"Digitalization of webcam images of abricot trees for determination of phenological timing"

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State of the art

Object recognition usually uses 3 types of information

1) The shape of the object

2) The texture

3) The color

(Lambrecht, 2010)

2

State of the art

Shape of plants

Drought stress may lead to wielting of plants

=>Rolling in of leaves of cereals

=>Hanging of leaves

3

State of the art: method based on shape

Further calculations to detect plant stress

Well watered plants

Last row – 28.5.

Plant suffering from drought stress

Last row – 29.5.

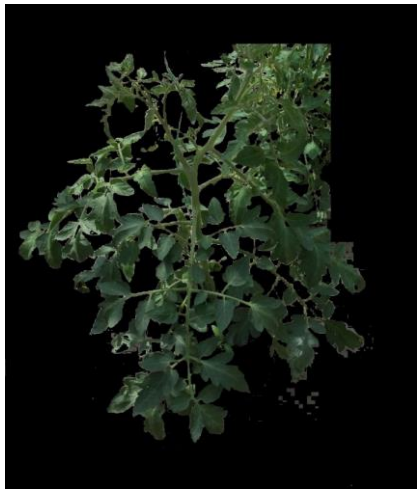
4

State of the art: method based on shape

Detect green colour

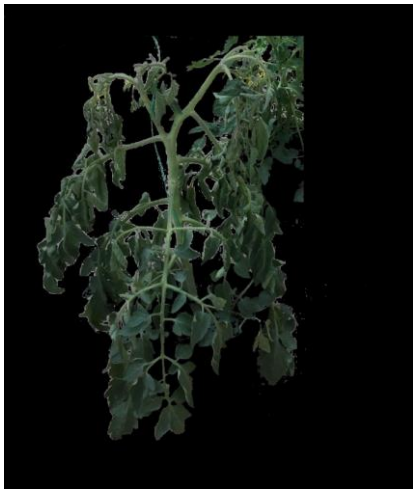
Well watered plants

Last row – 28.5.



Plant suffering from drought stress

Last row – 29.5.



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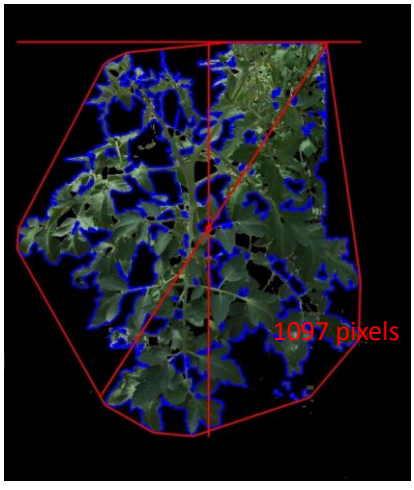
State of the art: method based on shape

Calculate center of plant and the minor axis of the ellipse (red) using plantCV software (Gehan et al., 2017)

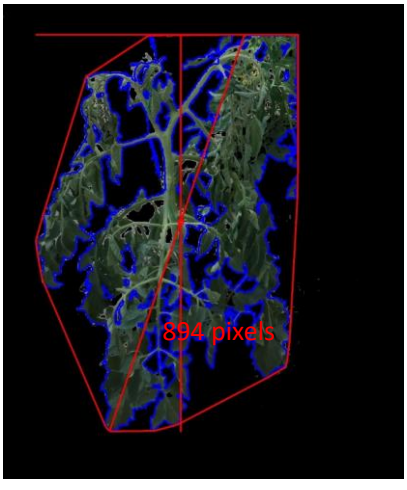
Well watered plants

Last row – 28.5.



Plant suffering from drought stress

Last row – 29.5.



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State of the art:

Analysis of images for determination of phenological timing is usually based on non automatic visual procedures

Some recent studies such as Bohlmann et al (2017) developed algorithms to automatically determine leaf growth of vegetation using webcam images and color detection

Research question of the present study:

Is it possible to automatically determine flowering using webcam images?

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METHODS: Site and available data

1) We are using webcam images of abricot trees

2) 5 years of data were made available to us by the company kbit and the „Verein Wachauer Marille“.

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METHODS

We first test 2 methods based on color differences

1. Method based on changes of white pixels due to flowering
2. Indirect method based on the burgeon pixels

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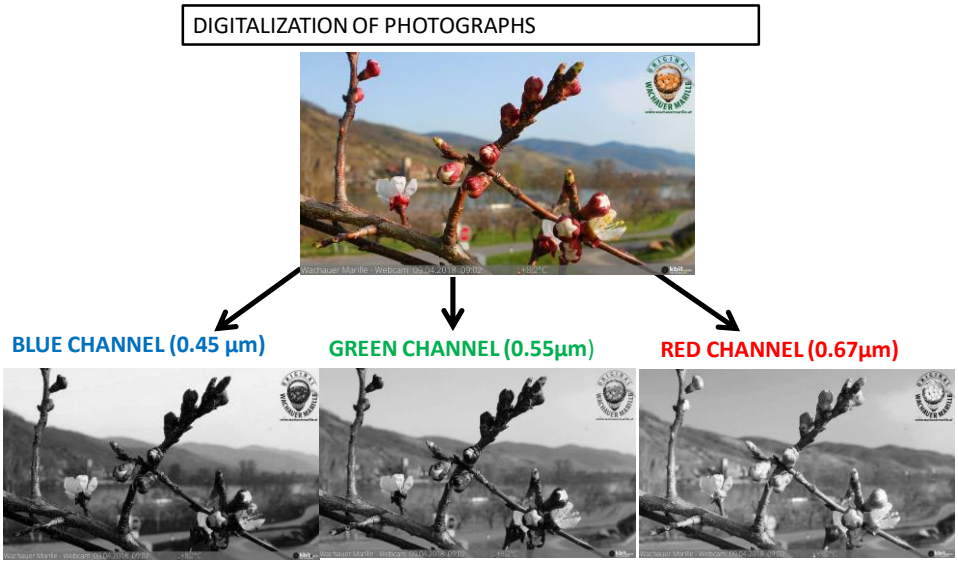
Plant monitoring using cameras and web cams: introduction



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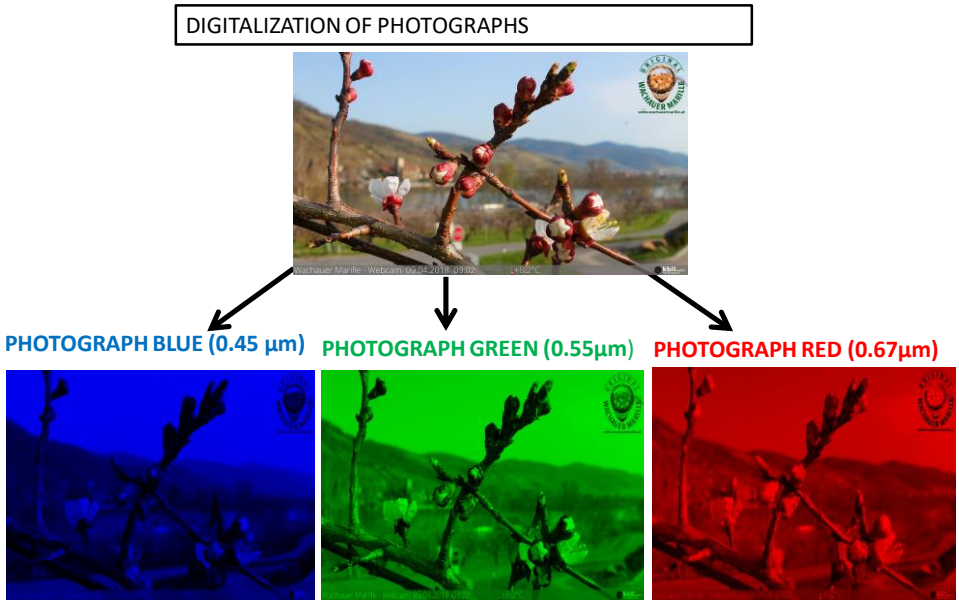
3. Plant monitoring using cameras and web cams: introduction



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Plant monitoring using cameras and web cams:

AUTOMATIC ANALYSIS OF WEBCAM IMAGES

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Plant monitoring using cameras and web cams: detection of white pixels

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Plant monitoring using cameras and web cams: detection of white pixels

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Plant monitoring using cameras and web cams: detection of white pixels

Automatic detection of flowers
Grayscale image Threshold = 130

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Plant monitoring using cameras and web cams: detection of white pixels

Automatic detection of flowers
Grayscale image Threshold = 150

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Plant monitoring using cameras and web cams: detection of white pixels

Automatic detection of flowers
Grayscale image Threshold = 150, remove blue sky

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Plant monitoring using cameras and web cams: detection of white pixels

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Plant monitoring using cameras and web cams: detection of white pixels

Automatic detection of flowers
Grayscale image Threshold = 130

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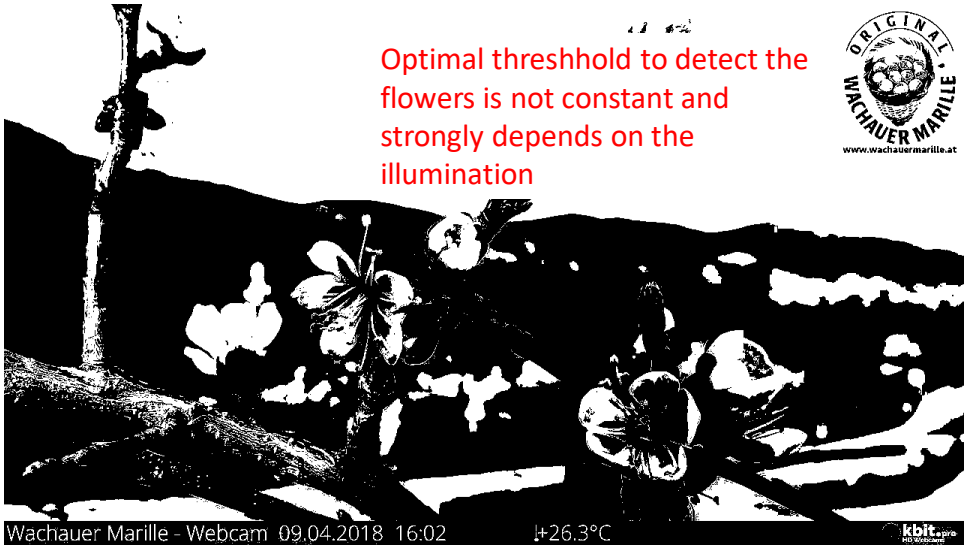
Plant monitoring using cameras and web cams: detection of white pixels

Automatic detection of flowers
Grayscale image Threshold = 150



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Plant monitoring using cameras and web cams: detection of white pixels

Correction of scene illumination: correction algorithm of Sonnentag et al., 2012

Pixel(R,G,B) = > Pixel (R*3*255/T, G*3*255/T, B*3*255/T)

Where T = R + G + B
R = pixel in red channel (1 – 255)
G = pixel in green channel (1 – 255)
B = pixel in blue channel (1 – 255)

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Plant monitoring using cameras and web cams: detection of white pixels

Correction of scene illumination

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Plant monitoring using cameras and web cams: detection of white pixels

Determine red pixels

If R > G +80 => Pixel = (255, 255, 255)

R = pixel in red channel (1 – 255)
G = pixel in green channel (1 – 255)
B = pixel in blue channel (1 – 255)

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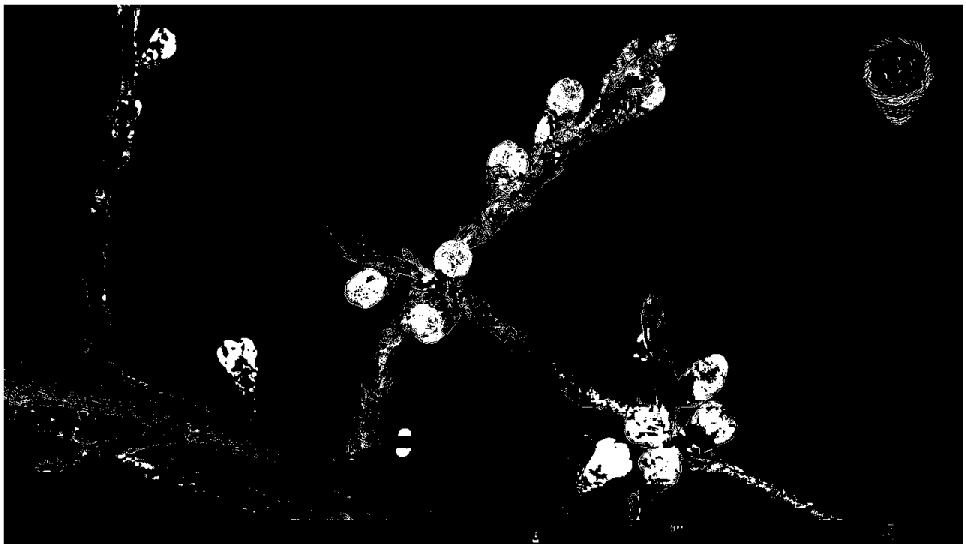
Plant monitoring using cameras and web cams: detection of white pixels



Determination of red pixels

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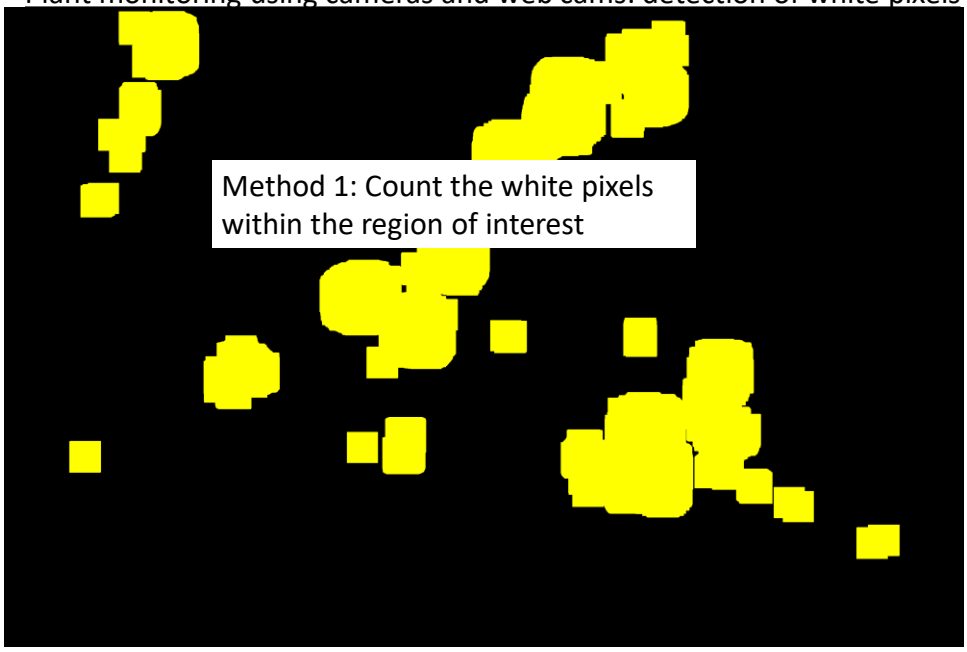
Plant monitoring using cameras and web cams: detection of white pixels



Determination of „region of interest“

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Plant monitoring using cameras and web cams: automatic analysis of web cams

Detect green leaves using

Greenness index = G/(R +G+B)

(Bolhmann et al. , 2017)

Excess greenness index = 2*G – (R + B)

(Hufkens et al., 2012)

G = green raw counts, R = red raw counts, B = blue raw counts

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Plant monitoring using cameras and web cams: automatic analysis of web cams: detection of green leaves

Detect green leaves

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Detection of green leaves
using Excess greenness index

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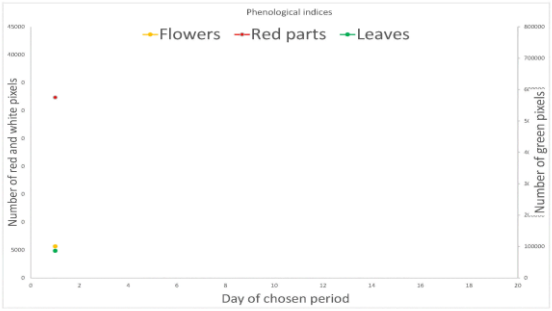
Detection of burgeons, flowers and green leaves using , redness index, flower algorithms and greenness index

Number of pixels



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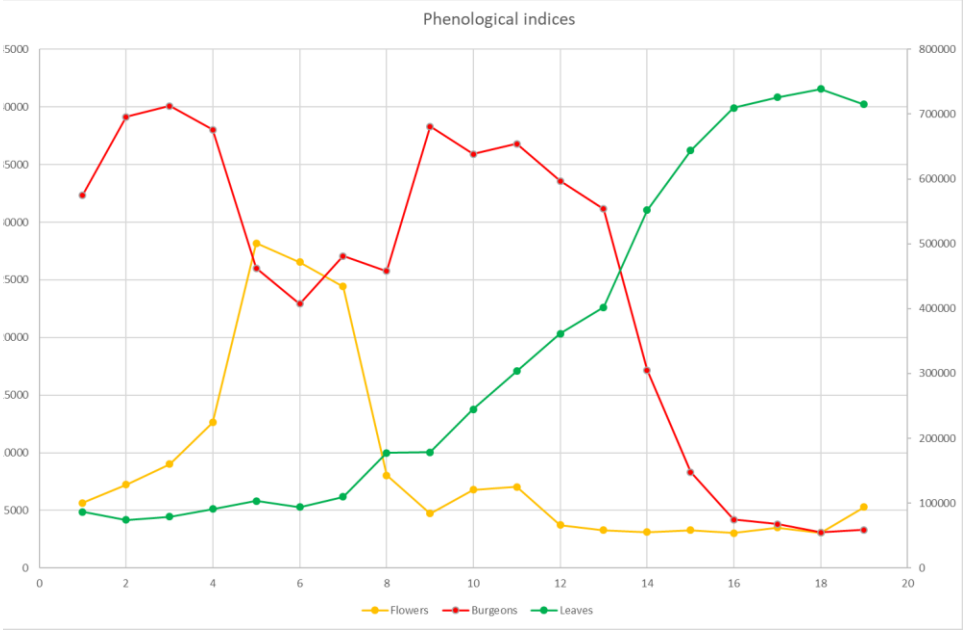
<u>Plant monitoring using cameras and web cams: automatic analysis of web cams</u>



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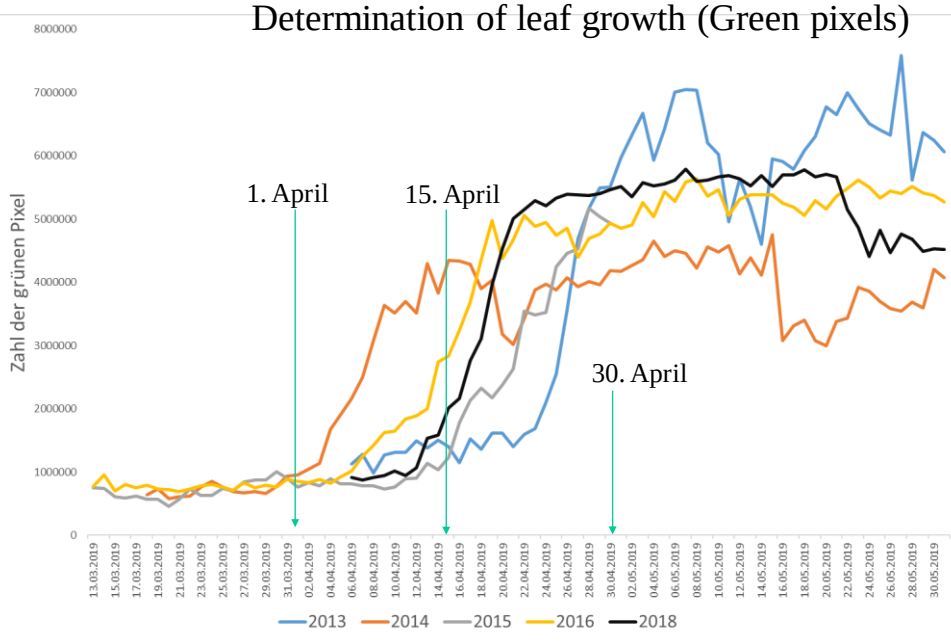
Determination of leaf growth (Green pixels)



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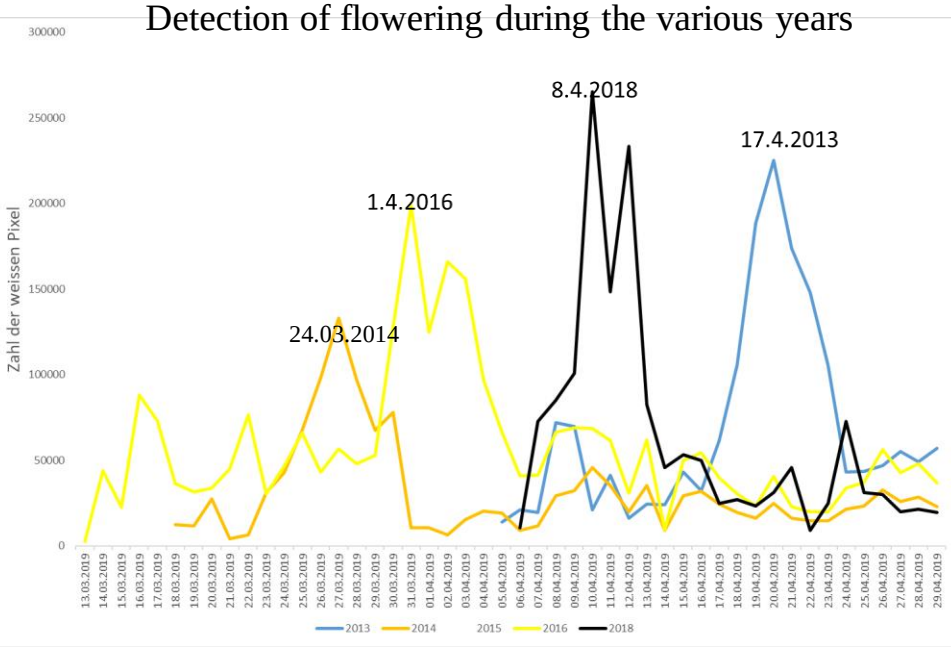
Detection of flowering during the various years



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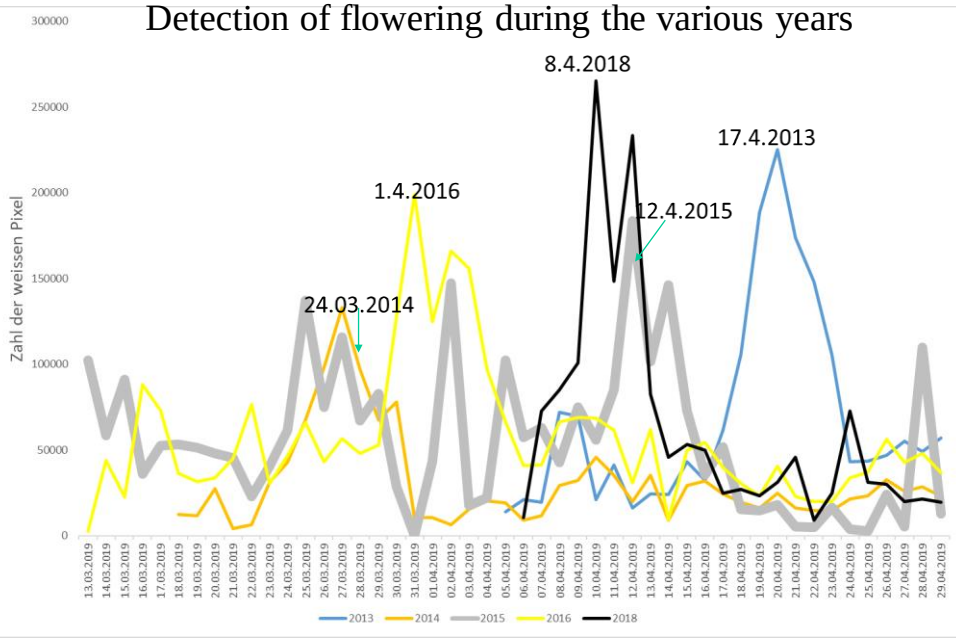
Detection of flowering during the various years



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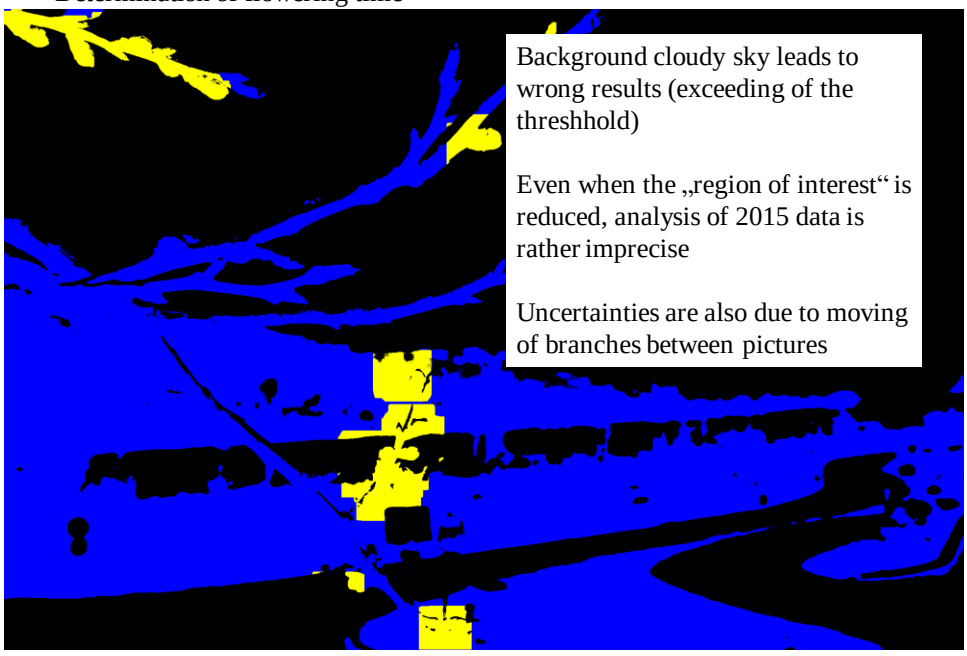
Determination of flowering time



Background cloudy sky leads to wrong results (exceeding of the threshhold)

Even when the „region of interest“ is reduced, analysis of 2015 data is rather imprecise

Uncertainties are also due to moving of branches between pictures

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Plant monitoring using cameras and web cams: 2 nd method based on buds

20.3.2019

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Plant monitoring using web cams: 2nd method based on buds

22.3.2019

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Plant monitoring using web cams: 2nd method based on buds

24.3.2019

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Plant monitoring using web cams: 2nd method based on buds

25.3.2019

38

Plant monitoring using web cams: 2nd method based on buds

26.3.2019

39

Plant monitoring using web cams: 2nd method based on buds

27.3.2019

40

Plant monitoring using web cams: 2nd method based on buds

28.3.2019

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Plant monitoring using web cams: 2nd method based on buds

29.3.2019

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Plant monitoring using web cams: 2nd method based on buds

30.3.2019

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Plant monitoring using web cams: 2nd method based on buds

1.4.2019

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Plant monitoring using web cams: 2nd method based on buds

Simple test with algorithm: 1) Correction of illumination and selection of red pixels
2) Calculation of mean intensity of 5x5 pixels (Mmean)
3) Select pixels where mean > 50
4) Determine number of these pixels (npixels)

FIRST VERY PRELIMINARY TEST RESULTS COMPARISON WITH FIRST METHOD:

	OBSERVATIONS		IMAGE ANALYSIS	
2013:	Beginning of flowering	17.4.2013	Max. npixels,	17.4.2013
	Max. of flowering appr.	19.4.2013	Max. Mmean	17.4.2013
			Max. white pixels	17.4.2013
2015:	Beginning of flowering	9.-10.4.2015	Max. Mmean	6.4.2015
	Max. of flowering appr.	10.4.2015	Max. npixels	11.4.2015
			Max. white pixels	12.4.2015
2016:	Beginning of flowering	25.3.2016	Max. npixels	25.3.2016
	Max. of flowering appr.	1.4.2016	Max. Mmean	25.3.2016
			Max.white pixels	1.4.2016
2018:	Beginning of flowering	8-9.4. 2018	Max. white pixels	8.4. 2018
	Max. of flowering appr.	11.4.2018	Max. npixels	10.4.2018
			Max. Mmean	10.4.2018

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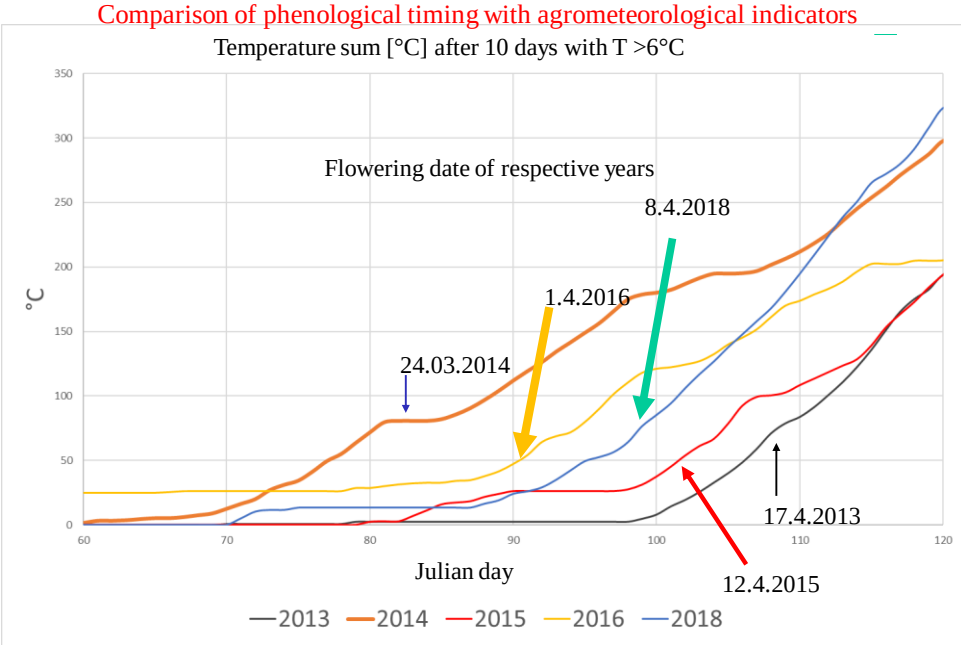
Comparison of phenological timing with agrometeorological indicators



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4. Conclusion

Automatic Webcam analysis works well for the determination of green leaves.

The determination of white flowers is more difficult. Two methods were tested within the scope of the present study.

The method 1 (white pixels) shows maximal values at the time of flowering but scattering is large

Uncertainty of the method is due to clouds in the background and moving of the branches

Method 2 (red pixels of buds) is still being evaluated. Some of the results are promising, but a method based on the shape of the buds could be the most suitable

Time of flowering shows a good correlation with temperature sum

OUTLOOK:
Test with algorithms based on the shape of the burgeons.

The appropriate algorithm needs first to be tested for each webcam.
Conditions of installation of webcams for phenological monitoring could be defined.

More detailed uncertainty and statistical analysis needs to be done

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Thank you for your attention!!

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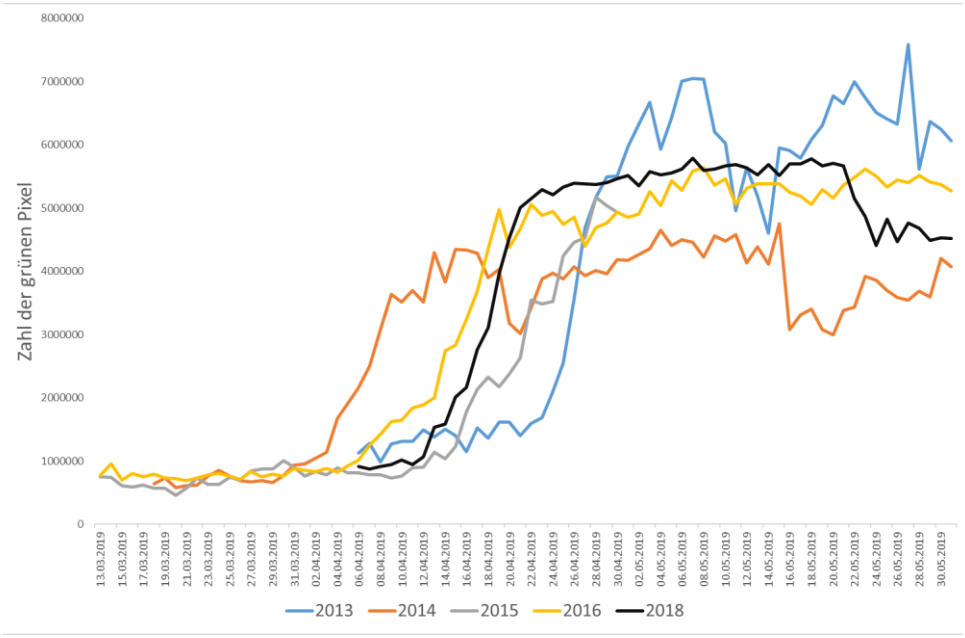
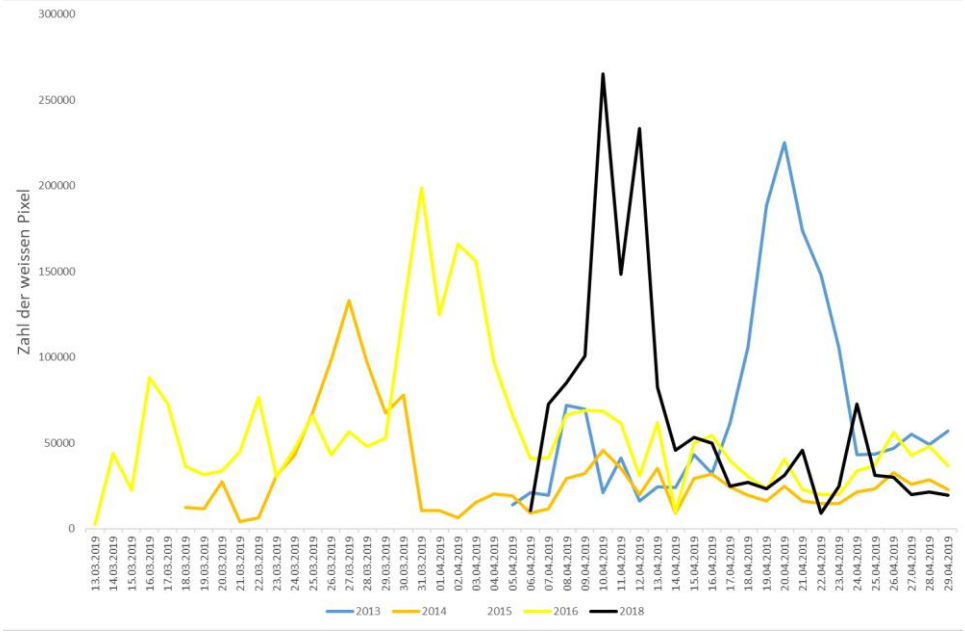
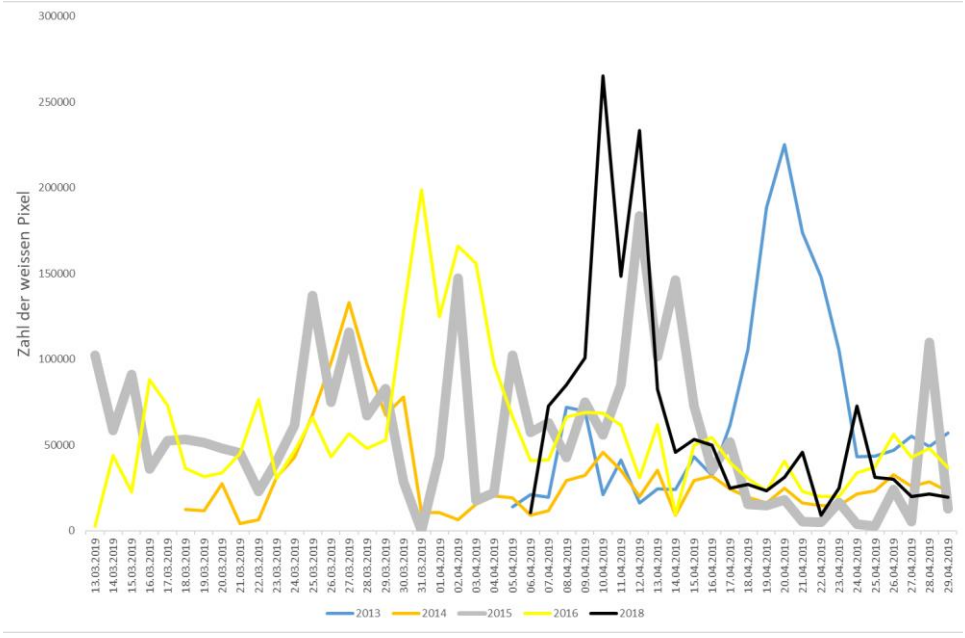

Zahl der grünen Pixel
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
2013
2014
2015
2016
2018

49


Zahl der weissen Pixel
300000
250000
200000
150000
100000
50000
0
2013
2014
2015
2016
2018

50



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3. Plant monitoring using cameras and web cams: automatic analysis of web cams

Correction of scene illumination

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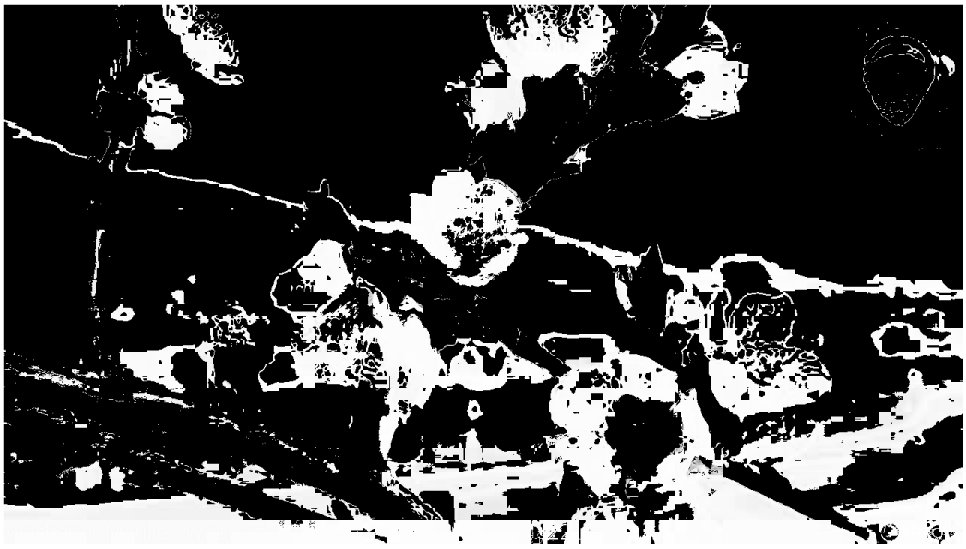
3. Plant monitoring using cameras and web cams: automatic analysis of web cams



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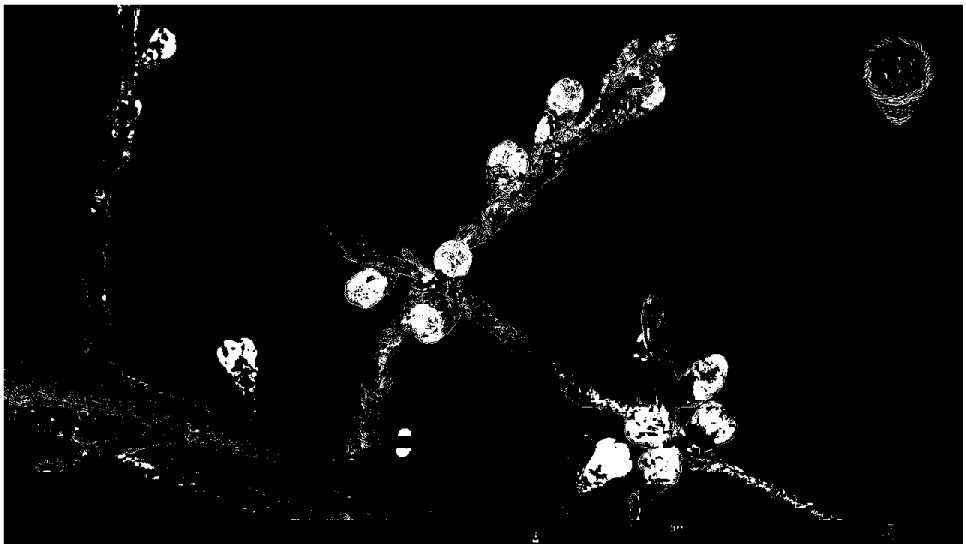
Plant monitoring using cameras and web cams: detection of white pixels



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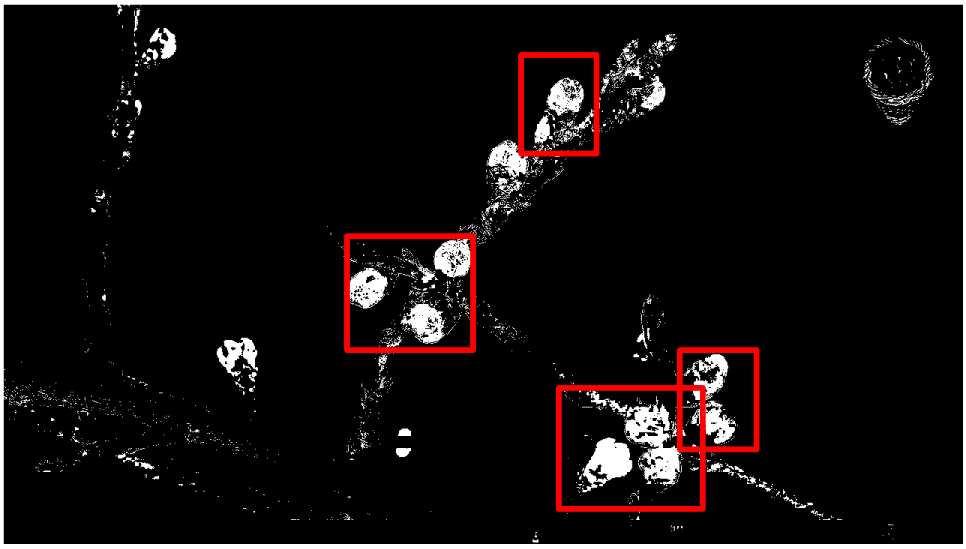
Plant monitoring using cameras and web cams: automatic analysis of web cams



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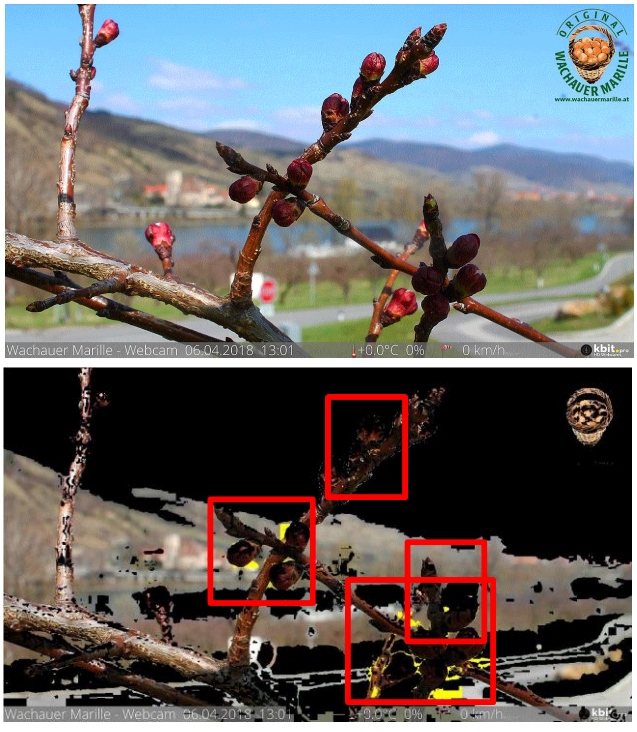
Detection of flowers at region of interest using greyscale image threshold 130 (red and green are filtered out before processing)



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3. Plant monitoring using cameras and web cams: automatic analysis of web cams

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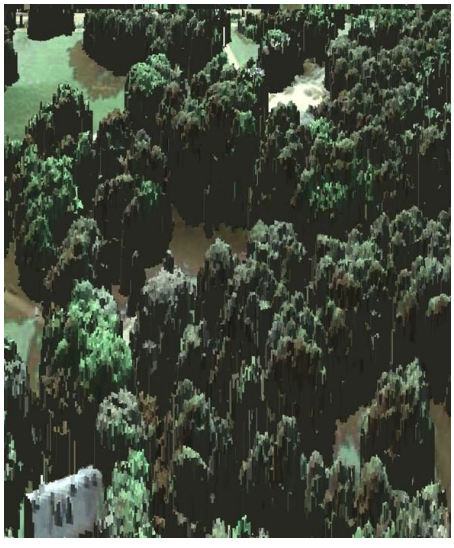
2. Thermal infrared methods: next issues solve problems of inhomogeneities in canopies

Analysis of energy balance using ray tracing radiative transfer models



Calculation of reflected radiance towards observer in the red, green, blue channels:

- 50 cm digital elevation map
- Reflectance in red, green and blue at the respective pixels

↓

Radiation model which calculates incident radiation and reflected radiance towards observer => ground reflectance field

↓

Radiative transfer model (Ray Tracing) which takes atmospheric effects into account

↓

Combine 3 RGB channels to make a visible picture

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