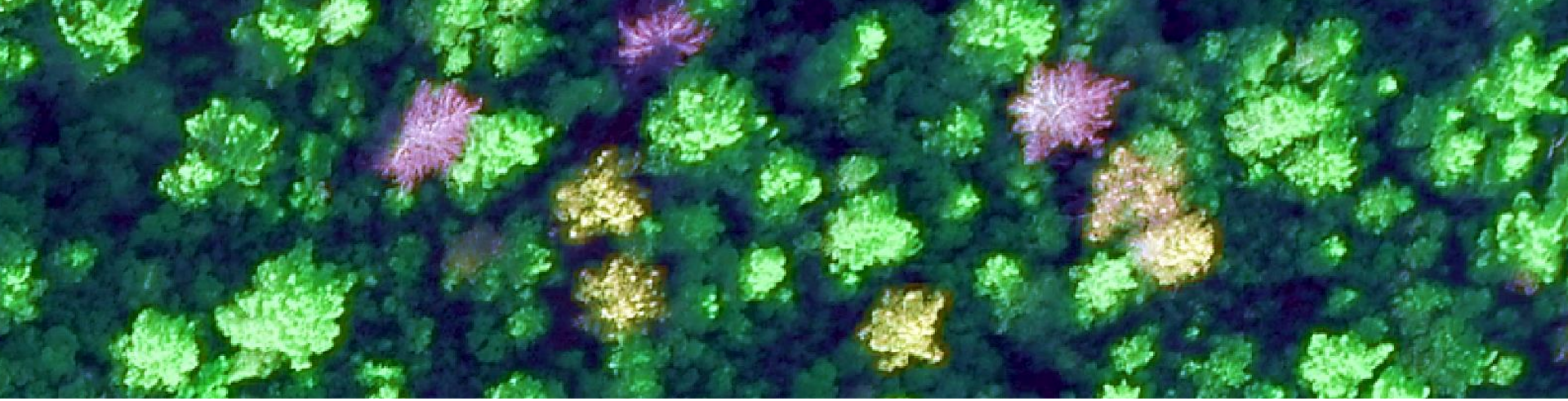

Early detection of diseases in forests and agricultural crops using advanced aircraft-based imaging

*Pieter S. A. Beck & Pablo J. Zarco-Tejada**
Joint Research Centre

EPPO-Euphresco colloquium, Paris, 27 September 2018
** now at University of Melbourne*

European Commission

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DG SANTE (EC)

XF ACTORS

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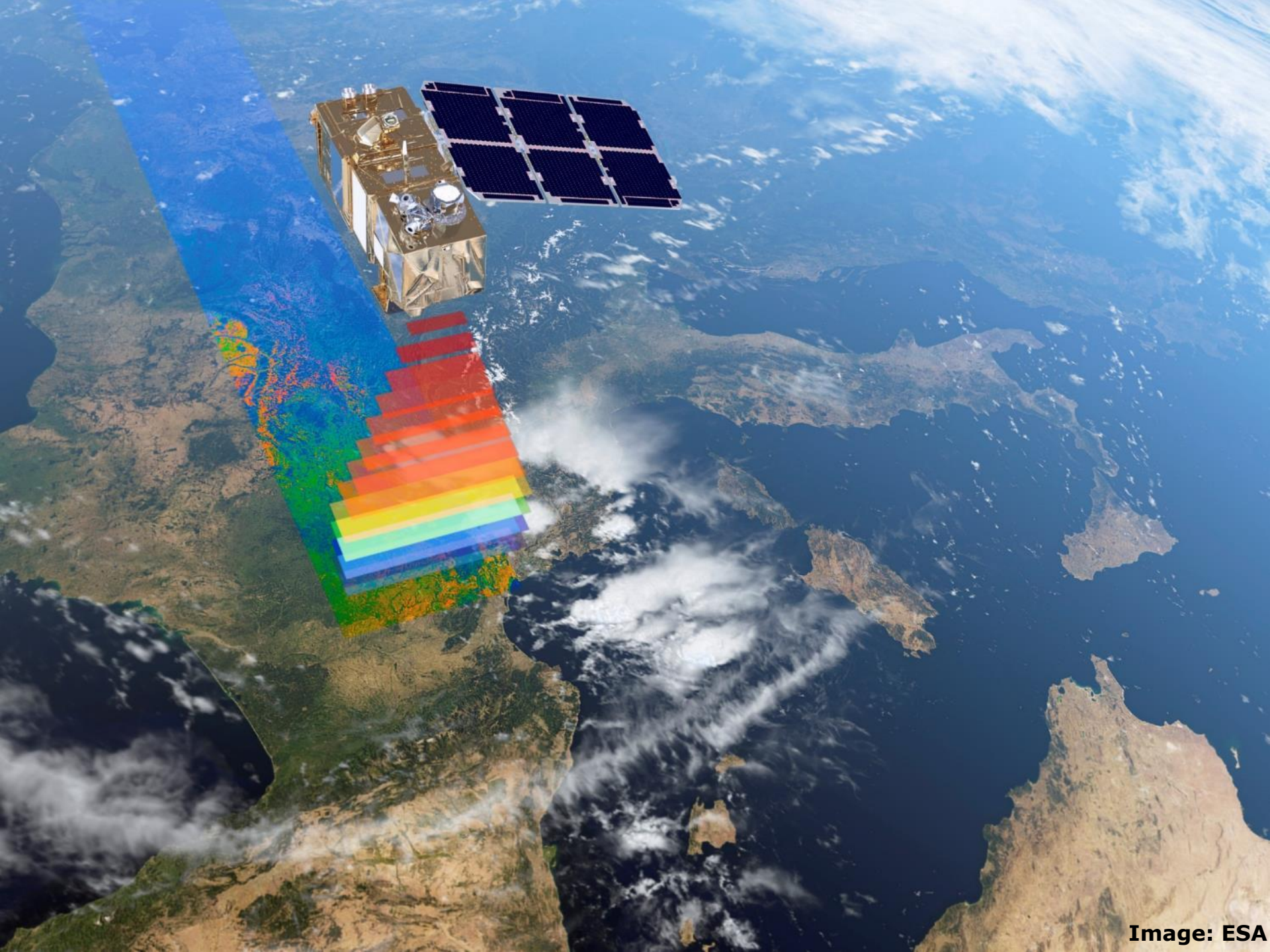
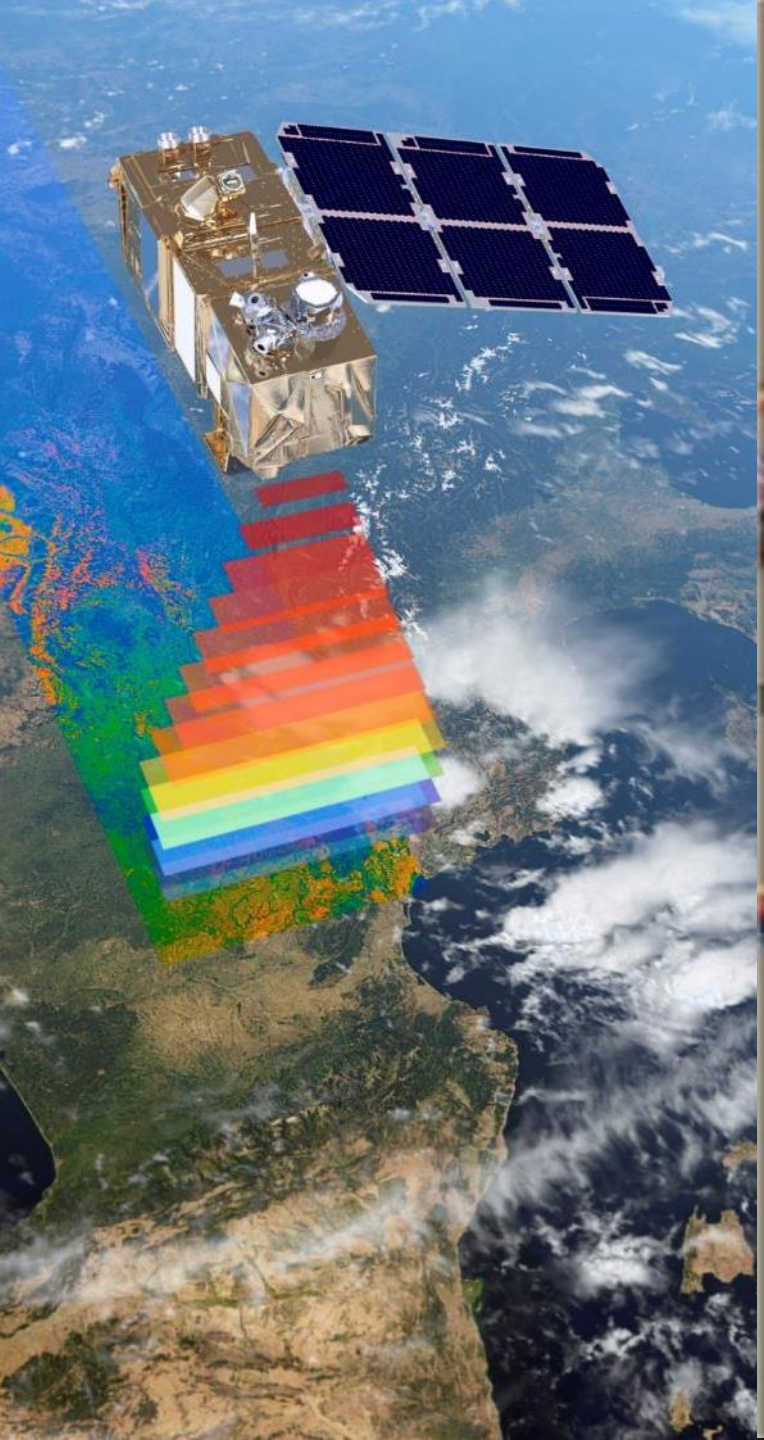


Image: ESA


esa



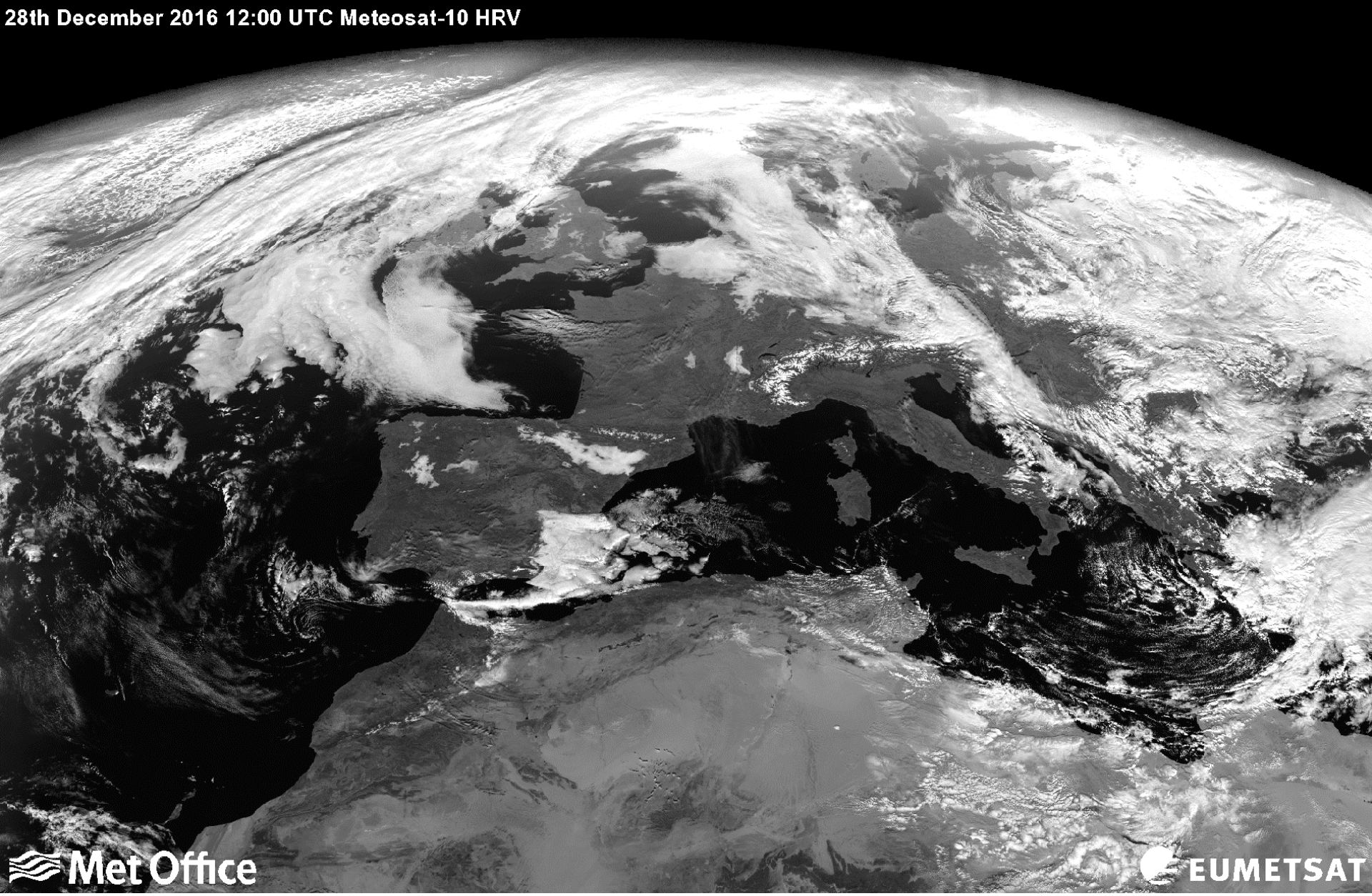

Honeywell

With choice, come trade-offs

With choice, come trade-offs

How large is the area you are monitoring?

How often do you need a new observation?



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With choice, come trade-offs

How large is the area you are monitoring?

How often do you need a new observation?

How small are the features you want to analyze?

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With choice, come trade-offs

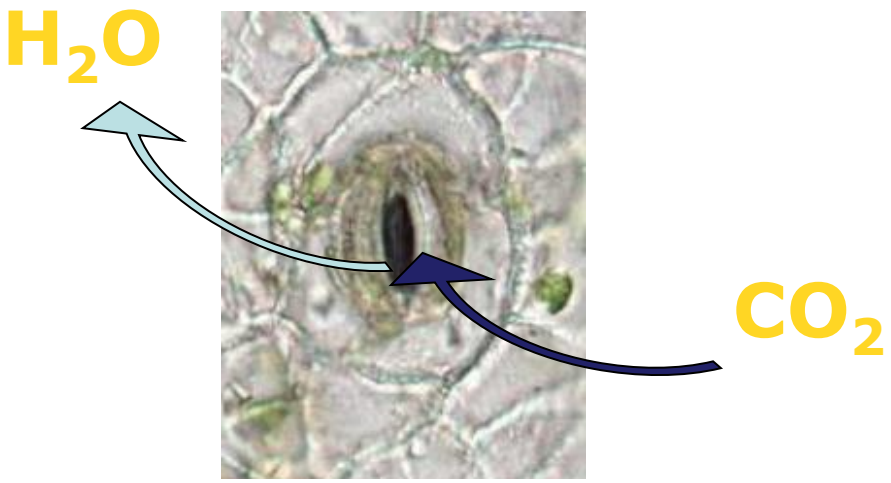
How large is the area you are monitoring?

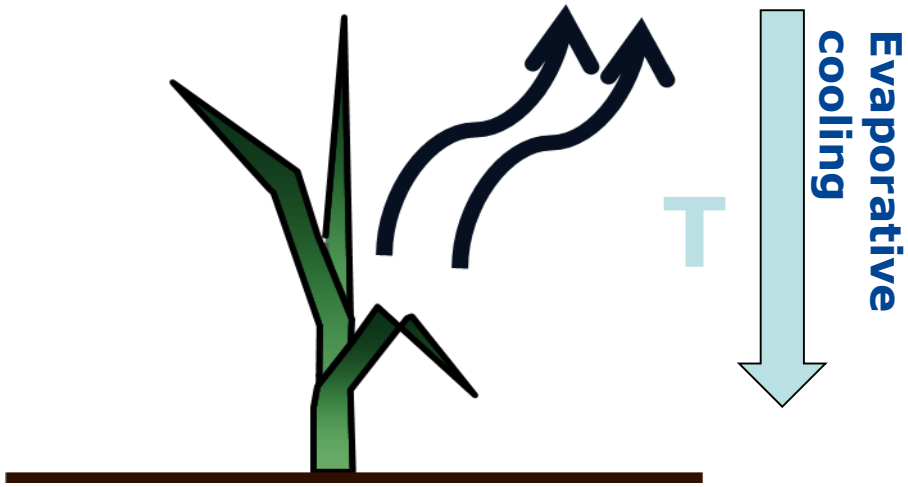
How often do you need a new observation?

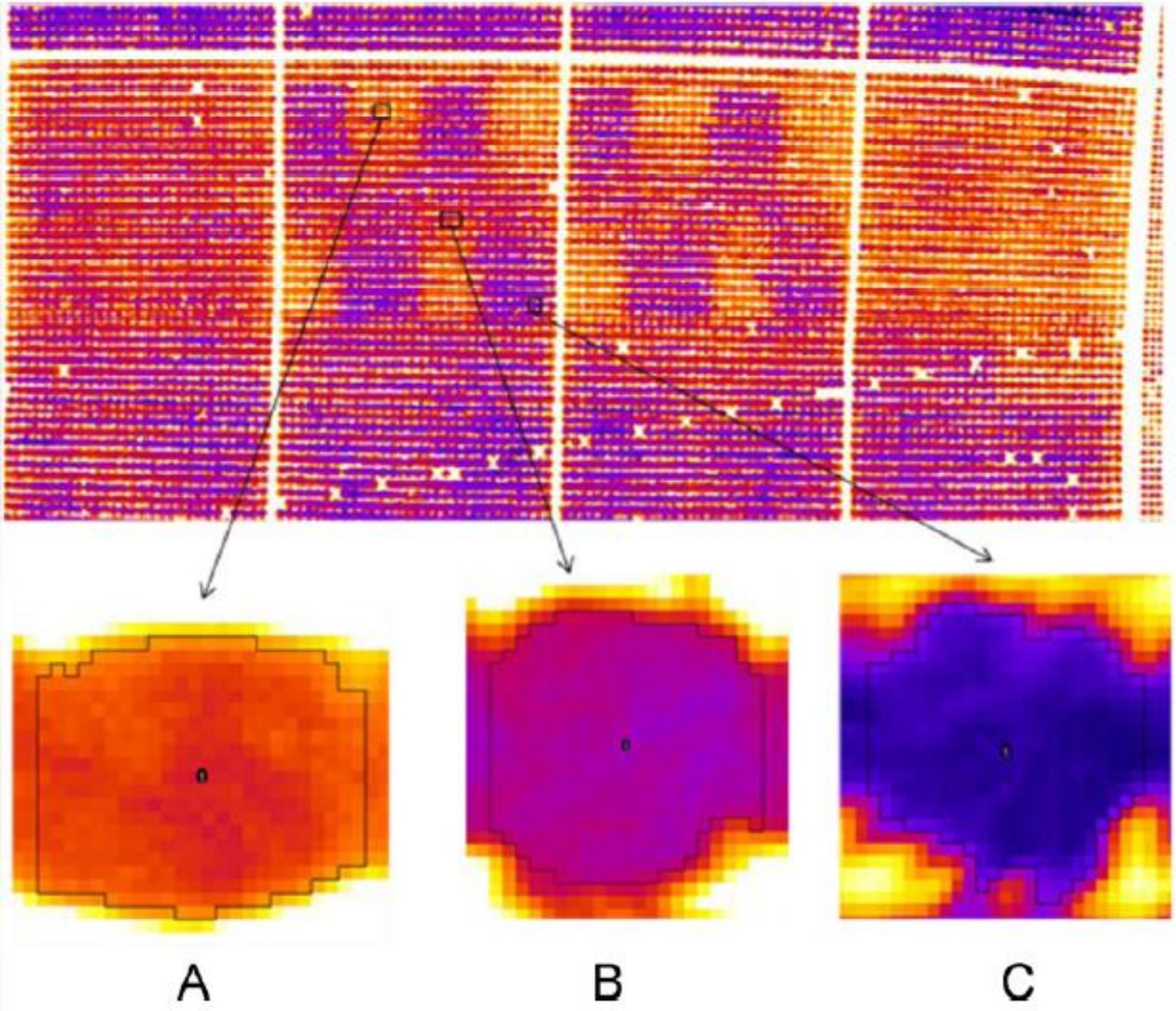
How small are the features you want to see?

What are you looking for?

Indicators of vegetation stress






308
305
302
299
296
A
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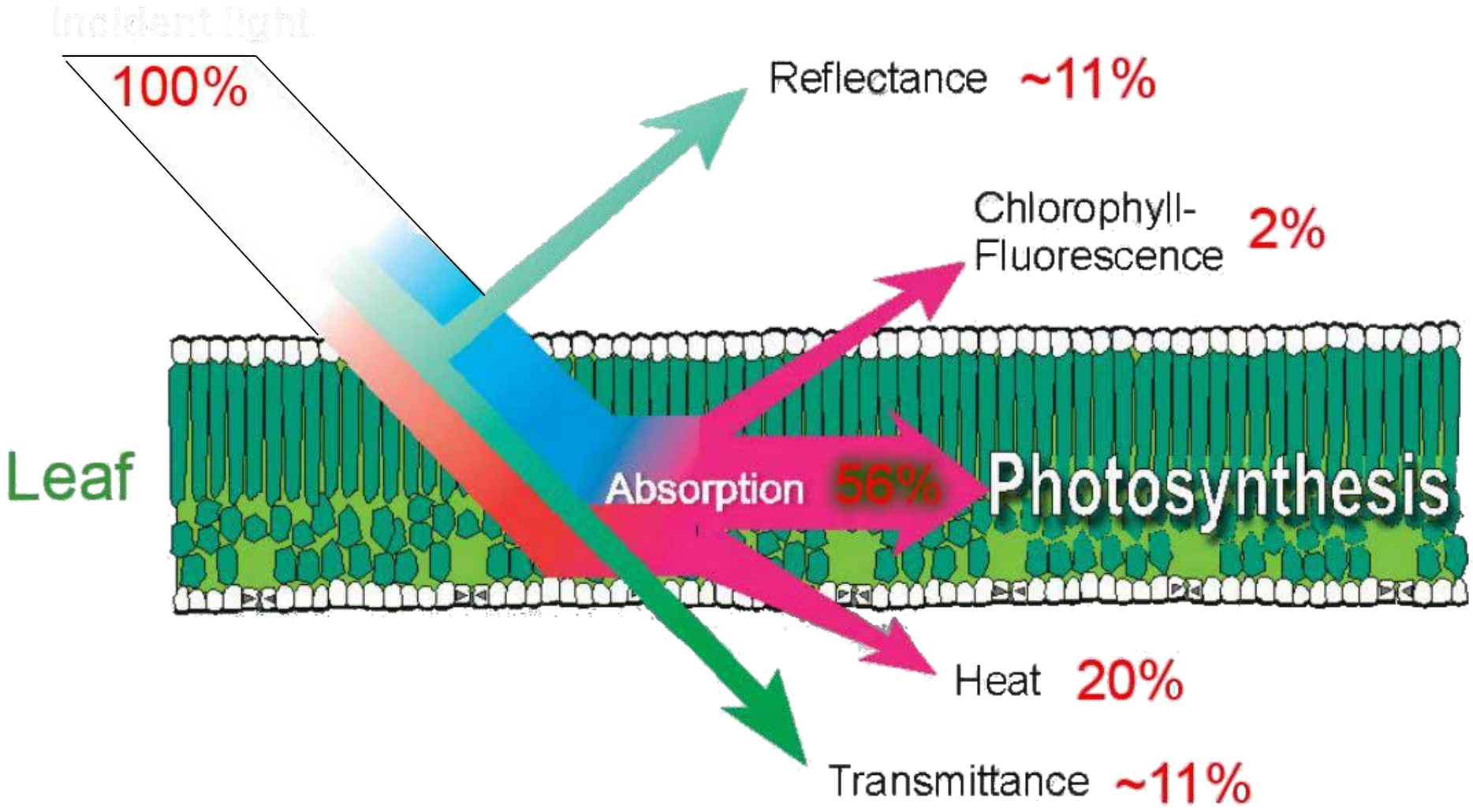
C

Photon-vegetation interactions: Energy budget



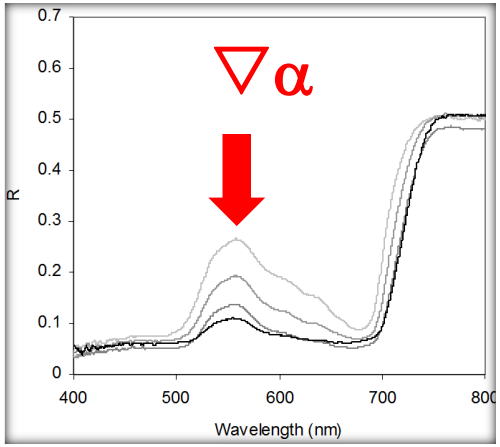
Mapping Photosynthesis from Space - a new vegetation-fluorescence technique
ESA bulletin. Bulletin ASE. European Space Agency. 11/2003; 116:34-37.

Indicators of vegetation stress

- Transpiration and CO_2 absorption reduction
- Photosynthesis reduction

Temperature

Photosynthetic pigments



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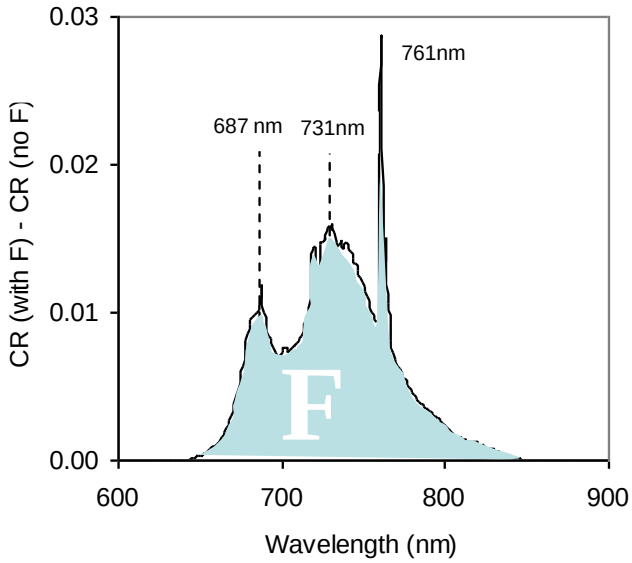
Indicators of vegetation stress

- Transpiration and CO_2 absorption reduction
- Photosynthesis reduction

Temperature

Photosynthetic pigments

Chlorophyll Fluorescence



Vegetation stress indicators from RS

- Transpiration and CO_2 absorption reduction
- Photosynthesis reduction

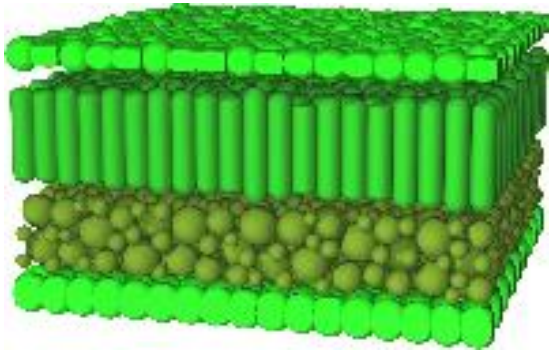
Temperature

Photosynthetic pigments

Chlorophyll Fluorescence

Structure

Canopy



Leaf

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Remote Sensing Indicators of Vegetation Stress

Visual

- **Pigment – related indices: C_{ab} / C_{ar} → nutrition / chlorosis**
  - **Nutrient deficiencies → pigment degradation → less absorption at specific bands → captured by indices sensitive to chlorophyll changes**

- **Structural indices → canopy structure / vegetative growth**
  - **Nutrient / water stress → affects canopy growth → effects in the near infrared → captured by indices sensitive to canopy structure**

Pre-visual

- **Xanthophyll cycle pigments (V+A+Z) → rapid changes phot. efficiency**
  - **PRI: Indicator of the epoxidation state (EPS) of the xanthophyll pigments → under stress V+A+Z ↑ → R530 ↓ → PRI ↑**

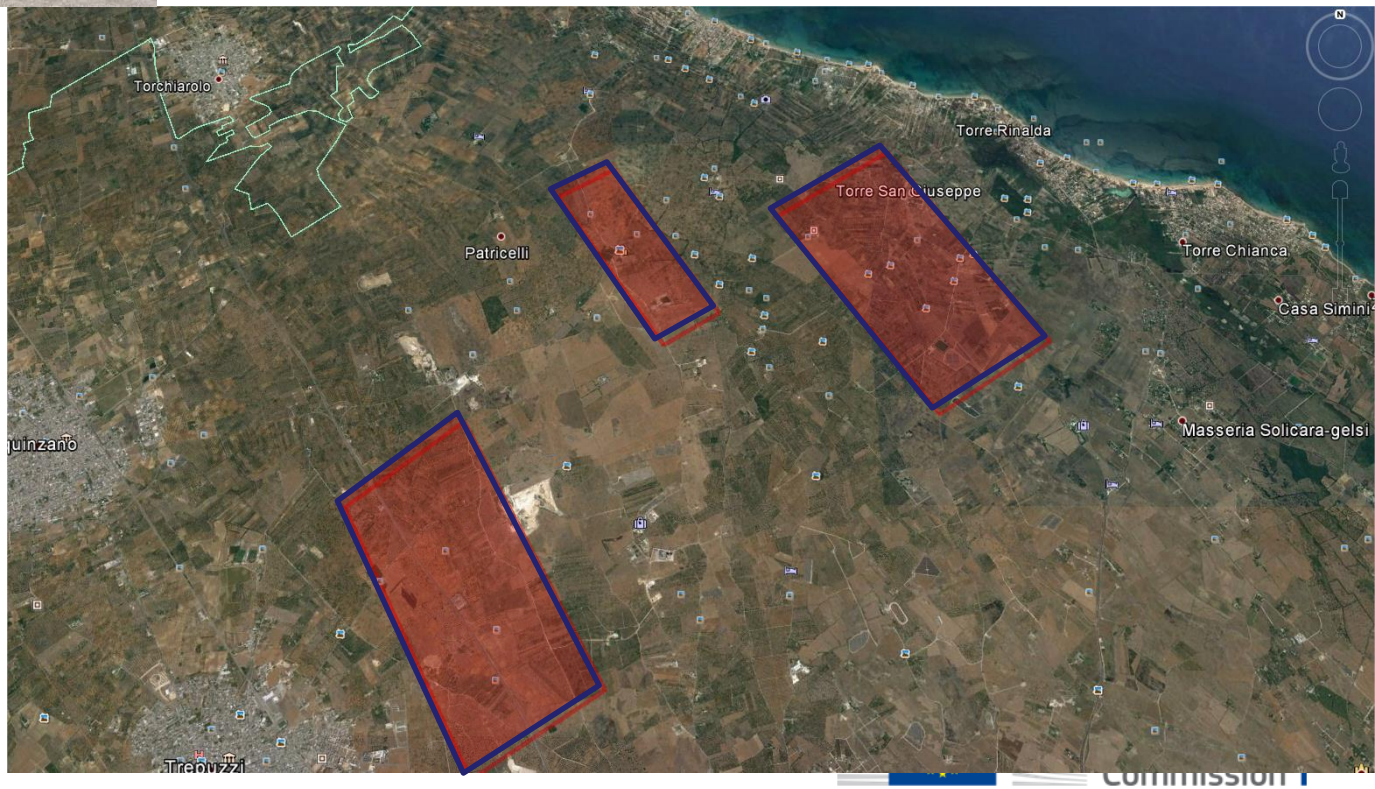
- **Chlorophyll Fluorescence (CF) → F emission → Photosynthesis**
  - **Excess energy → function of the photosynthetic state**
  - **3% - 4 % of the radiance levels**
  - **Main interest to monitor remotely photosynthesis & stress condition**

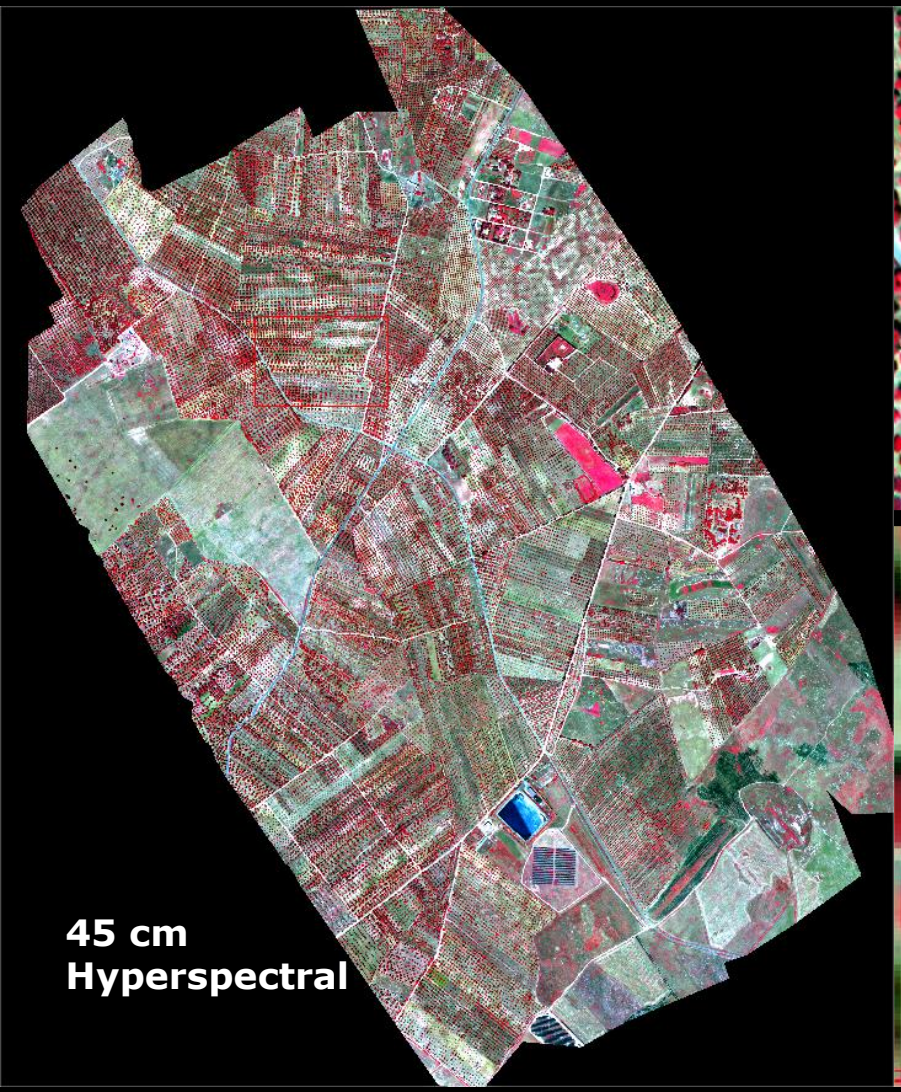
- **Temperature: T_c → T_c-T_a → CWSI**
  - **Stomata closure → Reduction in transpiration and CO_2 uptake → Decreased photosynthesis → *Temperature increase***

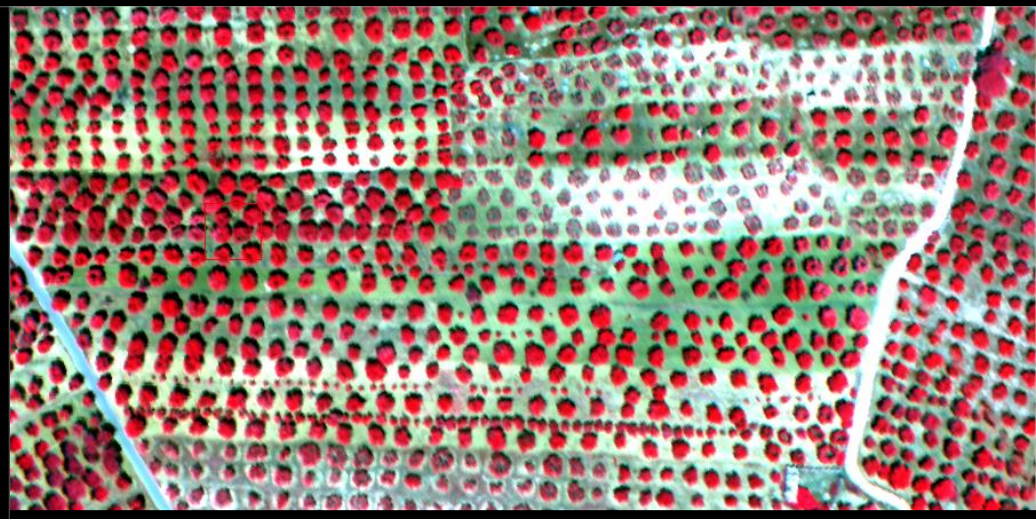
Remote Sensing–based detection of *Xylella fastidiosa* infection symptoms

Airborne campaigns 2016 + 2017
1,200 ha
200,000 trees scanned
Resolution ranging 7-60 cm
Hyperspectral + Thermal + RGB

5 field campaigns
4000 trees/year

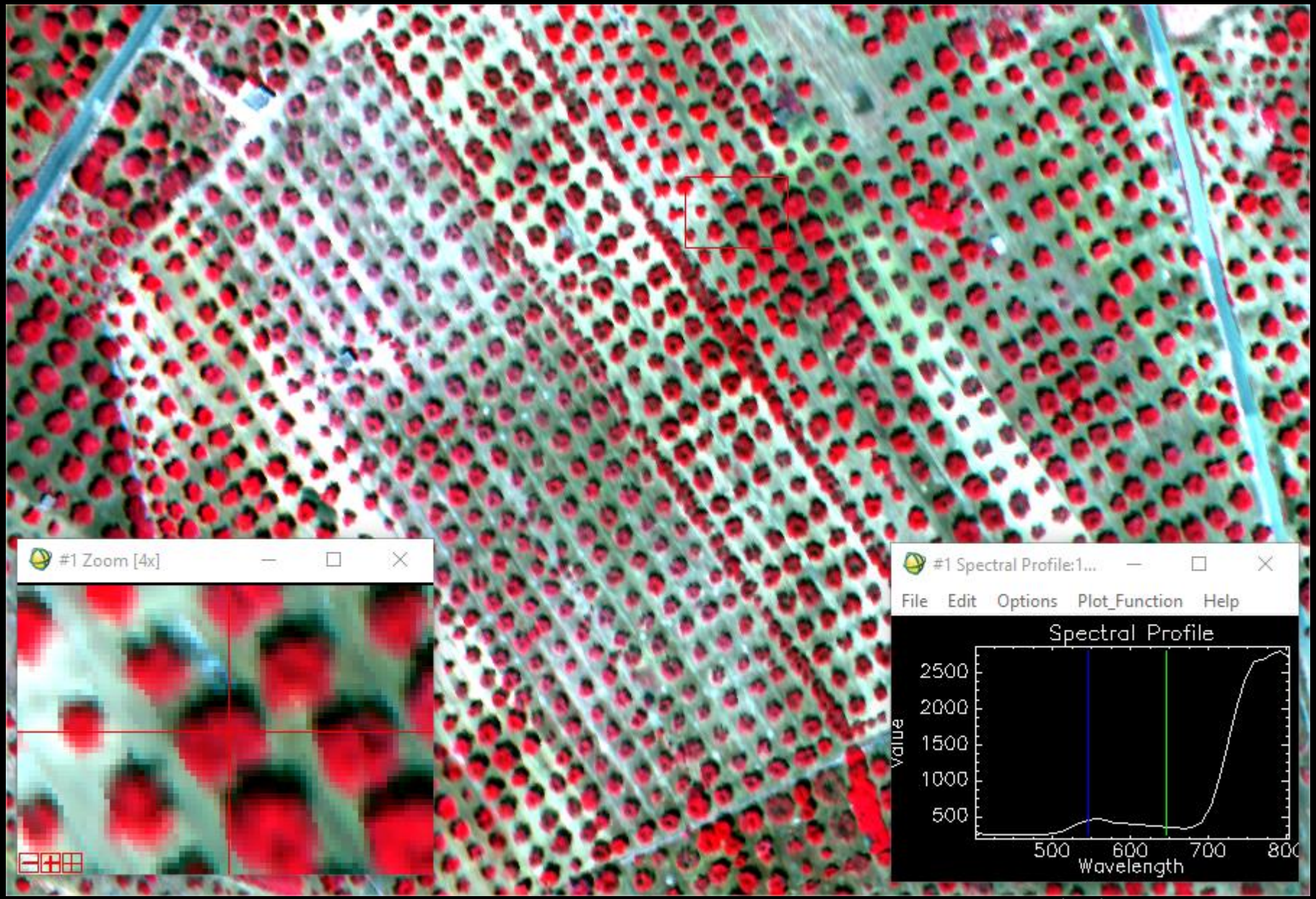






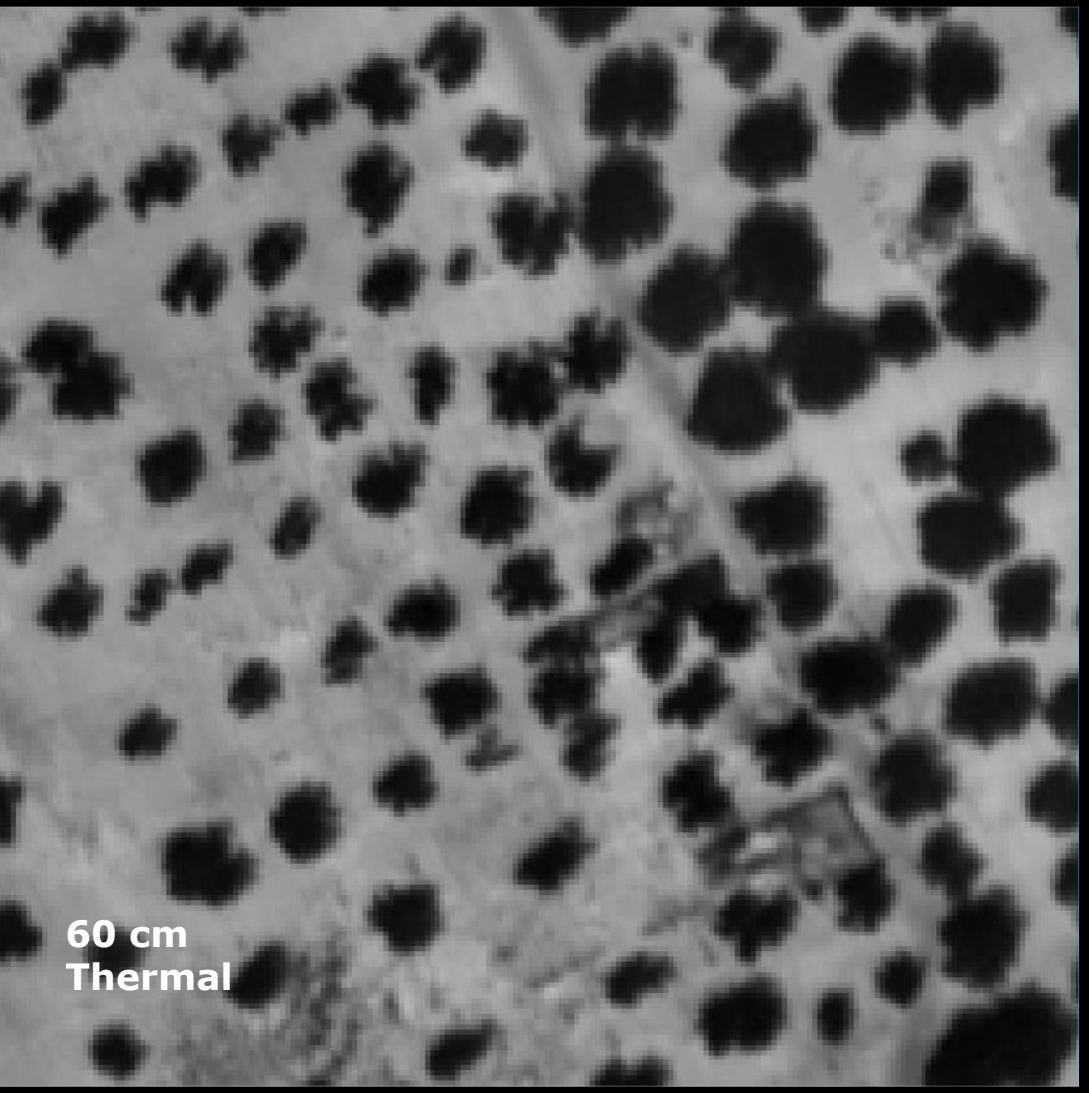
Zarco-Tejada et al. *Nature Plants* 2018

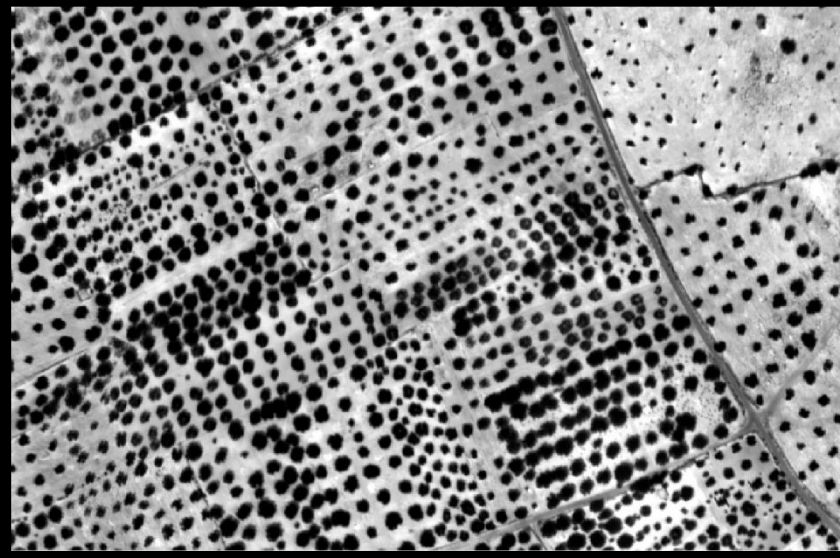
European Commission

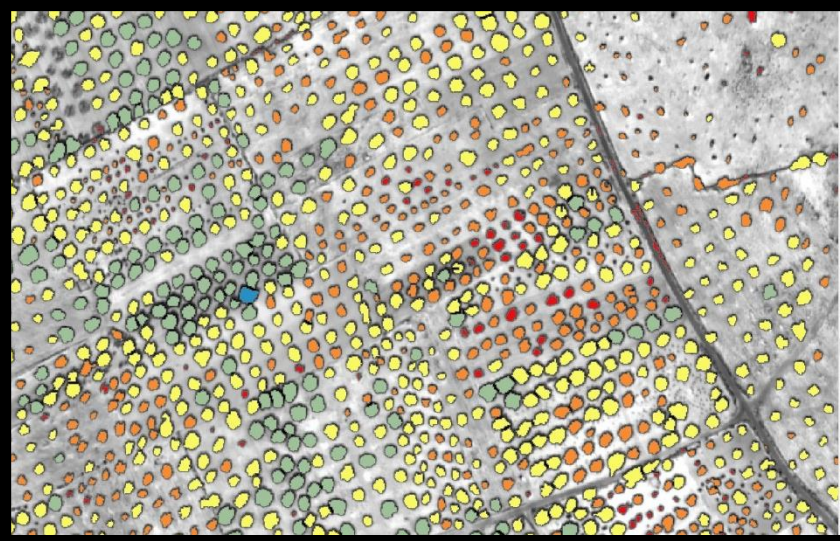


Zarco-Tejada et al. *Nature Plants* 2018

European Commission







Zarco-Tejada et al. *Nature Plants* 2018

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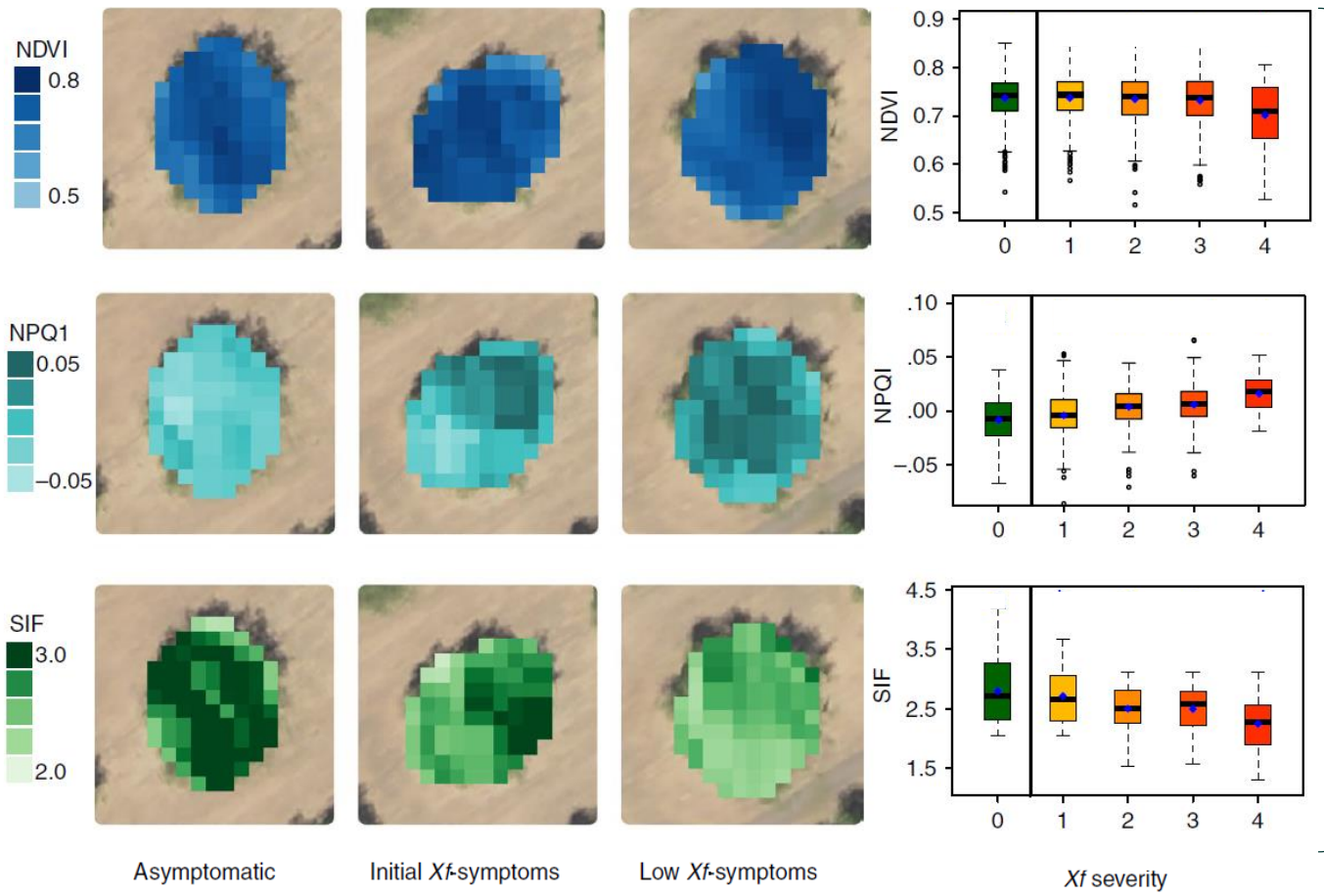

Detection accuracy for symptomatic trees (κ) > 80%

Zarco-Tejada et al. *Nature Plants* 2018

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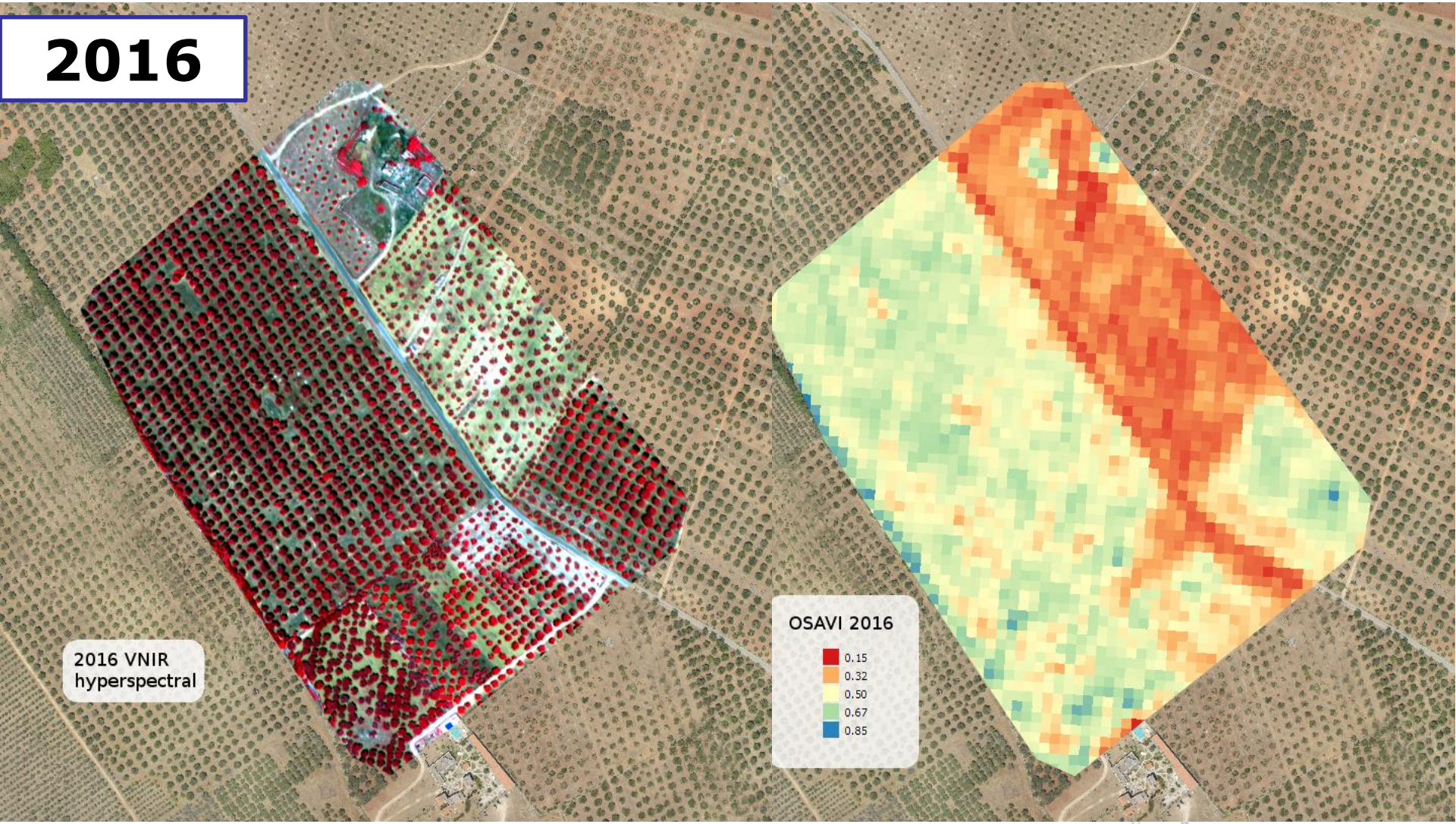
2016



Hornero et al. *in prep*

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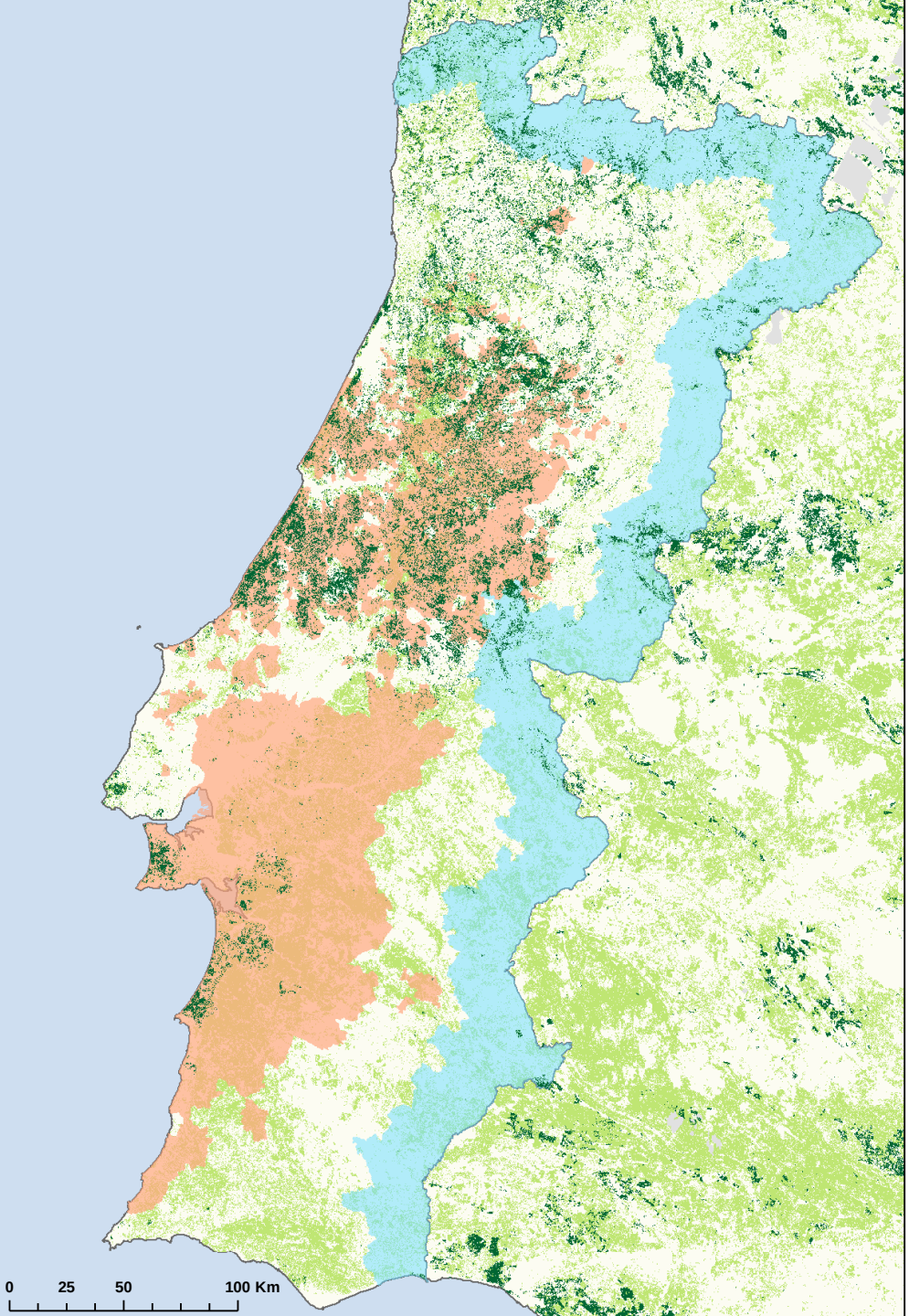

EC Decision on Pine Wood Nematode (2012/535/EU)**:**

[…] *In the buffer zones … identify and fell all susceptible plants which are dead, in poor health or situated in fire- or storm-affected areas.*

[…]

PWN Intervention zone

PWN Buffer zone

Broadleaved forest

Coniferous forest

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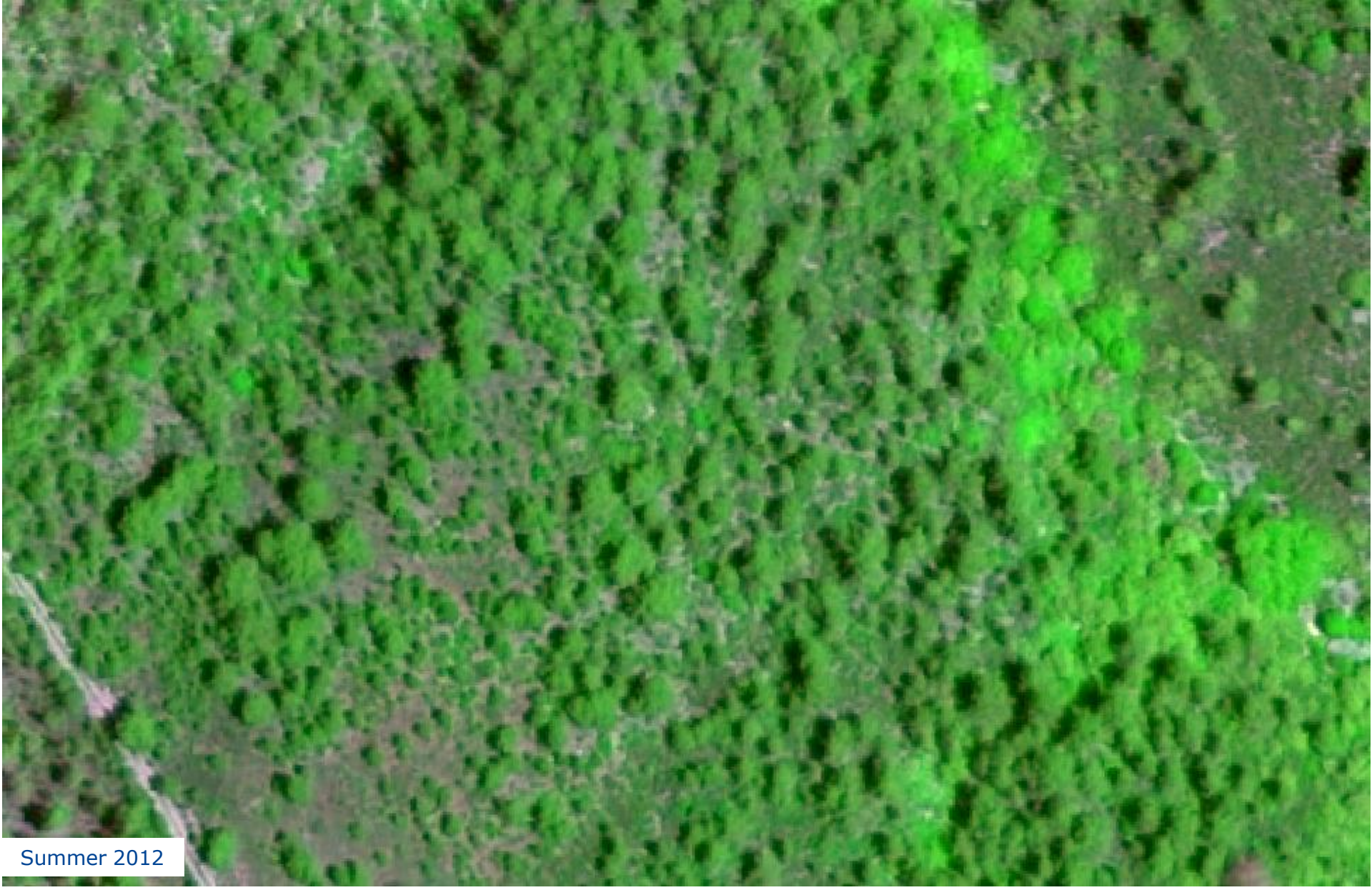
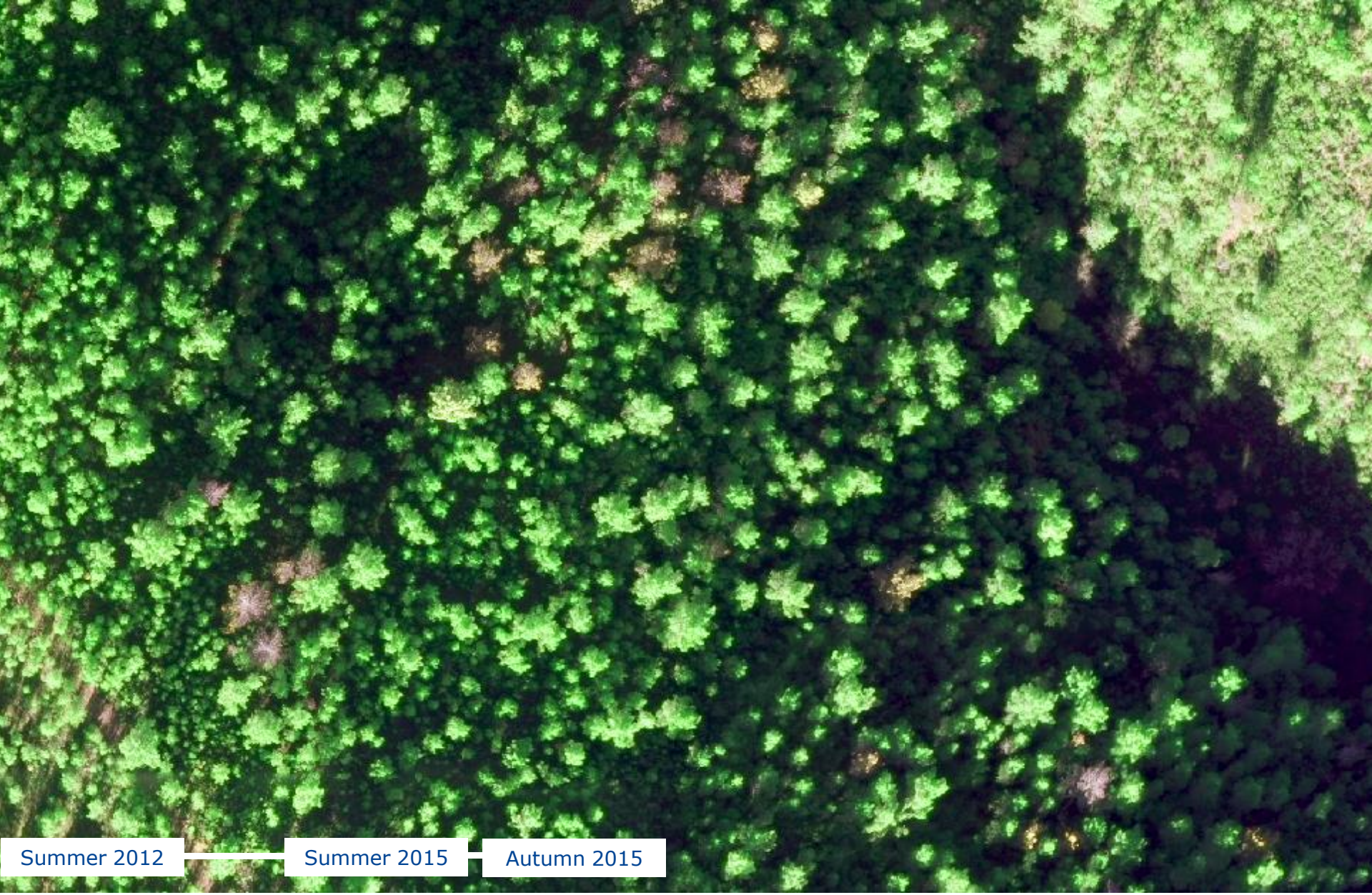


Summer 2012

European Commission

European Commission



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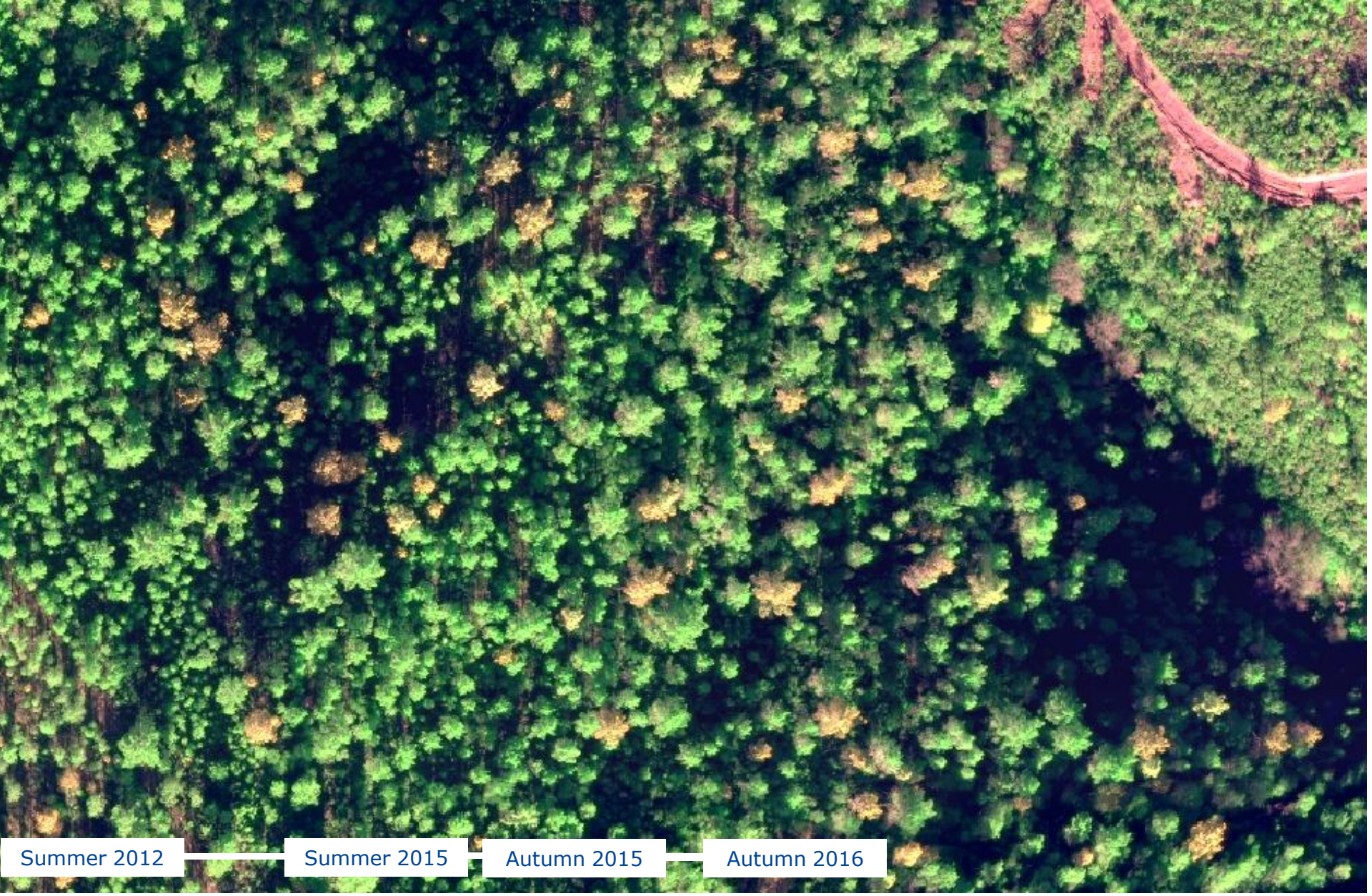

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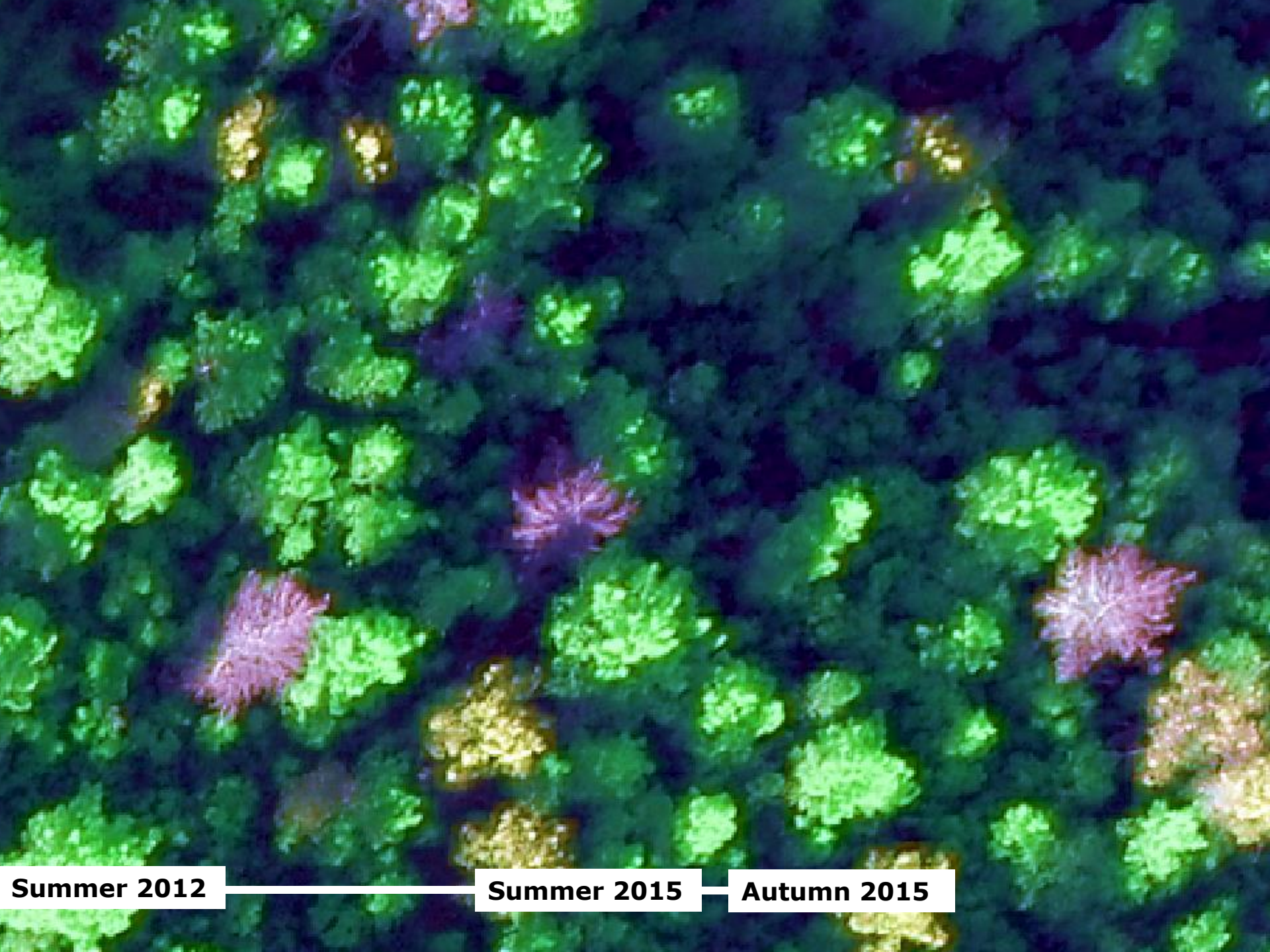
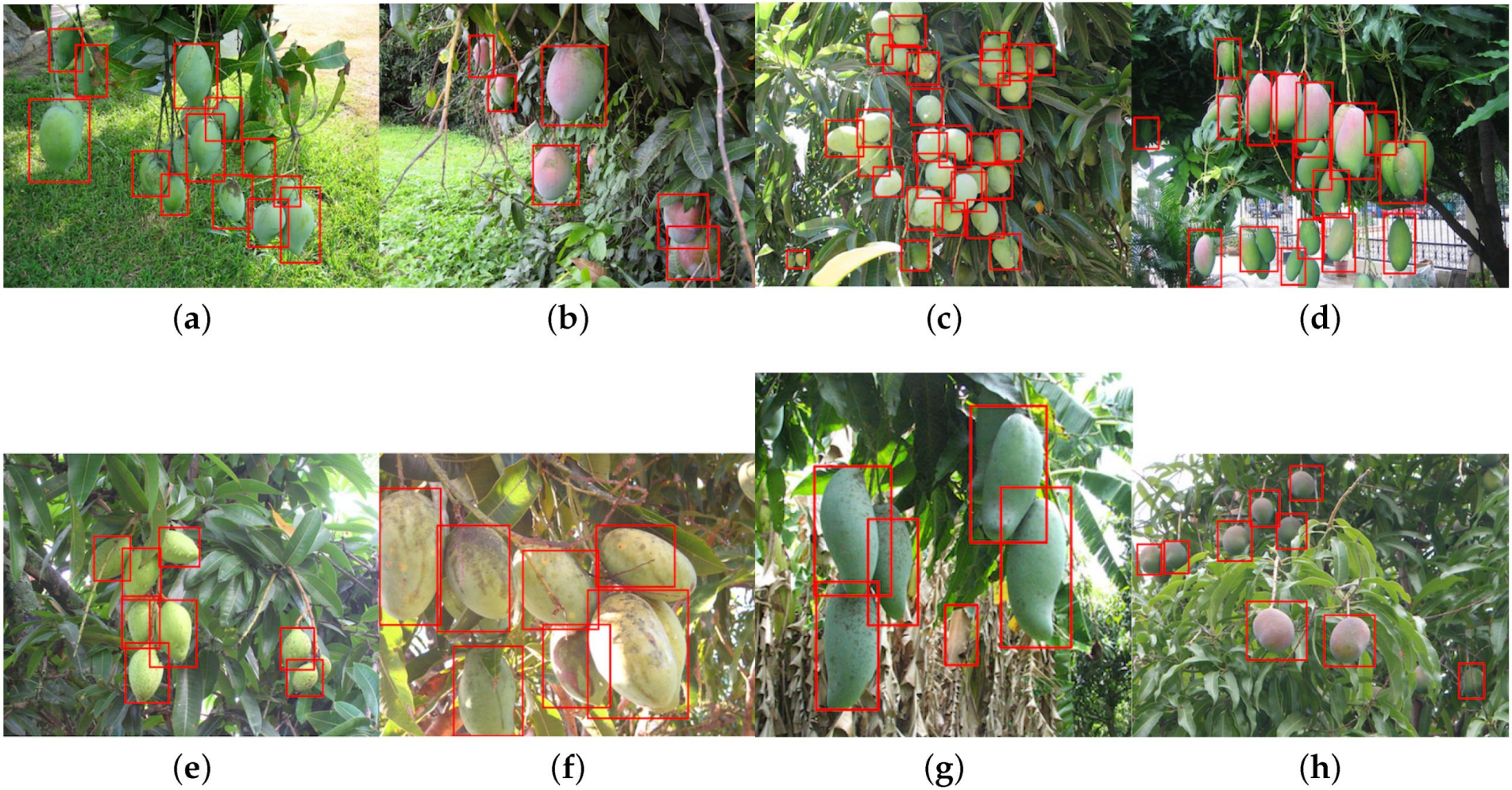

Summer 2012
Summer 2015
Autumn 2015



Sa, I.; Ge, Z.; Dayoub, F.; Upcroft, B.; Perez, T.; McCool, C. DeepFruits: A Fruit Detection System Using Deep Neural Networks. *Sensors* **2016**, *16*, 1222.

(a)

(b)

d'Andrimont, Raphaël, Guido Lemoine, and Marijn van der Velde. "Targeted Grassland Monitoring at Parcel Level Using Sentinels, Street-Level Images and Field Observations." *Remote Sensing* 10.8 (2018): 1300.

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Take home message 1 of 4

There is **no 'one-size-fits-all' approach** for the use of remote sensing to detect diseases in crops and forests. Approaches need to be tailored to the disease system.

Take home message 2 of 4

The range of remote sensing **data, platforms, and sensors** is rapidly expanding.

The increasing data volumes require matching processing platforms.

Take home message 3 of 4

For plant health applications there is, for now, a spectrum of applications ranging from those that are **grounded in plant physiology** (and can target non-visible disease symptoms), to those that rely heavily on **feature-recognition and machine learning** (largely restricted to visible symptoms)

Final take home message

Remote sensing won't replace other diagnostic tools in plant health any time soon, but hold the potential to make plant health monitoring more (cost-)efficient if it is deployed as **complement** of other inspection and testing methods.