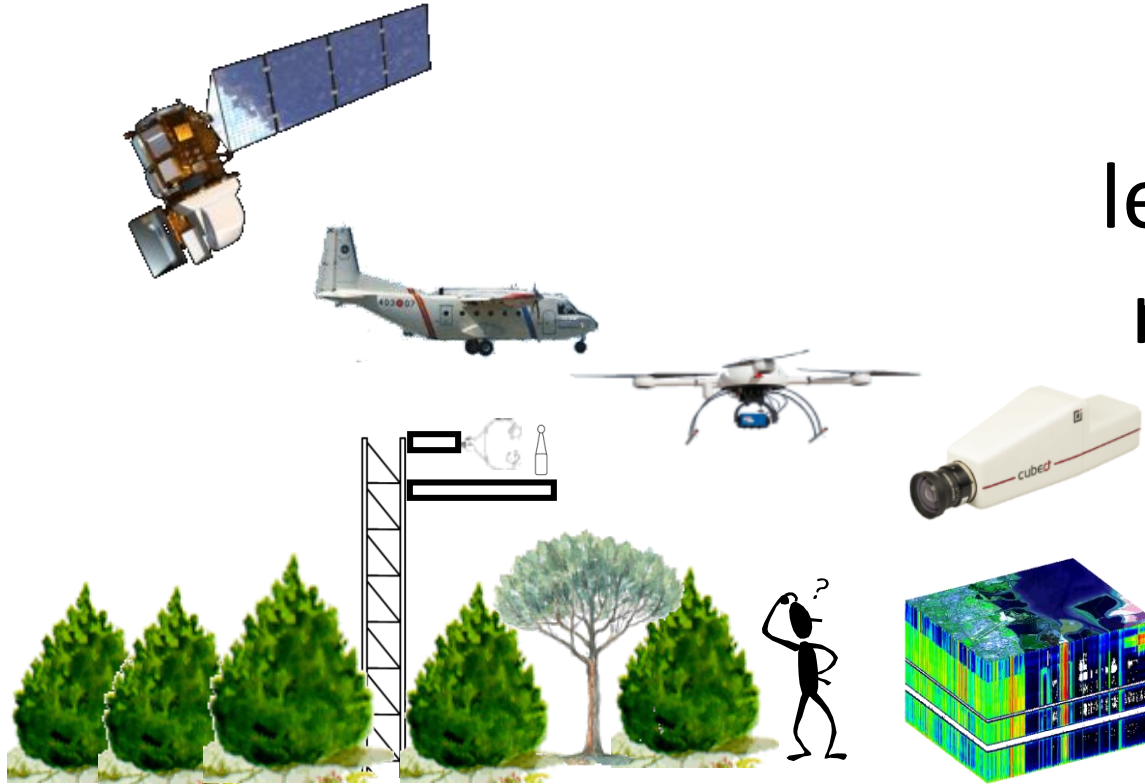
Protocolos y Librerías espectrales en
Espectroscopía de campo: de las buenas
prácticas a una mayor utilidad de los datos

Madrid, Instituto Nacional de Técnica Aeroespacial (INTA)

7 de marzo de 2019



First experiences in hyperspectral UAV spectroscopy: lessons learned and recommendations



LAST-EBD

LABORATORIO DE SIG Y TELEDETECCIÓN
ESTACIÓN BIOLÓGICA DE DOÑANA

Ricardo Díaz-Delgado
Remote Sensing and GIS Laboratory
Long-Term Monitoring at landscape scale of Doñana Protected Area

Estación
Biológica
Doñana
CSIC

Outline

- LAST-EBD: Main research lines and services
- UAS equipment
- Hyperspectral solution: Cubert S185
- “Ardea” (Microdrones MD4-1000) as platform: set-up & tuning
- Software, mission planning and Radiometric procedure
- Few prospective missions
- Lessons learned and recommendations

Laboratory of Remote Sensing and GIS (LAST-EBD)



<http://last-ebd.blogspot.com/>
<http://www.ebd.csic.es/laboratorio-sig-y-teledeteccion-last>



Sampling
design

Search,
Download
Processing

Data
harvesting

Analysis
Cloud
Computing

Publication
(also WMS)

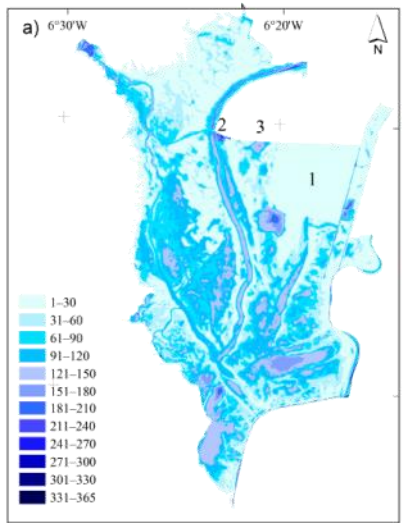
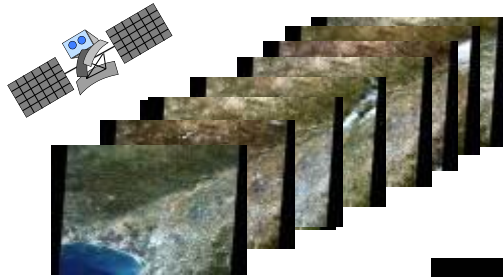
Training &
dissemination



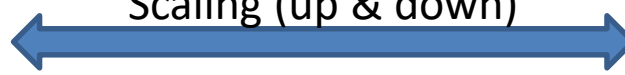
last@ebd.csic.es

Research lines and services LAST-EBD

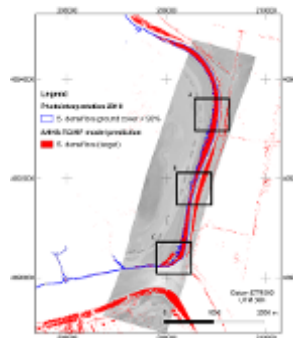
From satellite images



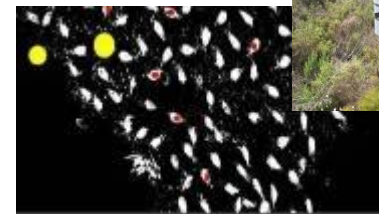
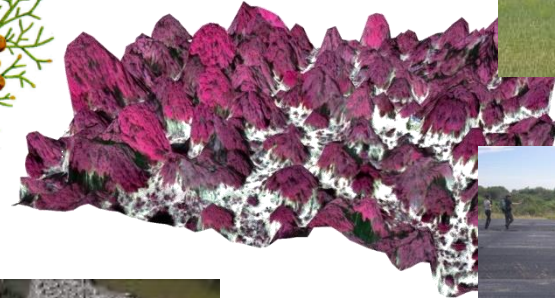
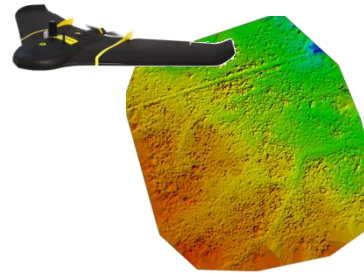
Scaling (up & down)



Airborne



Drone-borne



In situ



Multi and hyperspectral images for long-term ecological monitoring in natural areas (Doñana)

UAS Equipment

UAVs



Multispectral

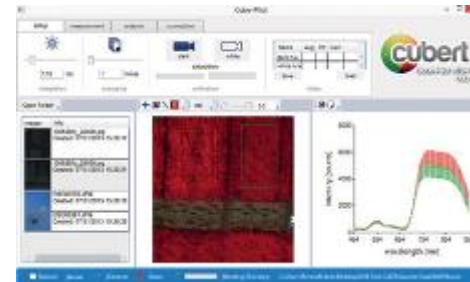


Thermal



Cameras

Hyperpectral



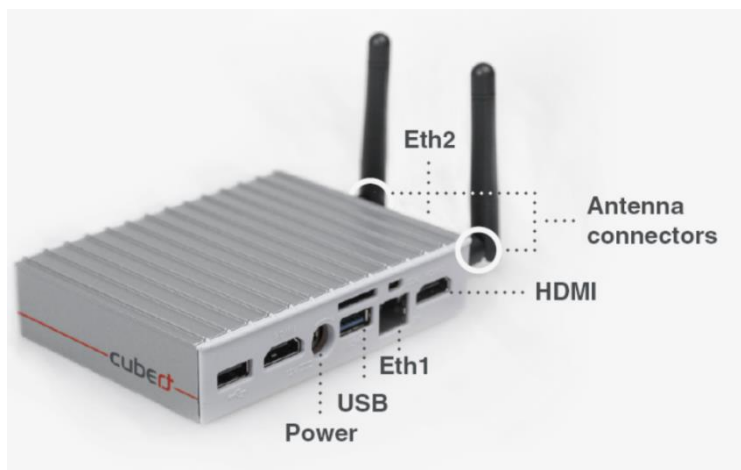
Visible



Hyperspectral solution: Cubert S185 (1)

Focal length: 17 mm (FOV=20°)

Full frame spectroscopy: 2D imager



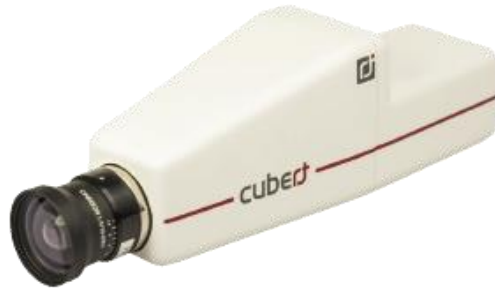
Data quality

Wavelength range	450 nm-950 nm(1000nm)
Detector	Silicon Sony ICX285
Spectral resolution (FWHM@f=23mm)	8 nm (@532 nm)
Spectral sampling	4 nm (125 channels) (138)
Spectral sampling (physical)	1,05 nm/Pix@450 nm; 4,54 nm/Pix@650 nm; 8,13 nm/Pix@900 nm
Wavelength accuracy $\Delta\lambda$ @ 532nm / 808nm@f=23mm	$\pm 2,5\text{nm}$ / $\pm 4,5\text{nm}$
Spatial resolution	1000*1000 Pixel
SNR @ 25ms	58dB
Spectral Data	2500 Spectras/Cube

Sensor Data

Type	Silicon
Cooling system	Passive air-cooled
Digitalization	12 bit
Integration time	0.1 ms up to 1000ms
Measure frequency (UAV)	3 Hz
Measure frequency (Lab; i5@ 3.40GHz; Realtek PCIe Dual GBE)	12Hz

Hyperspectral solution: Cubert S185 (2)



Total weight

UHD 185: 470.4 g
 Mini Pc, 128 SSD, Wi-Fi: 316.8 g
 GigE Cable: 2x 13.8 g
 Power Cable (0.7 m): 26.2 g
 Total: **841.0 g**

Additionally attachment material may be needed, depending on your UAV.

Available optics

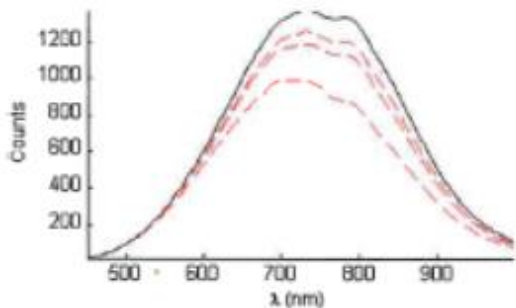
Values in cm/pixel.

Distance to scene	50m			80m			100m		
device	S185	S128	S137	S185	S128	S137	S185	S128	S137
Focal length									
10 mm	55	11	14	88	17	22	110	22	28
16 mm	34	6	8,8	55	11	14	68	14	17
23 mm	23	4,7	6	38	7,6	9,8	47	9,6	12
35 mm	15	3	4	25	5	6,4	31	6,3	8
50 mm	11	2,2	2,8	17	3,5	4,5	22	4,4	5,6

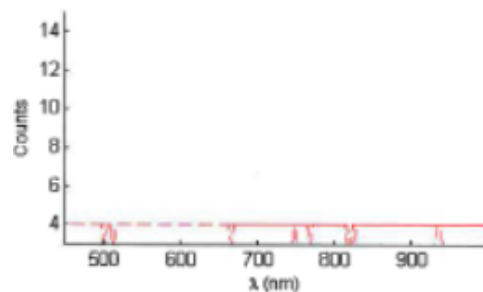
	Flight height (m)		
	50	80	100
HFOV=VFOV (m)	17.63	28.21	35.26
IFOV SHARPEN (cm)	1.70	2.75	3.40



Hyperspectral solution: Cubert S185 (3)



Sensor signal of incandescent light
82.9 ms



Sensor dark noise
82.9 ms



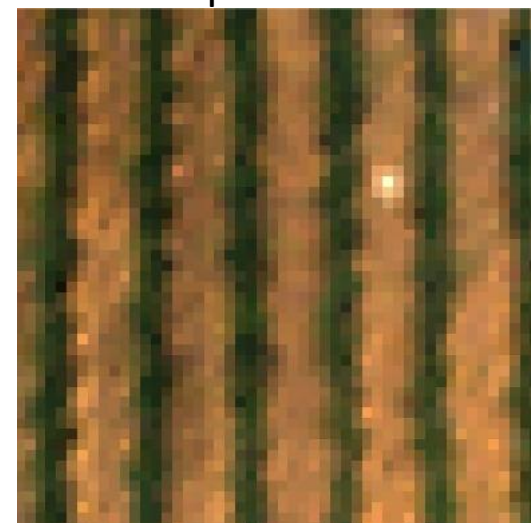
- In-house calibration at the Cubert GmbH
- Calibration procedure (white/gray Zenit target from Spheroptics) and dark current
- Sharpen process optional with 1 Mpix panchromatic band

	Flight height (m)		
	50	80	100
IFOV SHARPEN (cm)	1.70	2.75	3.40
IFOV (cm)	34.00	55.00	68.00

Sharpen cube image
1000x1000 pixels



Genuine cube image
50x50 pixels



“Ardea”: Microdrones MD4-1000



- Rate of climb: 7.5 m/s
- Operating speed: 12 m/s
- Maximum thrust: 118 N
- Weight: ca. 2,650 g (depending on configuration)
- Recommended load: 800 g
- Maximum load: 1.2 kg
- Maximum take-off weight (MTOW): 6,000 g
- Dimensions: 1,030 mm (from rotor hub to rotor hub)
- Flying time: up to 45 minutes (depending on load / wind / battery)
- Battery: 6S2P LiPo, 22.2V, 13000mAh
- Flat core motors: yes
- CFD optimised propeller: yes
- Closed carbon housing: yes
- IP43 protection: yes
- Temperature: -10 °C up to 50 °C
- Humidity: max 90% r.H.
- Wind susceptibility: vibration-free images up to 6 m/s
- Flight range: min. 500 m with remote control, with WP up to 20 km
- Service ceiling: 2000 m ASL, 4500 m ASL - 3-blade carbon rotors necessary
- Take-off altitude: up to 4000 m NN (WGS84)

Camera set-up and tuning in Ardea



Cube-Pilot Management Software (1)

Cube-Pilot (v. 1.5.7)

setup measurement view device

integration: auto ms averaging: 1 times

white dark saturation: calibration: status

open folder File info show

images info

images	info
	Auto012.cub Created: 24/4/2018 13:25:50
	Auto011.cub Created: 24/4/2018 13:25:44
	Auto010.cub Created: 24/4/2018 13:25:04
	Auto009.cub Created: 24/4/2018 13:24:28
	Auto008.cub Created: 24/4/2018 13:22:48
	Auto007.cub Created: 24/4/2018 13:20:52
	Auto006.cub Created: 24/4/2018 13:18:42
	Auto005.cub Created: 24/4/2018 13:13:04
	Auto004.cub Created: 24/4/2018 13:11:30

Remote Server: Camera: State: Working Directory: C:\Users\Cubert\Documents\Cubert\201903_0

File Info

Property	Value
Device Propertys	
Device	S185SE
SerialNumber	17C214
FactoryCalibration	13.09.2017
Software Version	1.5.6
Architecture	64bit
FlatFielding	N/A
RadiometricCalib	N/A
Original Filename	Auto012
Measurement Properties	
Capture Time	20180514_133424_024
Integration Time	0.8209403
Gain	1
# of Averages	1
Capture Mode	Ref
Dark Calibration	20170913_085852_530
Reflectance Calibration	20180514_132321_225
Environment Properties	
GetTemp	N/A
GetAxis	N/A
GPS Position	\$GPRMC,113155.000,A,3707.7642,N,00625.0135,W,1.63,138.49,140518,,A*76 \$GPGGA,113156.000,3707.7640,N,00625.0134,W,1.09,1.1,48.7,M,49.4,M,,0000*75 \$GPGSA,A,3,25,29,32,12,24,14,02,31,06,,,2.1,1.1,1.8*33 \$GPGSV,3,3,11,06,06,041,34,04,00,000,35,22,40,289,*4E \$PSRF156,23,1,0*09

GPS-unit USB

Cube-Pilot Management Software (2)

Cube-Pilot (v. 1.5.7)

setup measurement view device

integration: auto ms

averaging: 1 times

white dark

saturation:

calibration

Name	Avg	Int	Gain
dark n/a			
white n/a			

save load

status

Cube-Pilot (v. 1.5.7)

setup measurement view device

filename: Auto

mode: Reflectance

capture

user: Empty

comment: Empty

set

timelaps series

capture comment timelaps

Cube-Pilot (v. 1.5.7)

setup measurement view device

pseudo RGB: 650 500 450

sensitive wavelength: 650

brightness: 3 20

sharpen

export

full

gray labels

multiplier: 16.0

Envi

export

Cube-Pilot (v. 1.5.7)

setup measurement view device

ip: 192.168.10.100 port: 3000

start connect

remote connection

repeat count=3
UpdateView
GetSpectra="450;500"

send

user command

gain: 1
mult: 1.0

Trigger

expert settings

Model: S185SE S/N: 17C214

Calibration: 13.09.2017

radiometric cal.: N/A

FlatFielding cal.: ...N/A

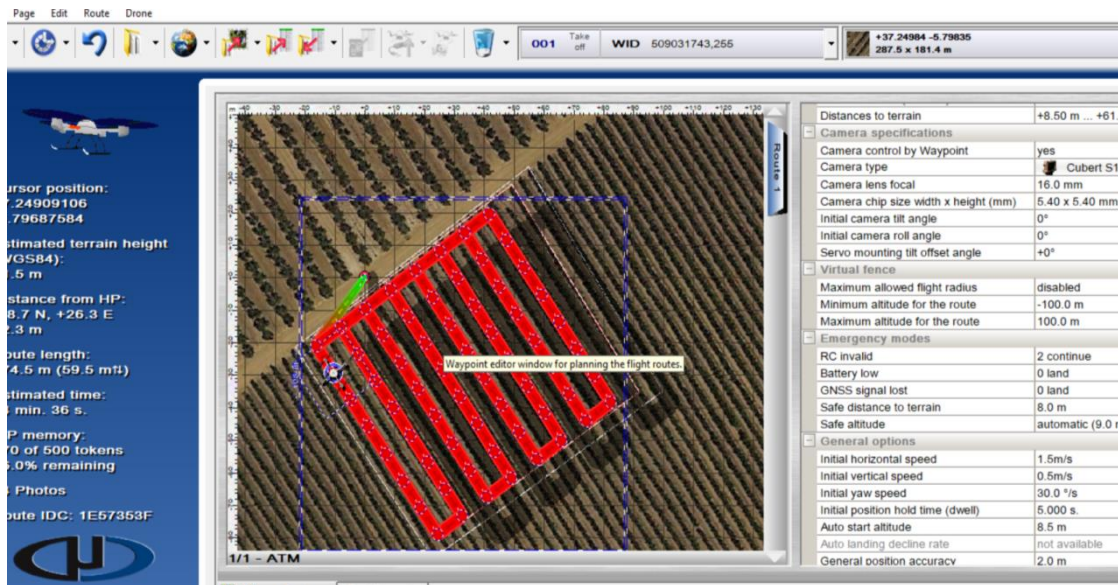
connected device

Mission planning (trigger connection)

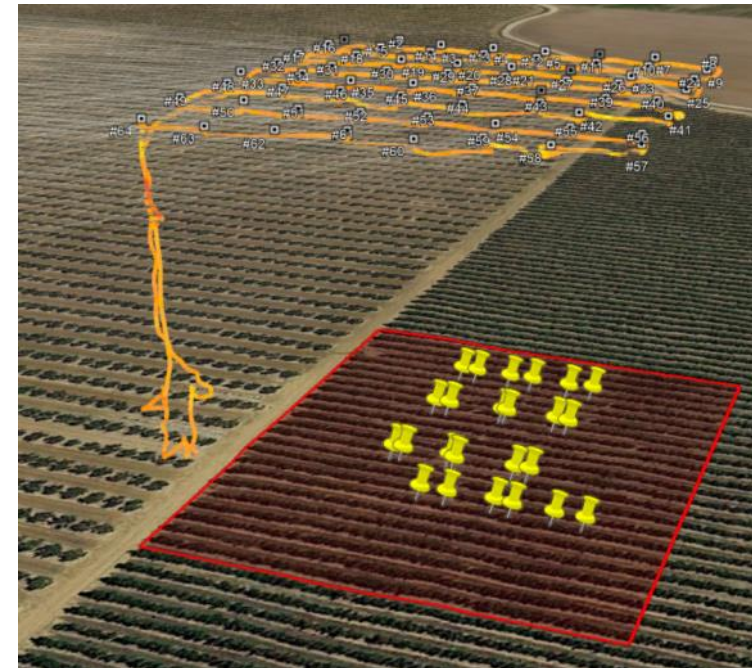
Cube-Pilot (v. 1.5.7)

setup	measurement	view	device
ip 192.168.10.100	port 3000	repeat count=3 UpdateView GetSpectra="450;500"	gain: 1 mult: 1.0
start	connect	send	Trigger
remote connection		user command	expert settings
			connected device

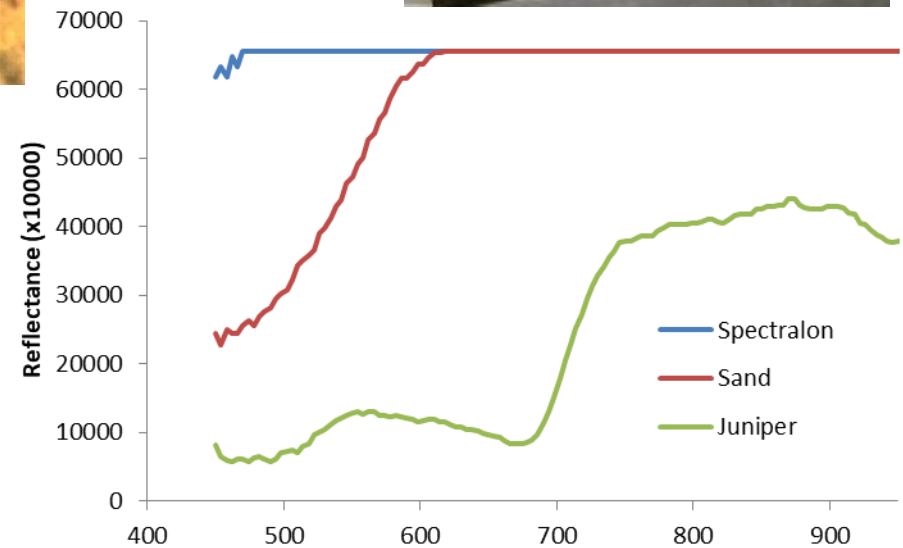
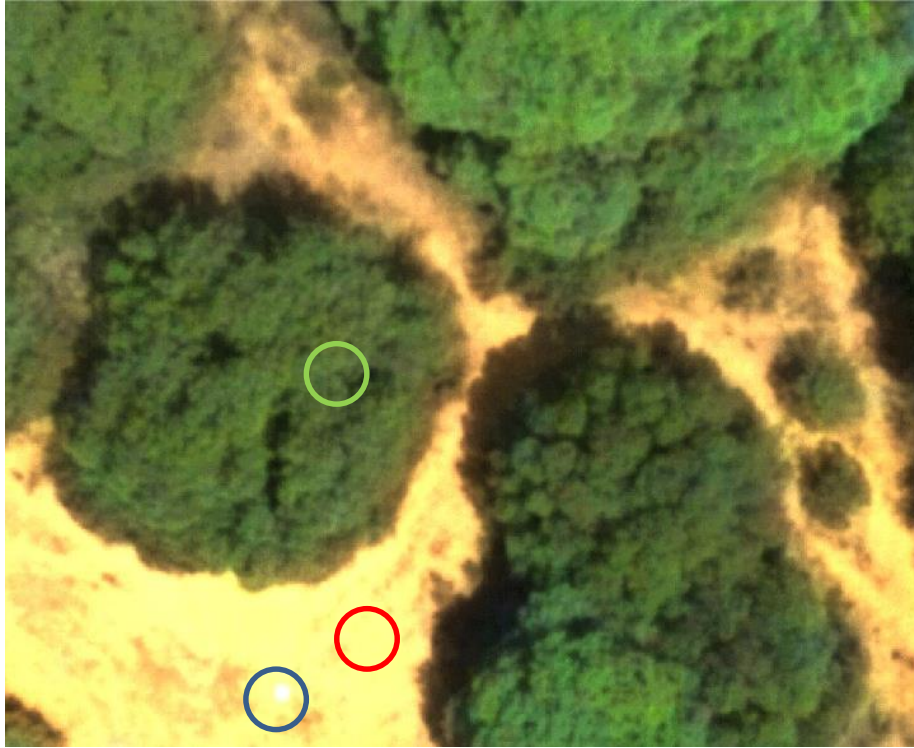
Model: S185SE S/N: 17C214
Calibration: 13.09.2017
radiometric cal.: N/A
FlatFielding cal.: ...N/A



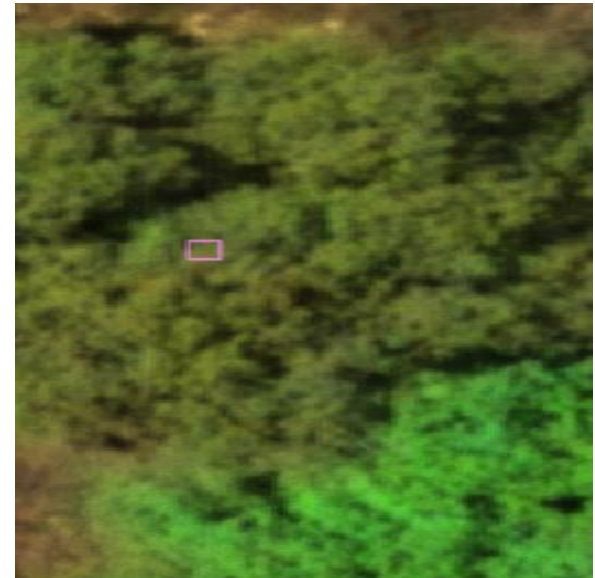
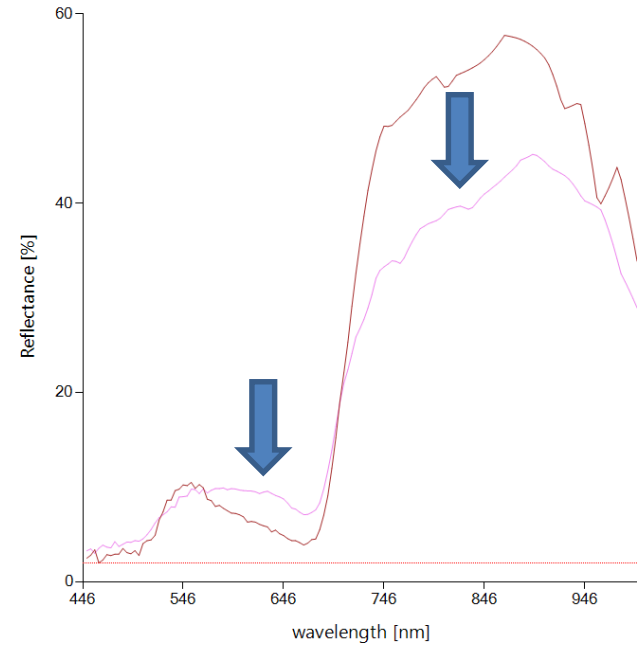
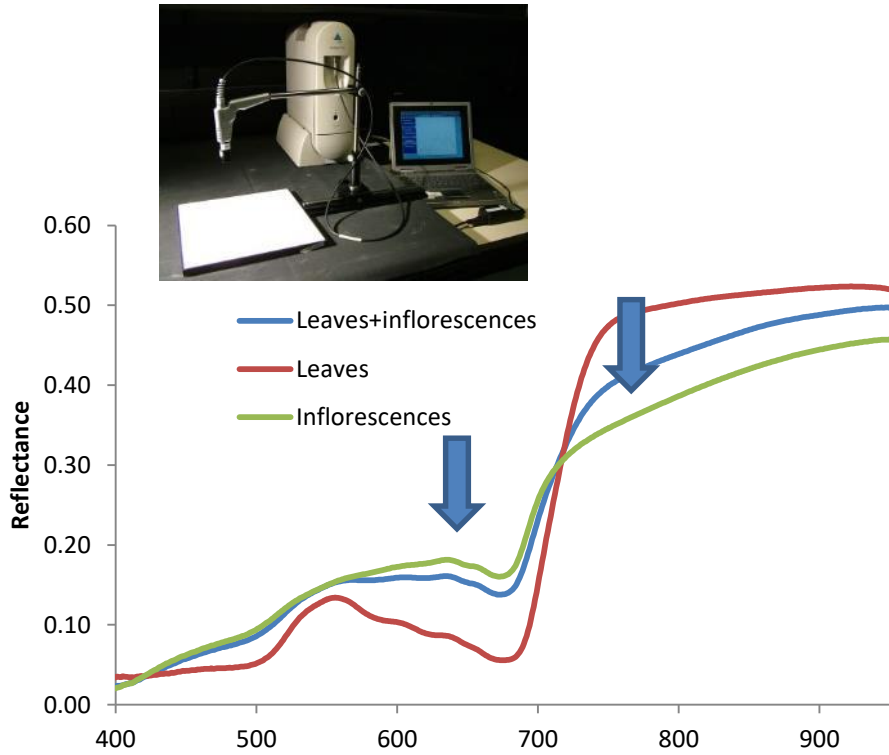
NO NMEA!!



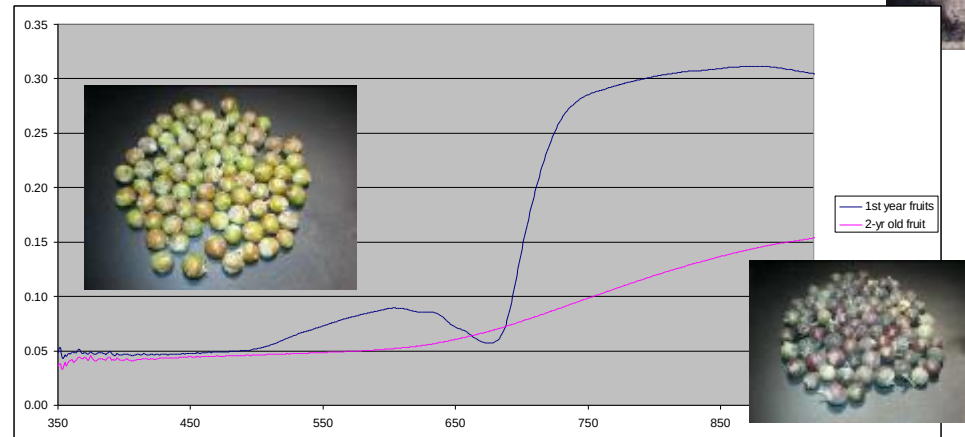
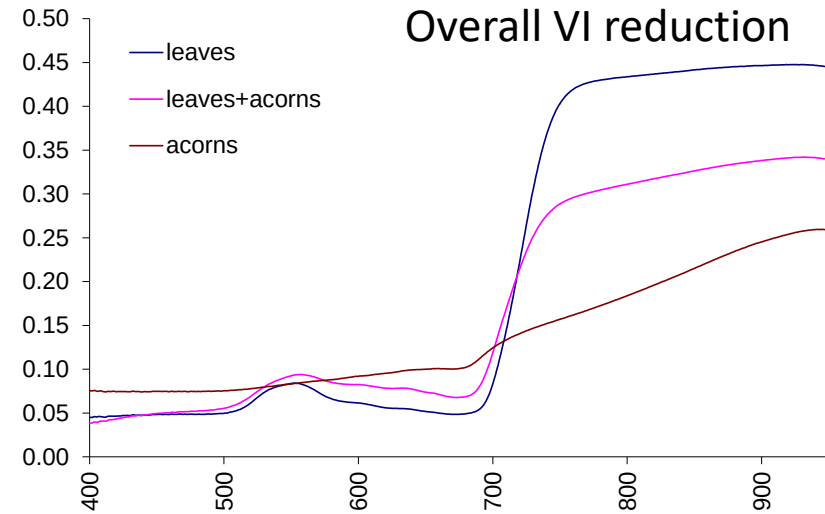
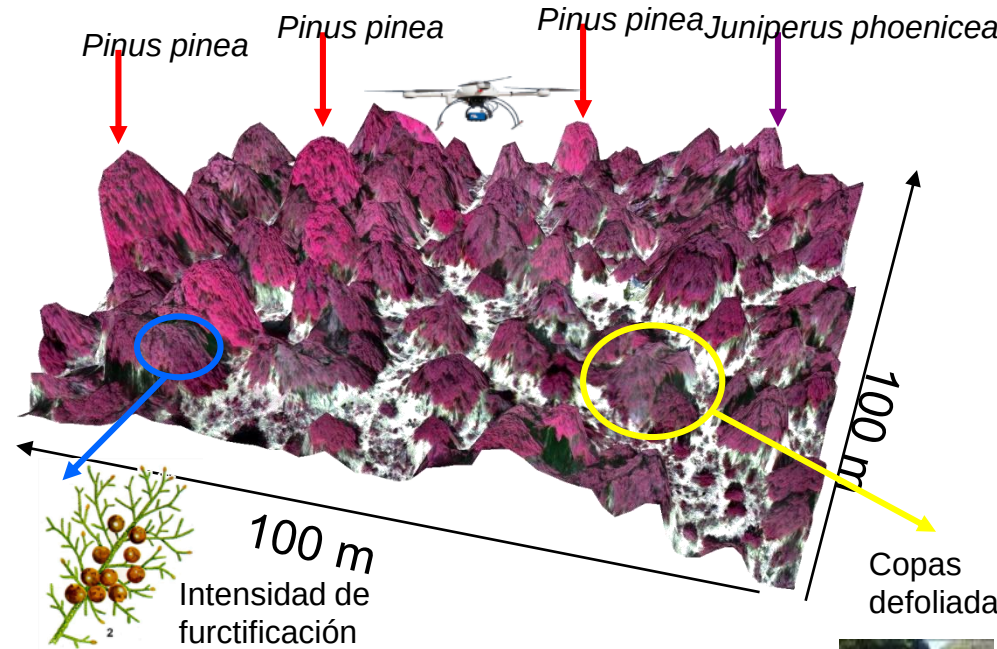
Pannels Inter-calibration



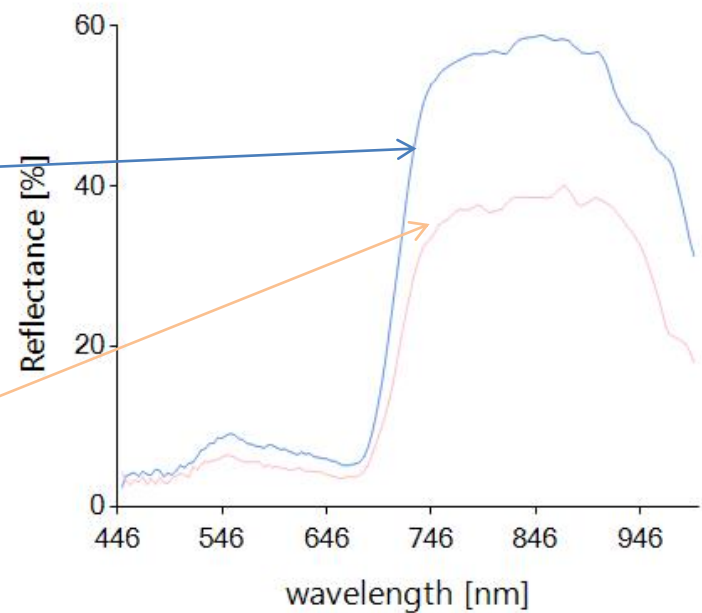
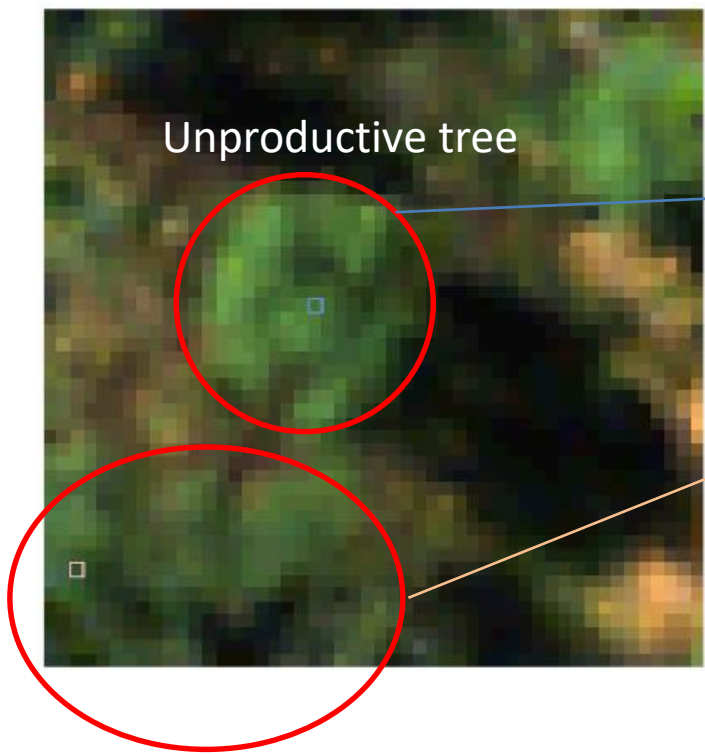
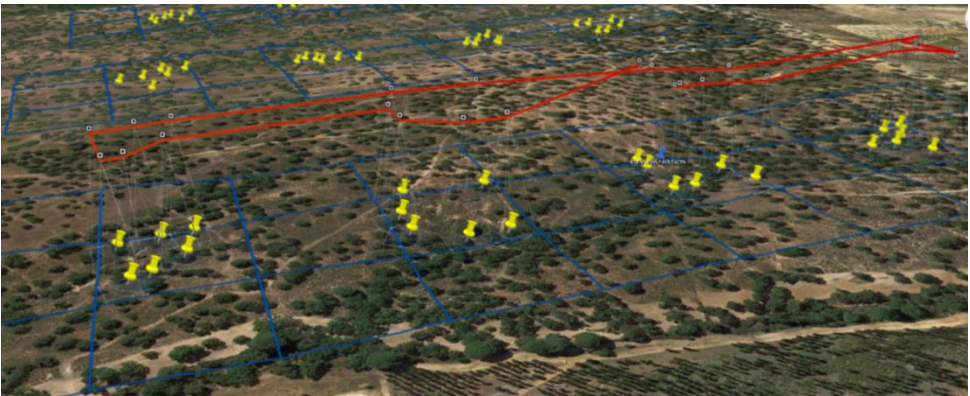
Prospective missions: Cork Oak flowering



Prospective missions: Cork Oak and Juniper fructing

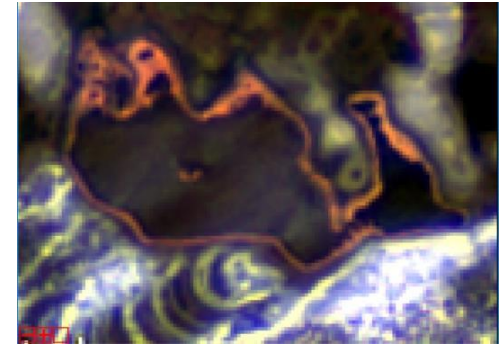


Prospective missions: Cork Oak and Juniper fruiting

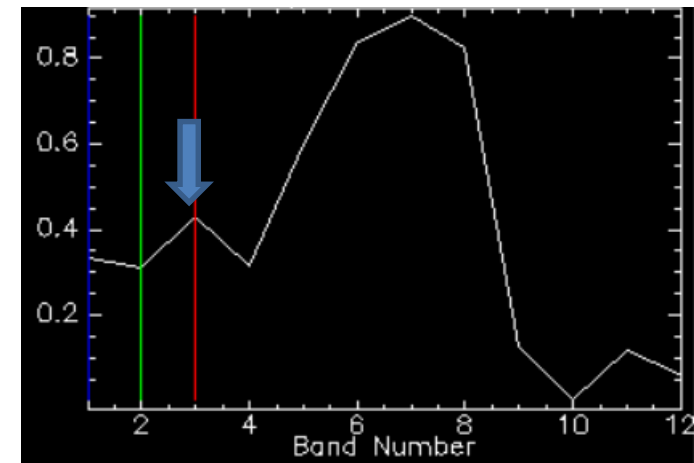
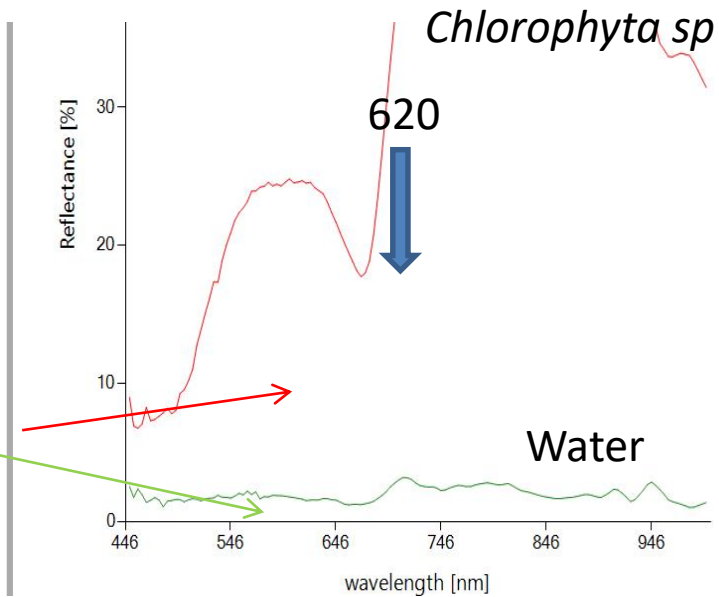
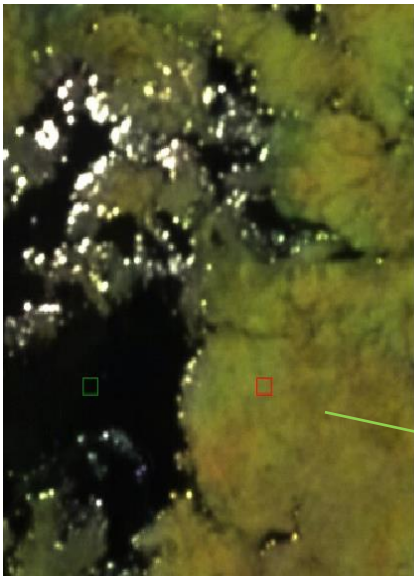


Productive tree (high acorn load)

Prospective missions: Algal blooms



Sentinel 2 (3-2-1) image (02/05/2018)



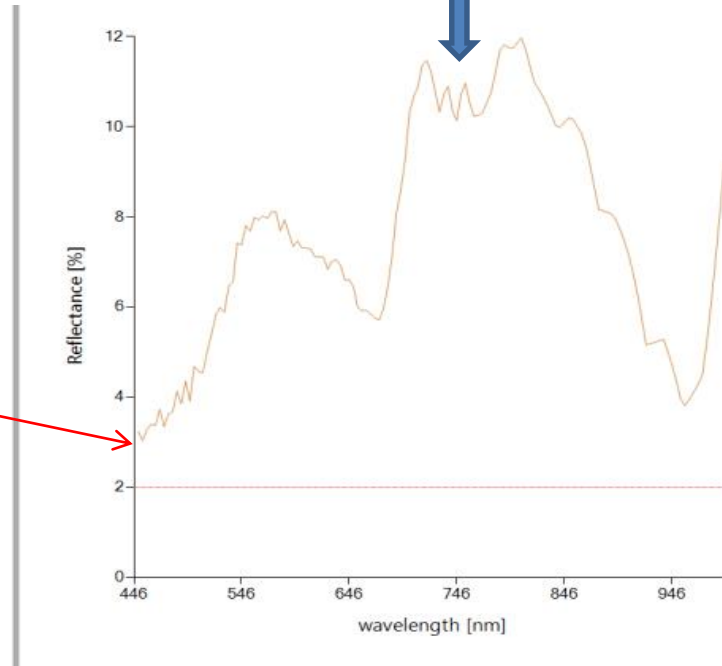
Prospective missions: Aquatic macrophytes



Lemna gibba

Spectral library collection

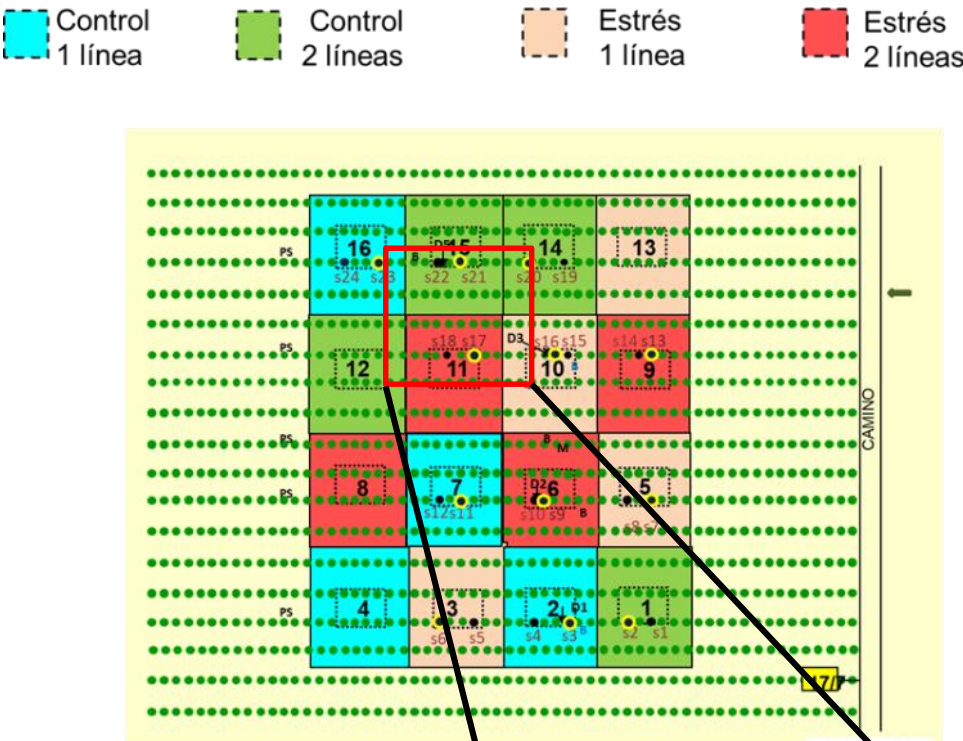
- Different flight heights
- Different species
- Different water conditions



Operational missions: Water stress in Olive orchards

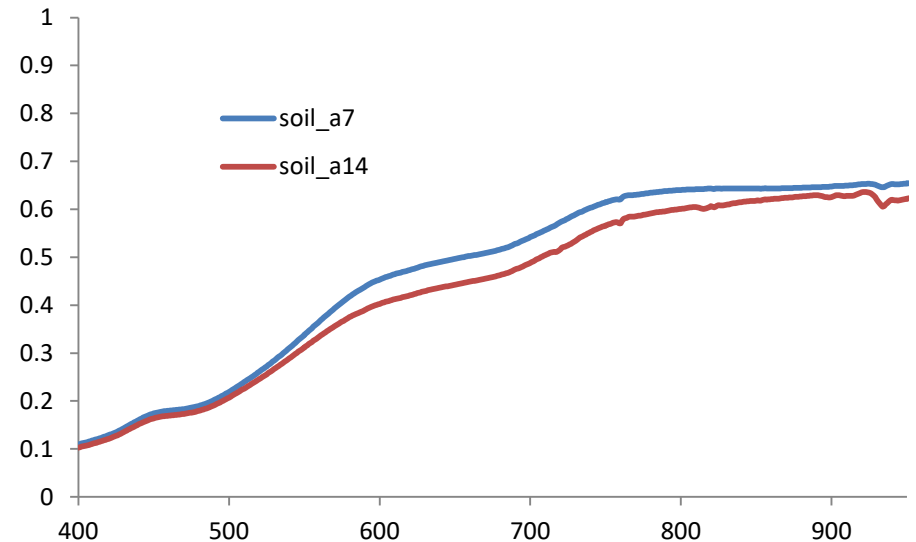
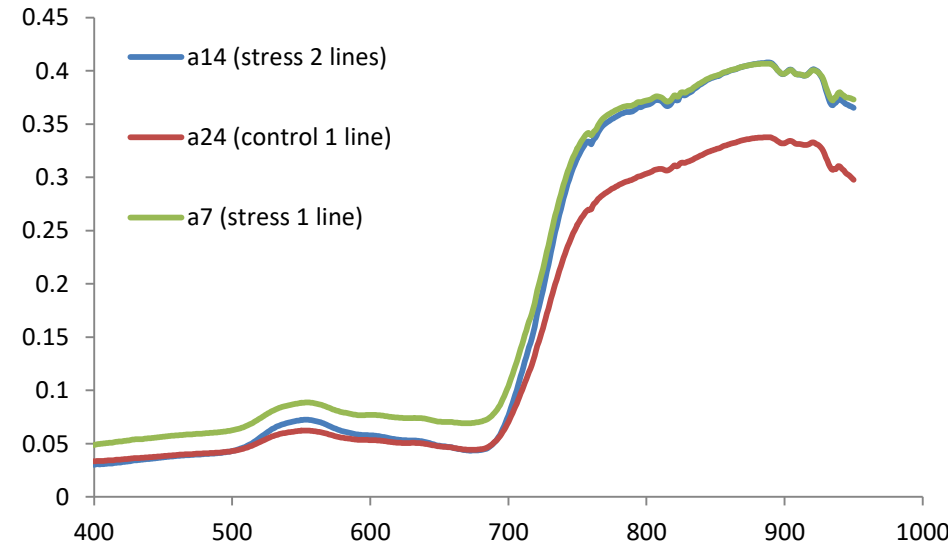
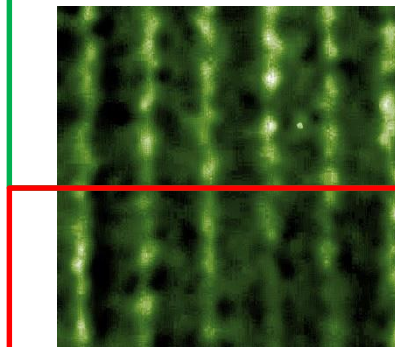
Distribución de tratamientos en 2018

4 x 1.5 m



650-500-450

PRI



Lessons learned & recommendations

- MTOM almost reached!
- No transparent workflow to generate mosaics (Pix4D)
- No NMEA recording for auto-trigger
- Preliminary radiometric consistency checked with vicarious calibration
- Mission planning for single images or overlapping?
- Consistent informative data for water stress detection in olive orchards
- Promising for fruit and flower production estimation
- Collection of spectral libraries in harsh areas



Thank you