Monitoring phenology of cherry-tree orchards from remote sensing: analysis of fAPAR time-series to identify flowering and the start of fruit growth.

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Introduction

- In Mediterranean regions, irrigation is the main consumer of freshwater, and the pressure on the use of water is increasing in these regions.

- Need to develop **methodologies to monitor and plan** the use of water resources **at the local and regional scale**

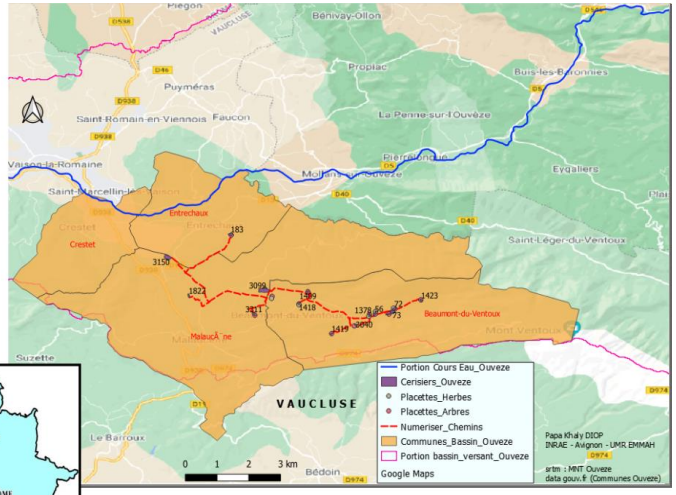
- **Remote sensing provide** access, at the local/regional scale, to **leaf area expansion**, which can be used as an **proxy to phenological dates**

How can we estimate flowering and fruit growth dates from Sentinel 2 satellite time-series?

Study site

13 cherry-tree orchards in the Ouvèze basin (SE France), monitored during 2021

VerSEau project, funded by RégionSud
Proximal to remote project, funded by KAUST



Approx. area 880 km^2

Id	Age	Area (ha)	Planting pattern (m)	Irrigated?	Grass?
50	> 5 years	0,72	6 x 7	Yes	Yes
56	> 5 years	0,84	8 x 7	Yes	Yes
72	> 5 years	0,89	7 x 7	Yes	Yes
183	> 5 years	1,10	5 x 5	Yes	No
1378	> 5 years	0,54	7 x 7	No	Yes
1409	planted in 2016	0,42	6 x 7	Yes	No
1418	> 5 years	0,22	6 x 7	Yes	Yes
1423	> 5 years	0,62	6 x 7	Yes	Yes
3031	> 5 years	0,25	6 x 7	Yes	Yes
3099	> 5 years	4,57	4.5 x 9	Yes	Yes
3150	planted in 2017	3,09	5 x 5	Yes	Yes
3311	> 5 years	0,74	7 x 7	Yes	Yes
3463	> 5 years	0,33	5 x 6	Yes	Yes

On each orchard, a homogeneous plot (15 x 15 m) was selected for RS and in situ monitoring

Study site

Challenge! Understanding the contribution of the grass when interpreting time-series

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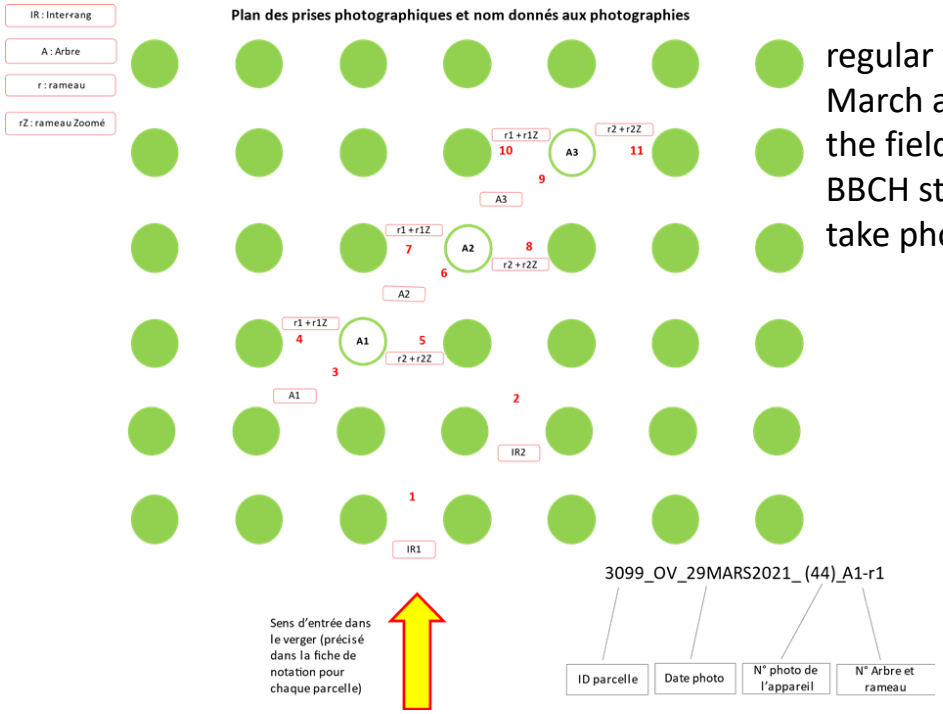
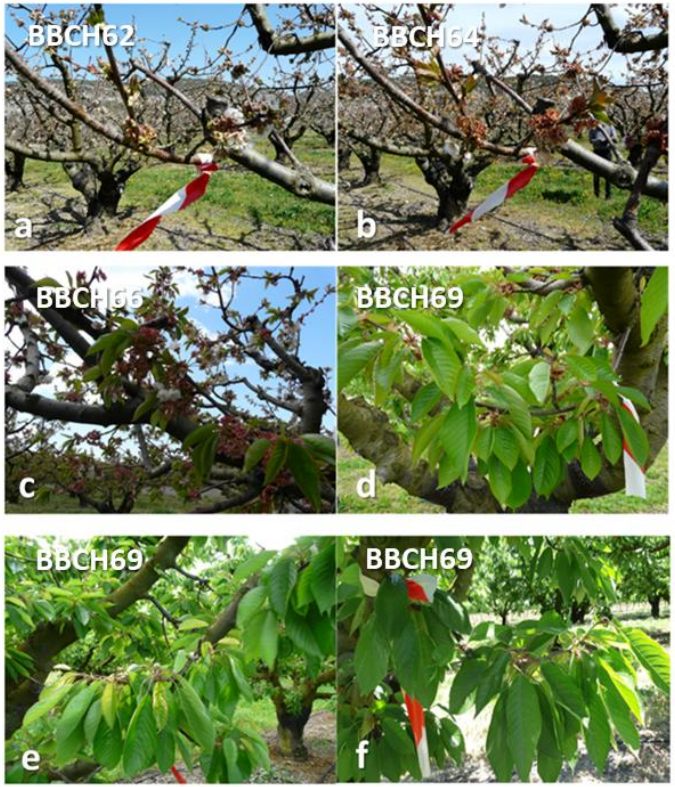
Materials and methods

In situ anntotation of tree phenology

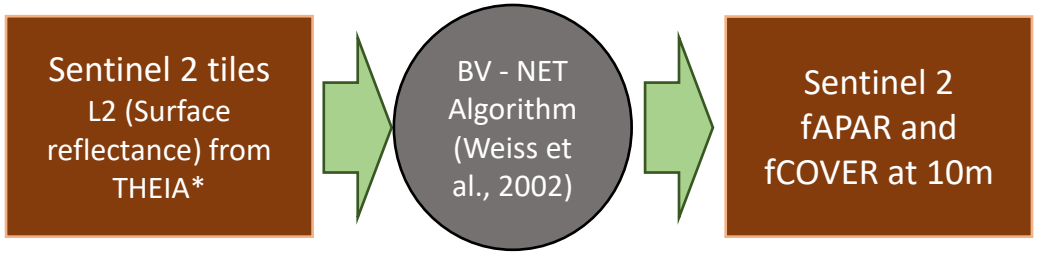


regular visits in March and April to the field to note BBCH stages and to take photographs



Materials and methods

Acquisition and processing of Sentinel 2 fAPAR and fCOVER time-series



*https://theia.cnes.fr

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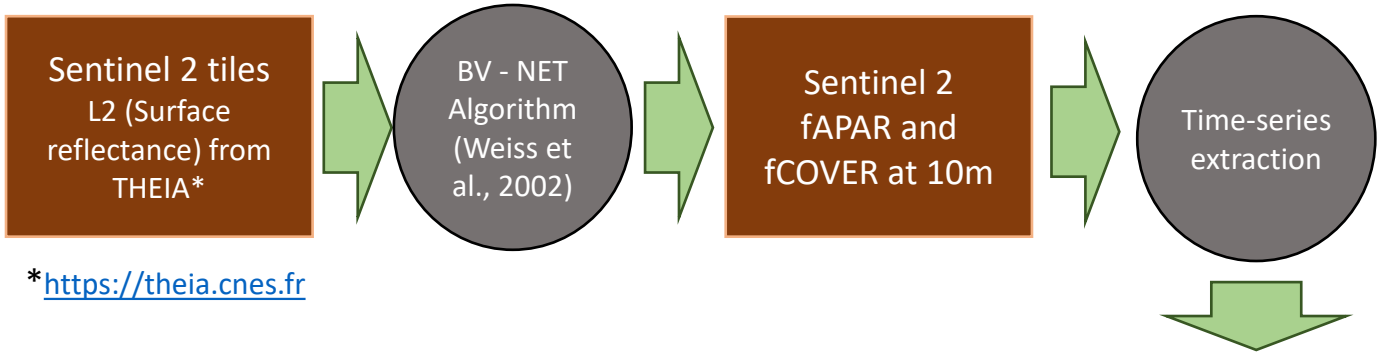

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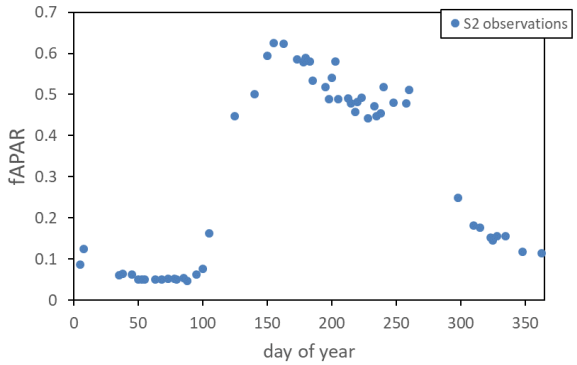

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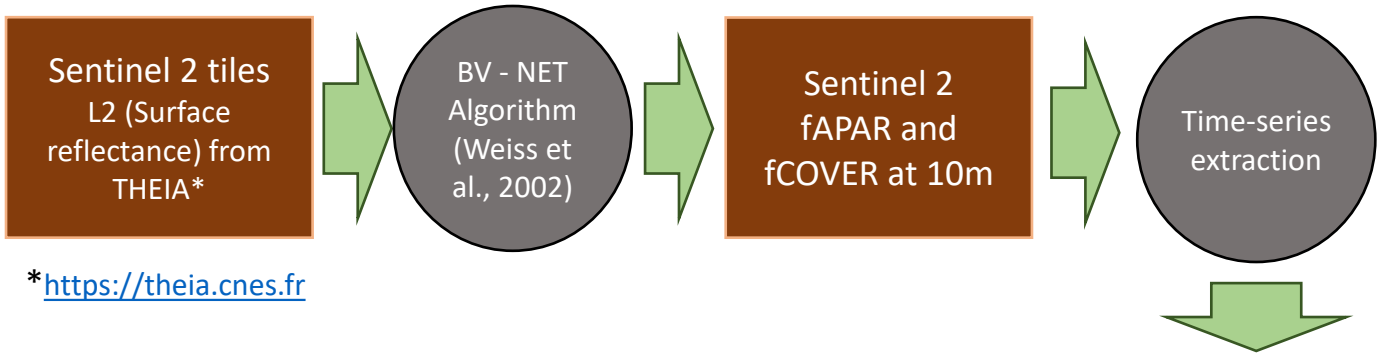

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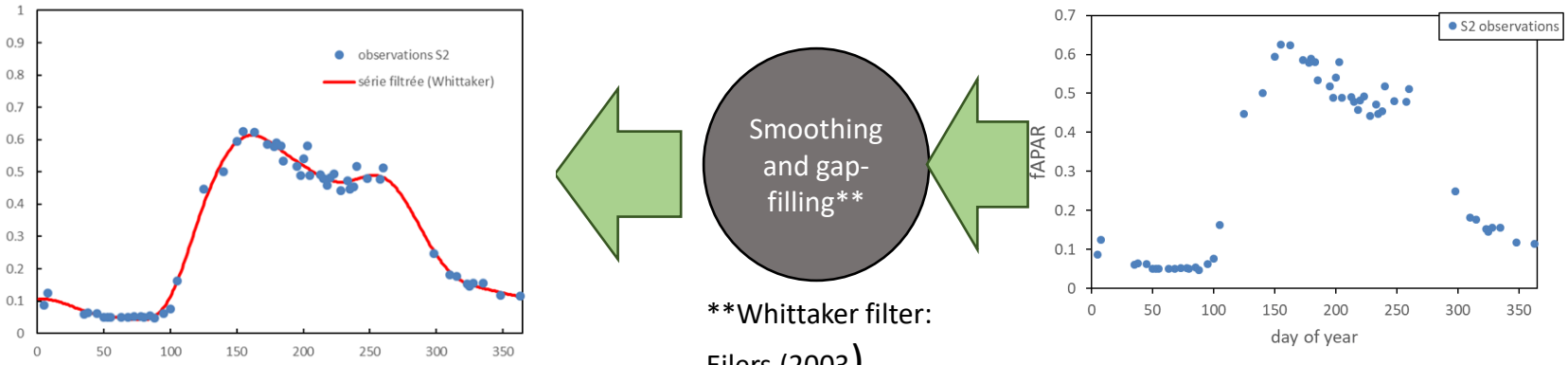


**Whittaker filter: Eilers,(2003)

Materials and methods

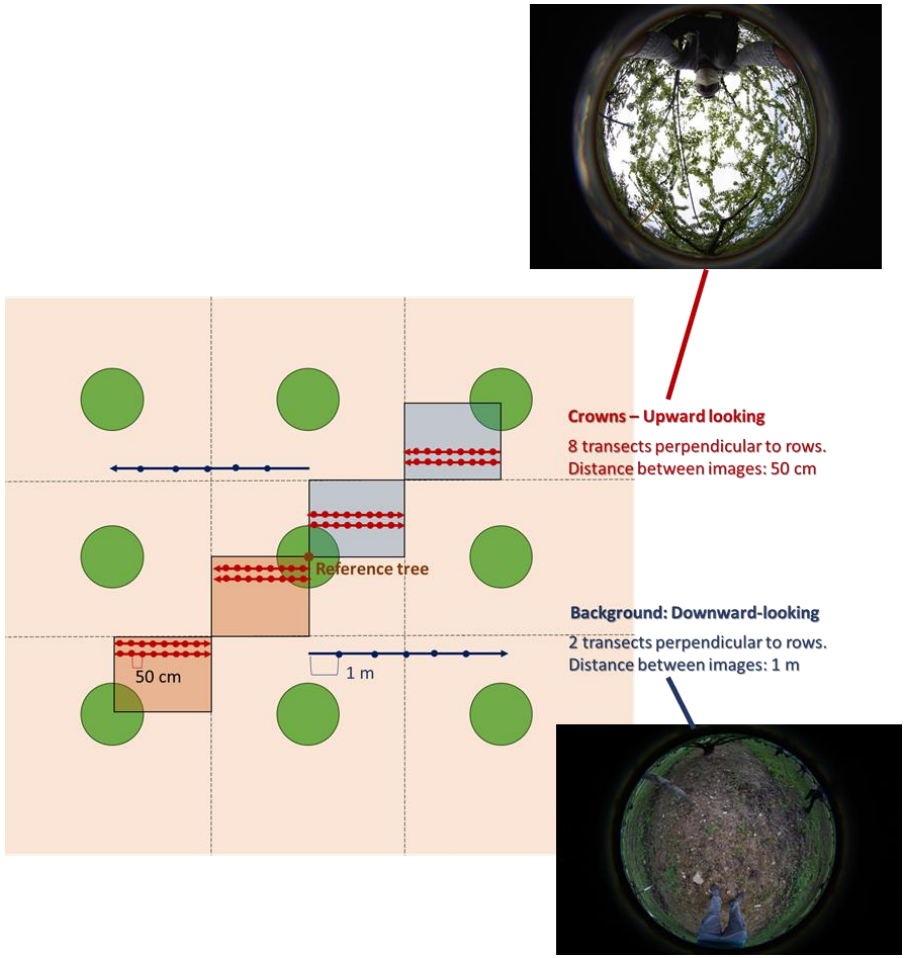
In situ validation of fAPAR and fCOVER

Objective:

a) *Understanding the contribution of crowns and background on the satellite observations*
b) *Validating the total canopy fAPAR / fCOVER from Senetinel 2*

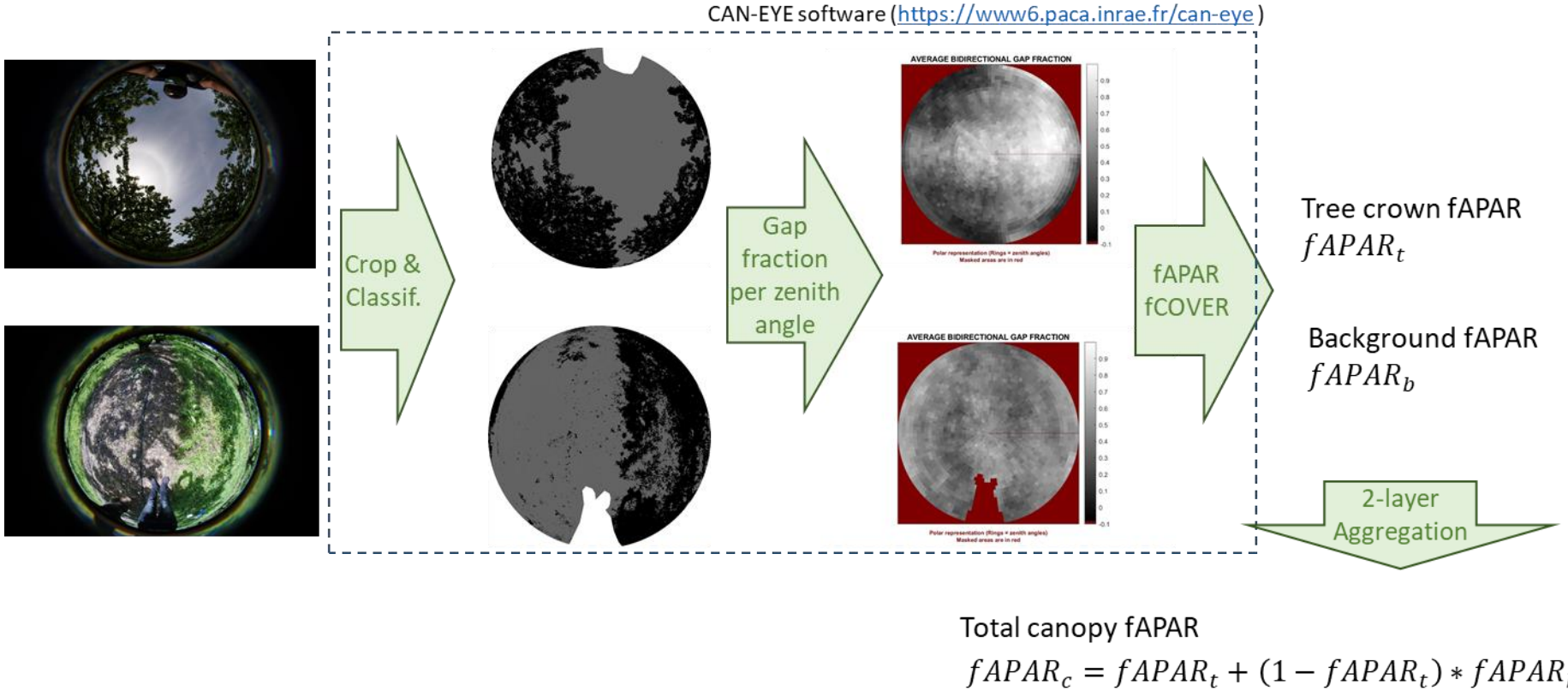
In situ sampling with digital hemispherical photographs:
up- and down-looking

2 dates: 5th May and 20th May 2021



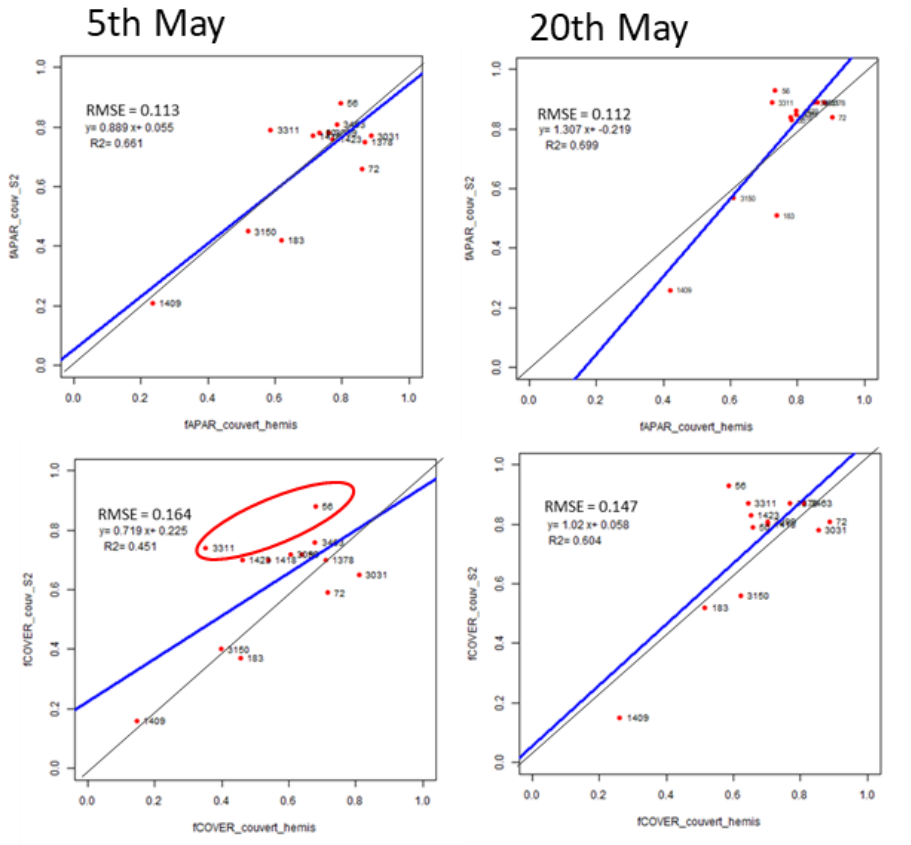
Materials and methods

In situ validation of fAPAR and fCOVER



Results

Validation of Sentinel 2 fAPAR and fCOVER products

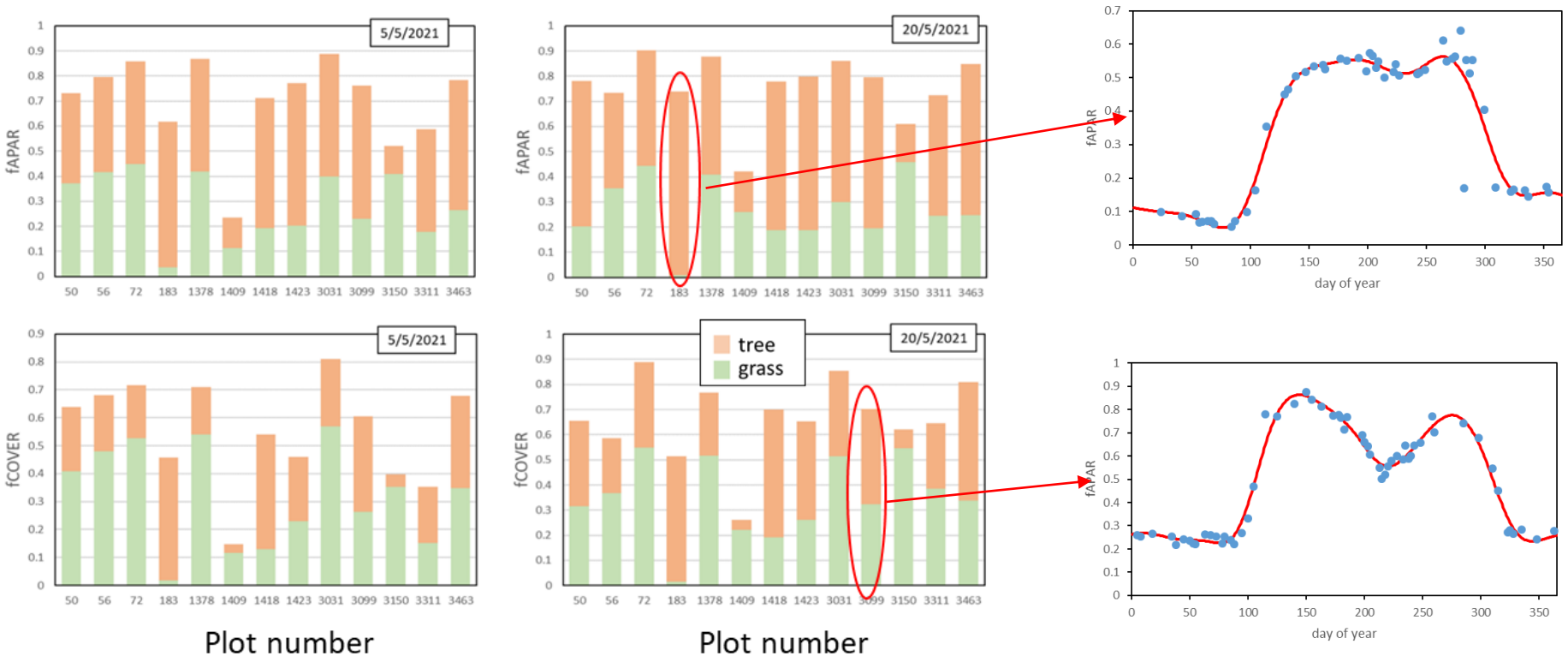


Overall, satisfactory results for total canopy fAPAR and fCOVER ($fAPAR_c$, $fCOVER_c$), RMSE 0.1 – 0.15

Slight over-estimation on specific plots with a small contribution from trees

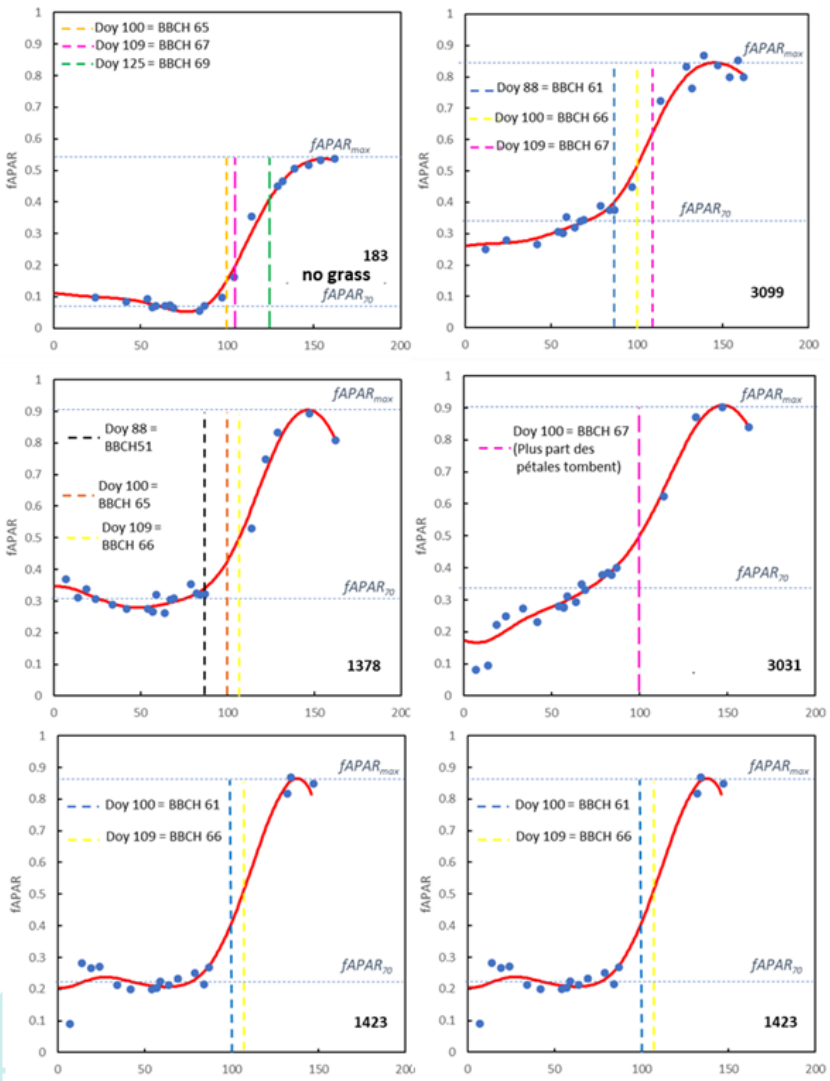
Results

Contribution of soil background to the total canopy fAPAR/fCOVER



Results

Relationshp between fAPAR/fCOVER and phenological dates



Normalising fAPAR and fCOVER to mitigate the influence of soil background

$$fAPAR_n = 100 * \frac{fAPAR_j}{fAPAR_{max} - fAPAR_{70}}$$

$fAPAR_{n,j}$: fAPAR normalisé (exprimé en %) pour le jour j,

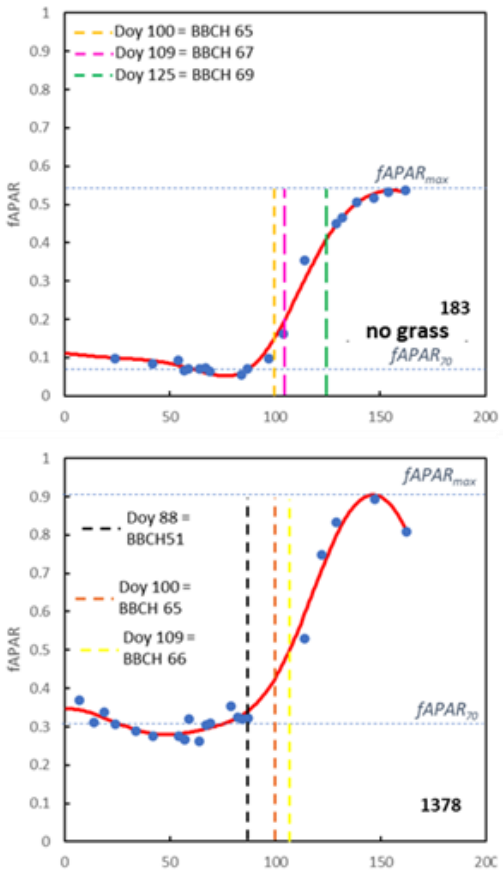
$fAPAR_{70}$: fAPAR at doy 70 (before flowering)

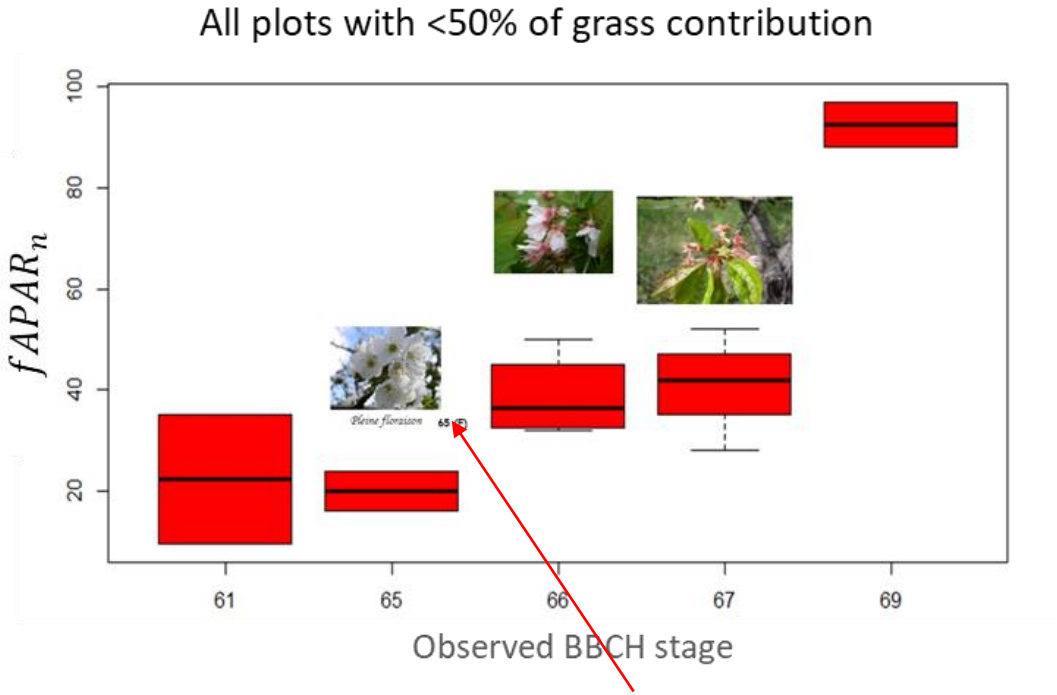
$fAPAR_{max}$: maximum fAPAR

Hypothesis: canopy greening after doy is exclusively driven by trees

Results

Relationshp between fAPAR/fCOVER and phenological dates





Full flowering occurs in during the first 20% of the total « greening »

Normalizing fAPAR permits to reduce the influence of the soil background

Conclusions and perspectives

- **Estimating phenological dates in orchards from satellite is challenging**, with grass in the background impacting the interpretation of time-series

- **Normalizing the fAPAR and fCOVER** with seasonal values (min, max) **reduces the effect of the background**. The **relationship** between the normalized indicators **with full flowering** dates seems consistent across plots

- Nevertheless, **quantifying the error** between observed and predicted dates **is still needed**. -> More observations

- **Disentangling the time-series** of grass and tree crowns **requires higher resolution**: e.g. SkySat (1m multispectral). In 2021, we are evaluating this possibility with UAV.