AEROMETRICLAB
I+D+i GEOMATICA

ETSIAM
Escuela Técnica Superior de Ingeniería Agronómica y de Montes

UNIVERSIDAD D CORDOBA

tvant
TRABAJOS DE VEHÍCULOS AEREOS NO TRIPULADOS

Jornada Sobre Drones
Sub. Gral. De Regadíos y Economía del Agua
Centro Nacional de Tecnología de Regadíos

GOBIERNO DE ESPAÑA
MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE

DRONES EN AGRICULTURA DE PRECISIÓN. AGRICULTURA 2.0

6 de octubre de 2016

Alfonso García-Ferrer

Moisés Jiménez


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DRONE CONNECTOR MEMBER

UNITED NATIONS

UNGM Registration number 432765

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TRABAJOS DE VEHÍCULOS AEREOS NO TRIPULADOS

senseFly
a Parrot company

dji

I+D

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Servicios

inspección

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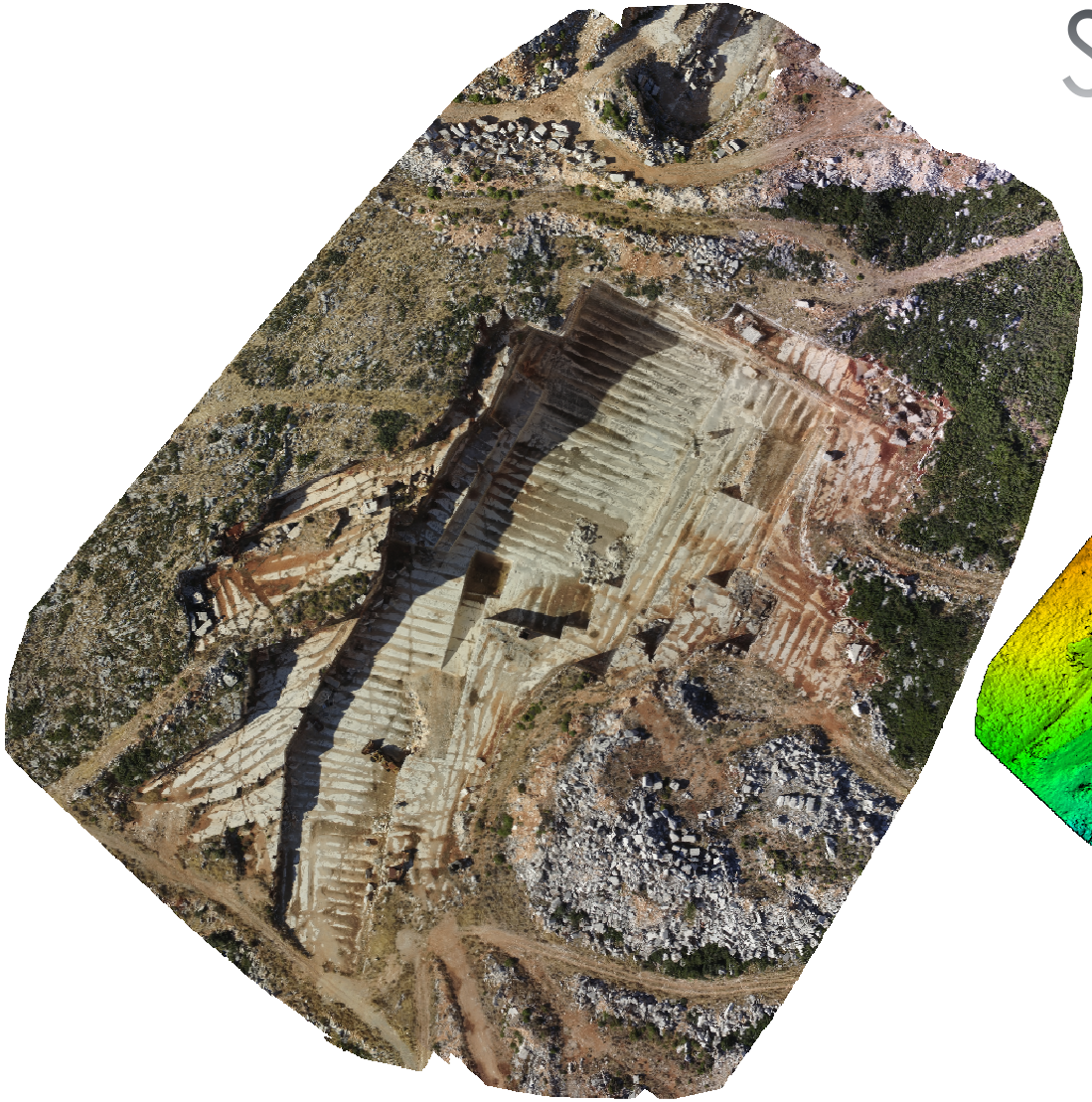
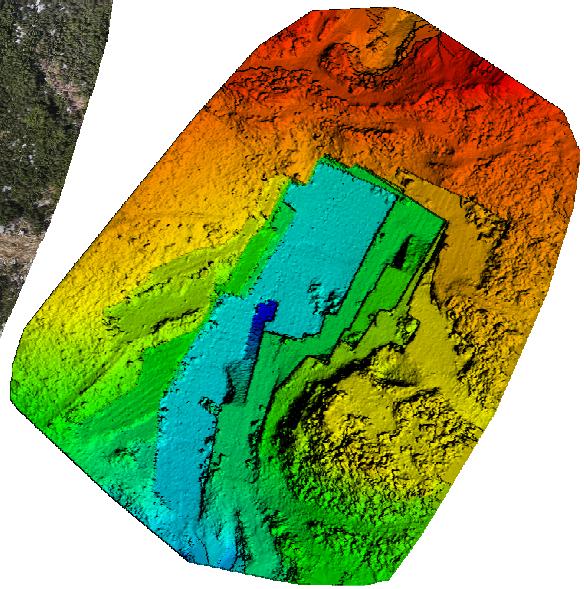
Servicios

Topografía





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Agricultura de precisión

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TRABAJOS DE VEHÍCULOS AEREOS NO TRIPULADOS

Agricultura de precisión

Alfonso García-Ferrer Porras

Catedrático en Ingeniería Cartográfica, Geodesia y Fotogrametría.

E.T.S Ing. Agrónomos y Montes Universidad de Córdoba.

¿CÓMO LO HEMOS HECHO?

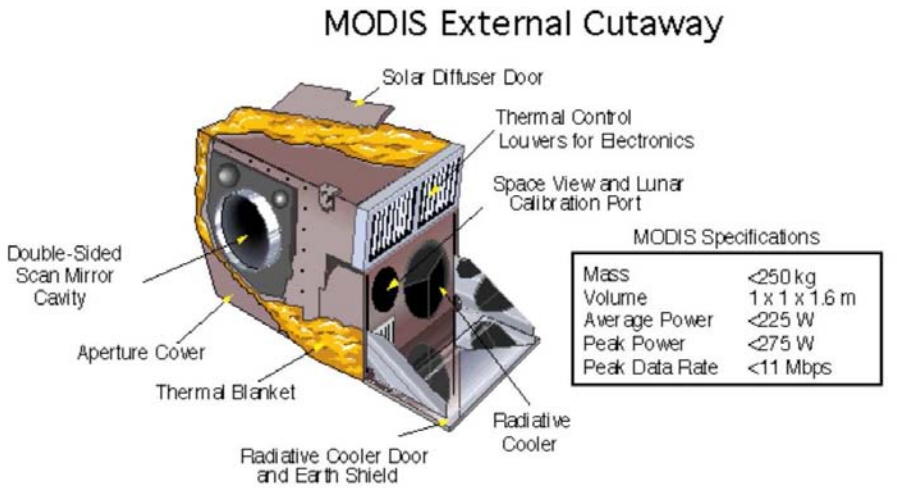
Quienes somos

Grupo multidisciplinar en el Departamento de Ingeniería Gráfica y Geomática. ETSIAM, Universidad de Córdoba.

Trabajando con UAS desde 2012.

FOTOGRAMETRÍA Y TELEDETECCIÓN

FOTOGRAMETRÍA Y TELEDETECCIÓN



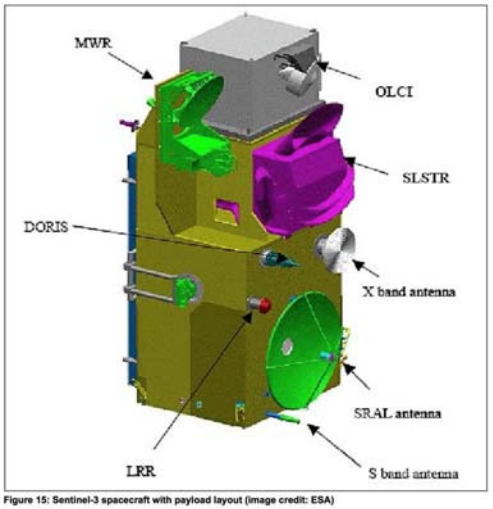
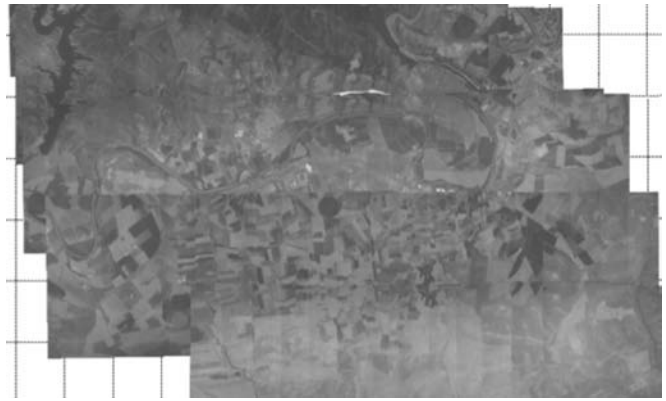
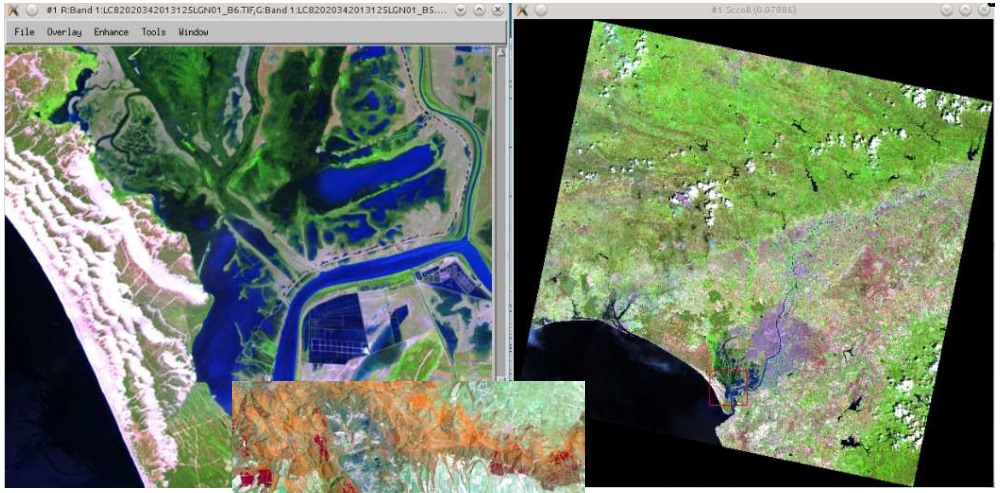
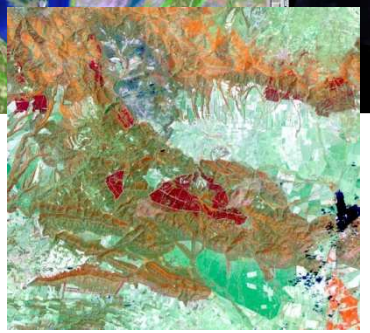


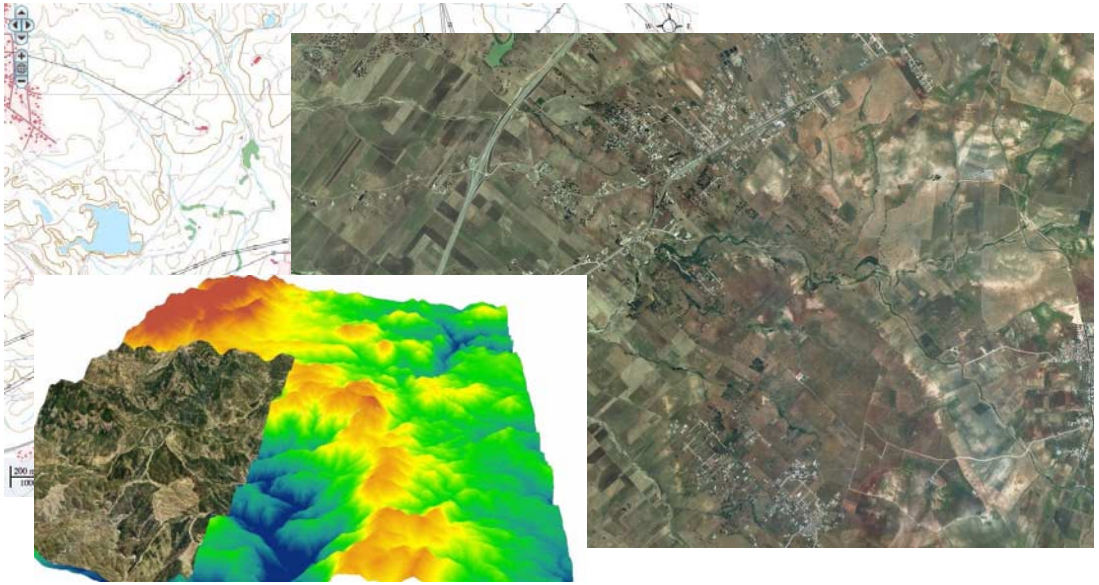
Figure 15: Sentinel-3 spacecraft with payload layout (image credit: ESA)

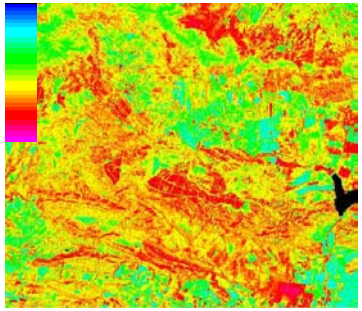
FOTOGRAMETRÍA Y TELEDETECCIÓN

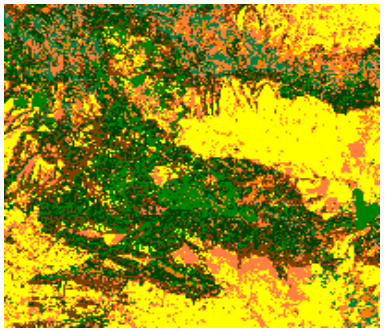








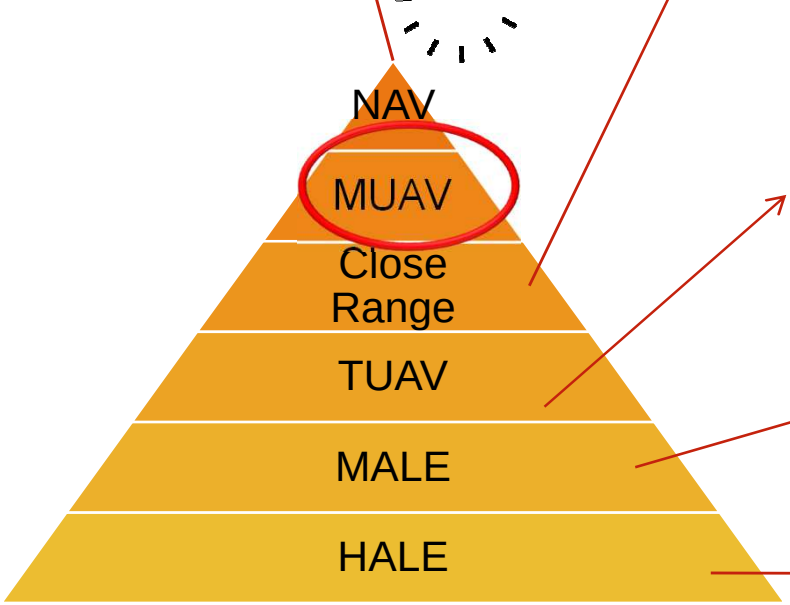




Cartografía de combustibles

www.aerometriclab.com

CLASIFICACIÓN UAS



Carga de pago
Alcance y Duración de vuelo

www.aerometriclab.com

RPAS. MUAV (MINI UAV) (<25KG)

Las plataformas mas interesantes…..

Ala giratoria

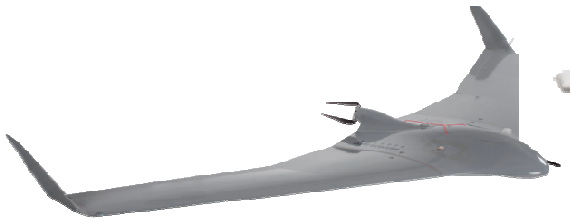
Single rotor

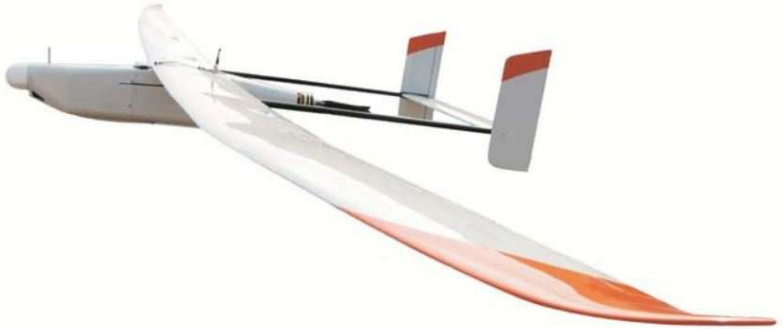
Coaxial

4-rotor

Multi-rotor

Ala fija



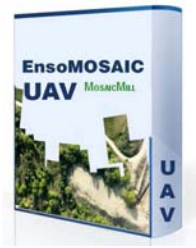


SENSORES

- Sensores: *Payload* (Carga de pago)
  - Una gran variedad de sensores según necesidades del usuario.

DIY (DO IT YOURSELF)
NUEVA FUENTE DE INFORMACIÓN AGROFORESTAL

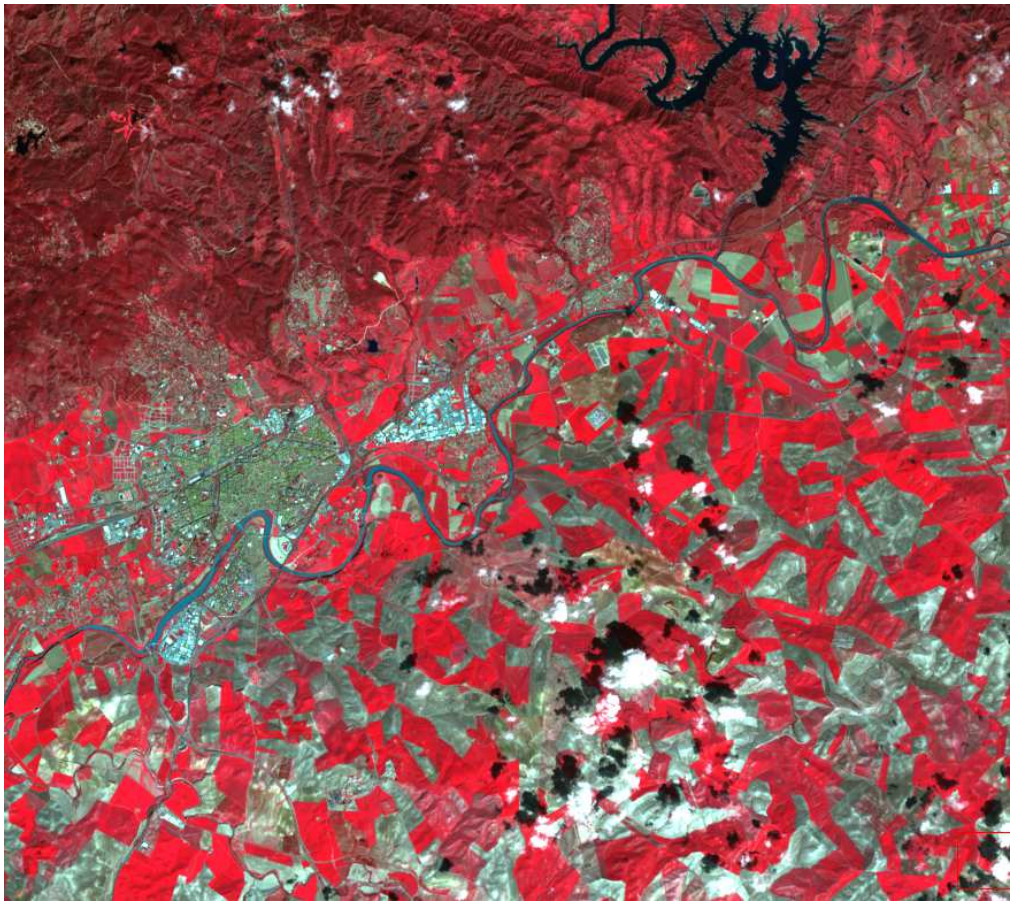
PIX4D



Modtran5

VENTAJAS

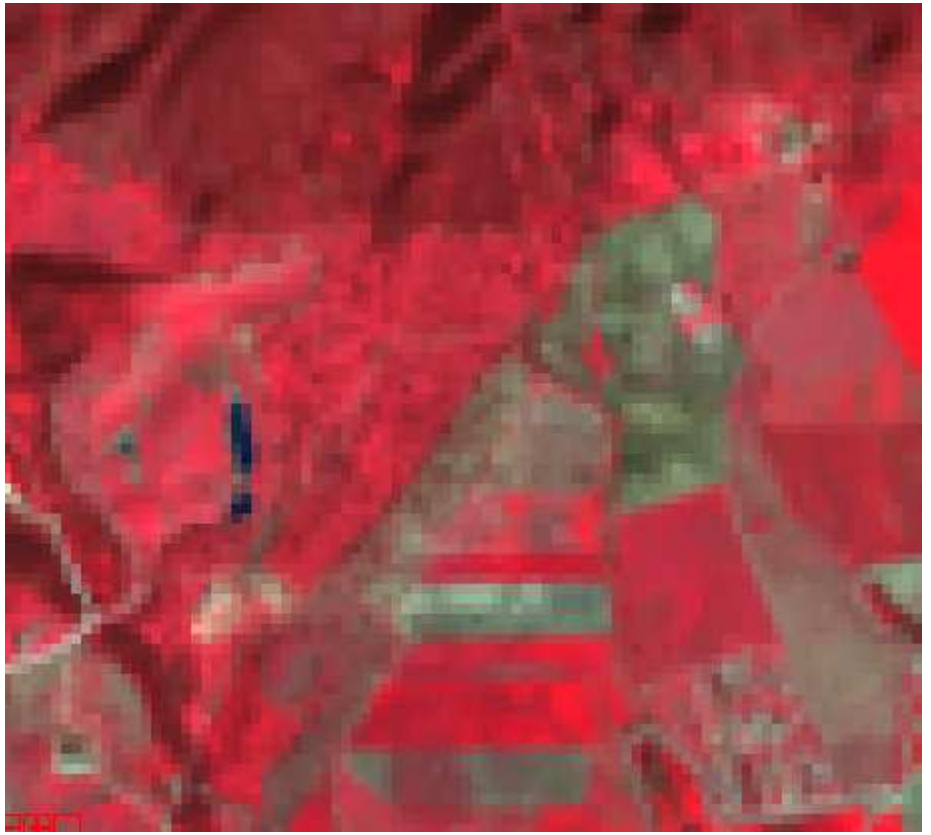
1. Costes de equipamiento, por comparación
2. Costes de producción
3. Resolución espacial



Landsat 8, 30m

VENTAJAS

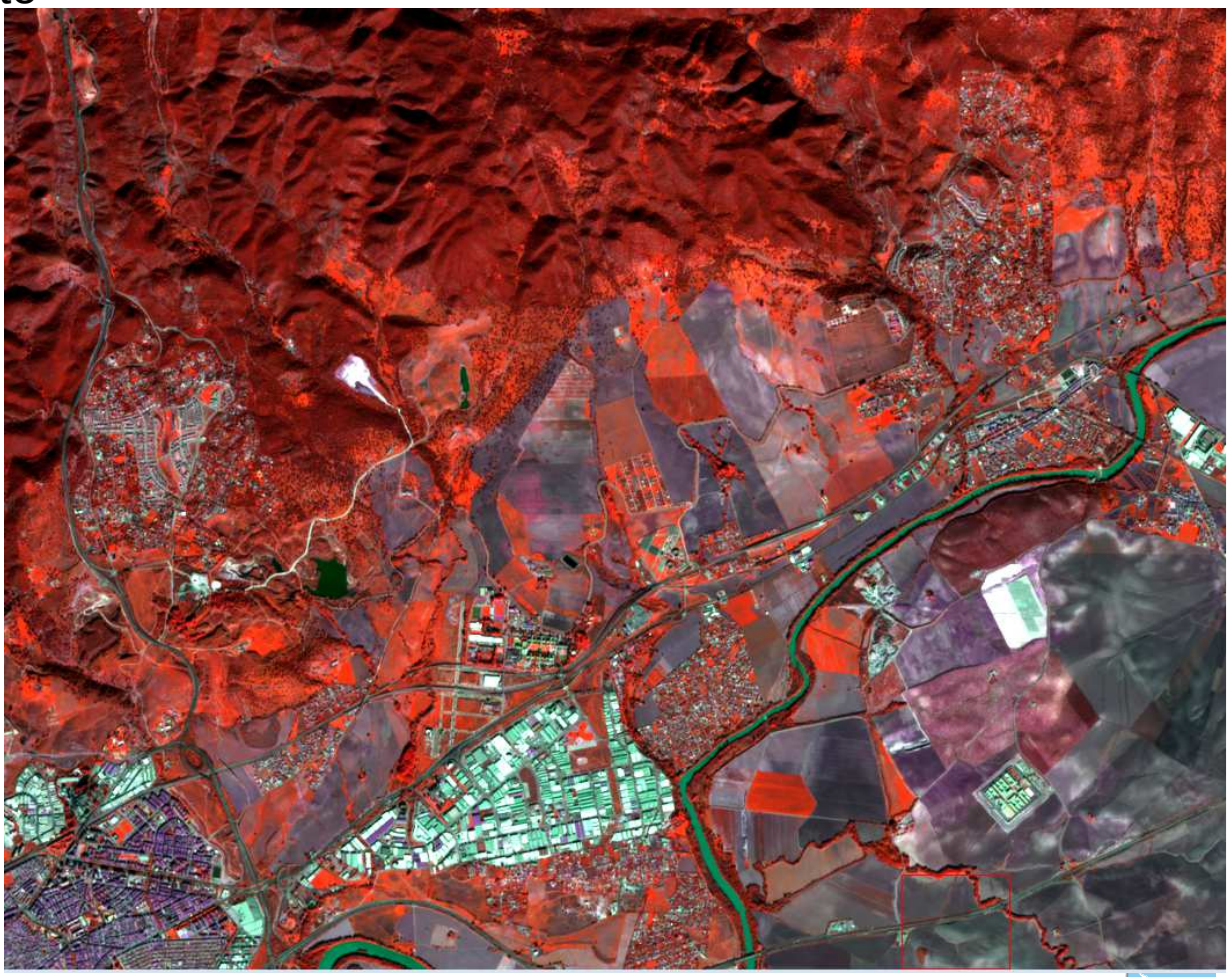
1. Costes de equipamiento
2. Costes de producción
3. Resolución espacial



Landsat 8, 30m

VENTAJAS

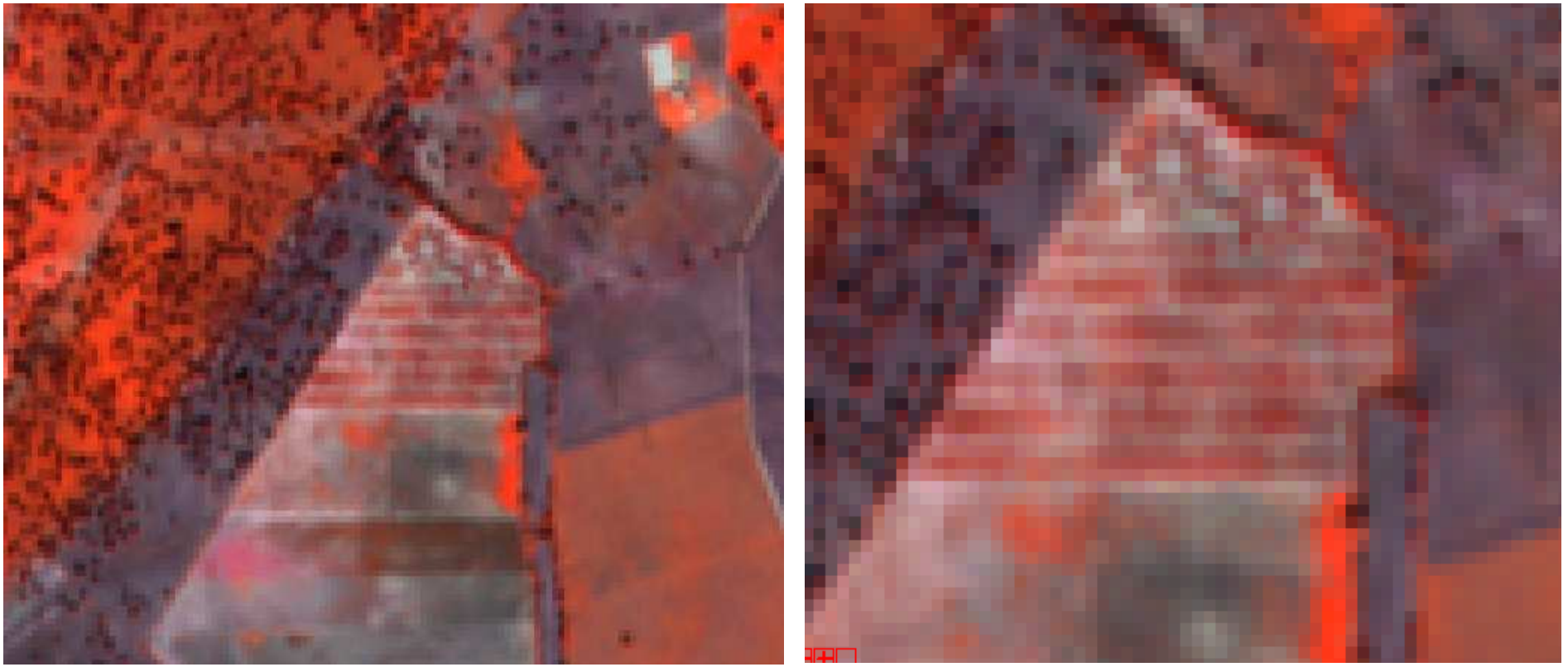
1. Costes de equipamiento
2. Costes de producción
3. Resolución espacial



Sentinel 2A, 10 m.

VENTAJAS

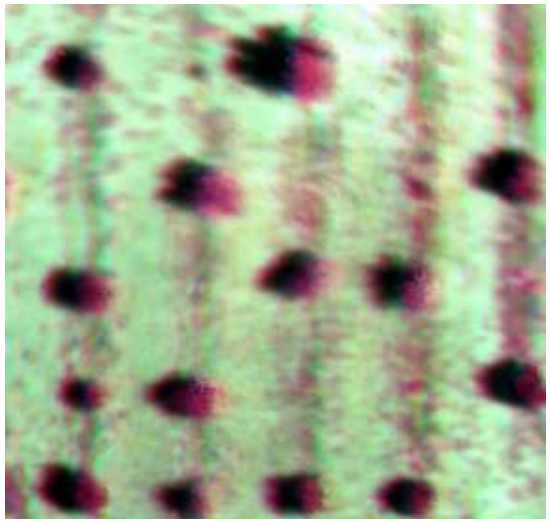
1. Costes de equipamiento
2. Costes de producción
3. Resolución espacial

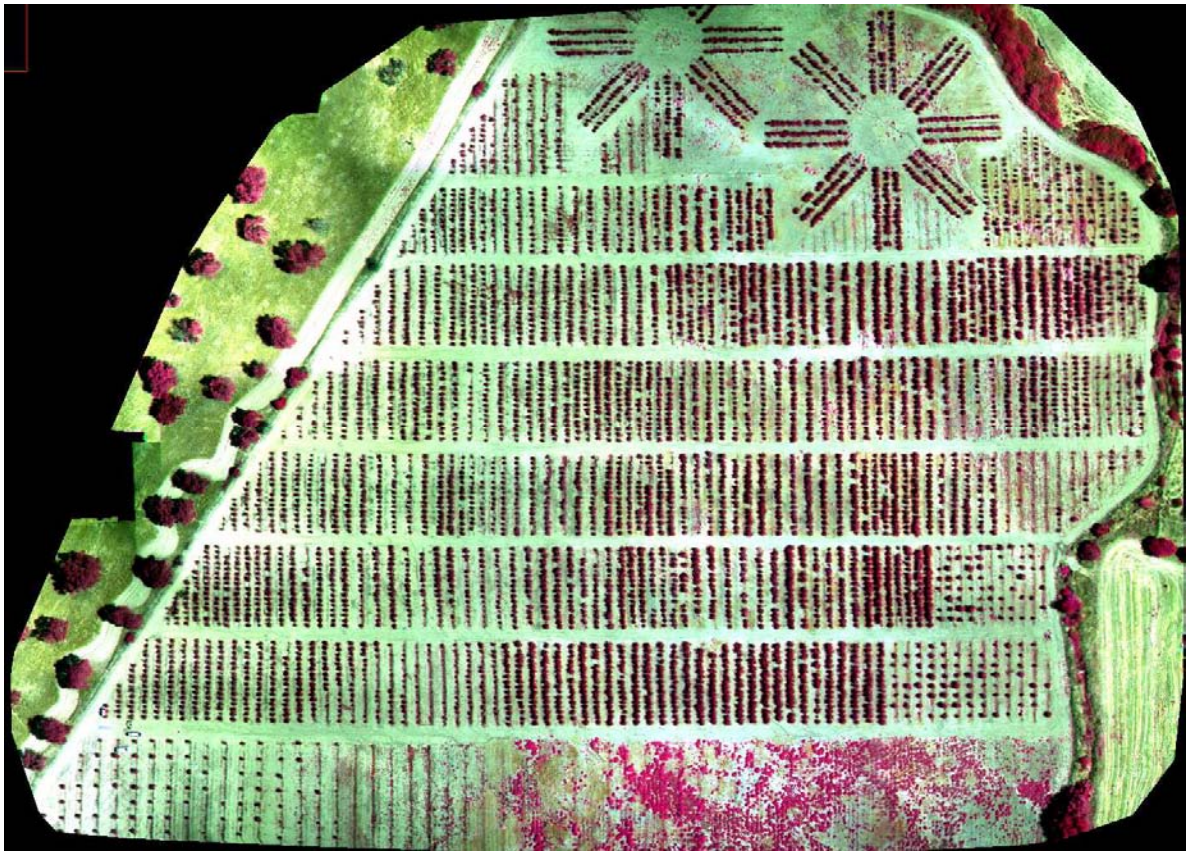


Sentinel 2A, 10 m.

VENTAJAS

1. Costes de equipamiento
2. Costes de producción
3. Resolución espacial





MD4-1000
Tetracam mini MCA 6
GSD 8 cm

VENTAJAS

Ikonos	0,8	3,2
QuickBird	0,6	2,4
GeoEye	0,4	1,6
WorldView	0,3	1,24

(Resolución pan y multi en metros)

LANDinfo
WORLDWIDE MAPPING LLC
Satellite Imagery Pricing
May, 2016

High Resolution Archive Pricing (50cm)	WorldView-1	WorldView-2/3	QuickBird	GeoEye-1	IKONOS (80cm)	Pleiades 1A/1B
Panchromatic	$14.00	$14.00	$14.00	$14.00	$10	$13
3-Band Pan-Sharpened	n/a	$17.50	$17.50	$17.50	$10	$13
4-Band Pan-Sharpened	n/a	$17.50	$17.50	$17.50	$10	$13
Panchromatic + 4-band Multispectral Bundle	n/a	$17.50	$17.50	$17.50	$10	$13
8-Band Multispectral	n/a	$19	n/a	n/a	n/a	n/a
8-Band Panchromatic + Multispectral Bundle	n/a	$19	n/a	n/a	n/a	n/a

*The minimum order area for archive imagery, for all sensors, is 25 sq. km with a 2km minimum order width
To receive archive pricing, QB,WV2,WV1, GE1 & IK imagery has to be **older than 90 days in archive. No hold on Pleiades imagery.
***Airbus default licensing is for 1-5 users; DigitalGlobe default licensing is single user -- pricing uplifts apply for additional users.

High Resolution New Tasking Pricing (50cm)	WorldView-1	WorldView-2/3	QuickBird	GeoEye-1	IKONOS (80cm)	Pleiades 1A/1B
Panchromatic	$24	$24	n/a	$24	n/a	$23
3-Band Pan-Sharpened	n/a	$27.50	n/a	$27.50	n/a	$23
4-Band Pan-Sharpened	n/a	$27.50	n/a	$27.50	n/a	$23
Panchromatic + 4-band Multispectral Bundle	n/a	$27.50	n/a	$27.50	n/a	$23
8-Band Multispectral	n/a	$29.00	n/a	n/a	n/a	n/a
8-Band Panchromatic + Multispectral Bundle	n/a	$29.00	n/a	n/a	n/a	n/a

*The minimum order area for new tasking collections, for all sensors, is 100 sq. km with a 5km minimum order width.
**On DigitalGlobe satellites 5% or less cloud cover guarantee is available for 50% uplift, 10% or less guarantee is 25% uplift. WV-3 specific new collects = 30cm pricing
***Pleiades 5% or less cloud cover guarantee is $10 per sq. km.
**** 0-15 degree Off-Nadir may be specified for an additional $2 per sq. km
********Airbus default licensing is for 1-5 users; DigitalGlobe default licensing is single user -- pricing uplifts apply for additional users.

VENTAJAS

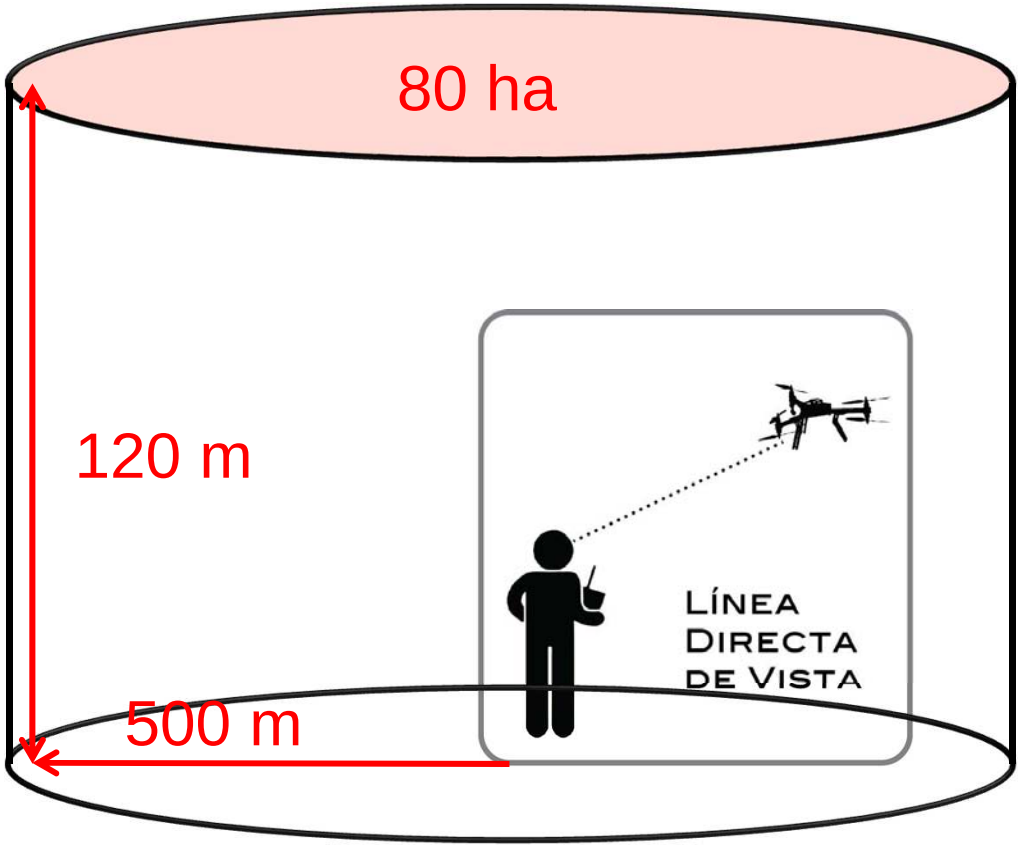
1. Costes de equipamiento
2. Costes de producción
3. Resolución espacial

Resolución temporal

En principio (lluvia, viento, tipo de sensor…)

INCONVENIENTES (POR AHORA)

- Normativa y legislación
- Vuelos BLOS
- Costes de algunos equipos
- Autonomía, baterías
- Calibración de sensores
- Estabilización de sensores



INCONVENIENTES (POR AHORA)

FEATURED STORY

Posted in Precision Agriculture • June 25th, 2016

COMMERCIAL

7 About 1(

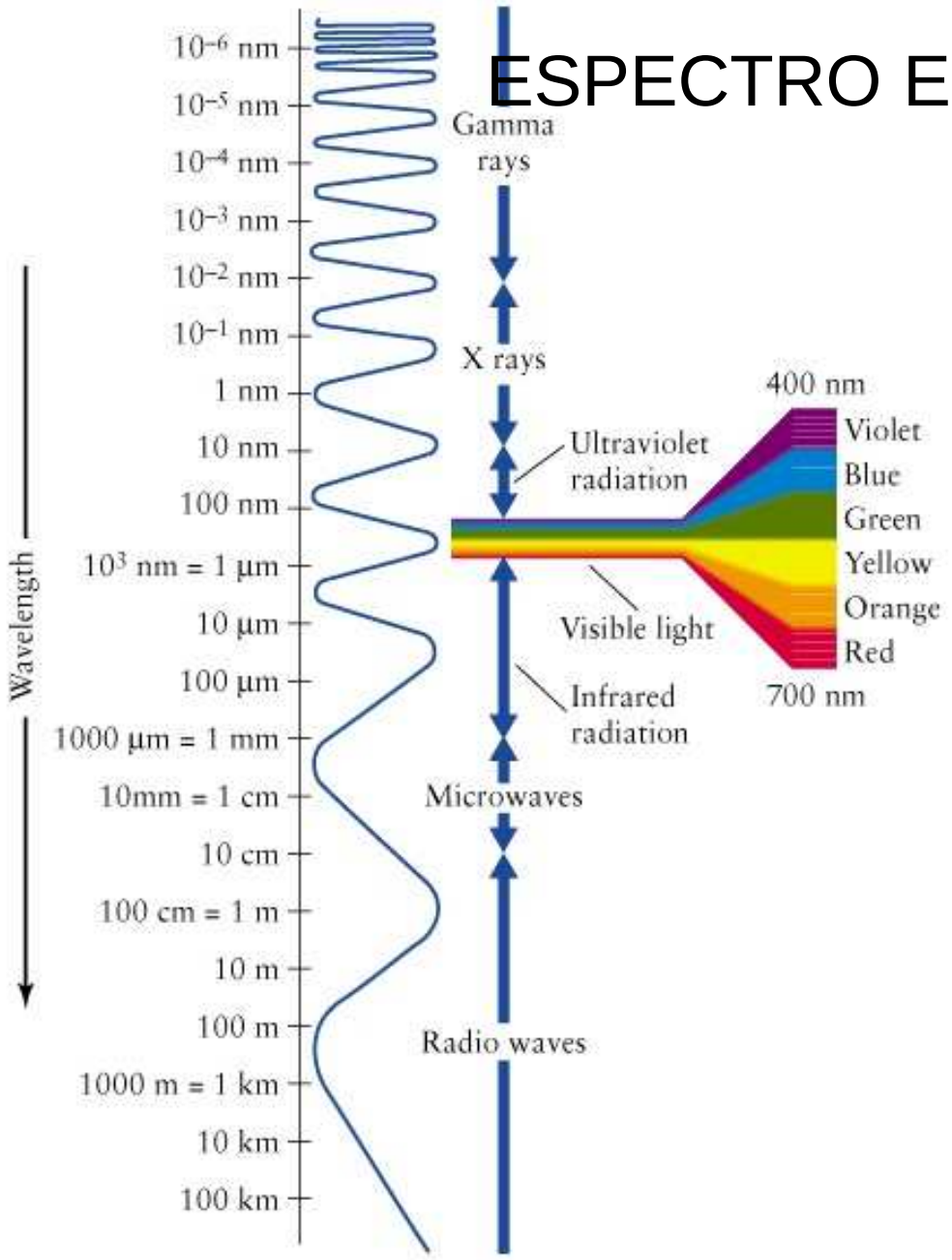
7 About 107: How FAA Regul
Impact the Commercial Dron

June 21, 2016

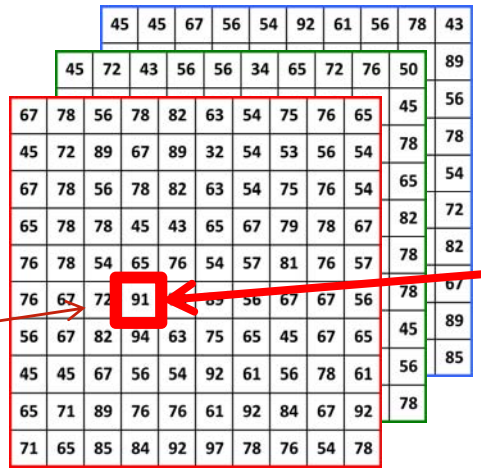
SUMMARY OF SMALL UNMANNED AIRCRAFT RULE (PART 107)

Operational Limitations	• Unmanned aircraft must weigh less than 55 lbs. (25 kg). • Visual line-of-sight (VLOS) only; the unmanned aircraft must remain within VLOS of the remote pilot in command and the person manipulating the flight controls of the small UAS. Alternatively, the unmanned aircraft must remain within VLOS of the visual observer. • At all times the small unmanned aircraft must remain close enough to the remote pilot in command and the person manipulating the flight controls of the small UAS for those people to be capable of seeing the aircraft with vision

ESPECTRO ELECTROMAGNÉTICO



SENSOR RGB, IMAGEN DIGITAL

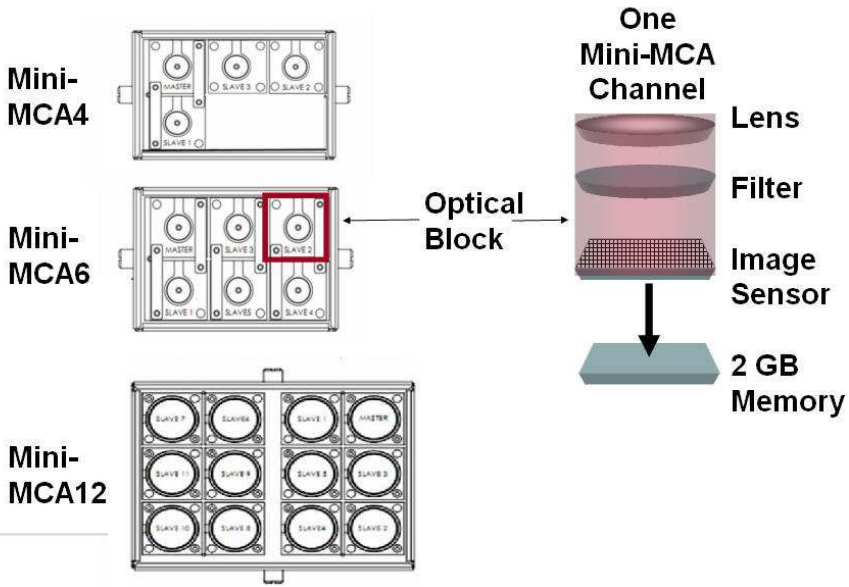


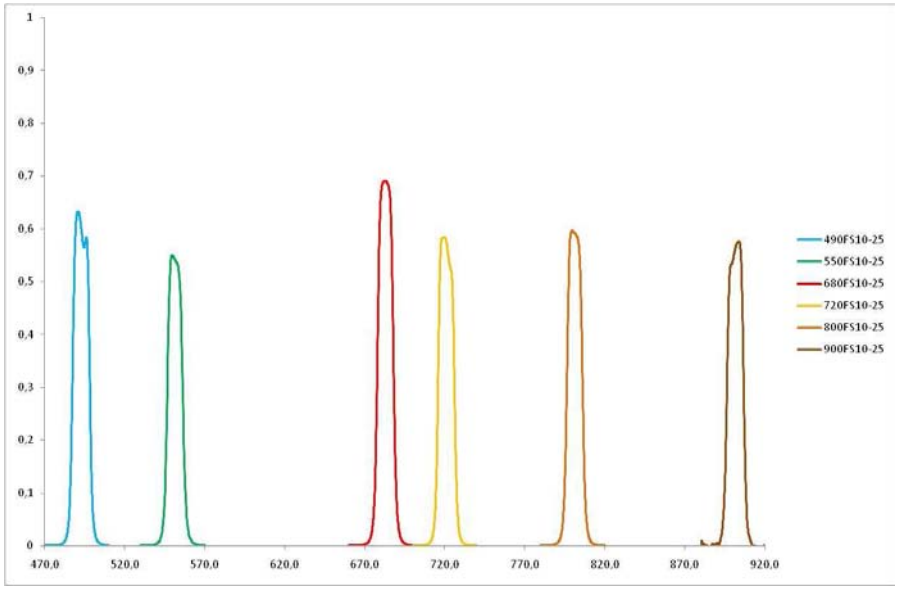
Nivel digital
Información radiométrica de un pixel

RGB (91,120,45)

www.aerometriclab.com

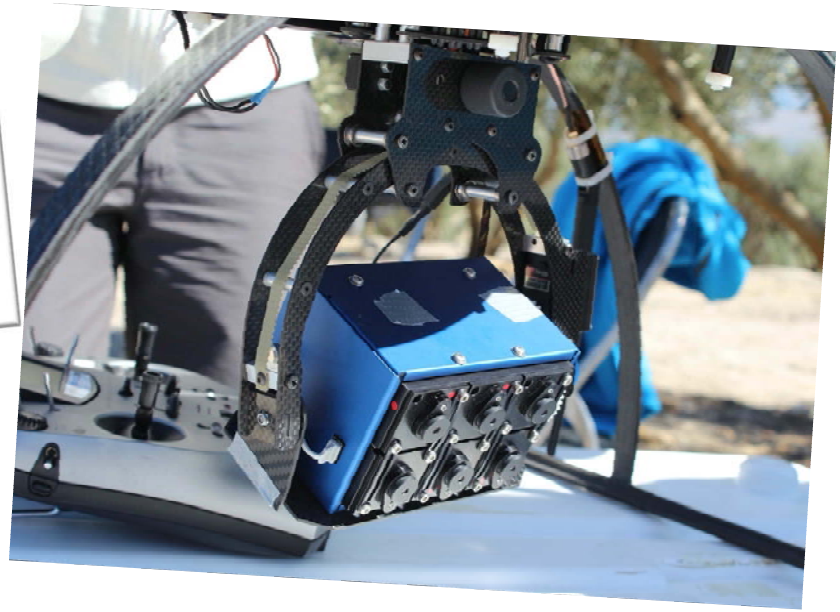
SENSORES MULTIESPECTRALES



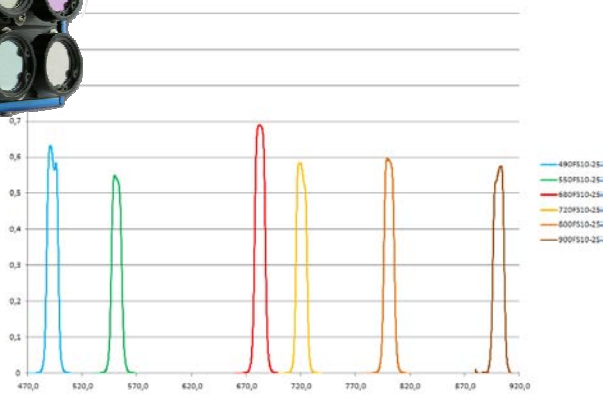


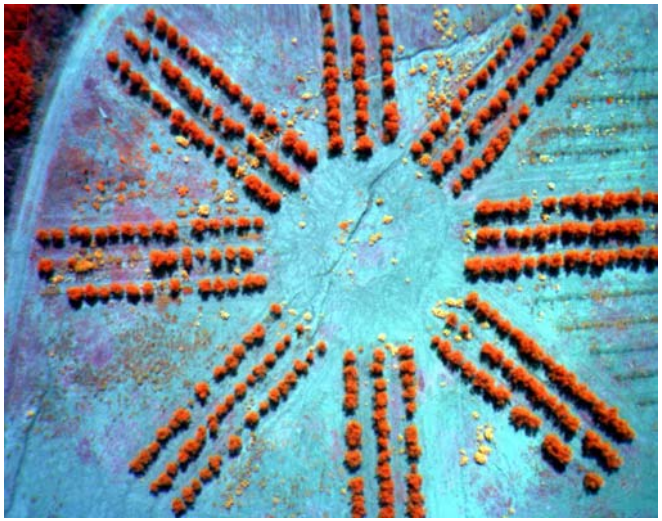
Mini MCA 6
www.tetracam.com

SENSORES MULTIESPECTRALES

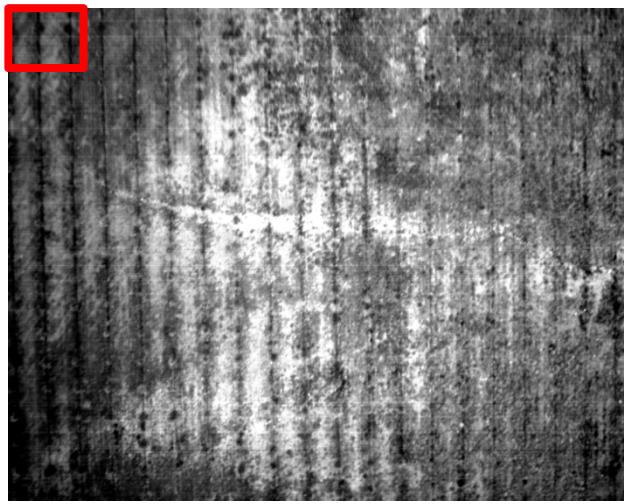


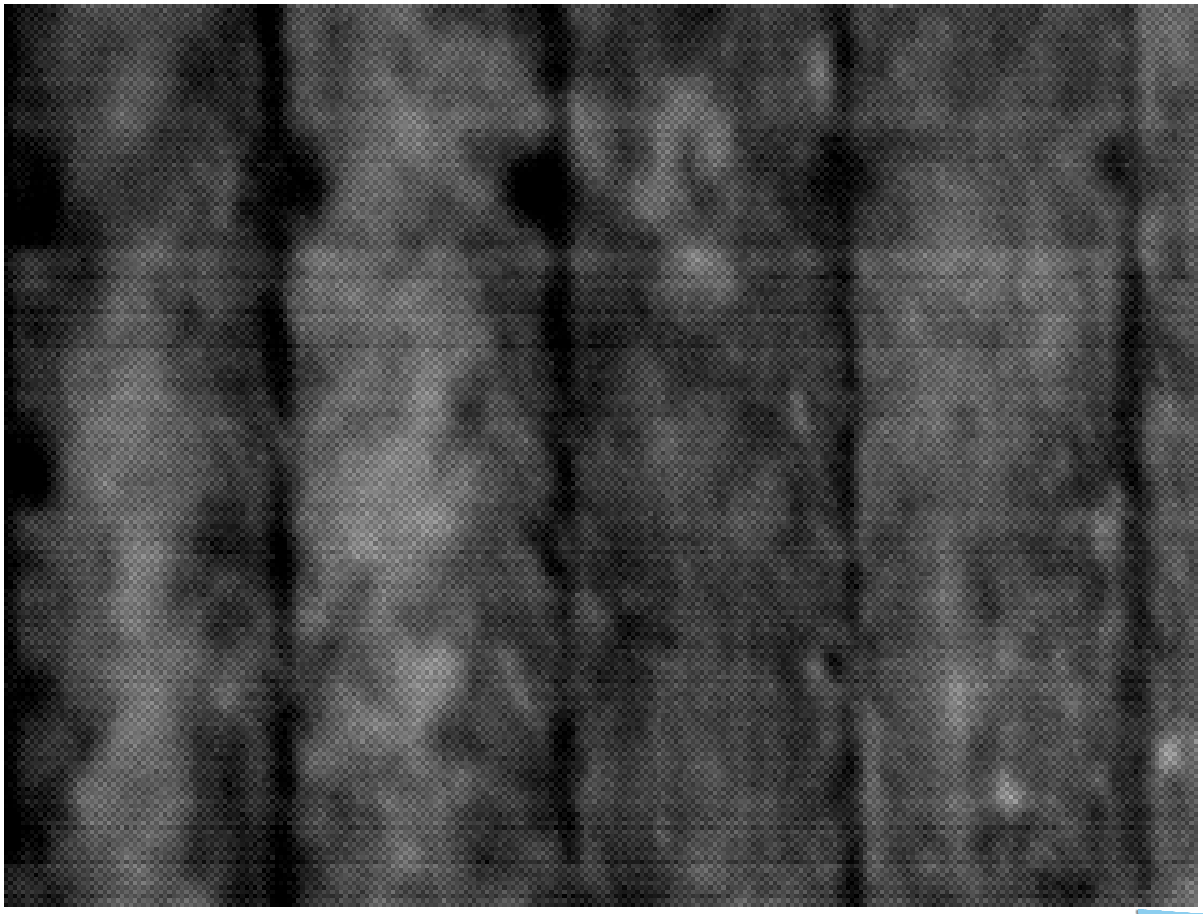
CÁMARAS DIGITALES MODIFICADAS





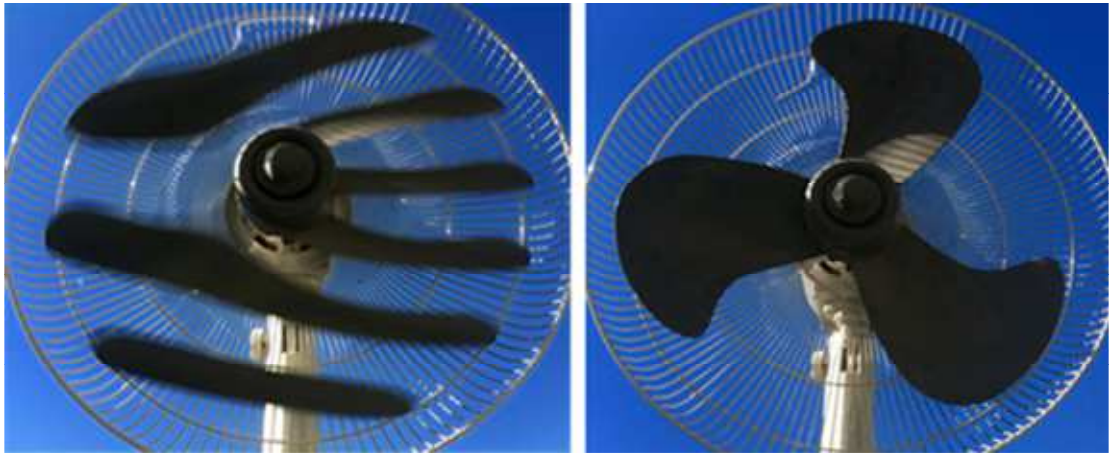
TTC MINI-MCA-6, ANÁLISIS DE IMÁGENES

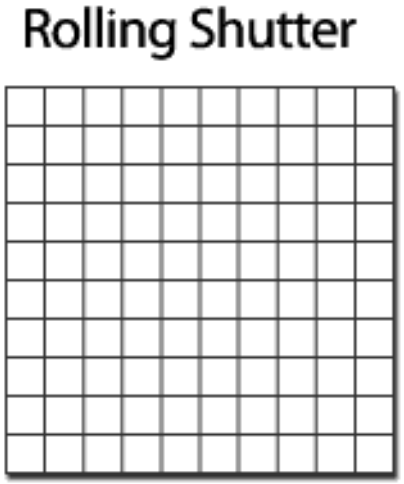


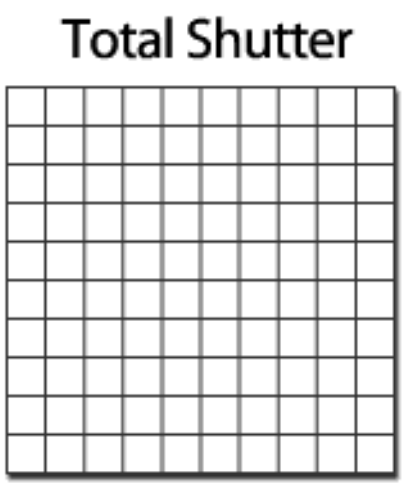


Vignetting y
Rolling Shutter

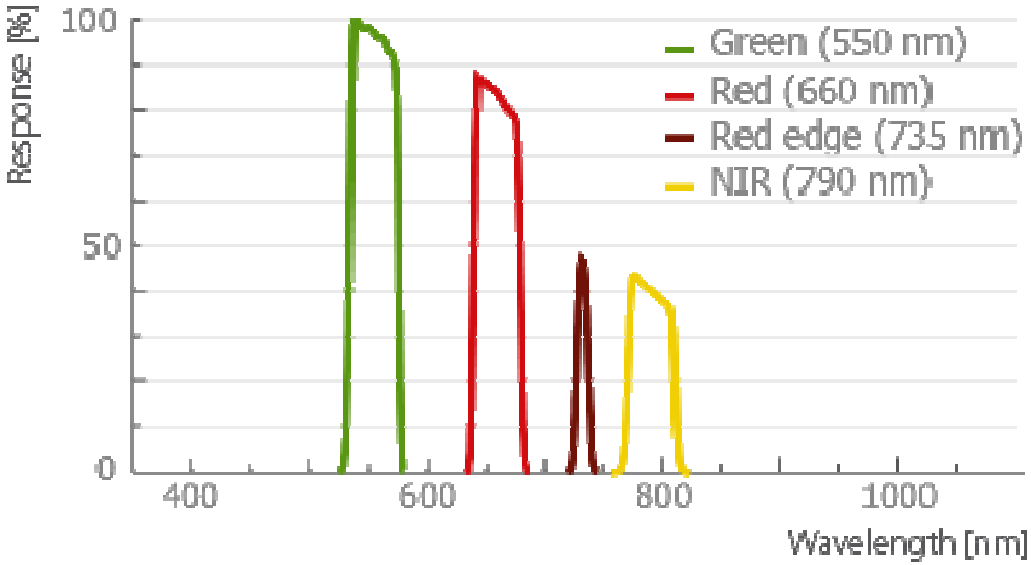
ROLLING SHUTTER: FORMACIÓN DE LA IMAGEN





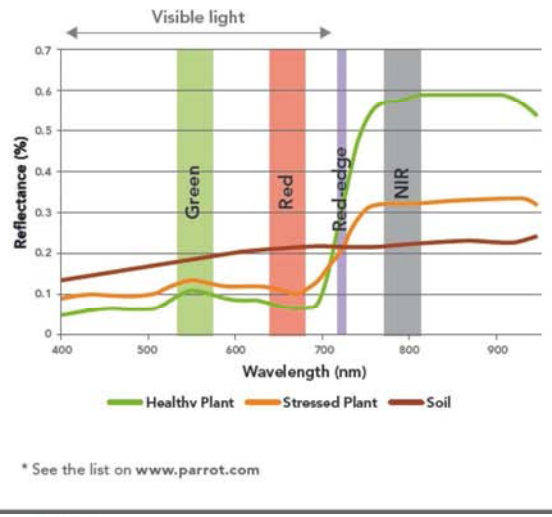


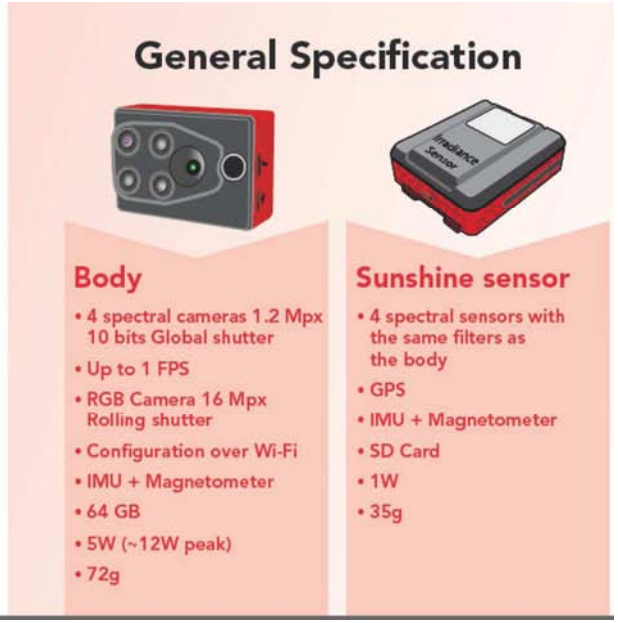
SENSORES MULTIESPECTRALES

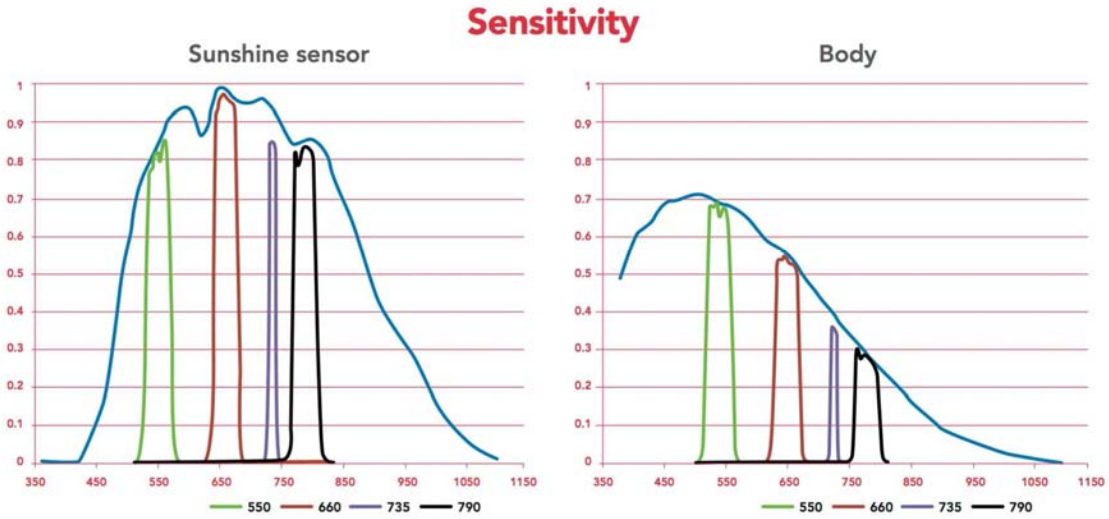


multiSPEC 4
www.sensefly.com

SENSORES MULTIESPECTRALES



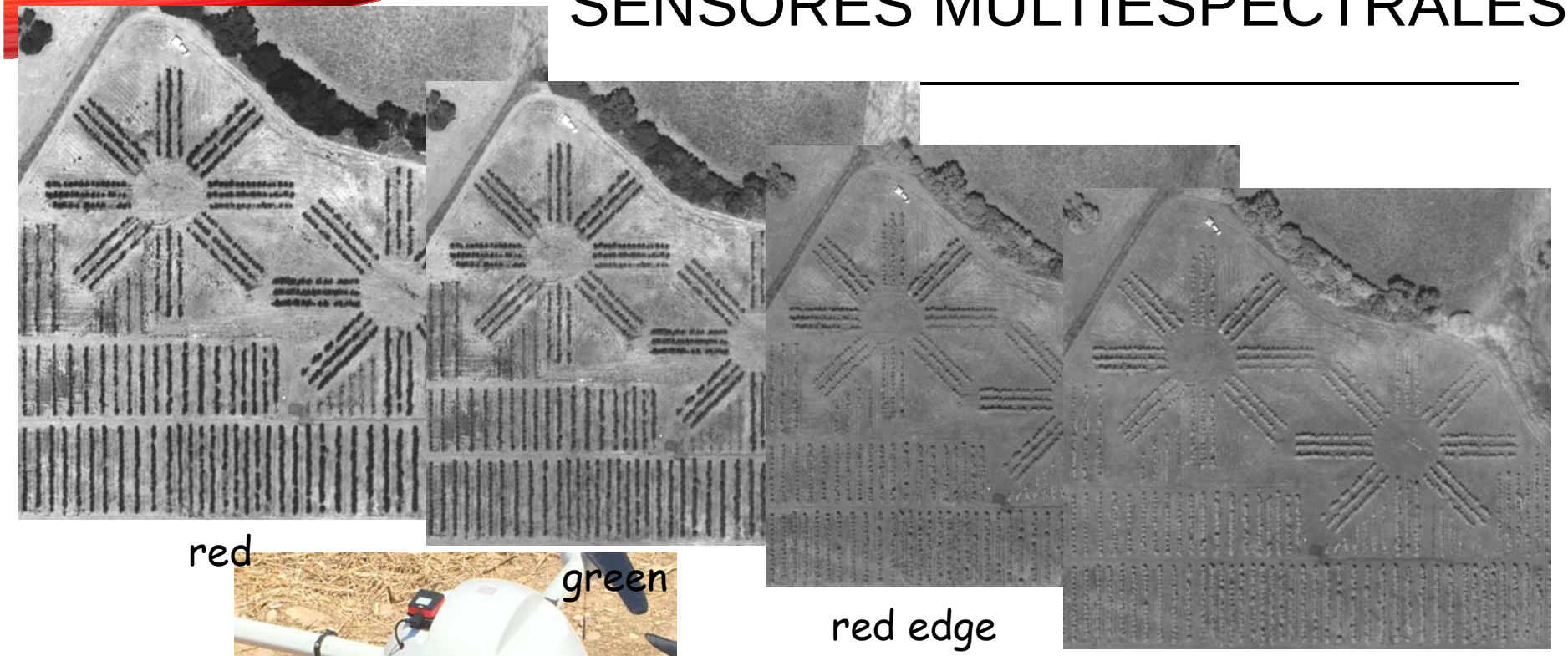




Sequoia
www.parrot.com

www.aerometriclab.com

SENSORES MULTIESPECTRALES



red

green

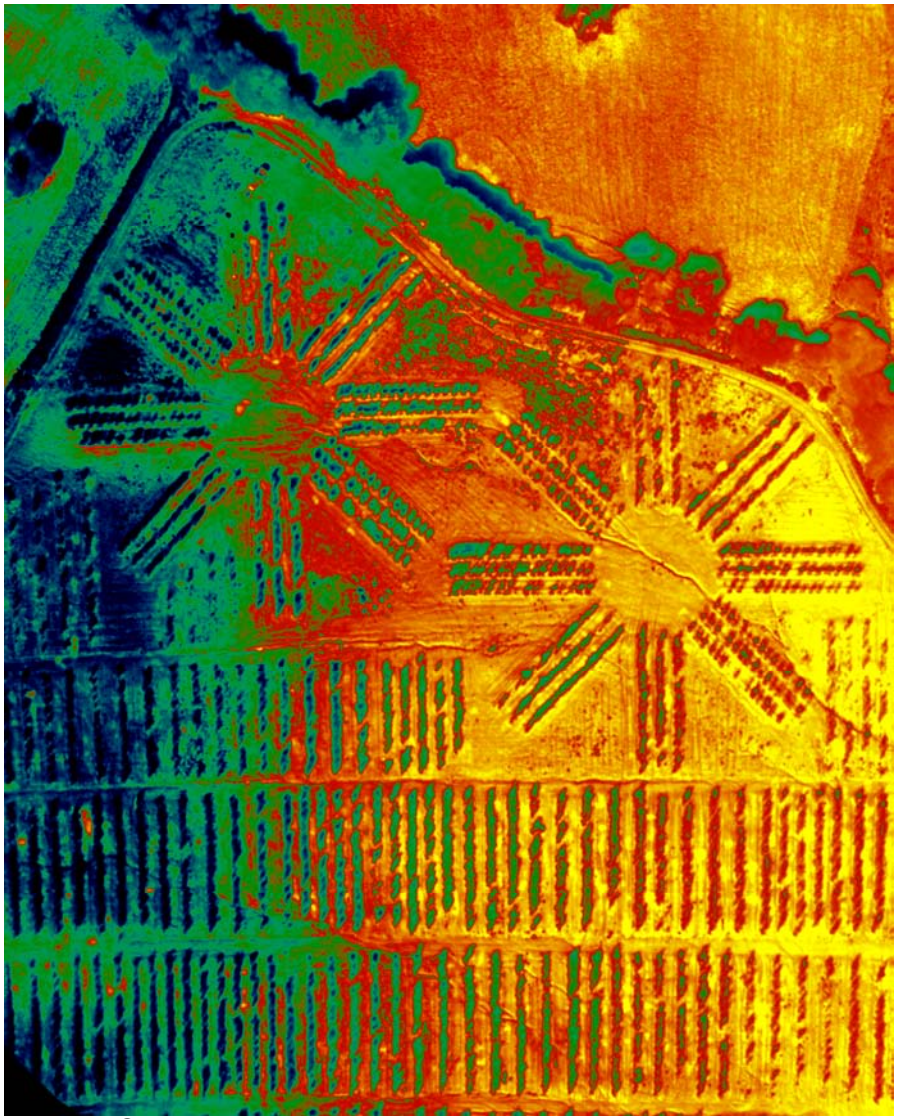
red edge

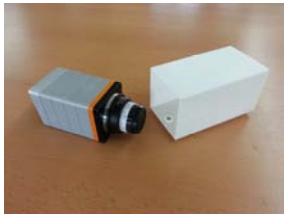
nir

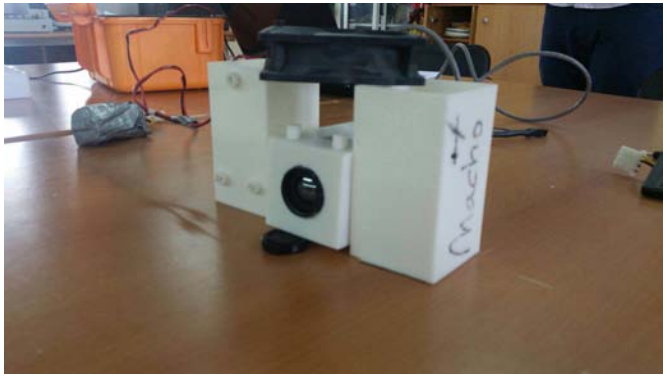
Sequoia
www.parrot.com

SENSOR TERMOGRÁFICO GOBI 640

SENSOR TERMOGRÁFICO GOBI 640







www.aerometriclab.com

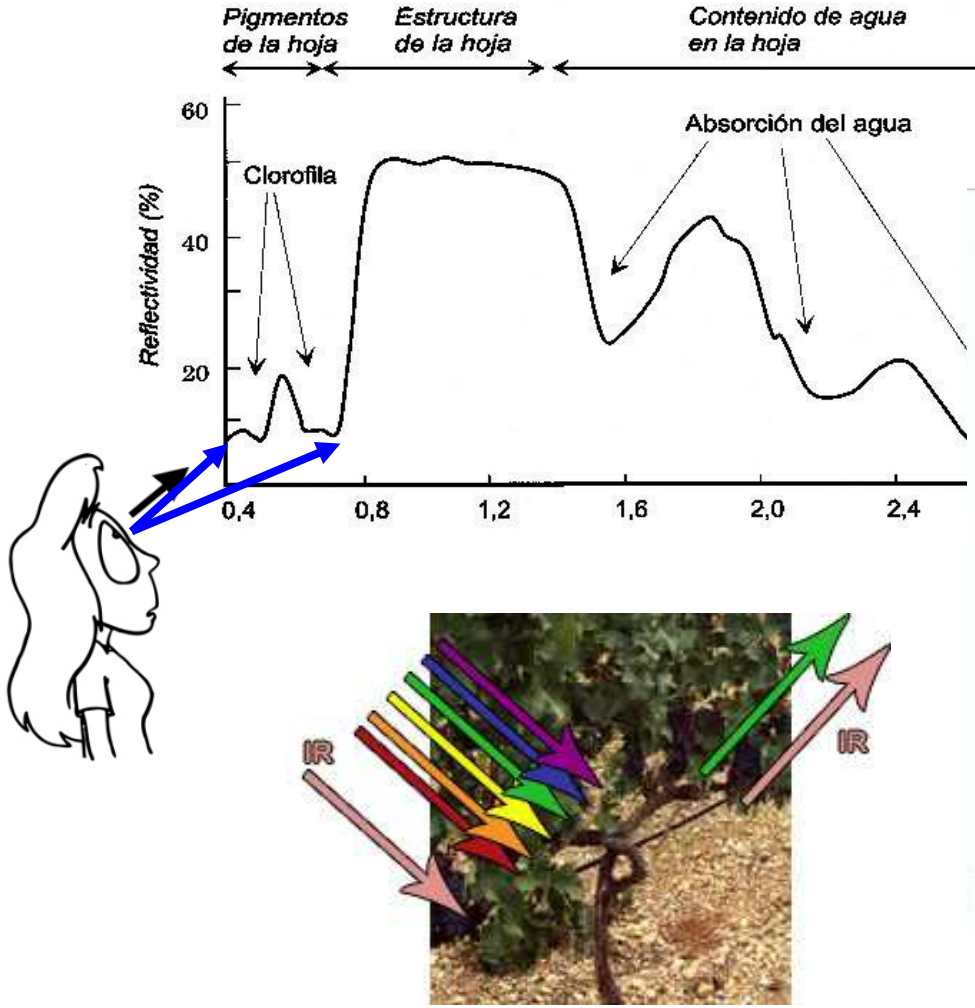
COMPARATIVA PARÁMETROS DE VUELO

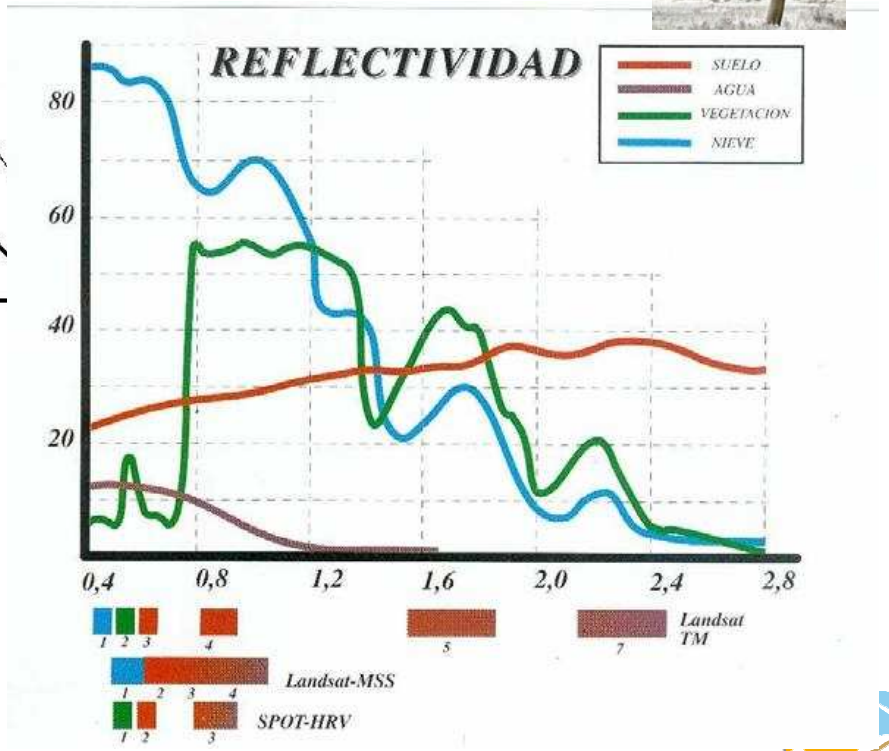
Ejemplo de influencia altura de vuelo y tipo de sensor sobre GSD

	Sony Nex 7	Tetracam mini MCA6	Gobi 640
			
	Focal 16 mm Imagen 6000x4000 pixel CCD: 3.9 mm	Focal 9.6 mm Imagen 1280x1024 pixel CCD: 5.2 mm	Focal 18 mm Imagen 640x480 pixel CCD: 17 mm
AGL120 m	GSD: 2.9 cm Imagen 175.5x117 m Superficie: 2.05 ha	GSD: 6.5 cm Imagen 83.2x66.56 m Superficie: 0.55 ha	GSD: 11.3 cm Imagen 72.53x54.4 m Superficie: 0.39 ha
AGL 80 m	GSD: 2.0 cm Imagen 117.0x78 m Superficie: 0.91 ha	GSD: 4.3 cm Imagen 55.47x44.37 m Superficie: 0.25 ha	GSD: 7.6 cm Imagen 48.36x36.27 m Superficie: 0.18 ha

APLICACIONES AGROFORESTALES

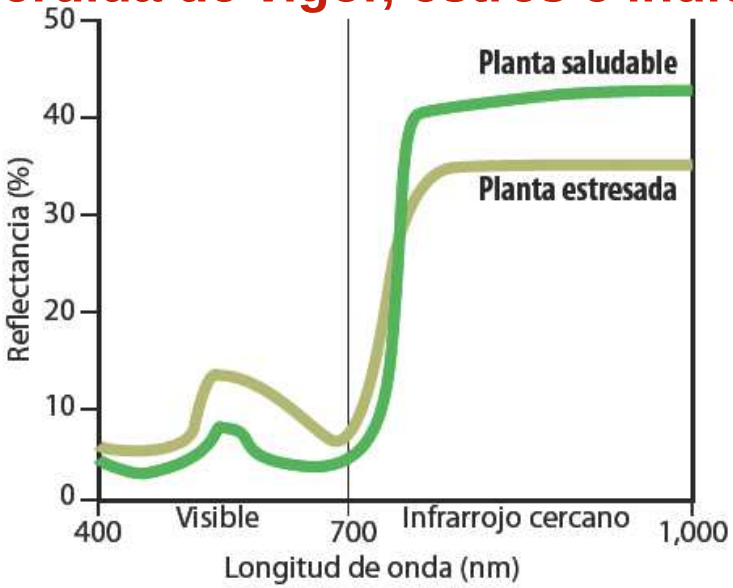
Respuesta espectral de cultivos y árboles

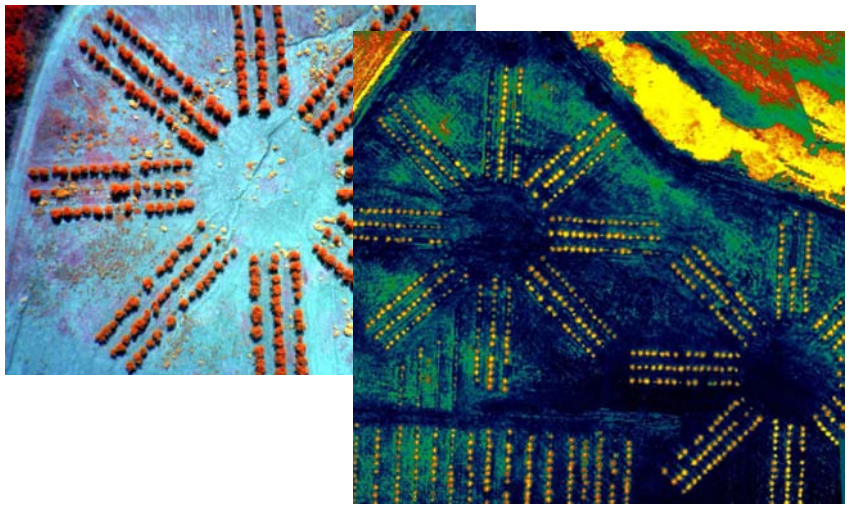


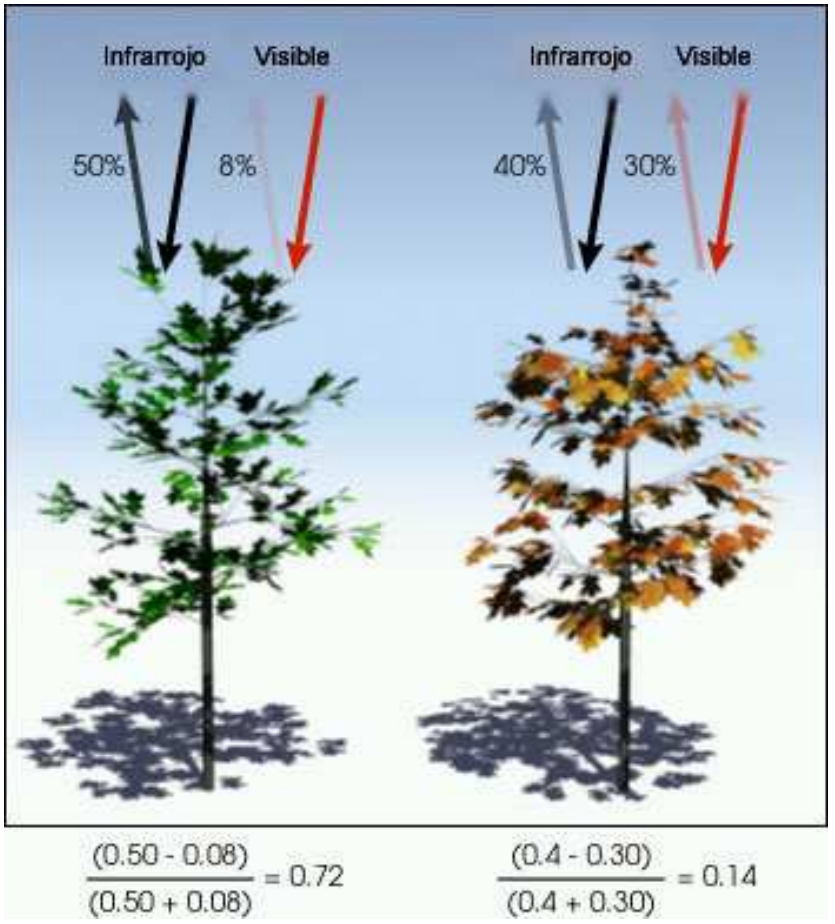


APLICACIONES AGROFORESTALES

Perdida de vigor, estrés e índices







NDVI = IR-R / IR+R

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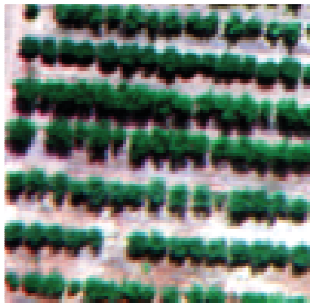
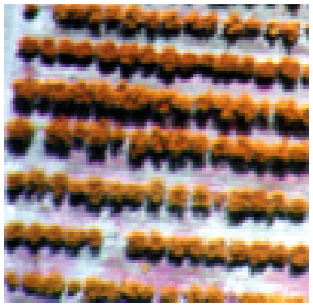
ÍNDICES DE VEGETACIÓN

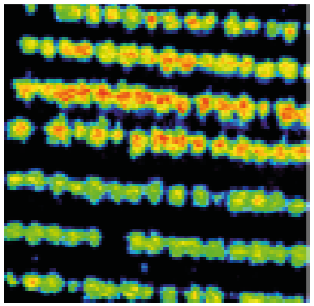
Index	Formula
NDVI, related to chlorophyll content (Tucker, 1979)	$NDVI = (R_{800}-R_{670}) / (R_{800}+R_{670})$
$NDVI_{705}$, related to chlorophyll content (Gitelson & Merzlyak, 1994)	$NDVI_{705}=(R_{750}-R_{705}) / (R_{750}+R_{705})$
Red Edge Position Index, related to chlorophyll content (Gitelson et al., 1996)	$RPI=(R_{750}/R_{700})$
Related to chlorophyll content in anthocyanin free leaves (Gitelson et al. 2006)	$Chl_{green} = (R_{760} / R_{550}) - 1$ $Chl_{red\ edge}=(R_{760} / R_{705}) - 1$
Plant Senescence Reflectance Index (Merzlyak et al., 1999)	$PSRI= (R_{680}-R_{500}) / (R_{750})$
Related to water content (Peñuelas et al., 1997b)	$WI= (R_{900}/R_{970})$
Green region NDVI, related to salinity (Poss et al., 2006)	$NDVI_{green}= (R_{550}-R_{670}) / (R_{550}+R_{670})$
Far red region NDVI, related to salinity (Poss et al., 2006)	$NDVI_{far\ red}= (R_{710}-R_{670}) / (R_{710}+R_{670})$
Simple Ratio Vegetation Index, related to salinity (Wang et al., 2002b)	$SRVI= (R_{830}/R_{660})$
Green and Indigo Ratio, related to salinity (Rud et al., 2011)	$GIR= (R_{436}/R_{554})$

ÍNDICES DE VEGETACIÓN

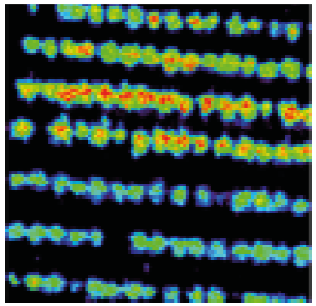




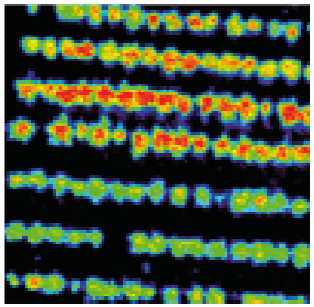
Muestra imagen olivar RGB y falso color



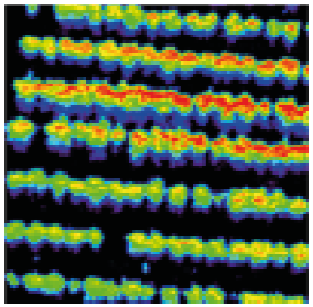
NDVI



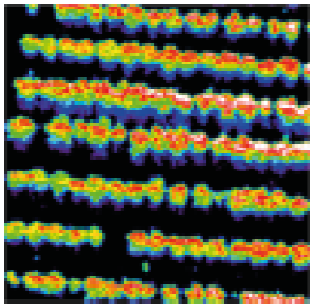
SR



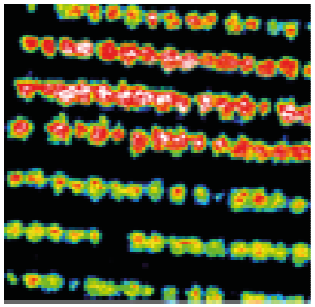
MSR



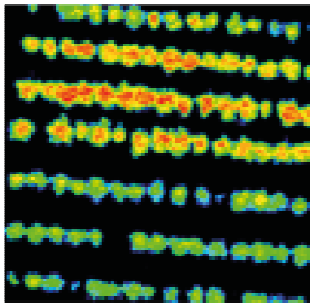
MTVI



TVI



OSAVI

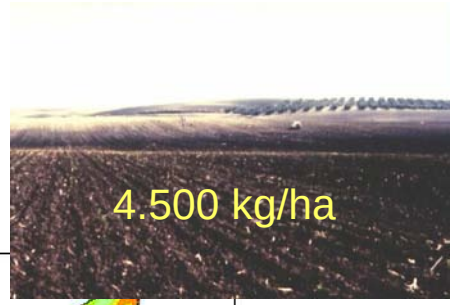


MSAVI

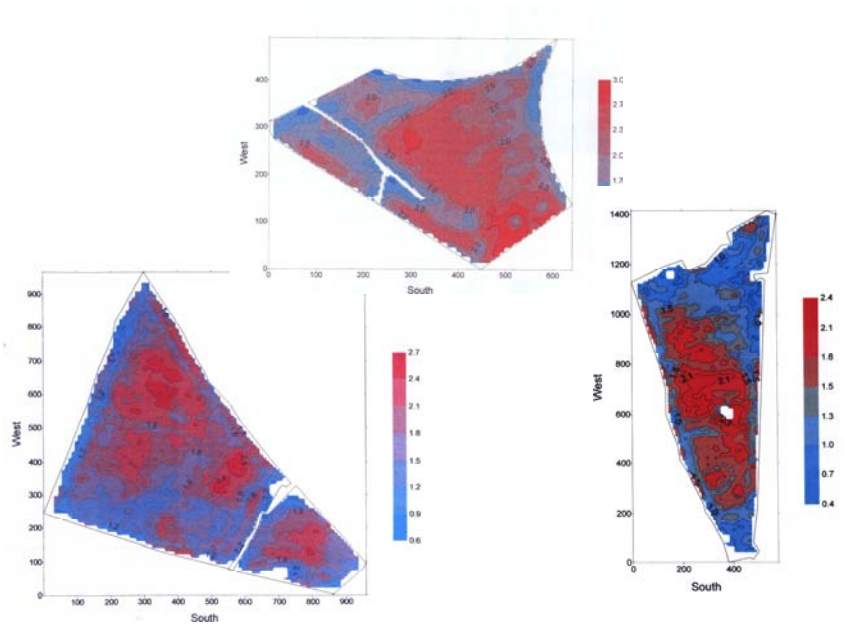
AGRICULTURA DE PRECISIÓN

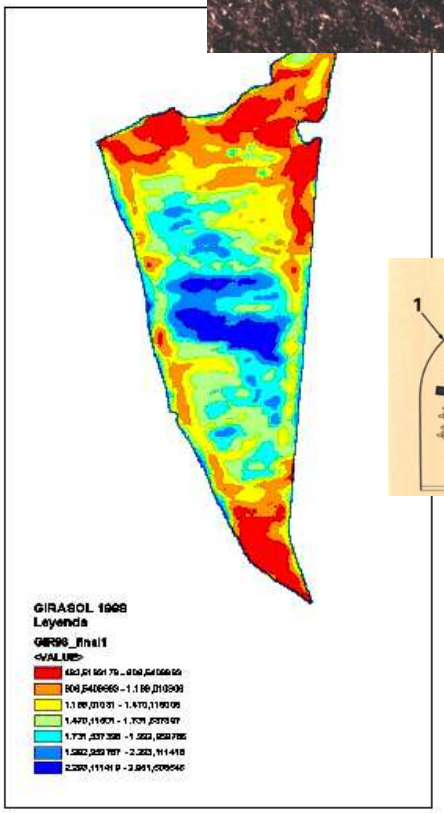
Toma de decisiones

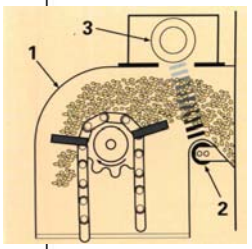
Tanto en agricultura convencional como en agricultura de precisión cada día es mas normal realizar un mapa de cosecha.



Estos mapas se realizan dotando a la cosechadora de un sistema GNSS y un calibrador de cosecha y muestran la variabilidad espacial del rendimiento.







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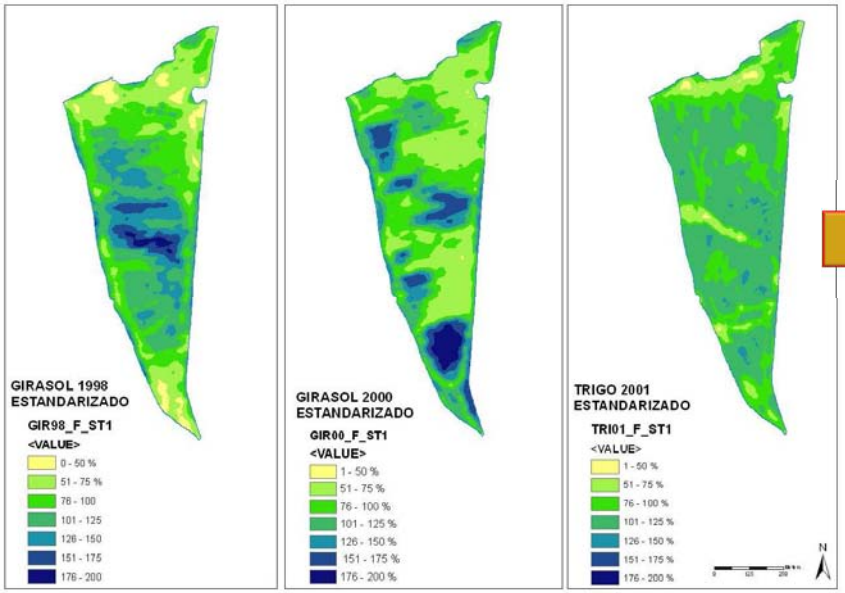
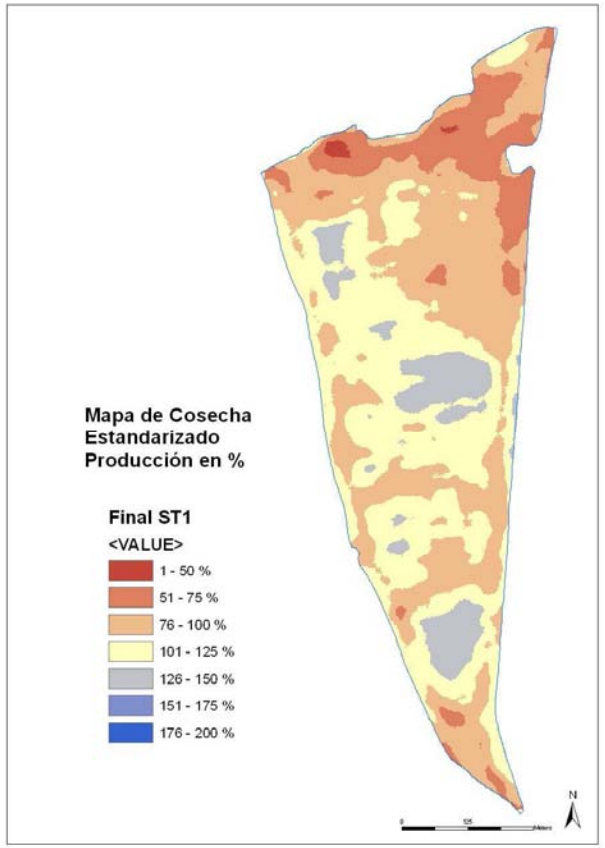
AGRICULTURA 1.0

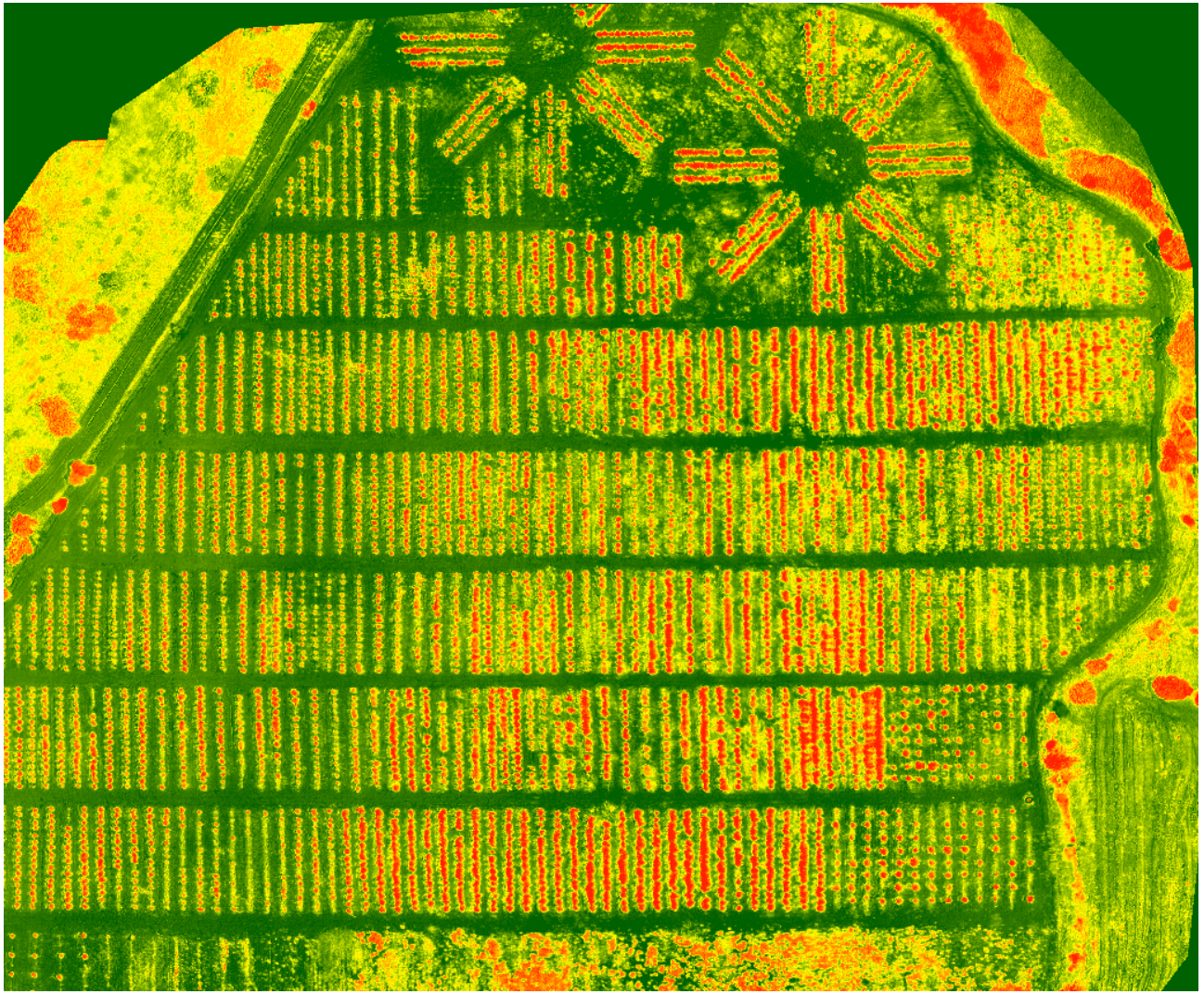
Toma de decisiones

Estas diferencias de rendimiento nos permiten valorar con el tiempo el manejo realizado, e ir adoptando acciones correctoras para las cosechas siguientes, ayudan a la toma de decisiones futura.





AGRICULTURA 2.0



NDVI

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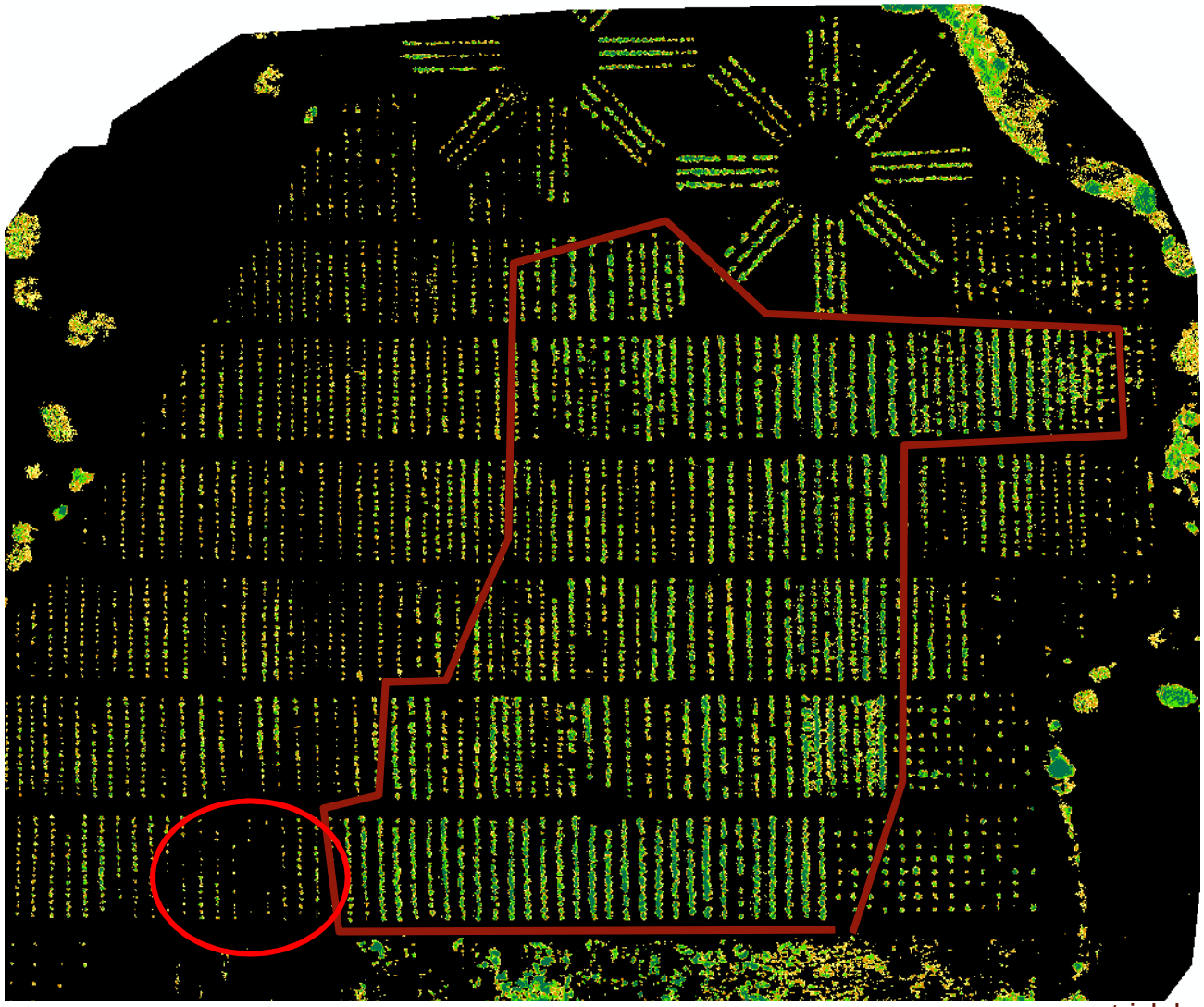
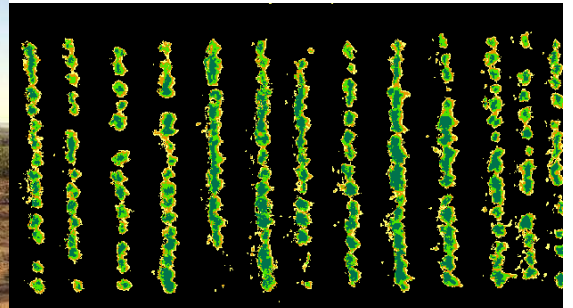
AGRICULTURA 2.0

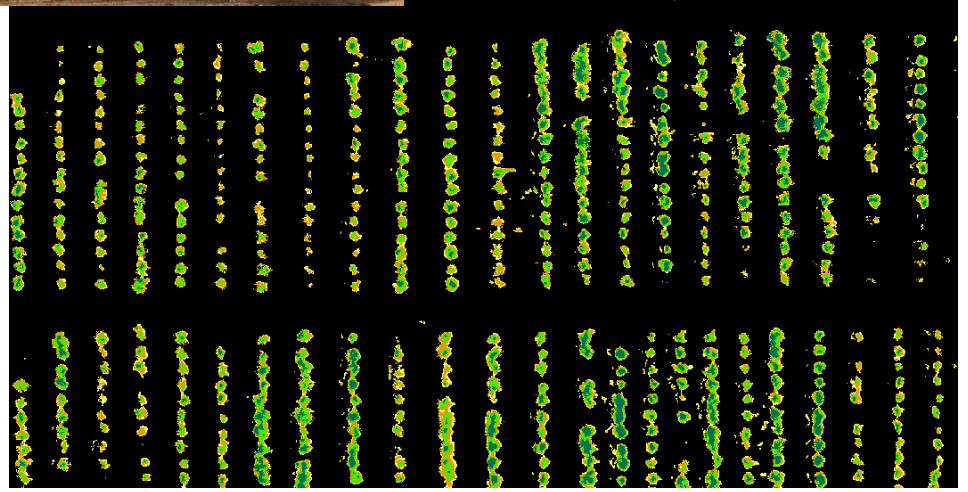
NDVI, copas aisladas

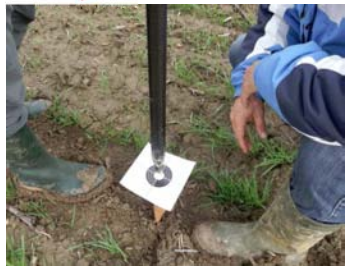


AGRICULTURA 2.0

NDVI, copas aisladas







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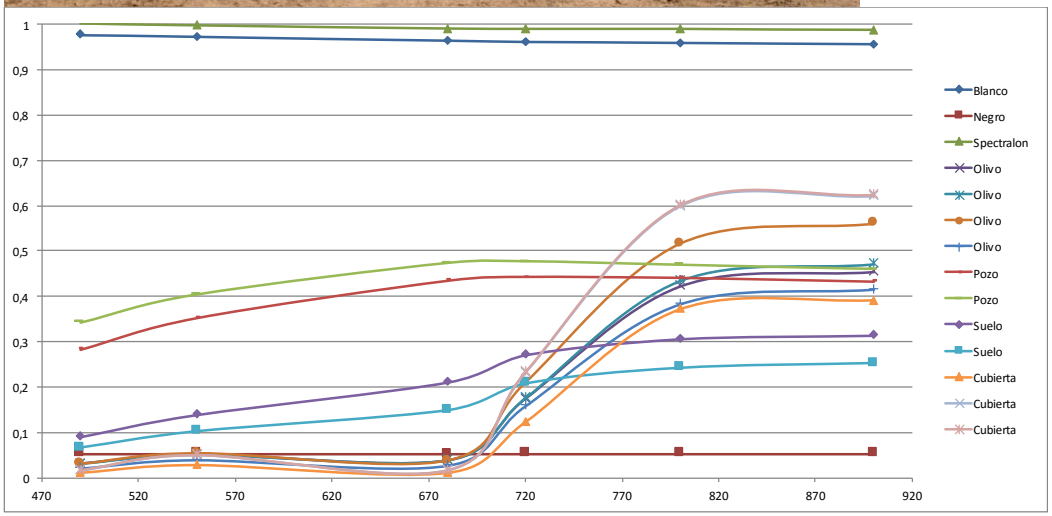
AGRICULTURA 2.0



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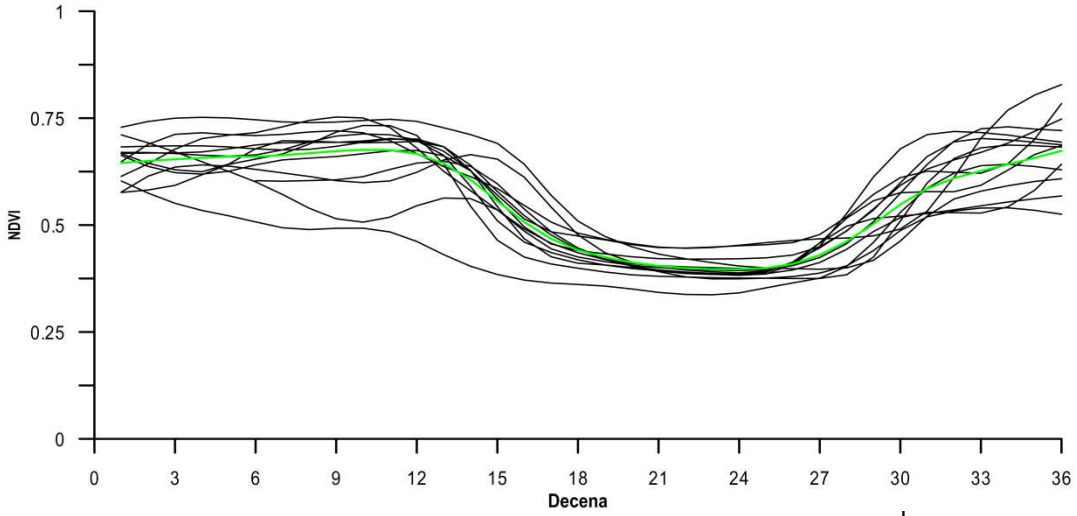
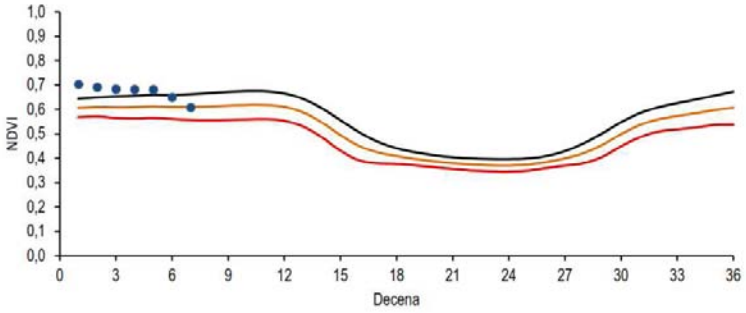
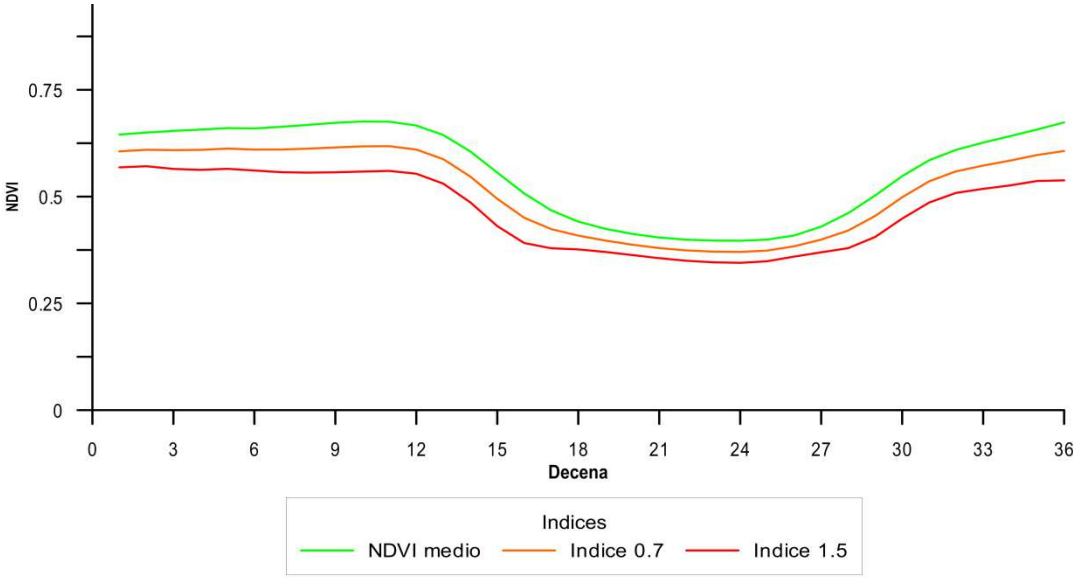
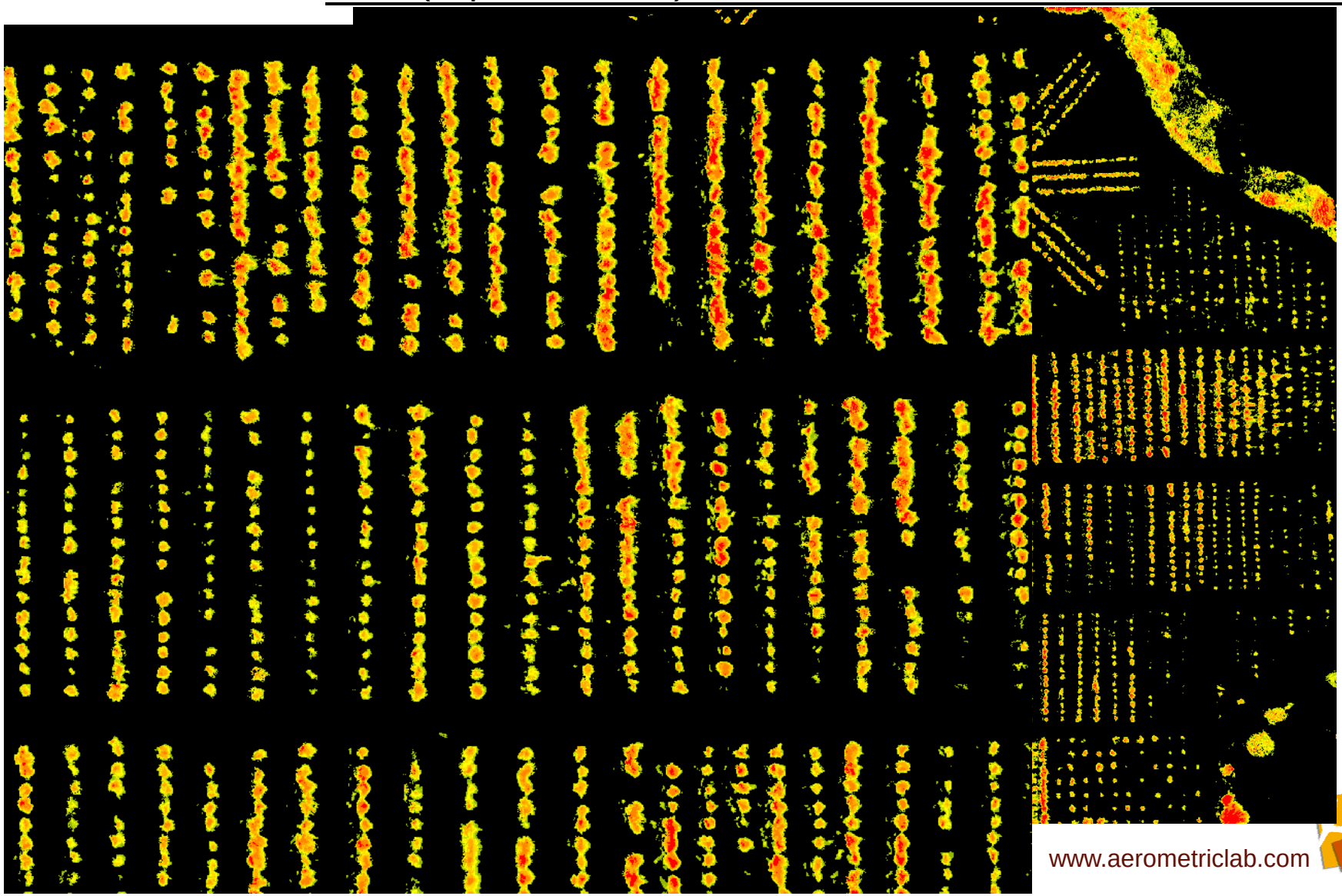




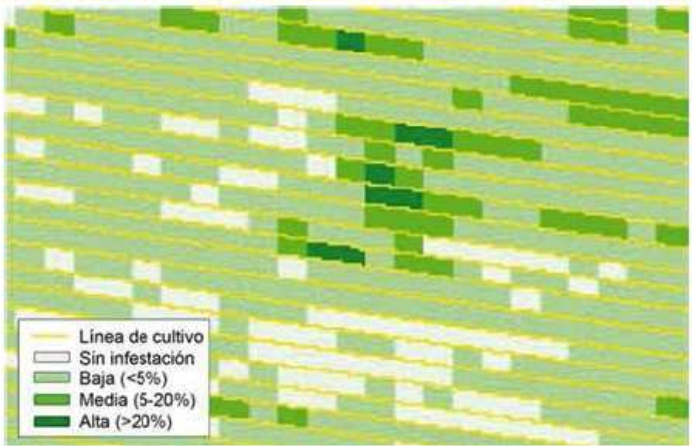


AGRICULTURA 2.0

SAVI (copas aisladas)



AGRICULTURA 2.0



Localización y tratamiento diferencial de malas hierbas en agricultura de precisión, (AGR 124 IAS-CSIC/UCO)

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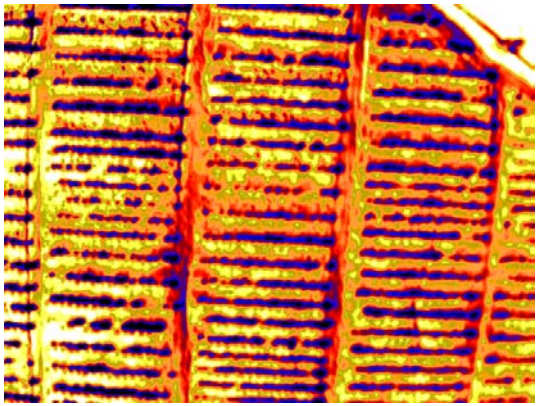
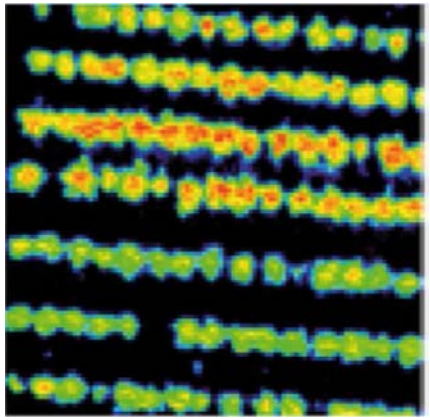
AGRICULTURA 2.0

Toma de decisiones

- Los mapas de índices derivados de los sensores estudiados sobre RPAS ayudan a la toma de decisiones sobre la marcha.
- Las diferencias de vigor en distintas zonas del cultivo o plantación indican que alguna alteración está impidiendo el desarrollo adecuado al estado fenológico actual, que podría ocasionar que no se alcancen los objetivos de cosecha deseados en esas zonas
- Por ejemplo un mal funcionamiento del sistema de riego, puede provocar una distribución irregular del agua, si además estamos utilizando fertirrigación, una inadecuada distribución de nutrientes, en esas zonas las plantas o árboles no se desarrollaran como es esperado, según el manejo planteado.





AGRICULTURA 2.0

Toma de decisiones

- El análisis estructurado de las causas que provocan esas diferencias, es el objetivo de técnicos e investigadores para dirigir las decisiones de manejo hacia un optimo económico y medio ambiental.

  - Conocimiento local y causas obvias:

  Encharcamiento, alimañas, plagas....

  - Características físicas del suelo

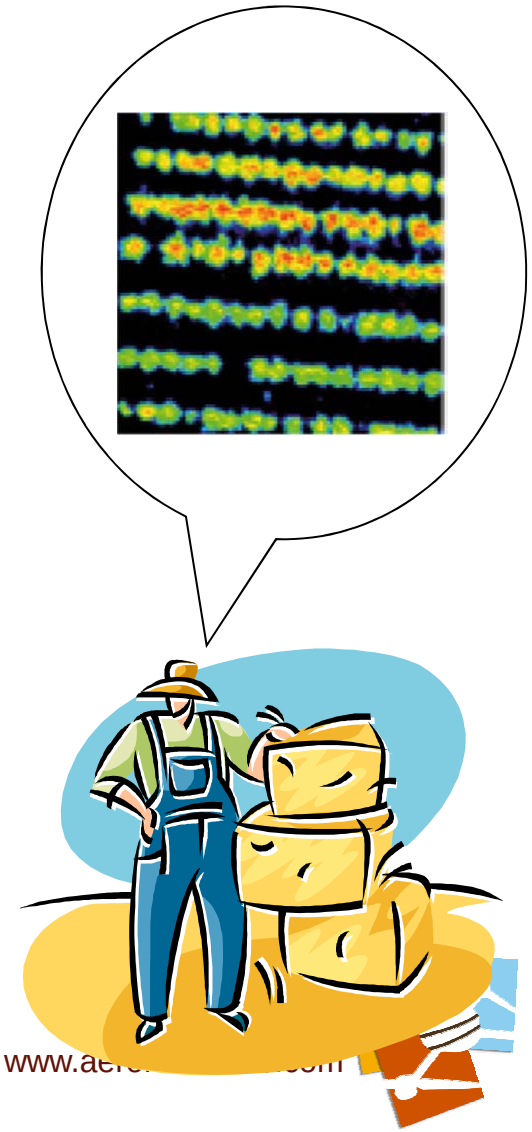
  Compactación, drenaje, tipo....

  - Características químicas del suelo

  N, P, K, MO, pH .....

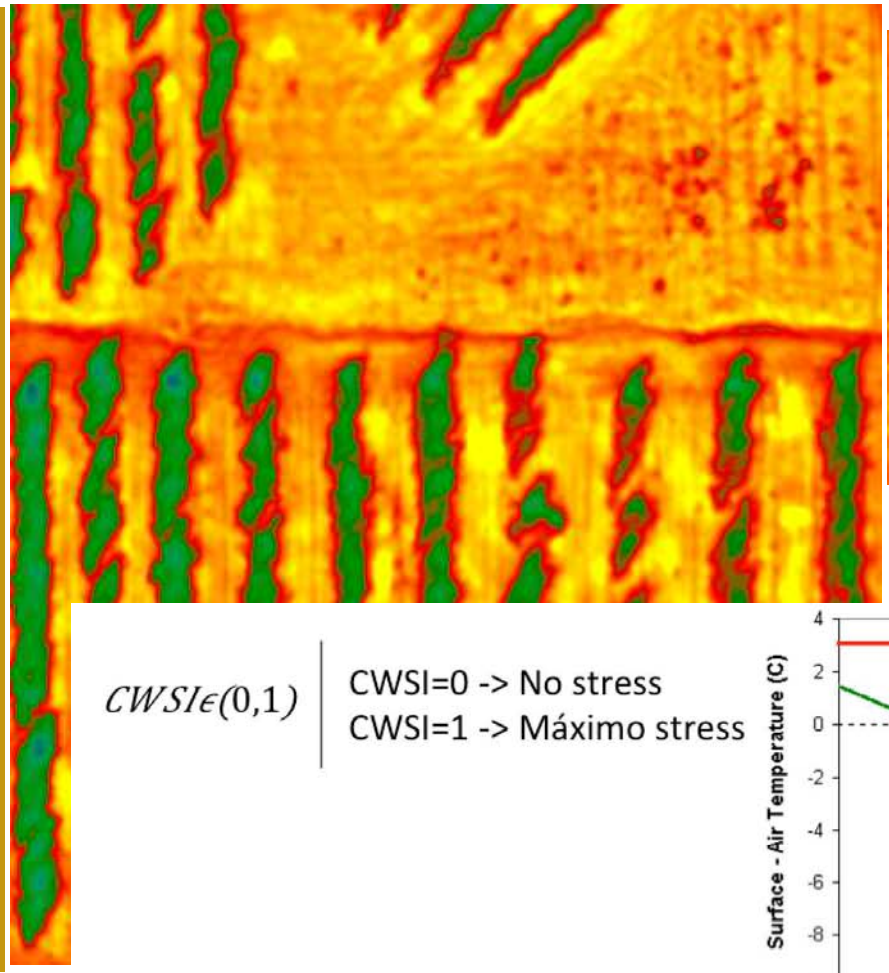
  - Manejo del cultivo

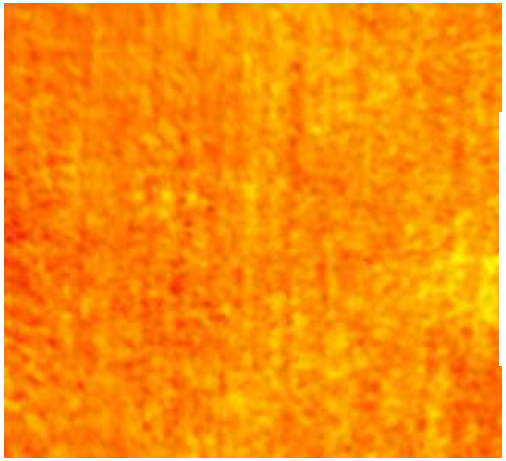
  Rotaciones, labores, residuos, variedades….



AGRICULTURA 2.0, SEGUIMOS

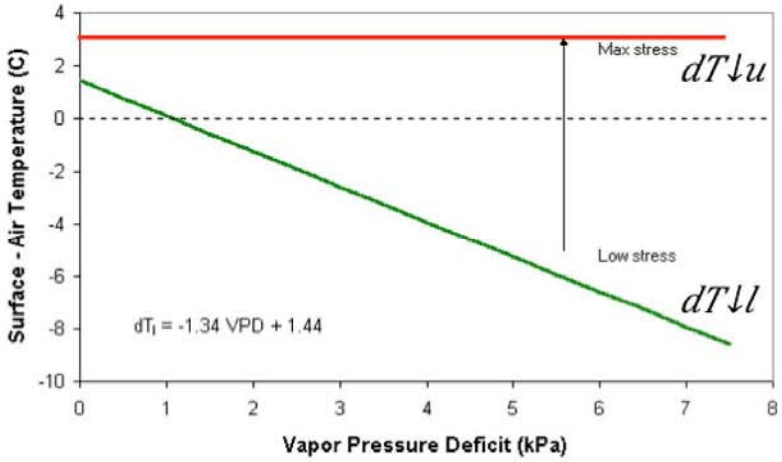
Toma de decisiones





$CWSI \epsilon (0,1)$

CWSI=0 -> No stress
CWSI=1 -> Máximo stress



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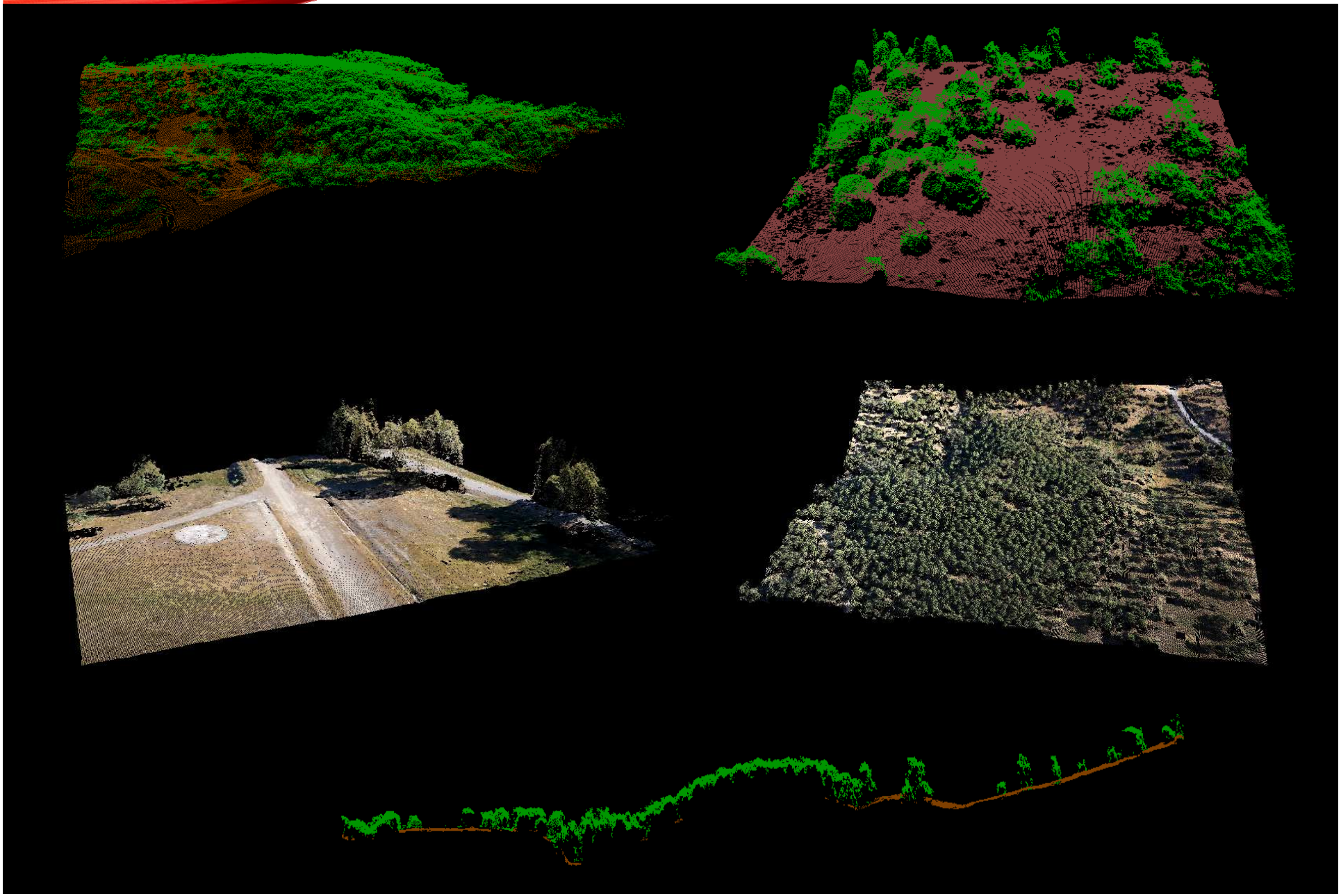

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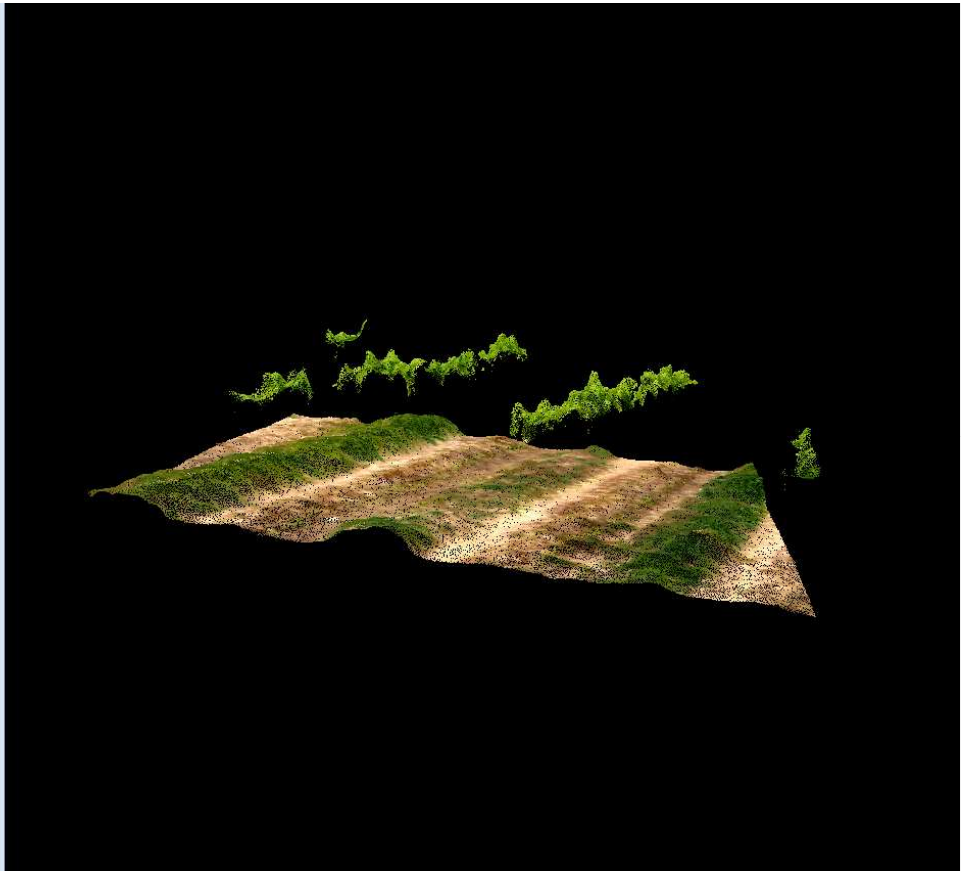

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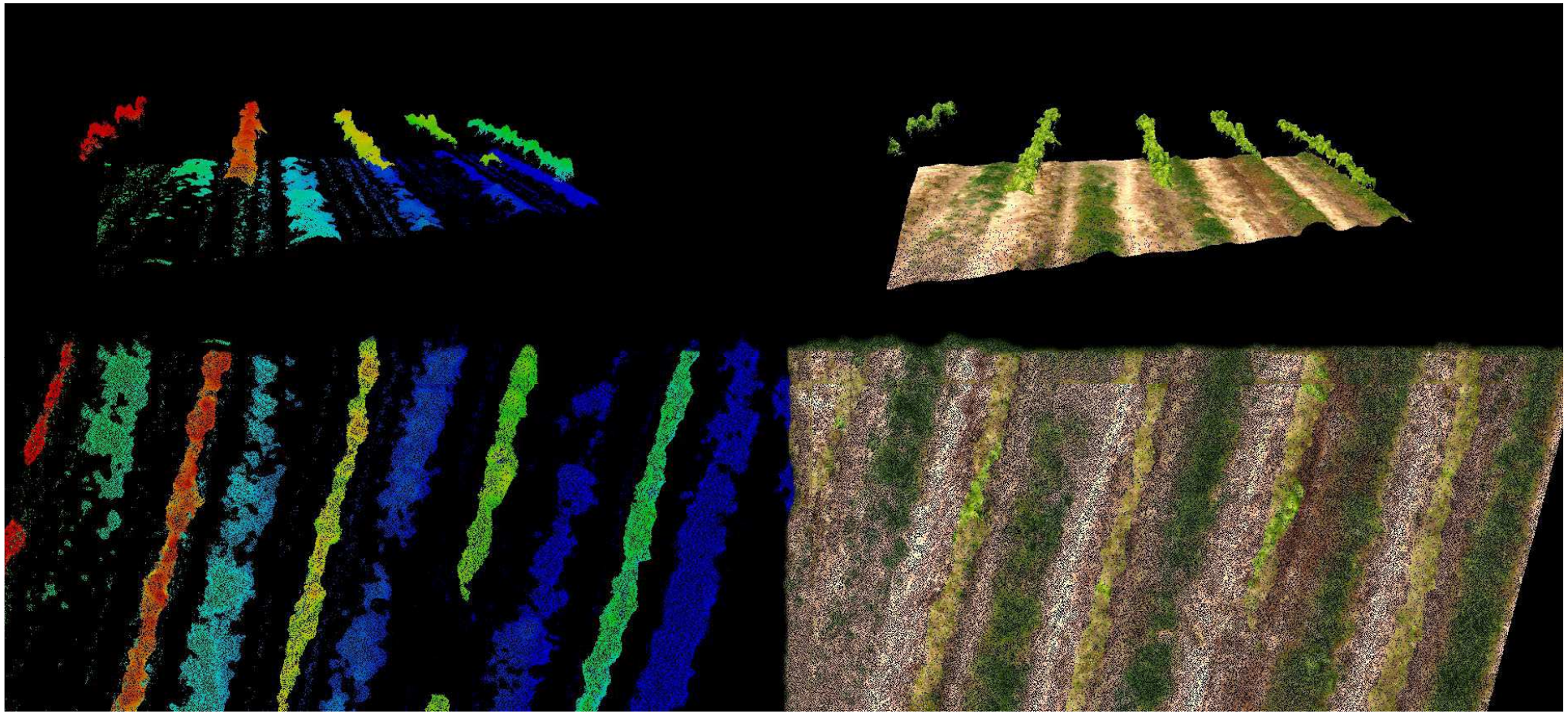
AGRICULTURA 2.0



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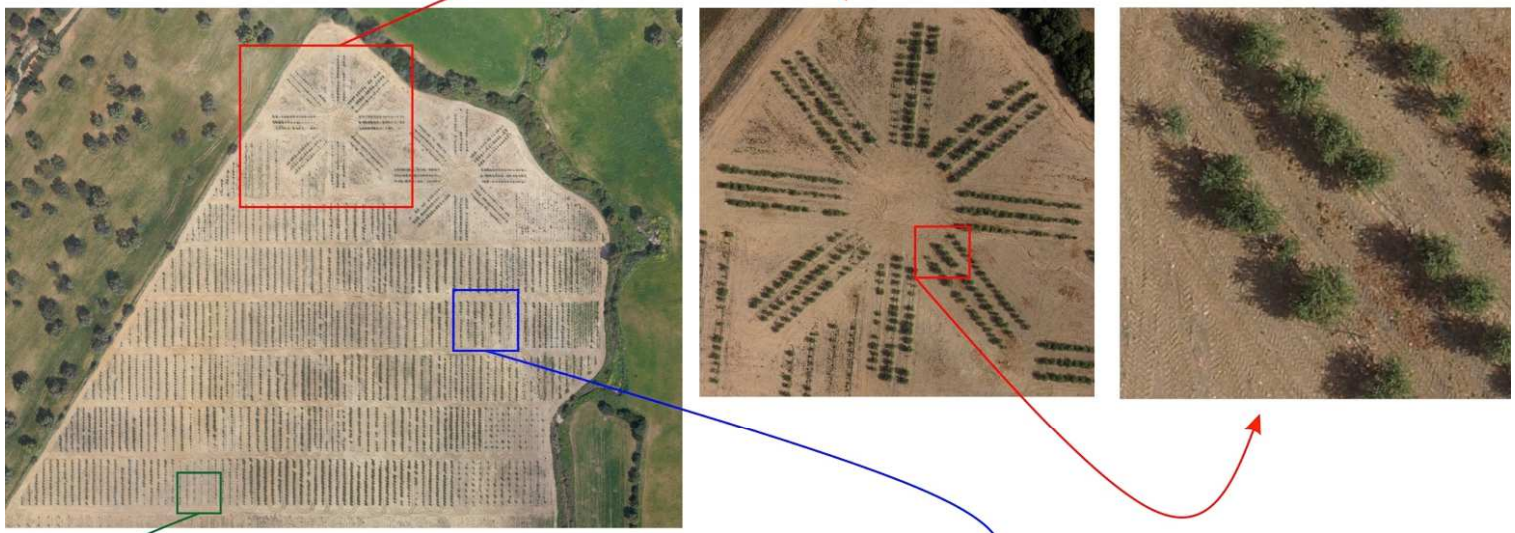
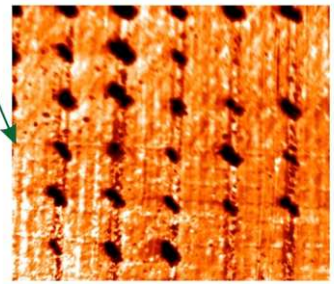
AGRICULTURA 2.0

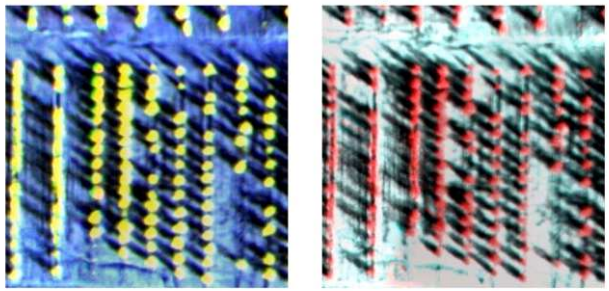


Sensores RGB



Sensores termográficos

Sensores multiespectrales



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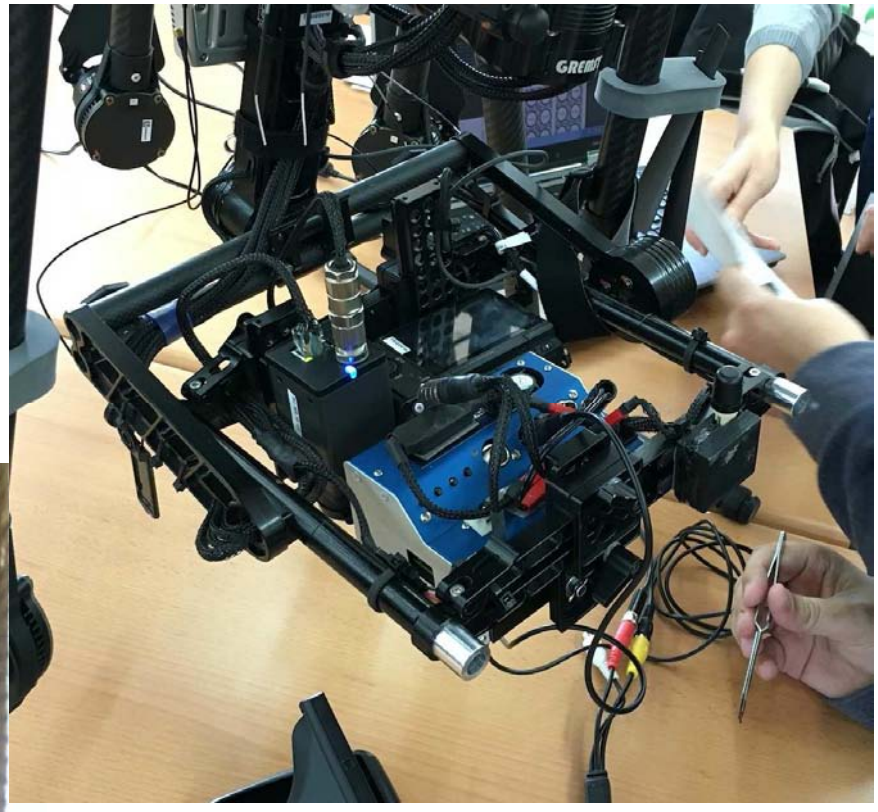
AGRICULTURA 2.0



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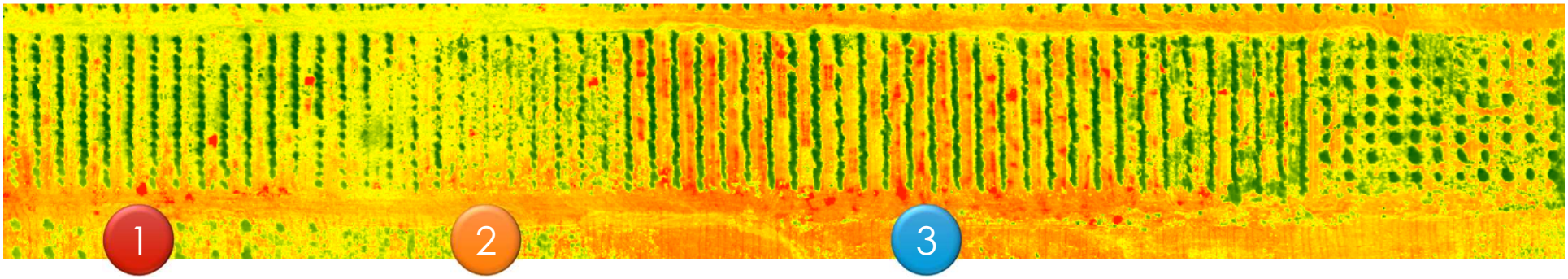
AGRICULTURA 2.0

Vuelo RGB 80 m AGL, GSD 2 cm

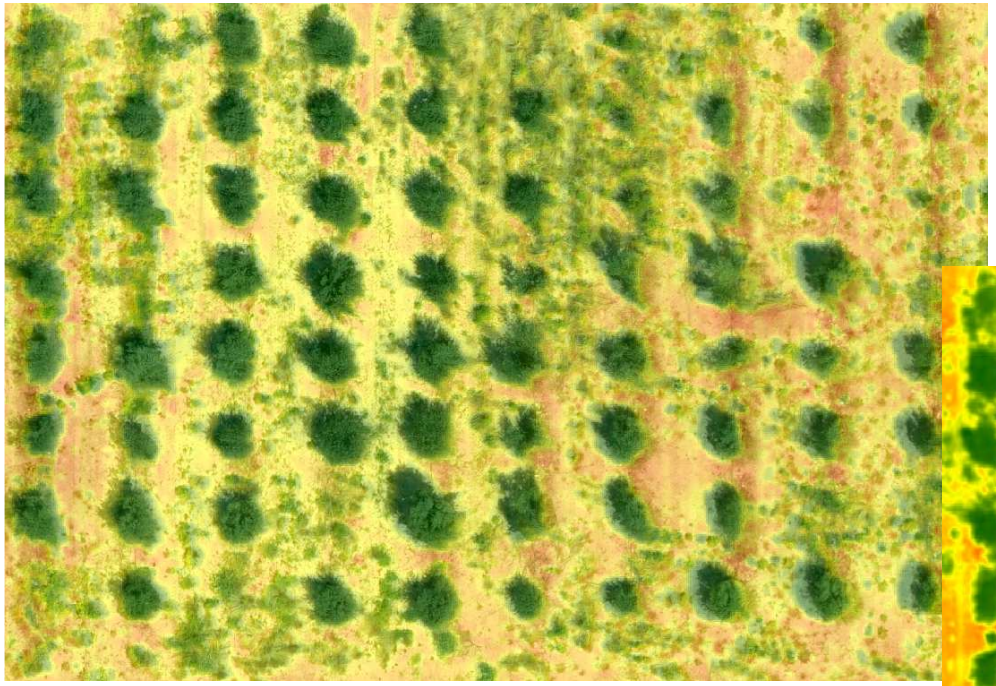
AGRICULTURA 2.0

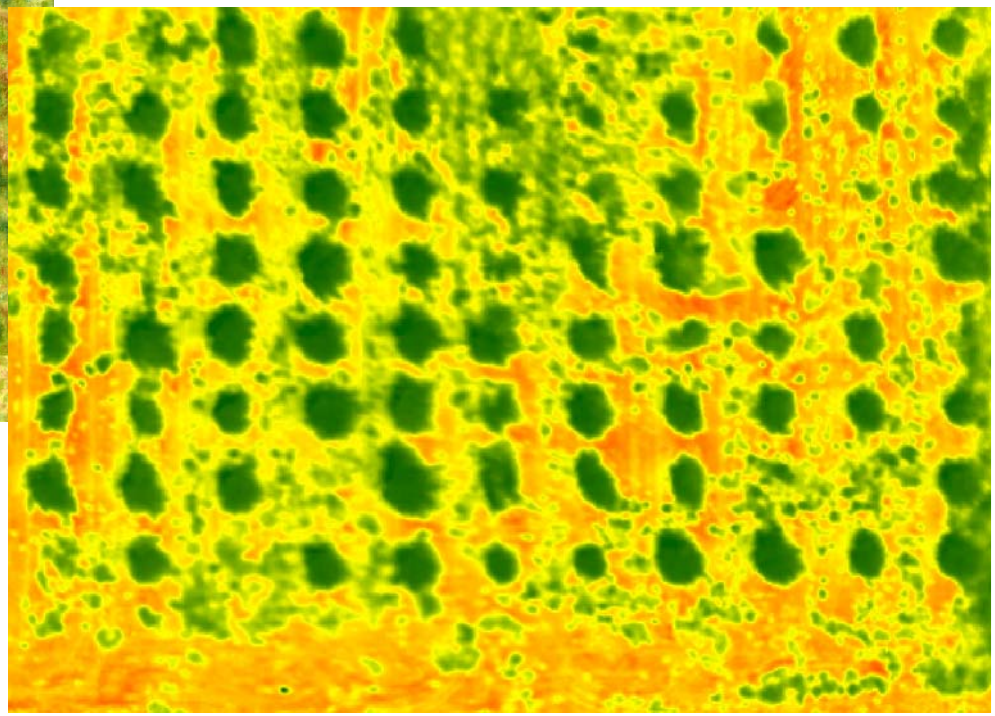
Vuelo termográfico 80 m AGL, GSD 8 cm



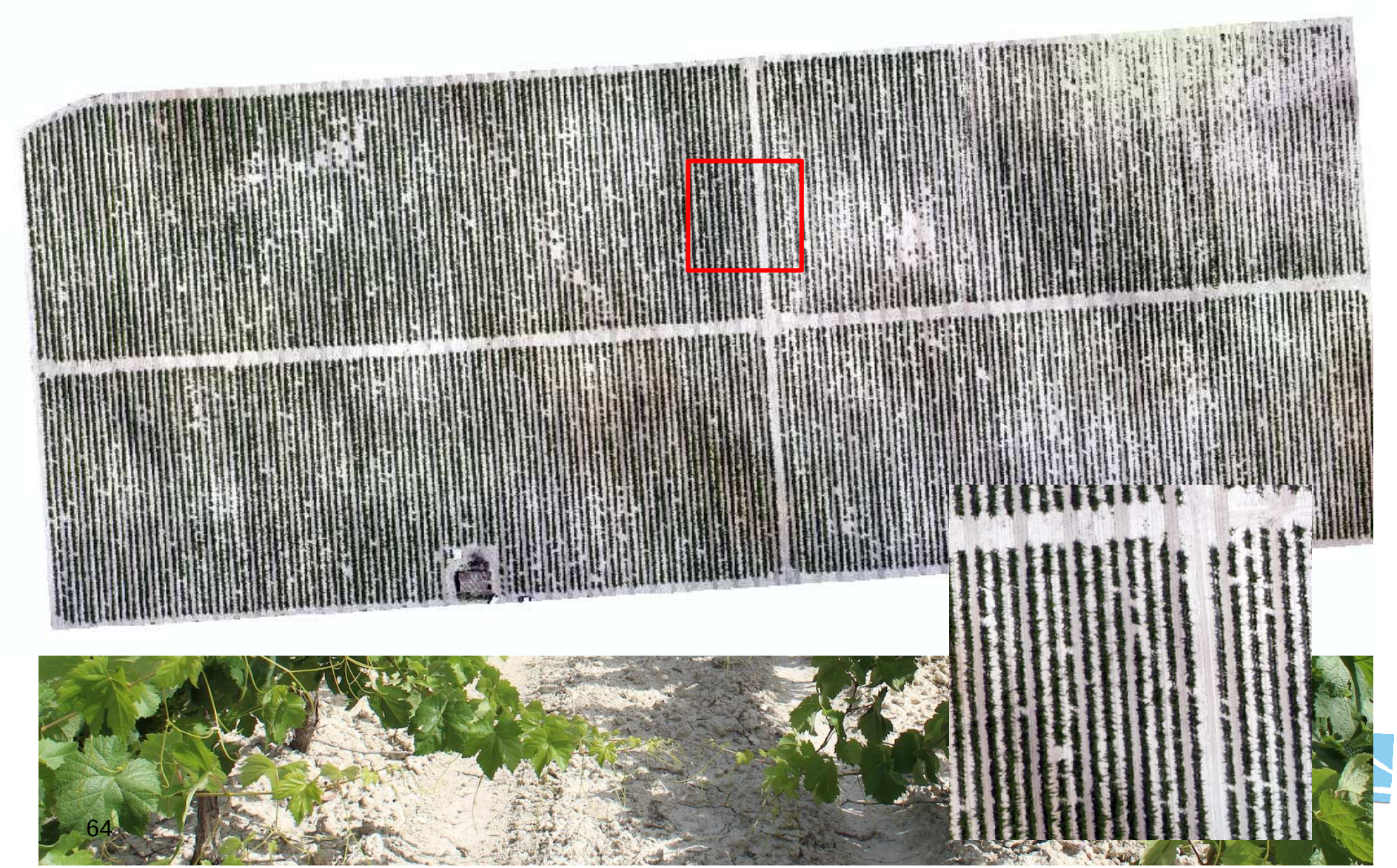
AGRICULTURA 2.0

AGRICULTURA 2.0

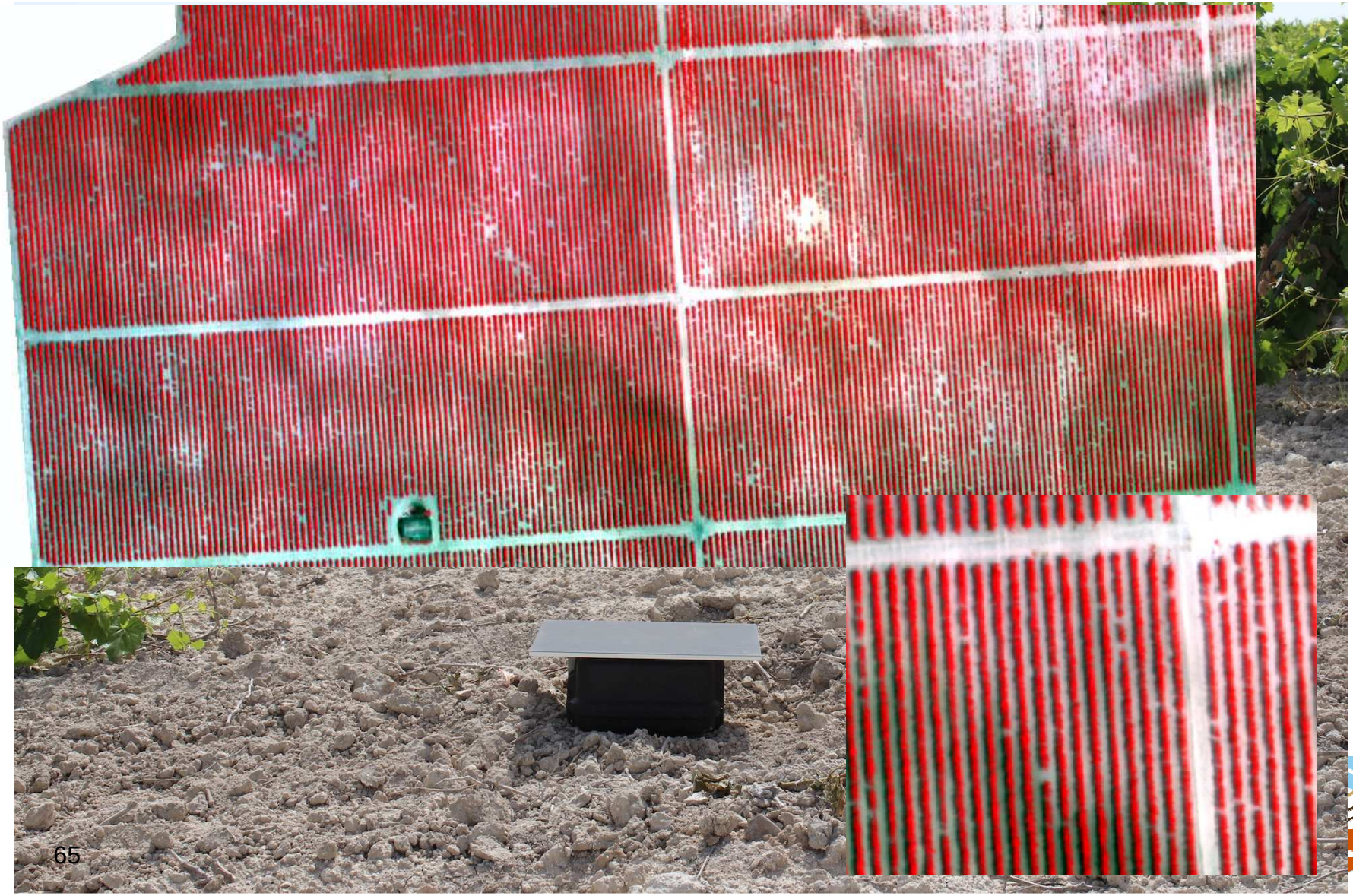




VIÑA RGB



VIÑA FALSO COLOR



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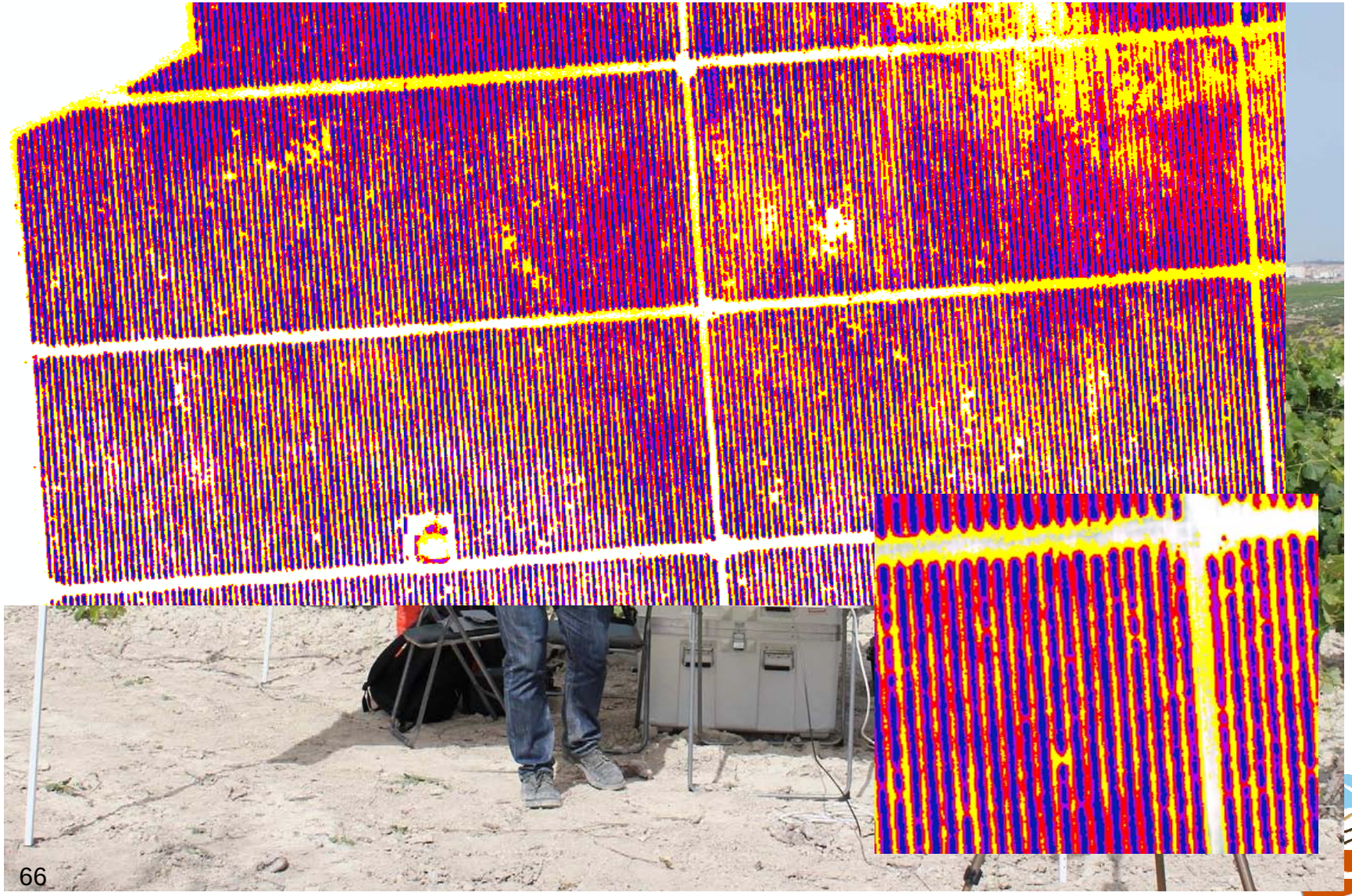
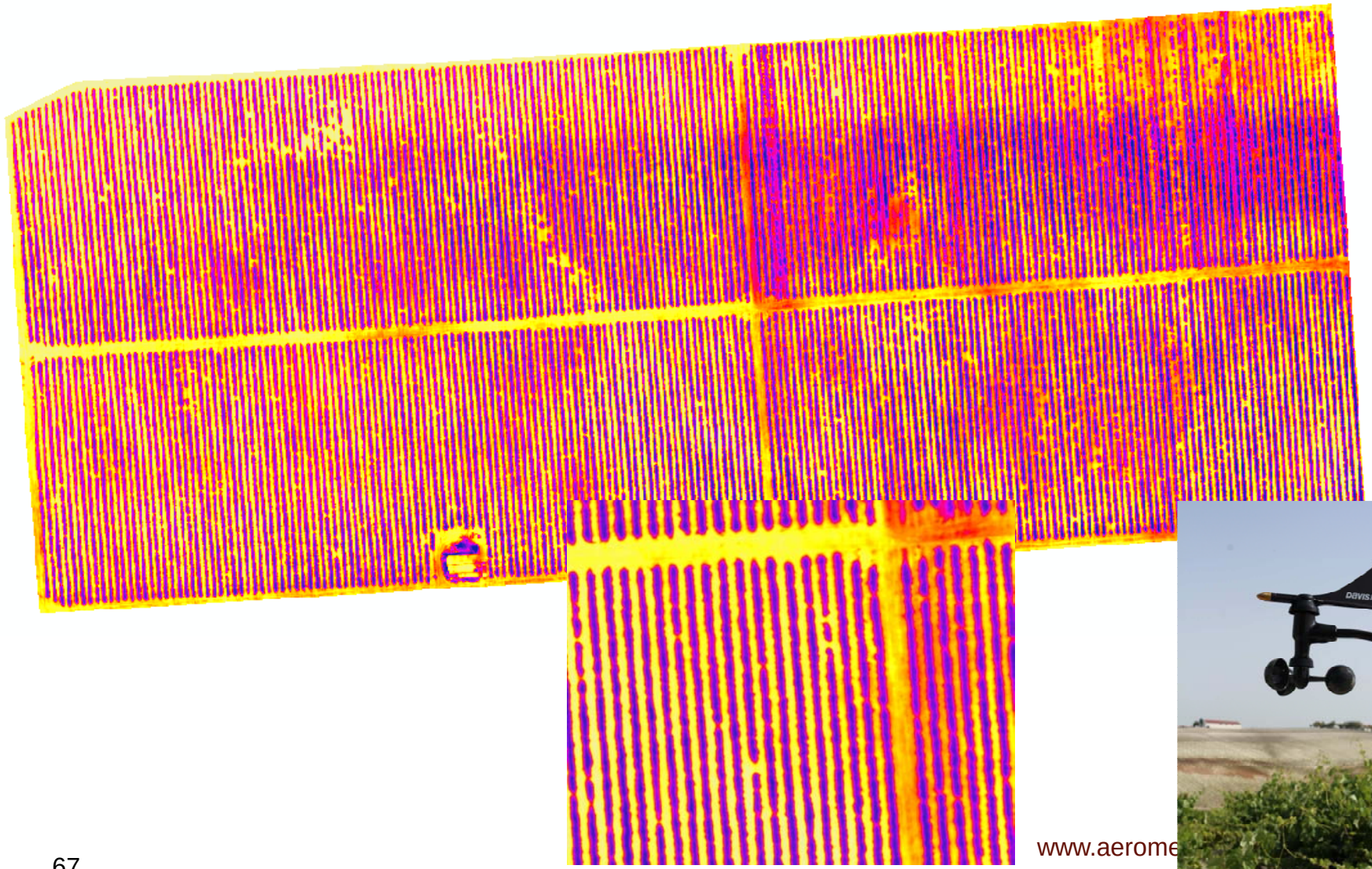


VIÑA TERMOGRAFÍA



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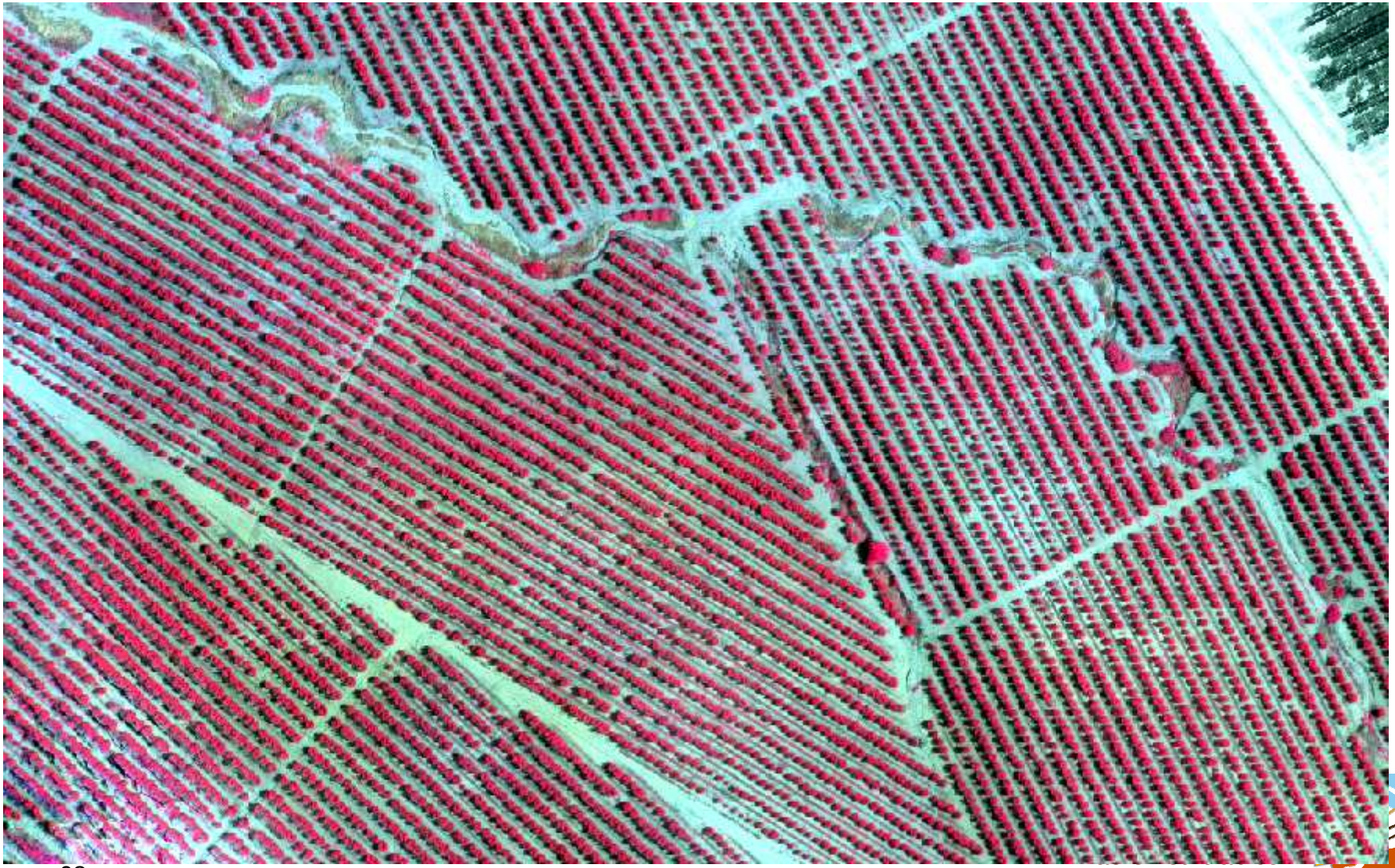
OLIVAR FALSO COLOR



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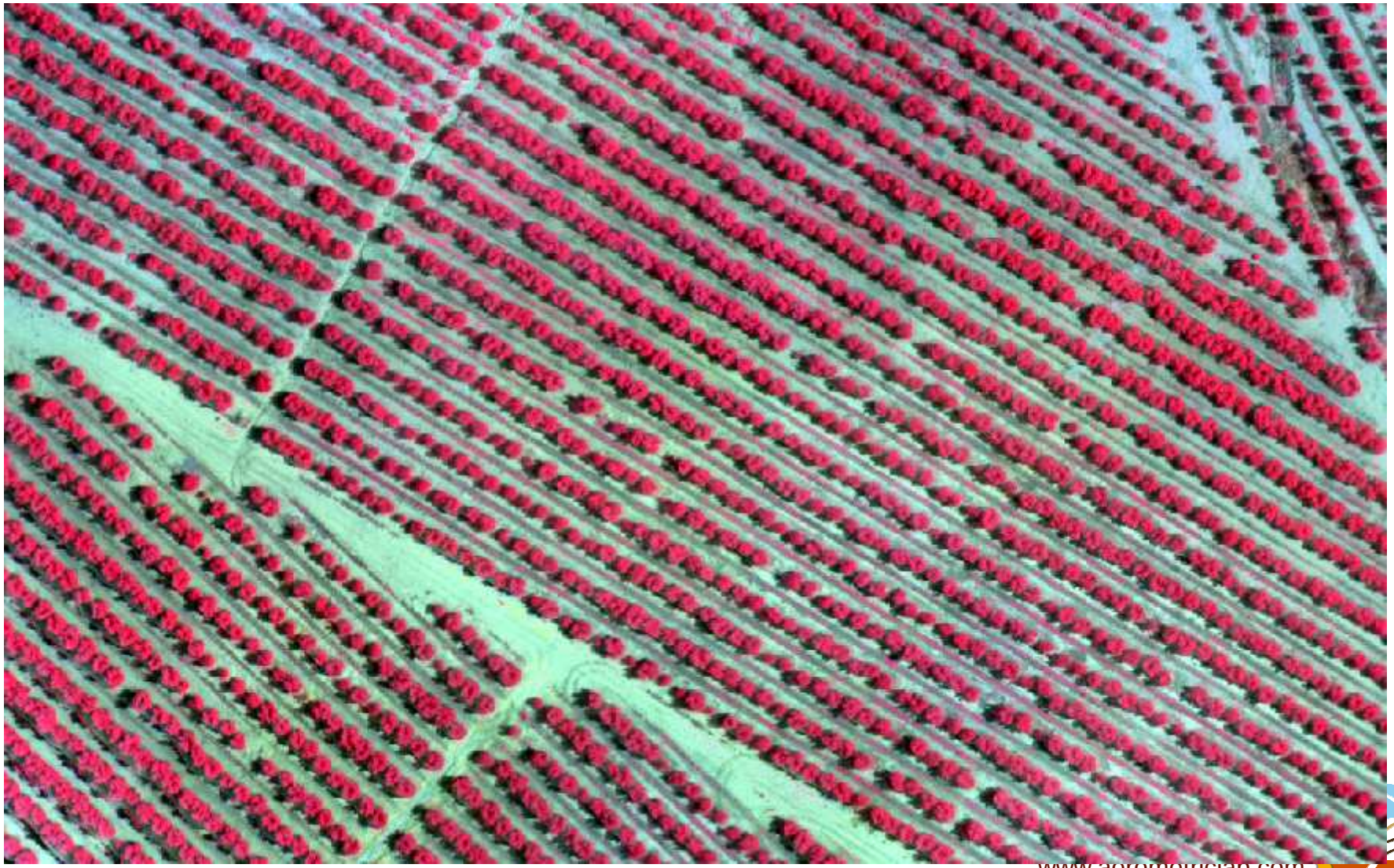

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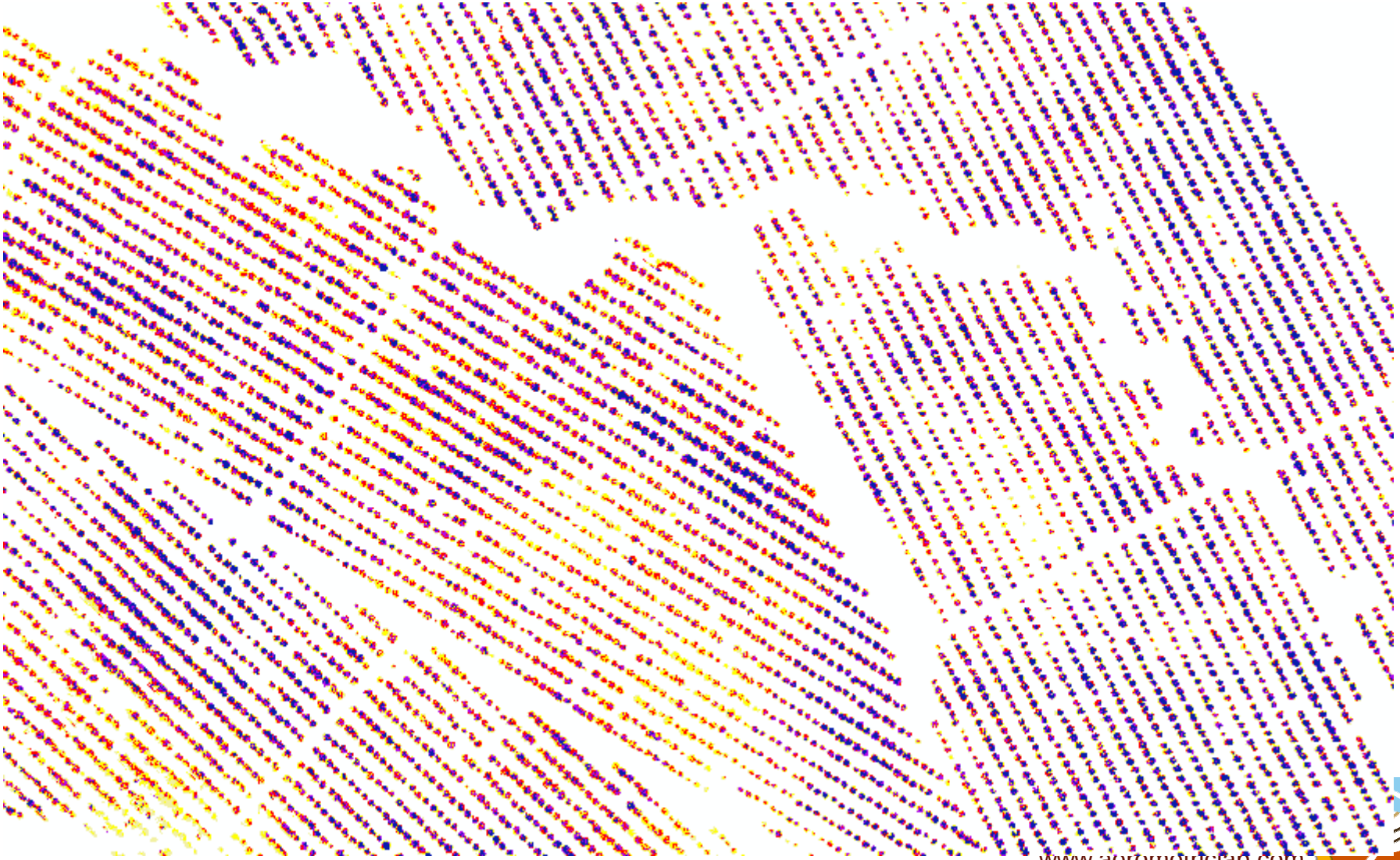

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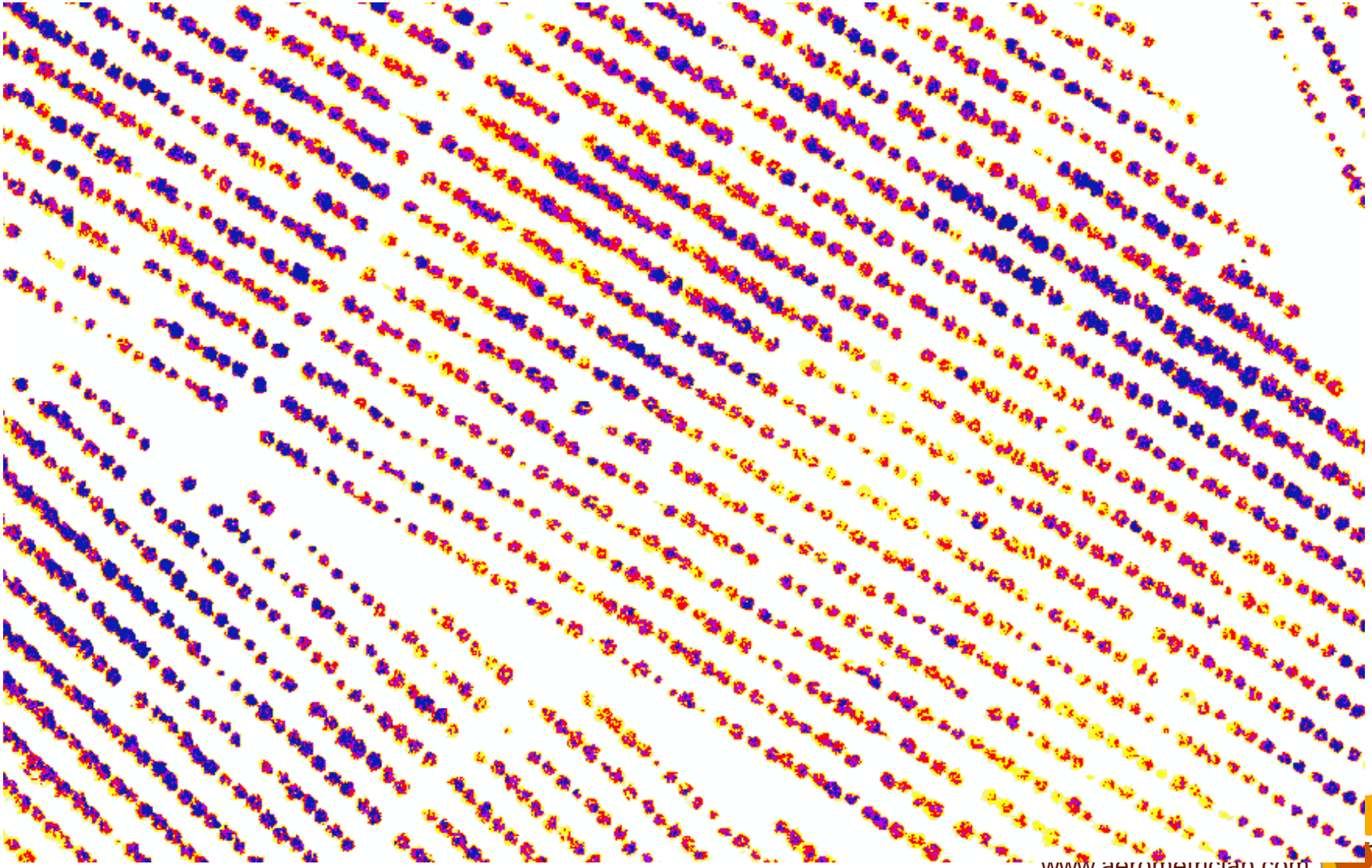

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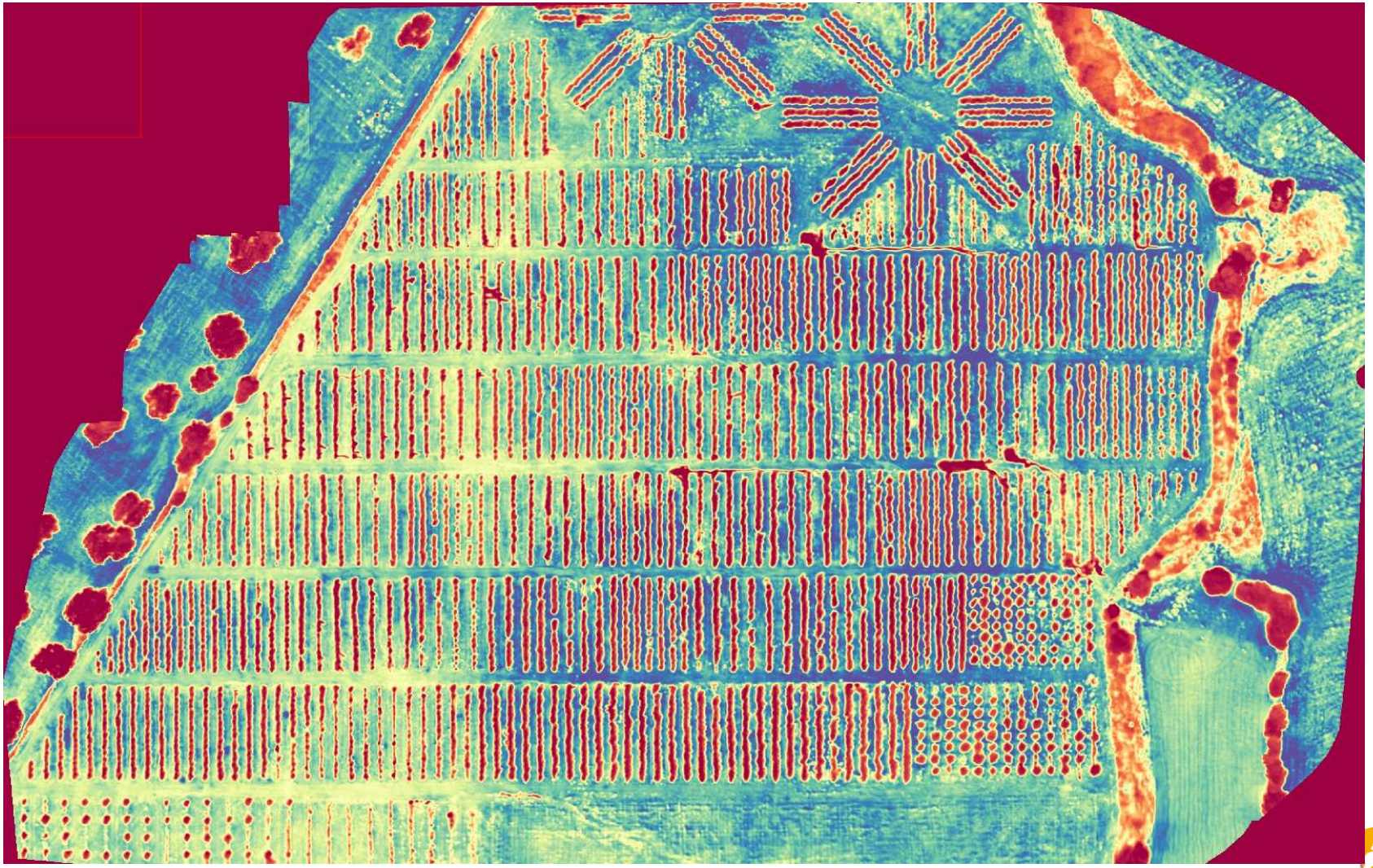

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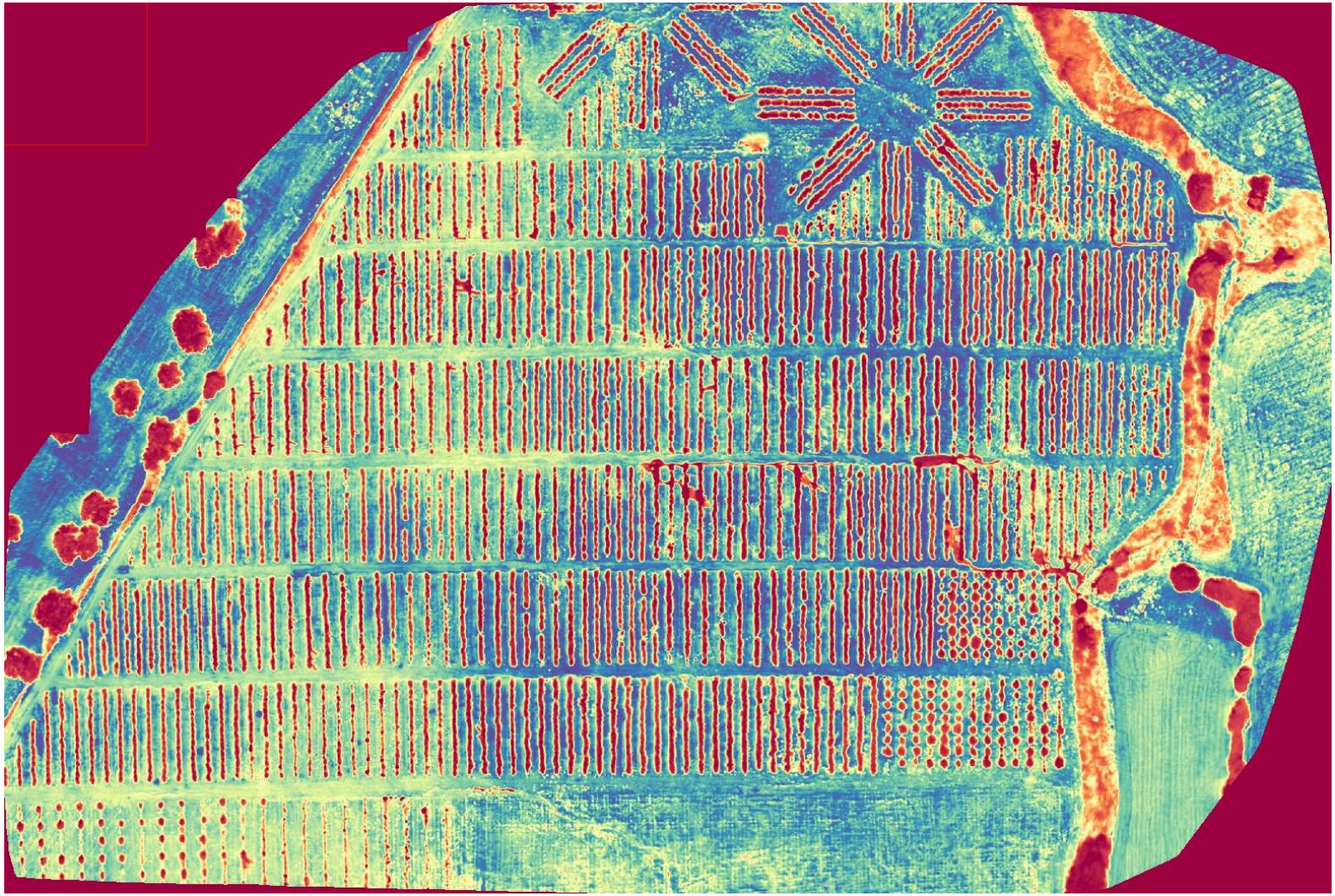

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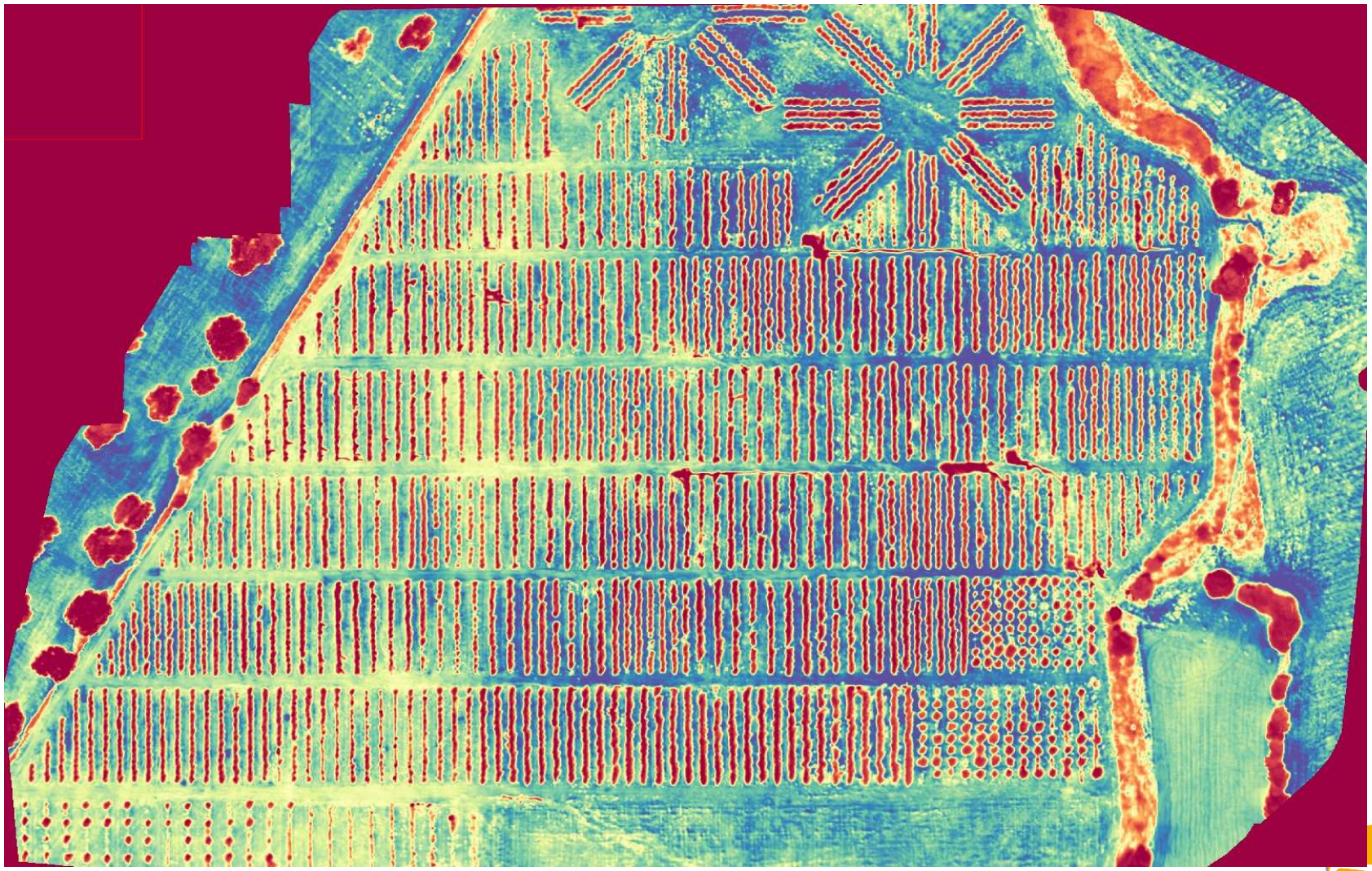

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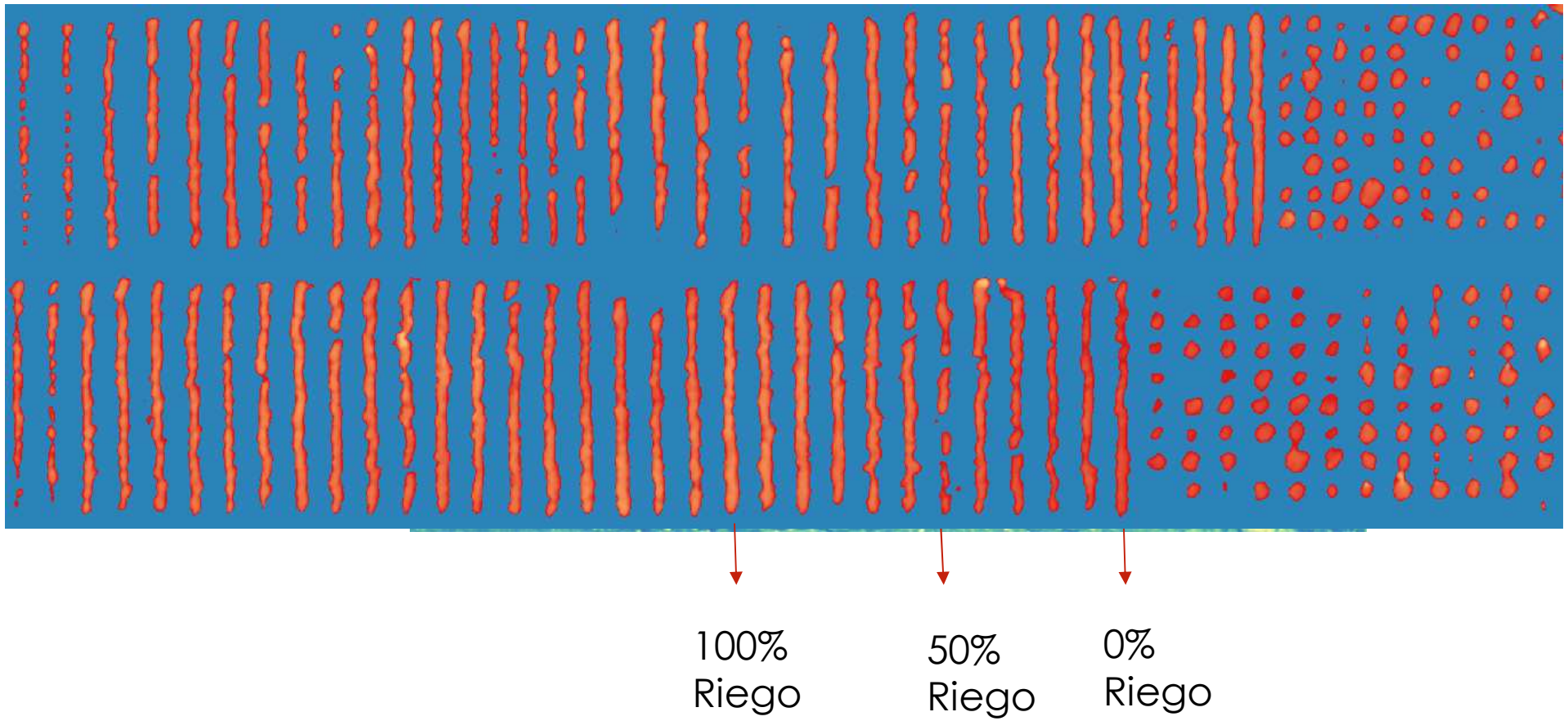

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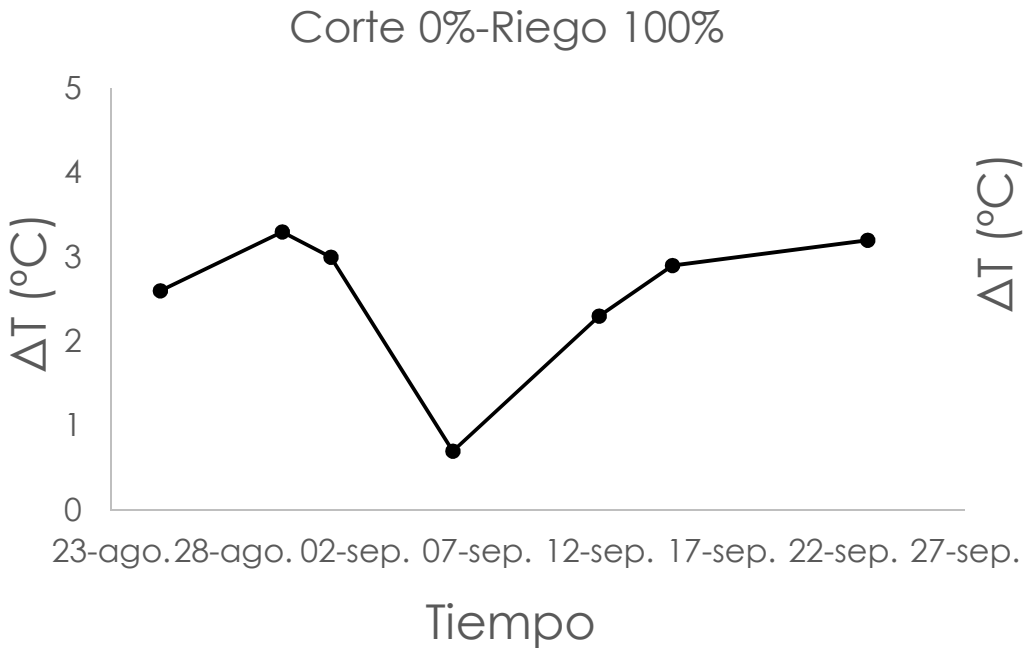

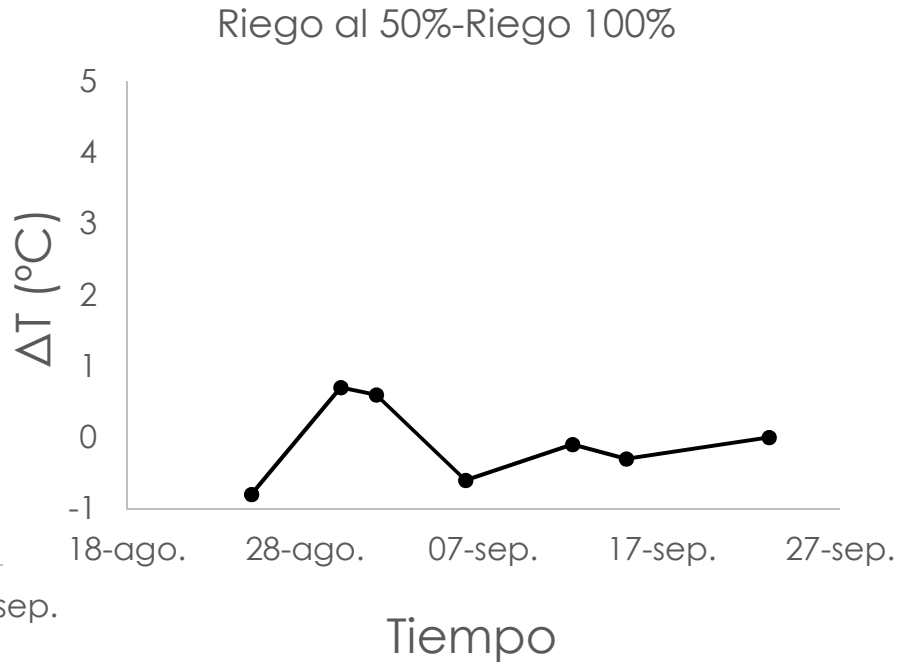

Los olivos sin riego respecto a los de 100% riego tienen un diferencial de temperatura de unos 3ºC, que disminuye a 1ºC cuando hay precipitaciones, ya que disminuye el estrés de éstos y tienden todos a igualarse. En los olivos con riego al 50%, mantienen la misma temperatura que los regados al 100%, por lo tanto, con la mitad de agua los olivos no sufren estrés.

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