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FMI IMAGE PROCESSING TOOL

(FMIPROT)

FIRST DEVELOPMENTS

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Climate Change Indicators and Vulnerability of Boreal Zone Applying Innovative Observation and Modeling Techniques

MONIMET

LIFE12 ENV/FI/000409

PROJECT LOCATION: Helsinki

BUDGET INFO:

Total amount: 2,755,288 €

% EC Co-funding: 1,366,952 €

DURATION: Start: 02/09/13 - End: 01/09/17

PROJECT'S IMPLEMENTORS:

Coordinating Beneficiary: Ilmatieteen Laitos (FMI)

Associated Beneficiary(ies): Luonnonvarakeskus (LUKE), Suomen Ympäristökeskus (SYKE), Helsingin Yliopisto (UHEL)

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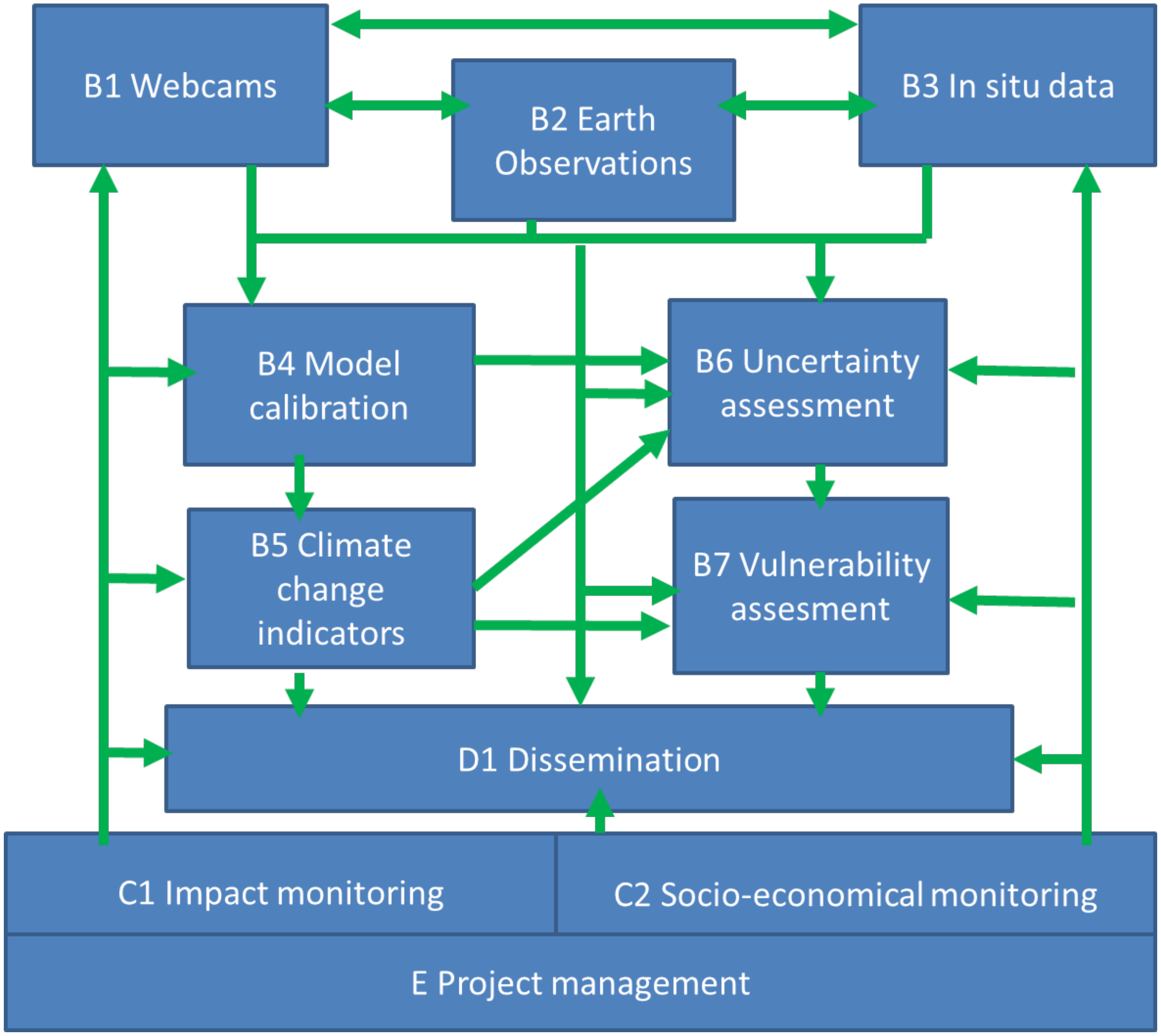
OBJECTIVES

- **To collect information, data and expertise that is currently spread over several institutes, in order to build a comprehensive platform for analysing climate change effects on seasonal dynamics of various phenomena**

- **To create links and add value to existing monitoring mechanisms such as ICOS and EO systems (GMES/COPERNICUS) and make use of data acquired in previous EU Life+ funded, and other projects related to ecosystem monitoring**

- **To create new webcam monitoring system in order to facilitate Earth Observation systems by providing time-series of field observation for calibration and validation, as well as to improve the assessment of forest ecosystem services**

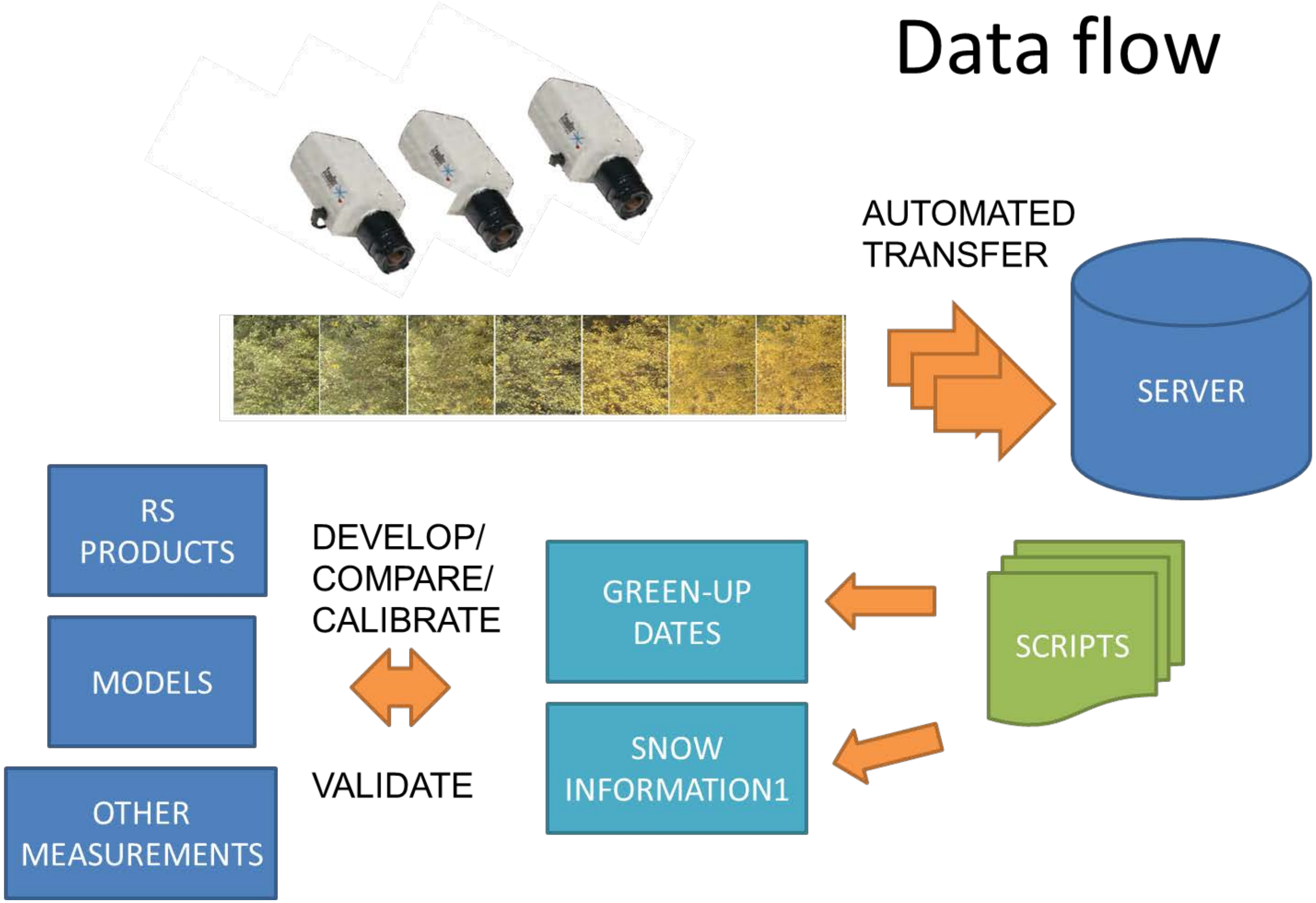
- **To synthesize modeling and observation approaches to identify climate change indicators**
- **To establish link between the climate change indicators and their effects in order to create vulnerability maps of boreal zone in connection to climate change scenarios**


B1 Webcams
B2 Earth Observations
B3 In situ data
B4 Model calibration
B6 Uncertainty assessment
B5 Climate change indicators
B7 Vulnerability assesment
D1 Dissemination
C1 Impact monitoring
C2 Socio-economical monitoring
E Project management

IMPLEMENTATION:

- The first step is implementing an innovative new system for in situ monitoring: a webcam network. This new network will provide an unparalleled insight into forest ecosystem services, enabling spatially representative monitoring of vegetative processes and their change over time. Indeed, this work will lead to the design and harmonisation of webcam networks all over Finland.

Data flow


AUTOMATED TRANSFER
SERVER
RS PRODUCTS
MODELS
OTHER MEASUREMENTS
DEVELOP/ COMPARE/ CALIBRATE
VALIDATE
GREEN-UP DATES
SNOW INFORMATION1
SCRIPTS

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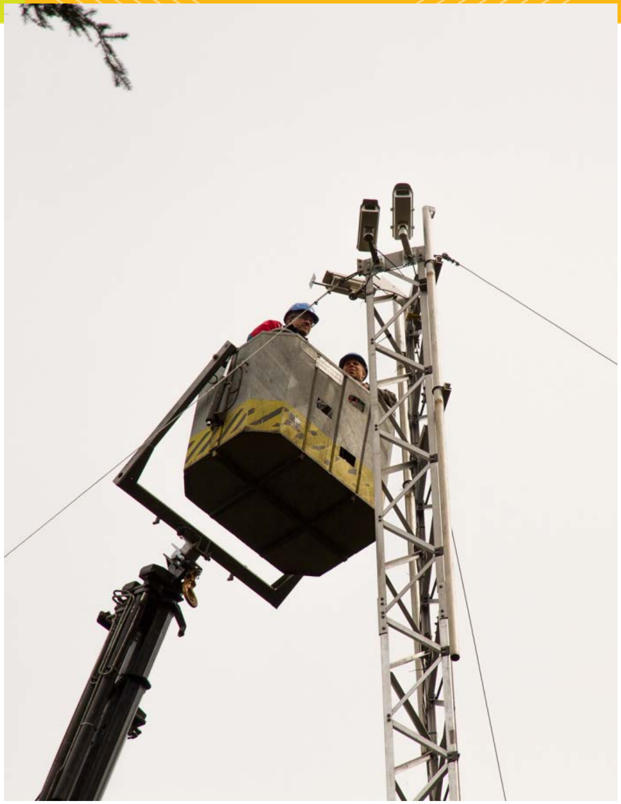
Cameras supporting research



- **time-series document about seasonal phenomena**
  - Phenological timings: budburst, shoot growth (length and timing)
  - Damages at research site
  - etc
- **Quality control of other instruments, eg.**
  - Are snow depth sensors working?
- **How did the weather look like?**
- **Benefits all kind of research conducted at sites**

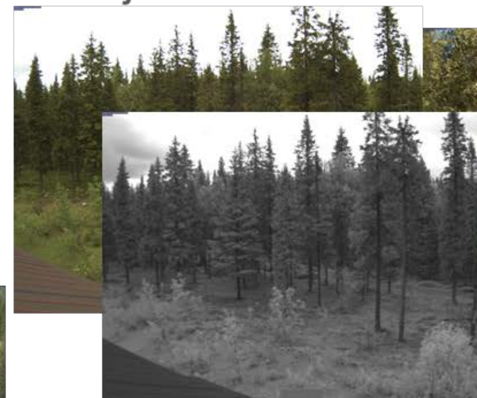
Camera sets ups 2015

Värriö

Kenttärova

Kaamanen

Paljakka



Lammi

Lompolonjänkä

Suonenjoki

Parkano

Background & Drivers

The idea of FMIPROT has first come out when MONIMET project team has started to use ``PhenoCam GUI´´ of PhenoCam project. [1] PhenoCam GUI is an image processing tool to get phenological data from the images of PhenoCam network. But PhenoCam GUI,

- **Covers phenological analysis,**
- **Requires certain filename convention**
- Requires to download images manually

The University of Hampshire, PhenoCam Network – Software Tools, http://phenocam.sr.unh.edu/webcam/tools/

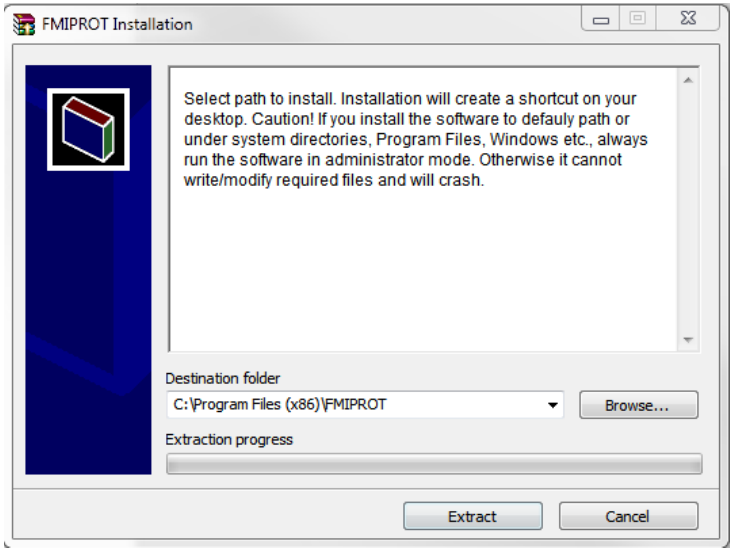
Thus, a more suitable and expandable tool is planned to;

- Download and handle images automatically,
- **Be designed in a way that more types of analysis will be added in time,**
- **Add more algorithms by external users,**
- **Be designed in a way to be used with many camera networks in the future**
- Be open source
- Be standalone

Introduction to FMIPROT

Software

- The language used in FMIPROT is **Python**.
- For GUI, **TkInter** module is used.
- Main module used for image processing is **Mahotas**.
- Software is now available only to project partners with distrubitions for
  - **Windows**
  - **Linux**
- **Installation is straightforward** for both distrubitions and does not require any auxilary installation; the code is compiled beforehand.
- Detailed **user manual** is included.



Windows installation dialog

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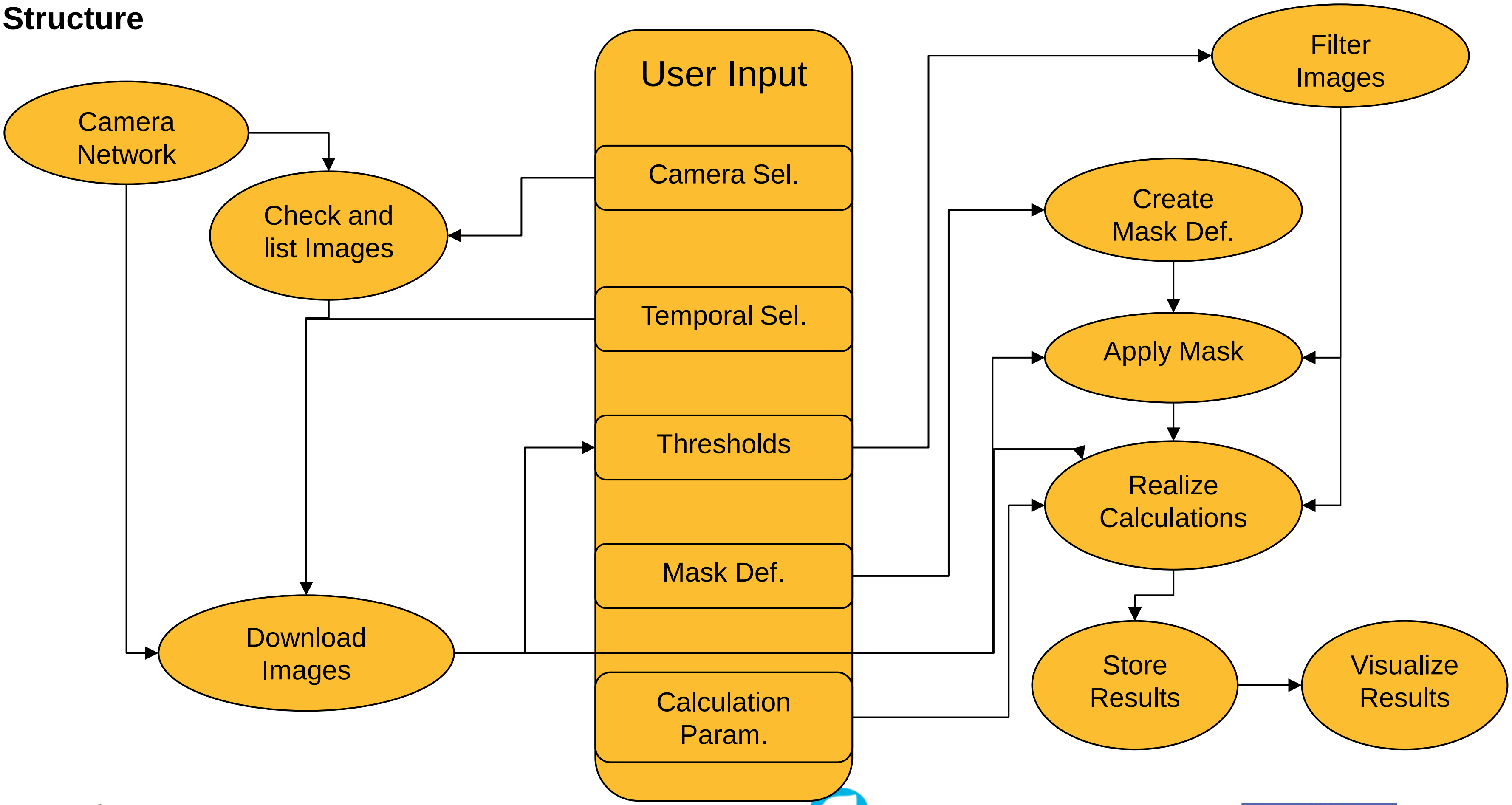
Introduction to FMIPROT

Structure



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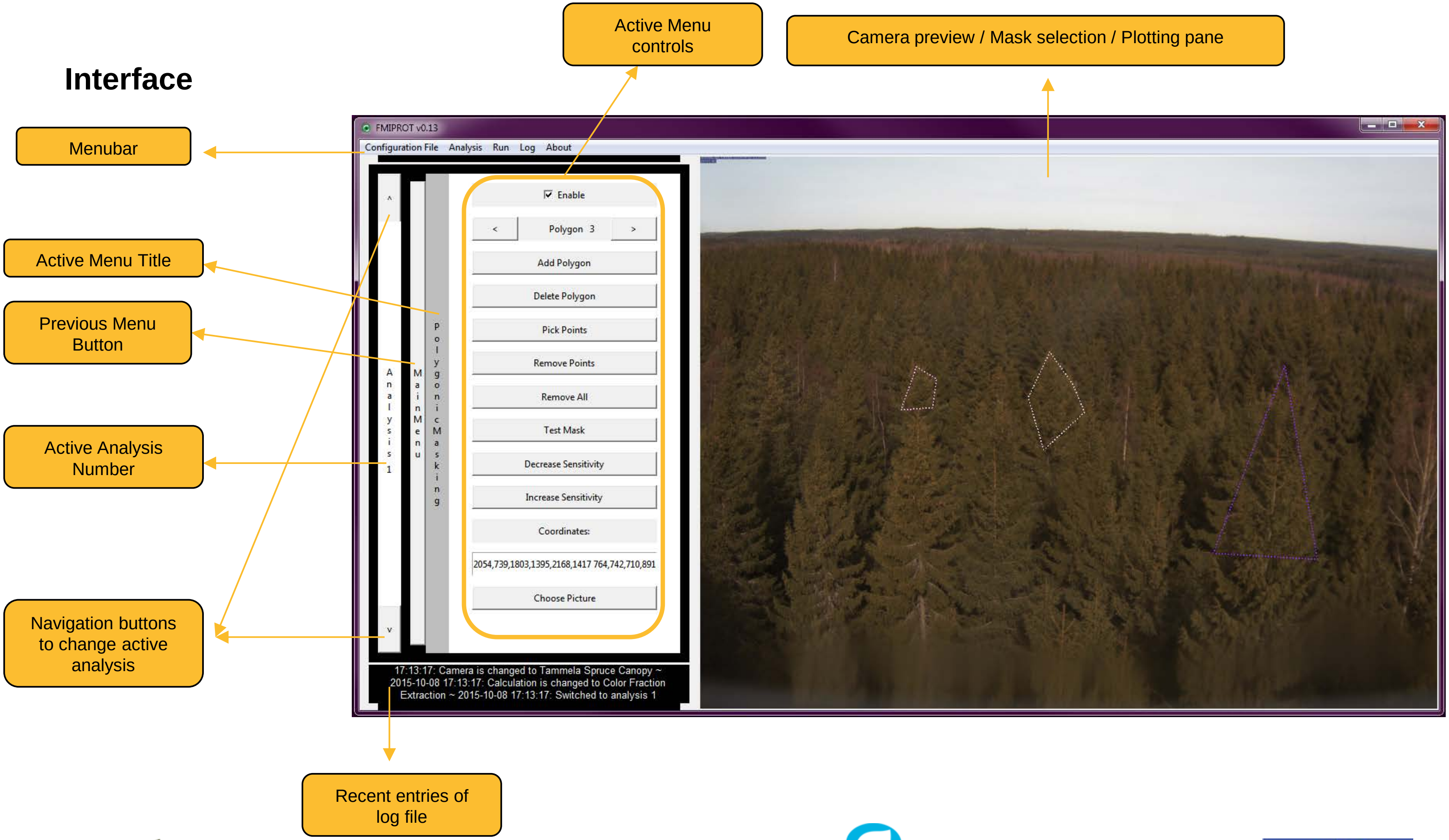
Introduction to FMIPROT

Interface



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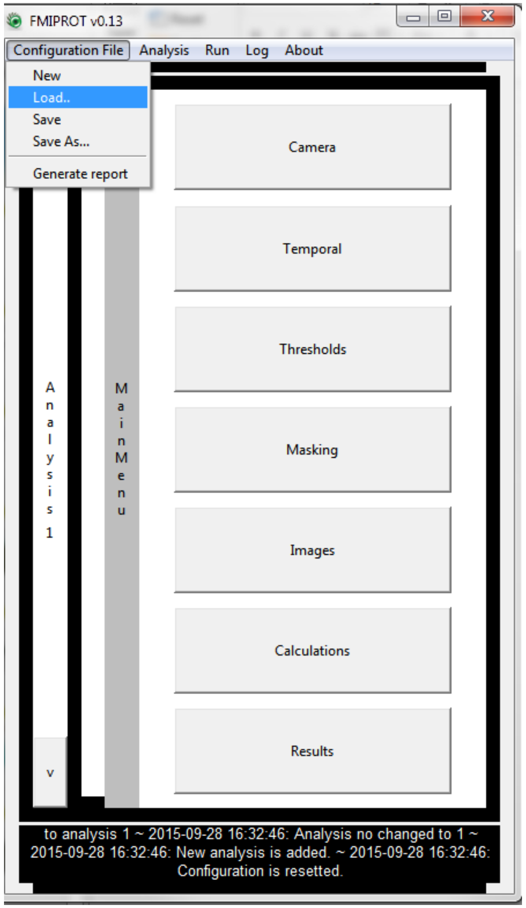
Introduction to FMIPROT

Configuration Files

Configuration files **store the input parameters of analyses**, to be loaded into FMIPROT later to modify/repeat analyses.

Configuration files provide possibility to,

- Make different types of **analyses at once** or same type of analyses with different input parameters **for comparative use.**
- Distribute the analyses parameters easily to **work with it in a group**
- Repeat anaylses in case of failure, software crash etc.



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Introduction to FMIPROT

Configuration Files

Configuration files store,

- Camera selection
- ROI Number (assigned automatically by the software)
- Temporal selections
- Threshold selections
- Masking selection
- Calculation selection(s) and input parameters

Configuration files are basicly text files, organized in its own way which is explained in the user manual.

Introduction to FMIPROT

Data Format of Results

Results from the analyses are saved as either **text files** with the extention ``.dat´´ or **HDF5** files with the extention ``.h5´´, depending on the dimensions of the output data.

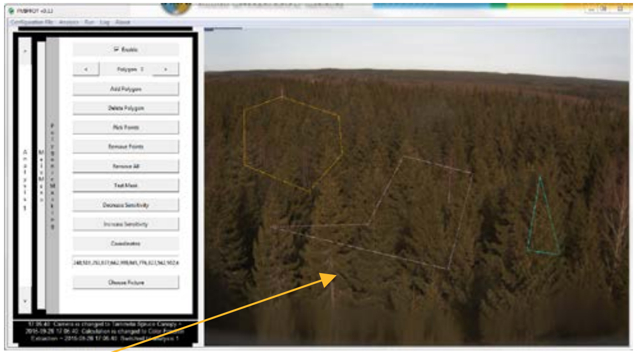
For one dimensional output, text files are used and each output array is recorded to a column, as time of the image/event is in the first column. First row is the header and contains the names of the arrays. Data types are dependent on the output that the analyses gives, but converted to strings to record to the text file. Below is an example for the result file content for color fraction analysis.

For the output data with more than one dimension, HDF5 files are used. HDF5 files can store different datatypes with different dimensions in the same file so it is quite convinient to use in that sense.

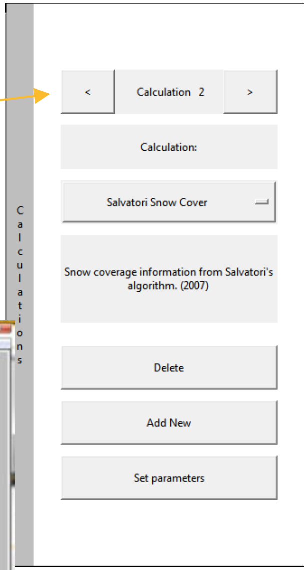
!Time	Blue Fraction	Green Fraction	Red Fraction	Brightness
2014-06-10_15:01:36	0.201534672656	0.419101416083	0.379363911261	0.221846544172
2014-06-11_10:01:35	0.193225028607	0.413768522727	0.393006448666	0.201502348727
2014-06-11_10:31:35	0.200048274019	0.412351012631	0.38760071335	0.210366631397
2014-06-11_11:01:35	0.190593235249	0.417636975312	0.391769789439	0.208757227443
2014-06-11_11:31:35	0.191850426232	0.417561216471	0.390588357297	0.215187387855
2014-06-11_12:01:37	0.192847409264	0.416182331703	0.390970259033	0.218922309308
2014-06-11_12:31:37	0.190220621901	0.416207212018	0.393572166081	0.225288752206
2014-06-11_13:01:38	0.193666456294	0.408274378219	0.398059165487	0.2464528901
2014-06-11_13:31:38	0.191274862779	0.415922234753	0.392802902469	0.219384240144
2014-06-11_14:01:38	0.188447545963	0.415934245851	0.395618208185	0.220065944836
2014-06-11_14:31:38	0.193560123697	0.414066584418	0.392373291886	0.217155547272
2014-06-11_15:01:38	0.191731485752	0.413774761427	0.394493752821	0.245630733007
2014-06-12_10:01:35	0.182602791227	0.430860449725	0.386536759048	0.187466373015

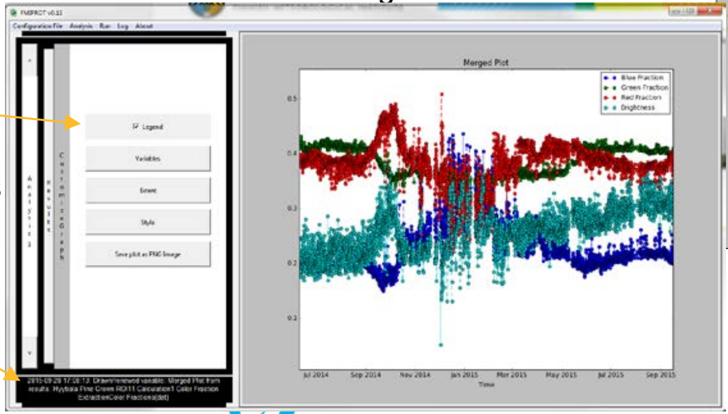
Introduction to FMIPROT

Features



- Connection to MONIMET Camera Network
- Temporal selection for images; seperately for date and time.
- Threshold selection for brightness and color index fractions of images
- Polygonic masking; **multiple polygons for one region of interest**
- Storing downloaded images for future analyses
- Possibility to use only downloaded images, independent of the network
- **Multiple calculations in one analyses**
- Report generation in HTML format for analysis configurations
- Check the image archive and report for quantitative information about images
- Plotting results for 1D and 2D data
- **Customizable plots**
- **Detailed logging**
- Possibility to run only one or all of the analyses





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Introduction to FMIPROT

Features – Connection to MONIMET Camera Network

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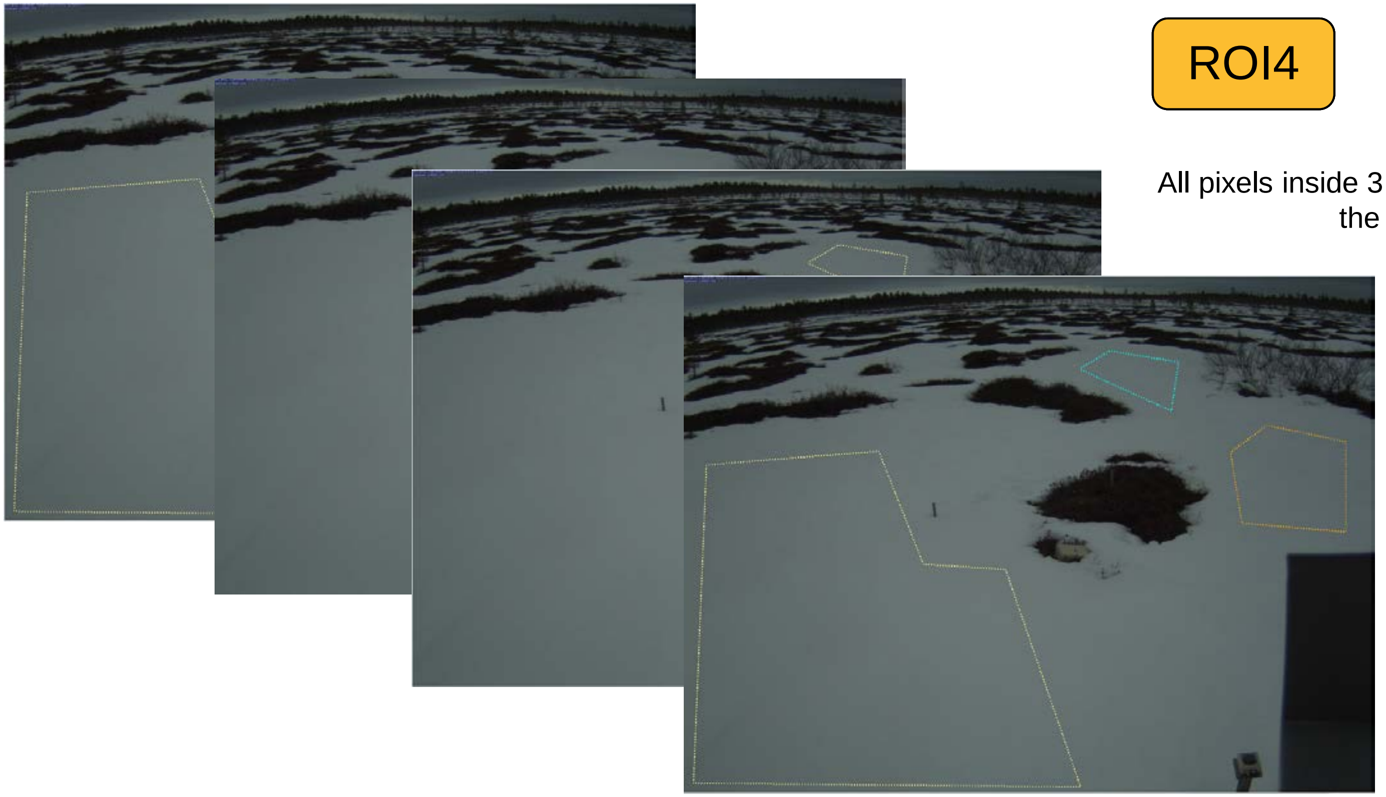
Features – Polygonic masking; multiple polygons for one region of interest



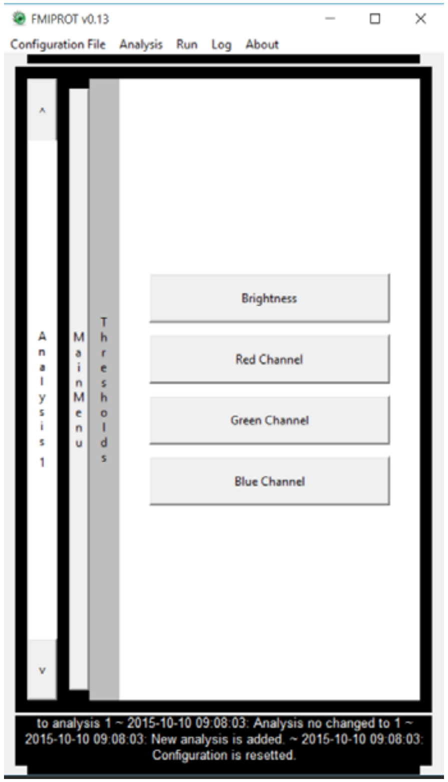
ROI4

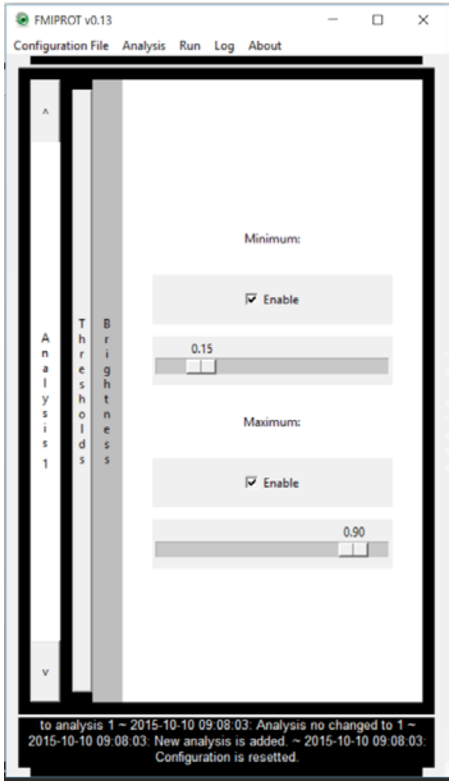
All pixels inside 3 polygons are included in the calculation

Introduction to FMIPROT

Features – Threshold selection for brightness and color index fractions of images

Selection:





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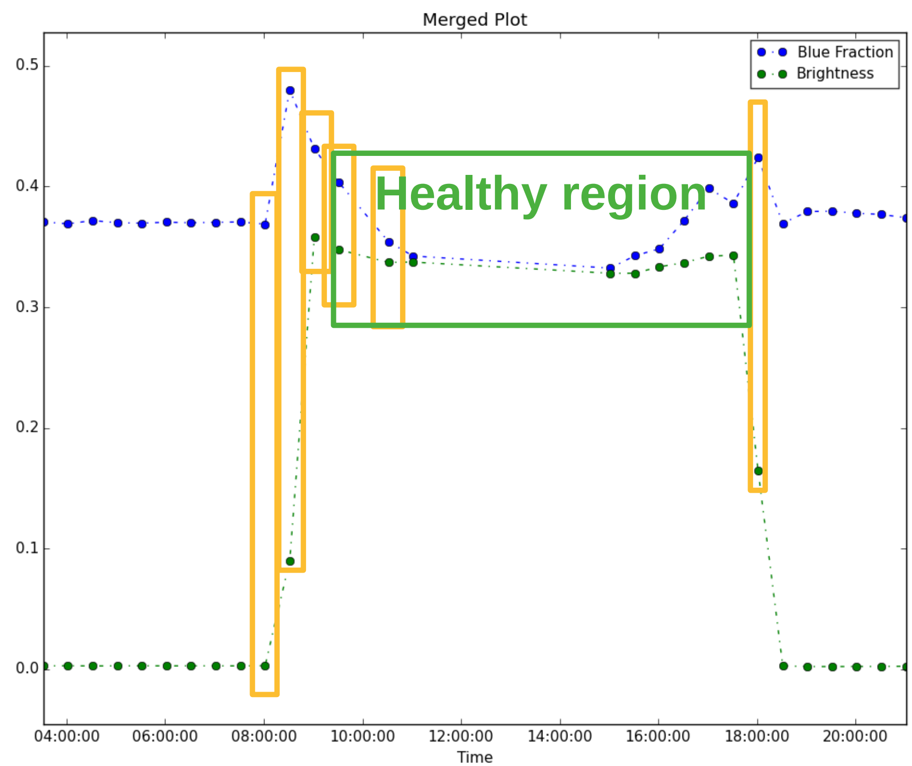
Introduction to FMIPROT

Features – Threshold selection for brightness and color index fractions of images

Example: Punkaharju Spruce Ground Camera Images for 05.02.2015

Time	Blue Fr.	Brightness
2015-02-05_08:01:34	0.368	0.003



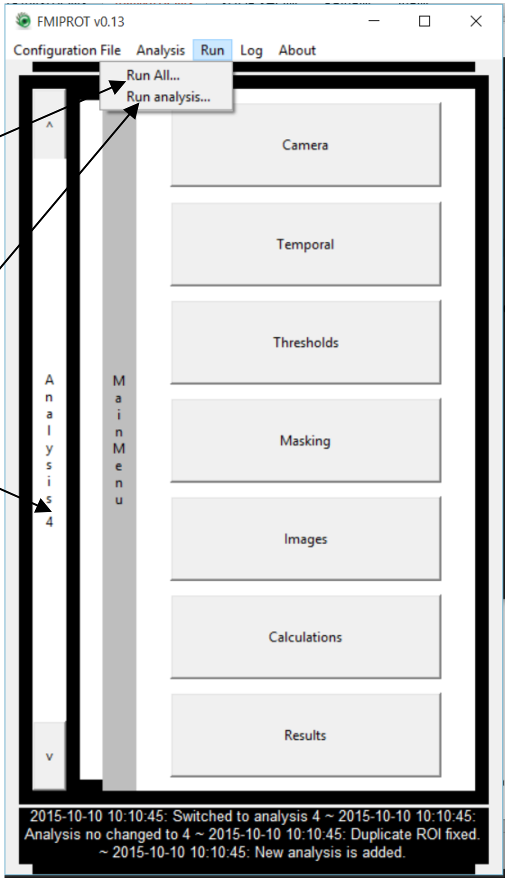
Color Fractions

Introduction to FMIPROT

Features – Run only one or all of the analyses

Run all analyses that are set up

Run only Analysis 4



Introduction to FMIPROT

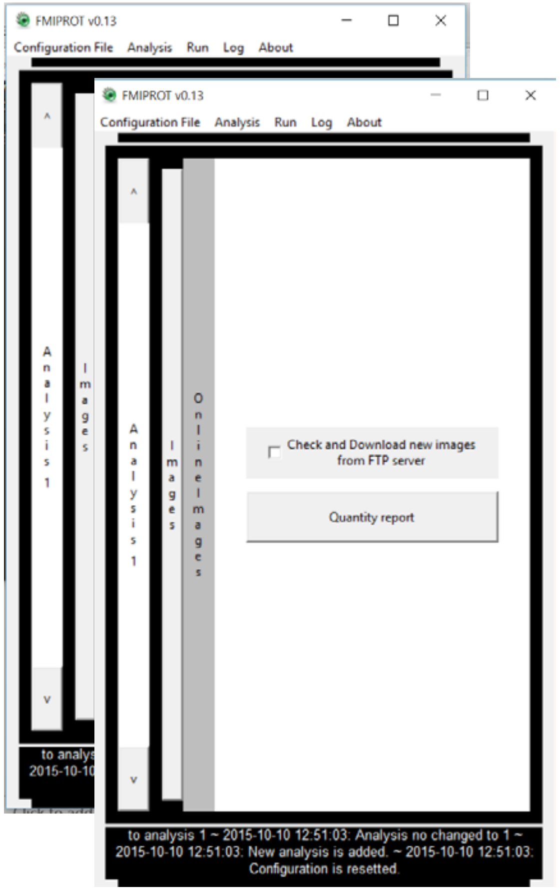
Features – Possibility to use only downloaded images, independent of the network

Select the path for local images to:

- Store the downloaded images from camera network to a specific directory
- User images already downloaded before from a specific directory

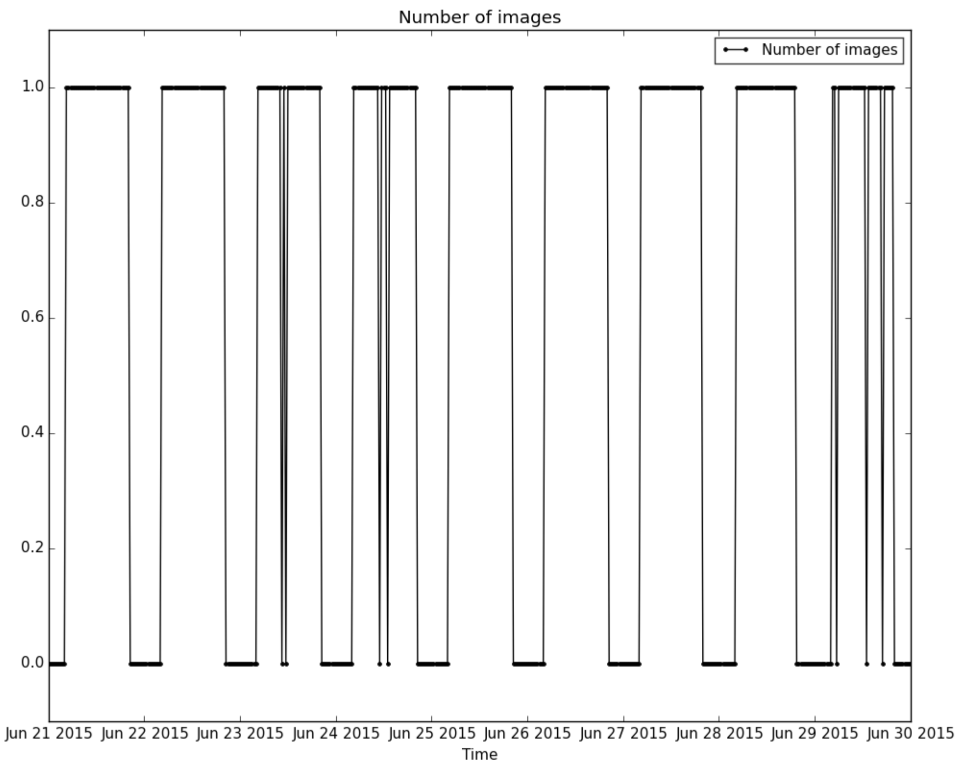
Disable “Check and Download new images from FTP server” to

- User only images that are downloaded before, do not download any images from the camera network



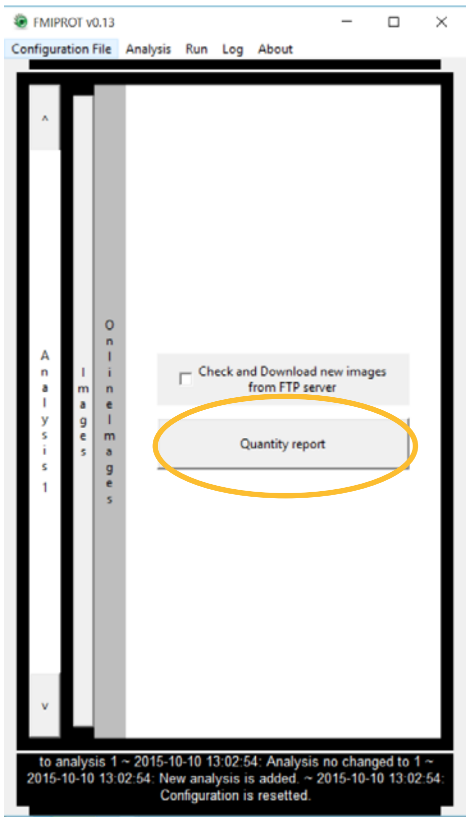
Introduction to FMIPROT

Features – Get quantitative information of images in the camera network with one button



Number of images per 30 minutes for Tammela Spruce Canopy Camera

Number of images per day for Tammela Spruce Canopy Camera



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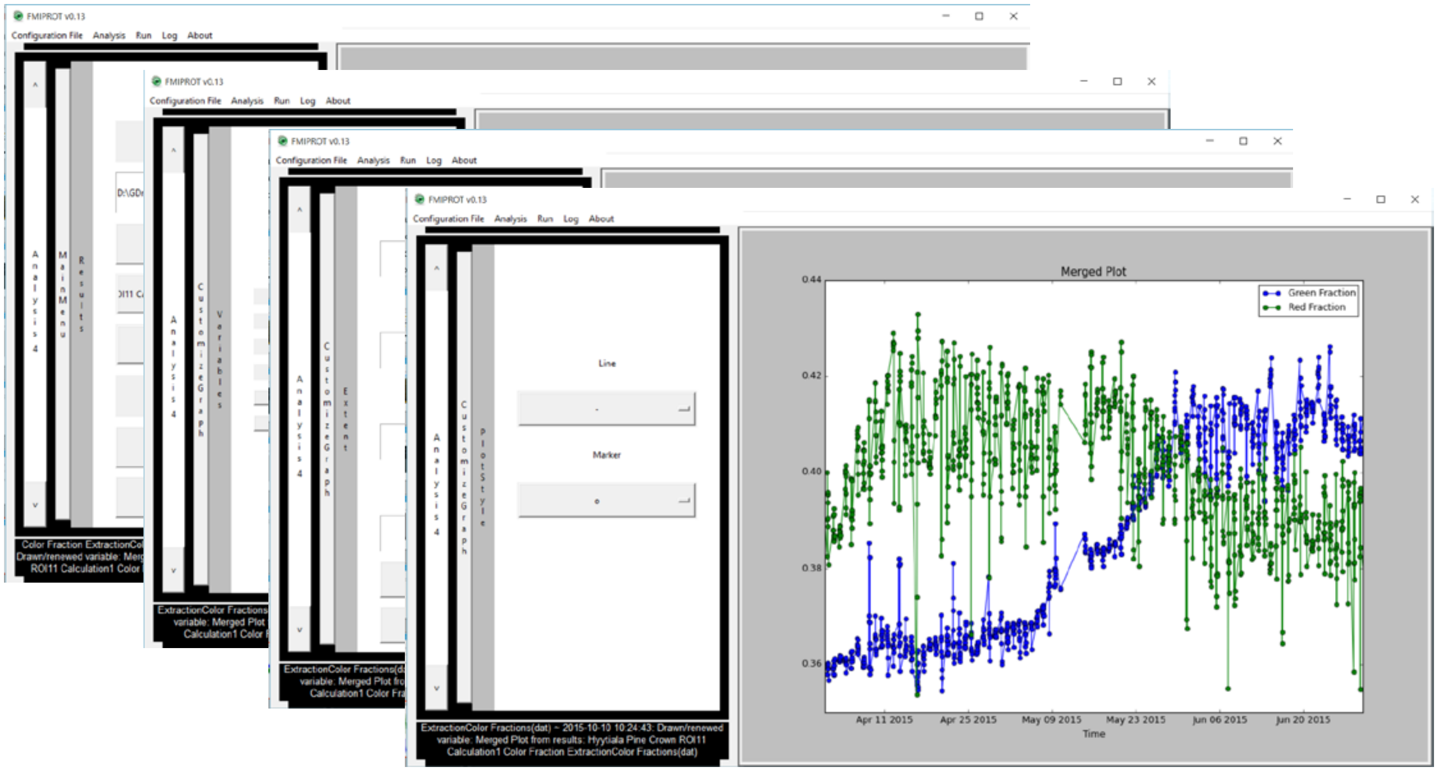
Introduction to FMIPROT

Features – Plotting



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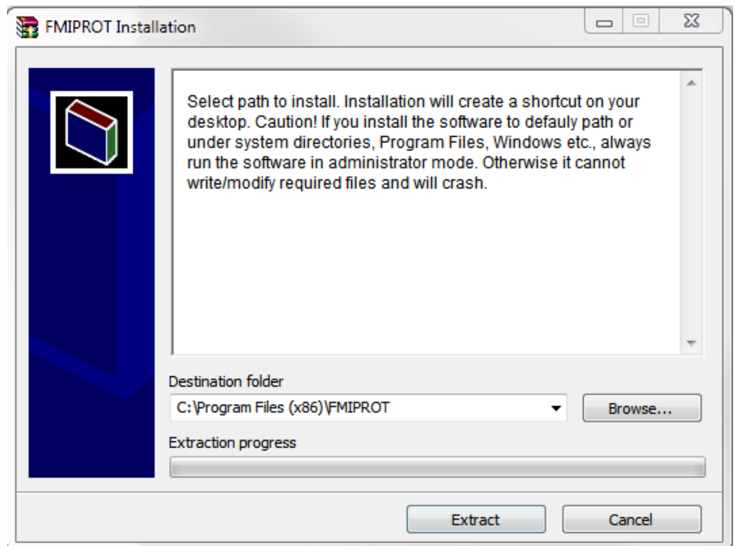
Step by Step Analysis

Installation

Windows:

Run installation file (fmiprot_v#_setup.exe). In the dialog, click “Extract”.



When it ends, run program from the shortcut in your desktop.

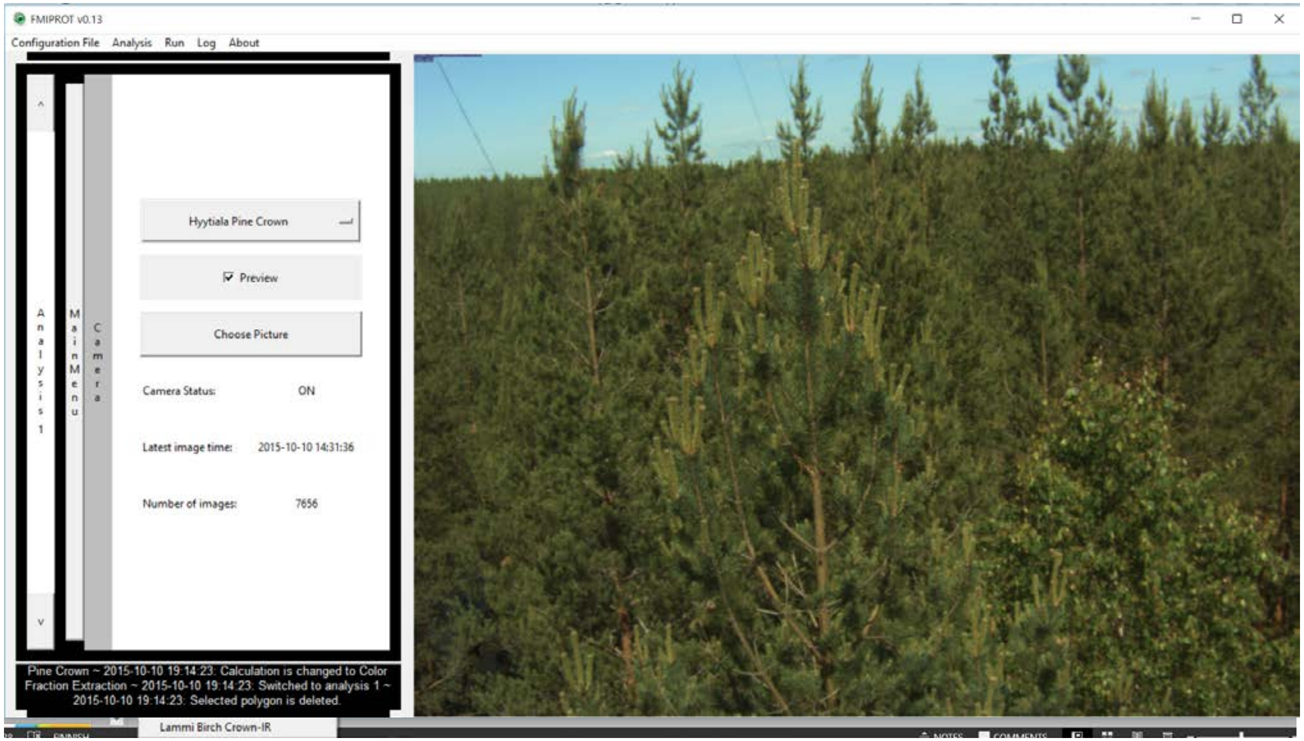
Linux:

Extract the TAR archive (“fmiprot_v#.tar.gz”) to any directory. Run “fmiprot” to run the software.

Step by Step Analysis

Camera Selection

Go to “Camera” Menu and select a camera



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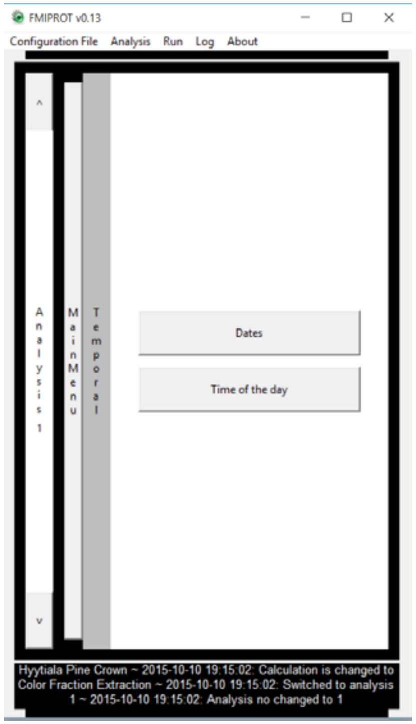
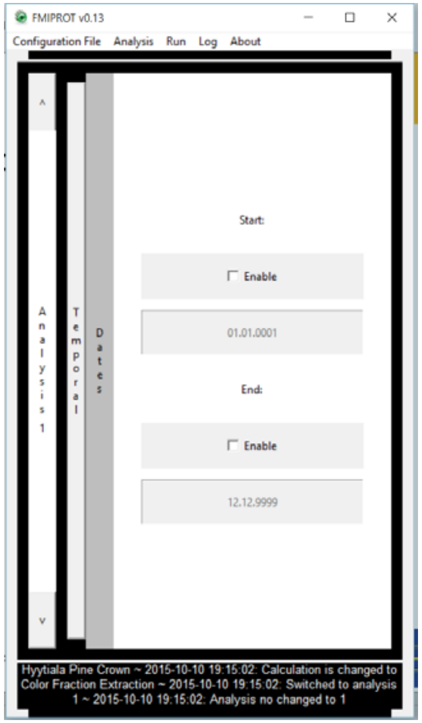
Step by Step Analysis

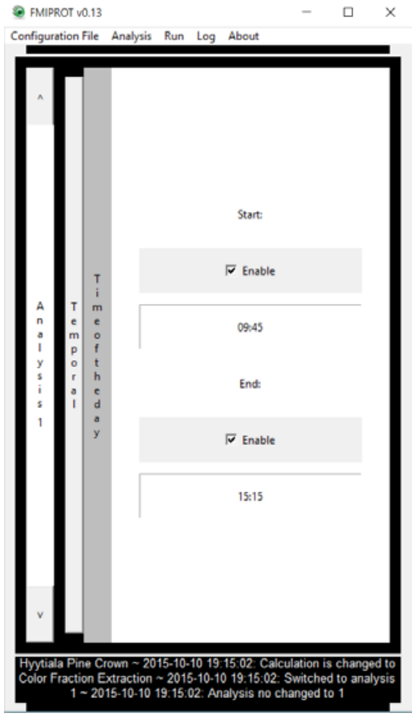
Temporal Selection

Go to “Temporal” menu to select the dates and times of the images





(No date filtering)



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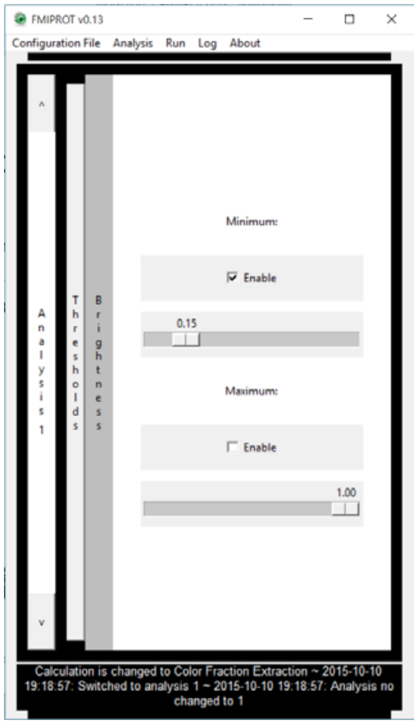
Step by Step Analysis

Thresholds selection

Go to “Thresholds” – “Brightness” menu to filter out too dark images



Step by Step Analysis

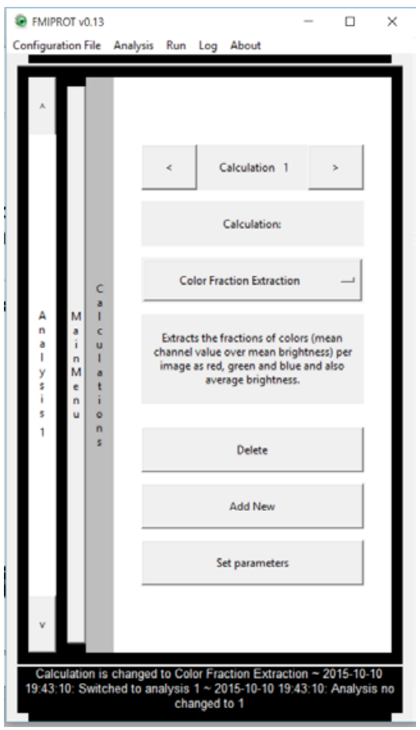
Masking Images

Go to “Masking” menu to select the region of interest

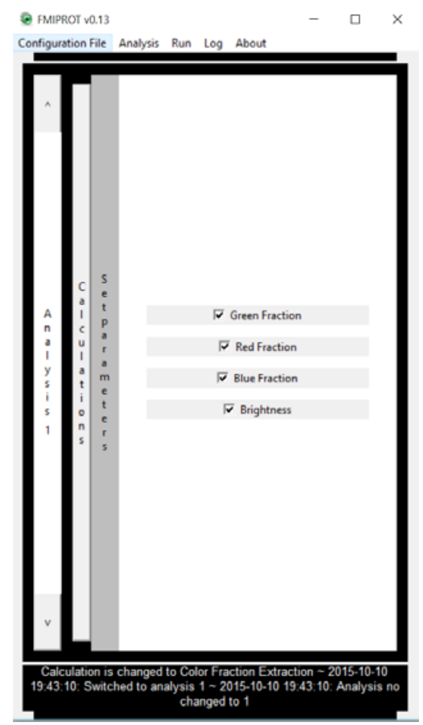
Step by Step Analysis

Setting up calculations

Go to “Calculations” menu and select the algorithm to apply on the images.



Select “Set Parameters” menu to set up the calculation.

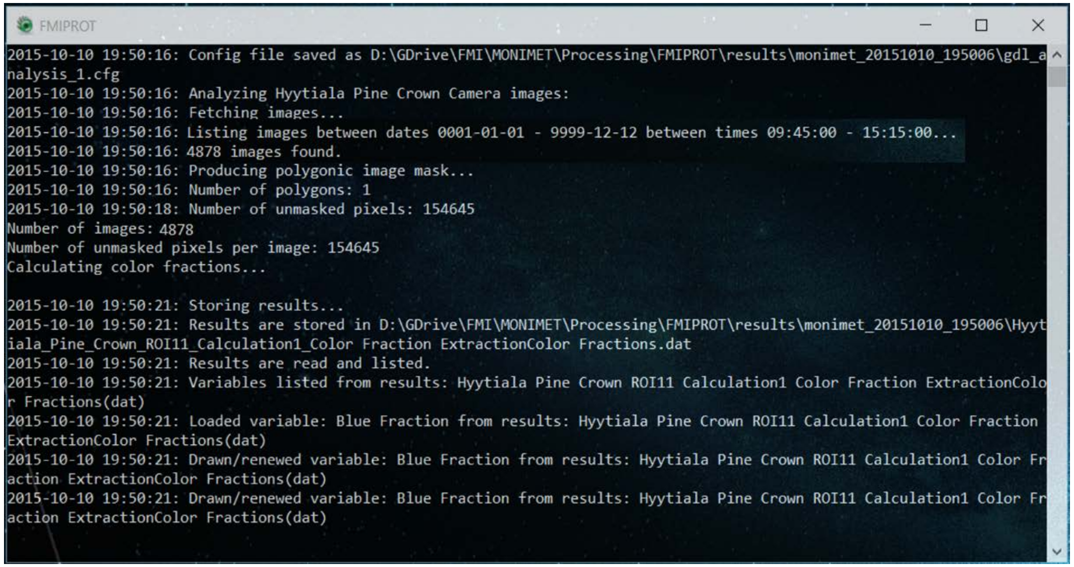


Step by Step Analysis

Running analyses

Click on “Analysis” >> “New” from the menu bar and repeat previous steps to add more analyses.

Click on “Run” >> “Run All..” or “Run Analysis…” to run all the analyses or the current one. Log entries can be seen from the console window while the analyses are being run.



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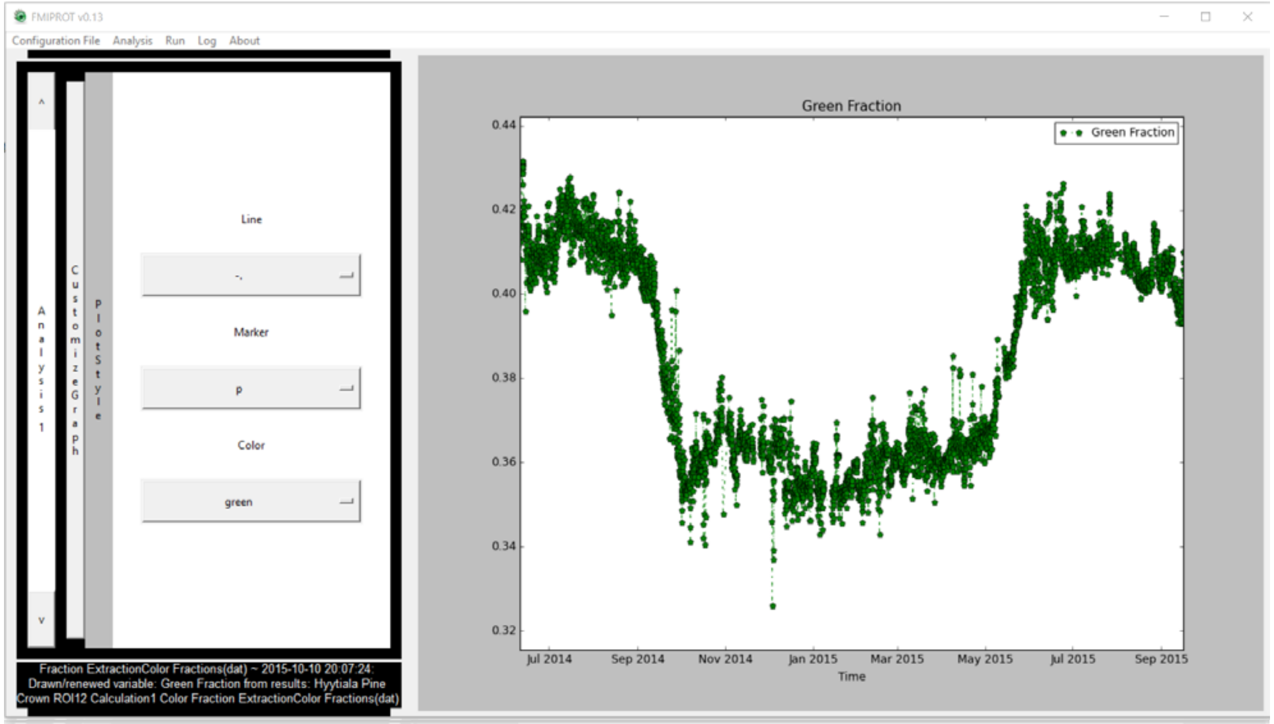
Step by Step Analysis

Showing Results

FMIPROT automatically switches to “Results” menu when the analyses are done. Select the results and variables to plot them. Go to “Customize Graph” to edit the graph.



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Color index ratios

Ratios of color indices in an image are usable to get information about especially phenological events. Using green and red fractions in an image, one can get results for the change in seasons of a vegetation. [2]

Junbin Zhao, Yiping Zhang, Zhenghong Tan, Qinghai Song, Naishen Liang, Lei Yu, Junfu Zhao, Using digital cameras for comparative phenological monitoring in an evergreen broad-leaved forest and a seasonal rain forest, Ecological Informatics, Volume 10, July 2012, Pages 65-72, ISSN 1574-9541, http://dx.doi.org/10.1016/j.ecoinf.2012.03.001.

Ratio of a color index is the ratio of the sum (or mean) of the indices of that color in a selected area to the sum (or mean) of all color indices in that area in an image.

$$GF = \frac{\sum G}{\sum R + \sum G + \sum B}$$

$$RF = \frac{\sum R}{\sum R + \sum G + \sum B}$$

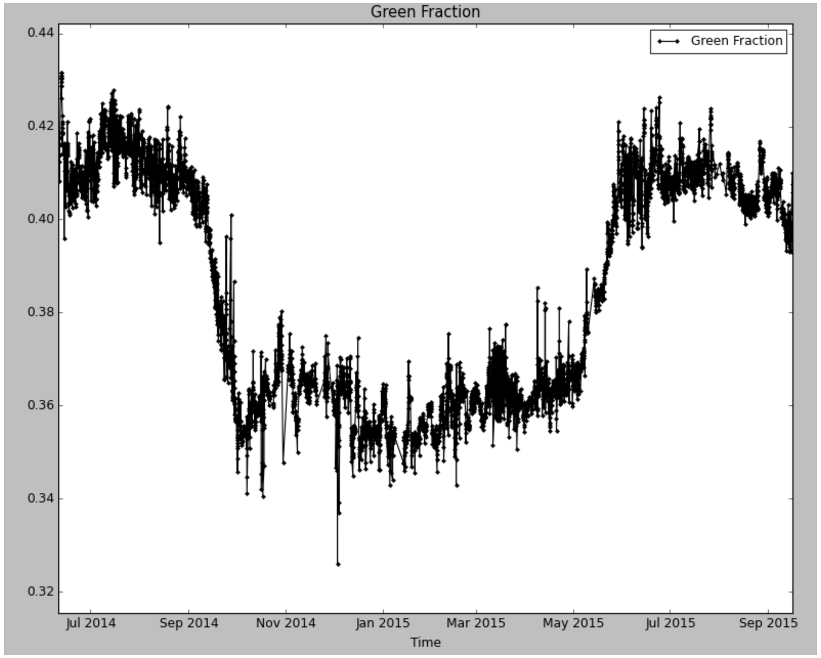
$$BF = \frac{\sum B}{\sum R + \sum G + \sum B}$$

$$Brightness = \frac{\sum R + \sum G + \sum B}{Npix * 255 * 3}$$

$\sum C$: Sum of values of color indices for R: Red, G: Green, B: Blue
$Npix$: Number of pixels

Color index ratios

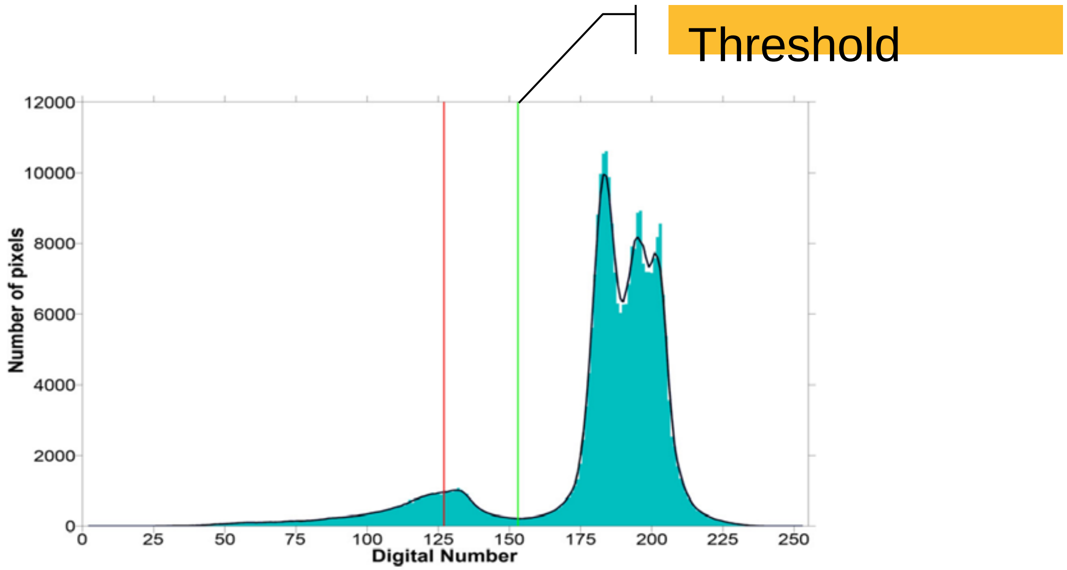
In FMIPROT, fractions for red, green and blue channel and the brightness of a selected area of an image can be calculated at the same time in one analysis. In the example below, **green fraction** of the area shown in picture from **Hyytiälä Canopy Camera** is plotted for June 2014 – September 2015.



Snow Detection & Snow Cover Analysis

Webcam images are also usable to extract snow cover information. An algorithm based on defining a threshold value according to the histogram of an image to classify a pixel as covered by snow or not is studied by Salvatori et. al. Using the algorithm with georectification of the images, snow coverage information of the visible area is obtained. [3]

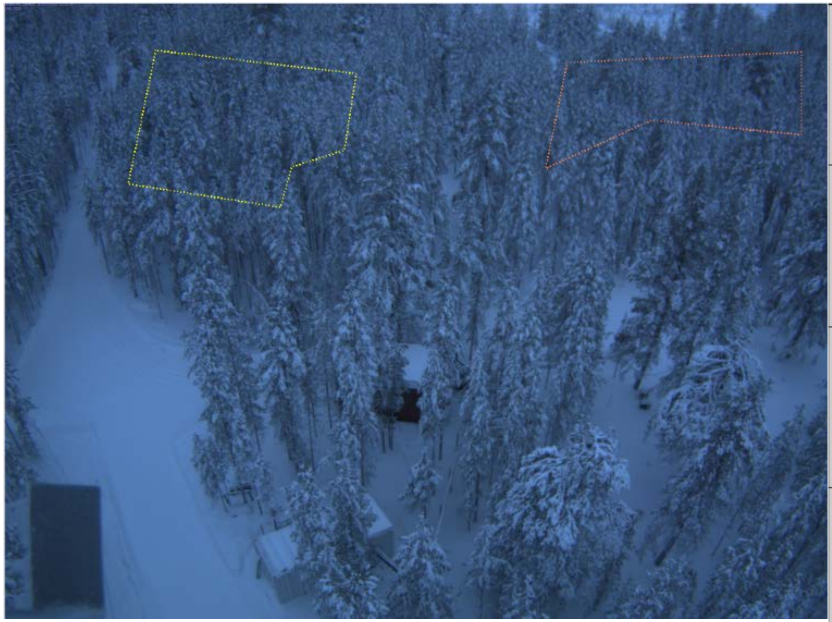
Salvatori, R., Plini, P., Giusto, M., Valt, M., Salzano, R., Montagnoli, M., Cagnati, A., Crepaz, G., and Sigismondi, D. (2011) Snow cover monitoring with images from digital camera systems, Ital. J. Remote Sens., 43, 137–145

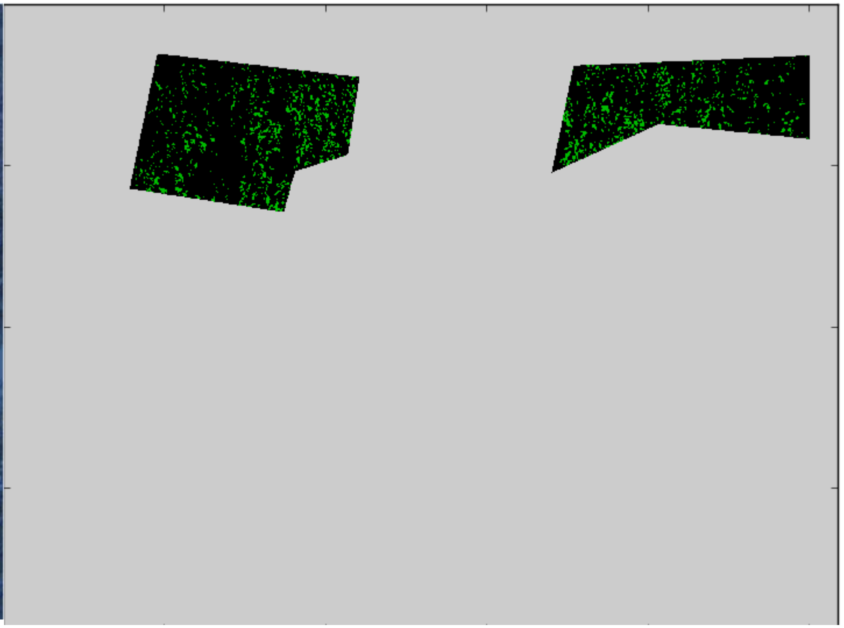


Selection of the threshold [4]

Snow Detection & Snow Cover Analysis

The algorithm is added to FMIPROT to study **how it works on the boreal region, both for the snow on the ground and the snow on the trees.** Below is an example for detecting snow on trees.



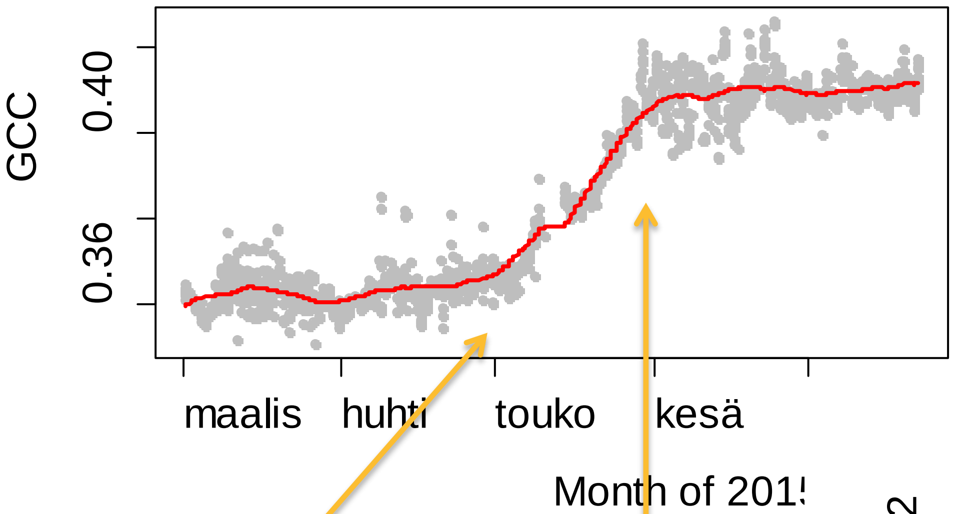


Snow Depth

MONIMET Camera Network also includes snow sticks on the ground visible by ground cameras. Although this study is not started yet, **using image segmentation and pattern recognition, it is planned to detect snow depth from the snow sticks by FMIPROT**. Snow sticks visible by Sodankylä Ground Camera is shown below.

Can we detect deciduous green up against conifer background?

Results



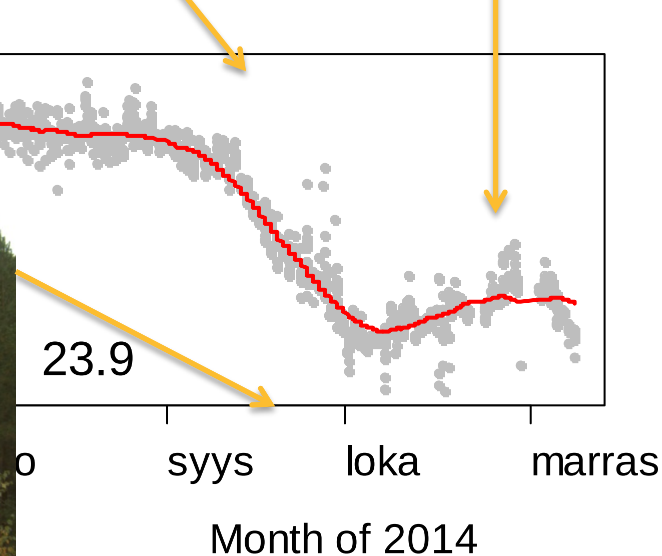
Leaves turning yellow and dropped between Sep-Oct

Possibly last ones dropped by late Oct

Leaves emerged

In early May.

Fully developed la
May



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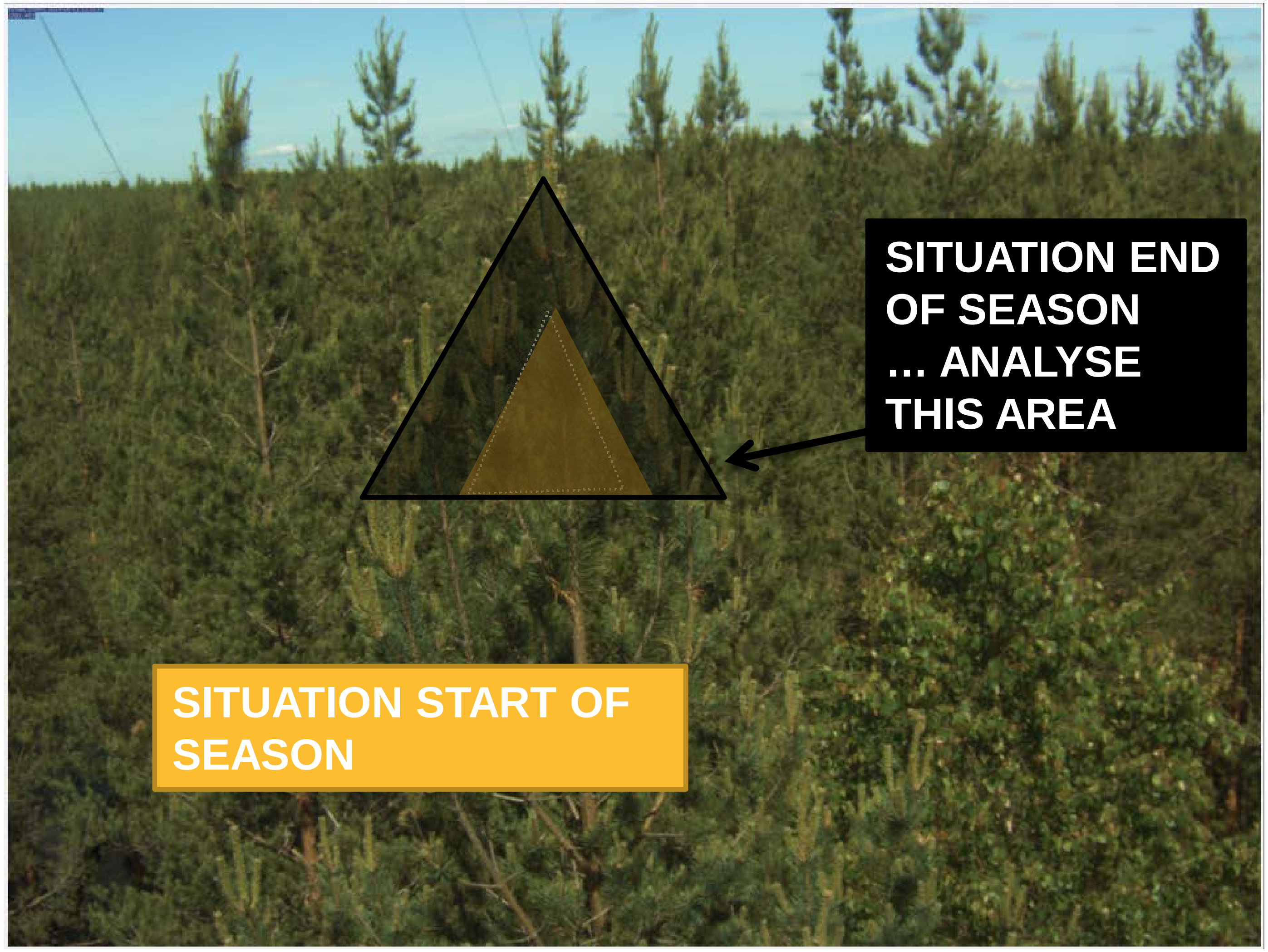
Conifer colour changes?



In conifers changes require more interpretation

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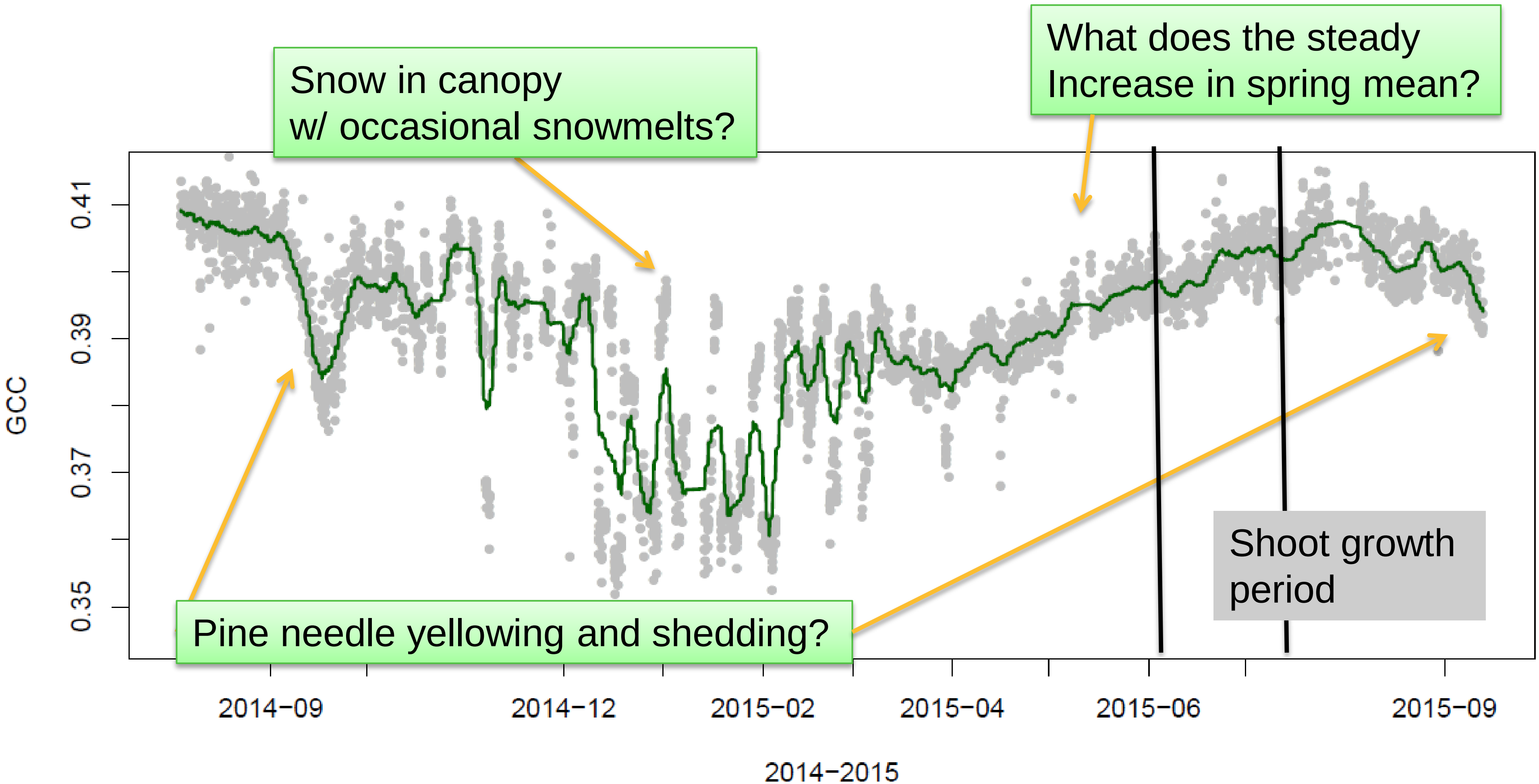

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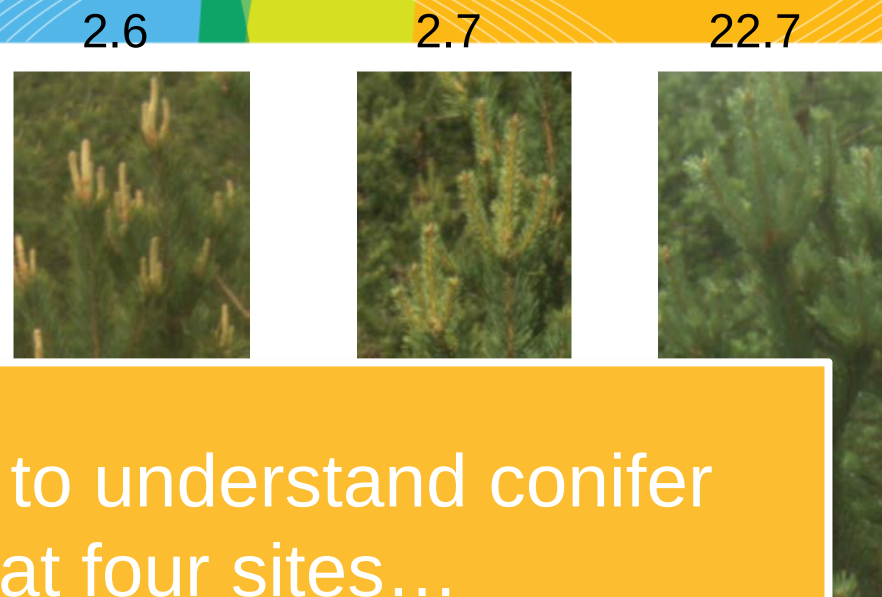
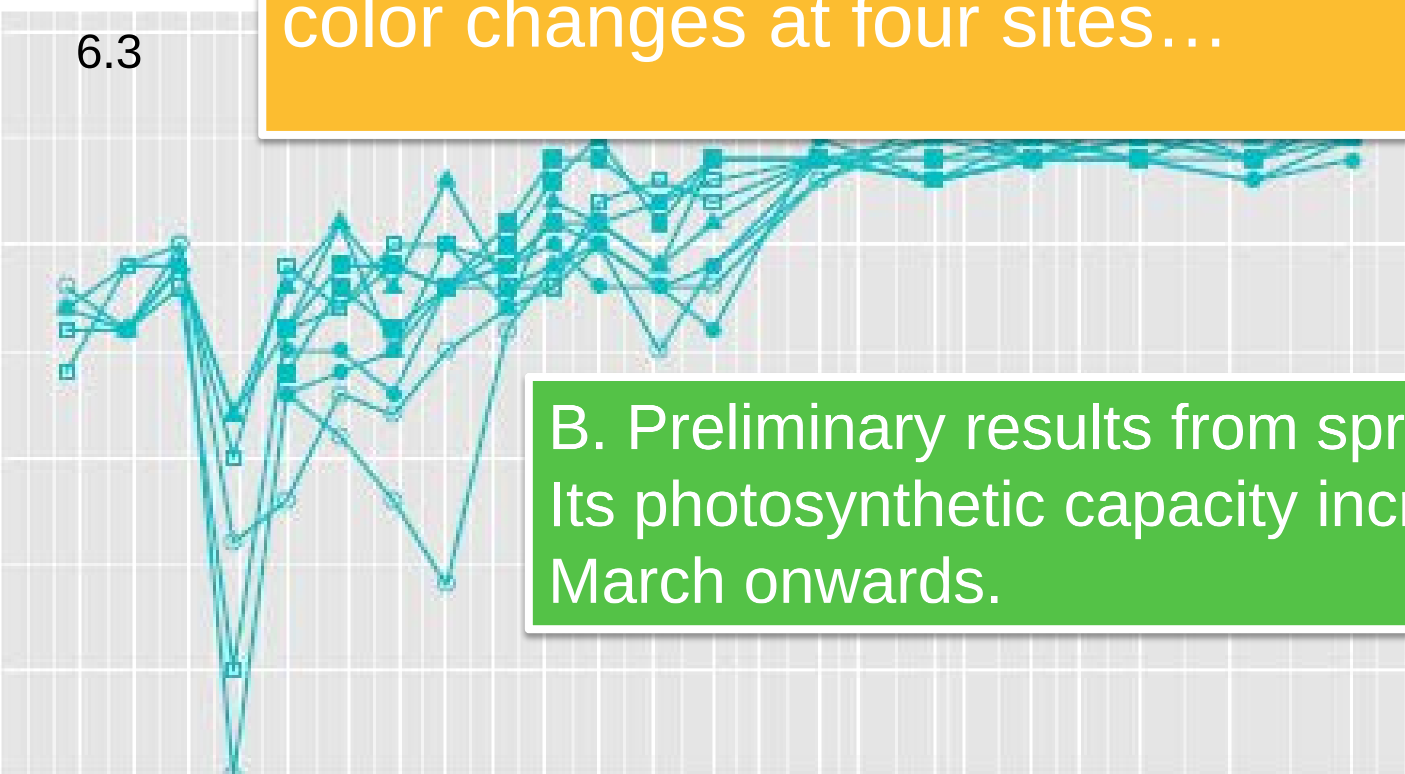
Spring increase - possible explanations?

A. Shoot growth period

ex

the





Tests continue to understand conifer color changes at four sites…

B. Preliminary results from spruce show that Its photosynthetic capacity increased from March onwards.

Mikko Peltoniemi

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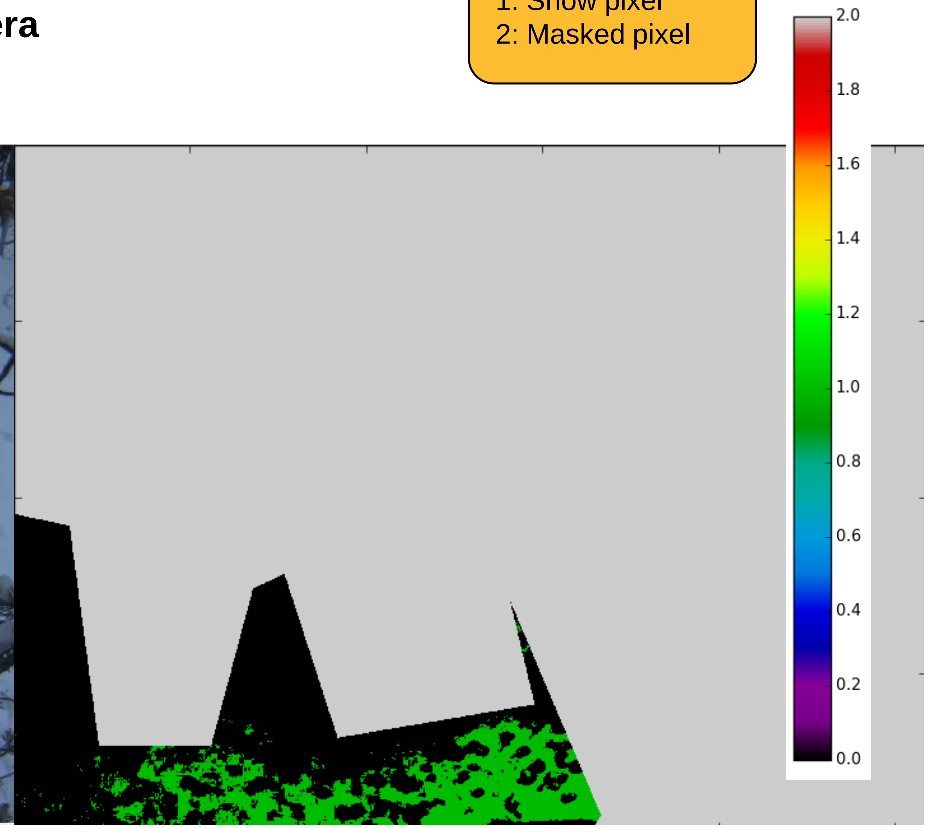
Snow Detection – Sodankylä Pine Ground Camera

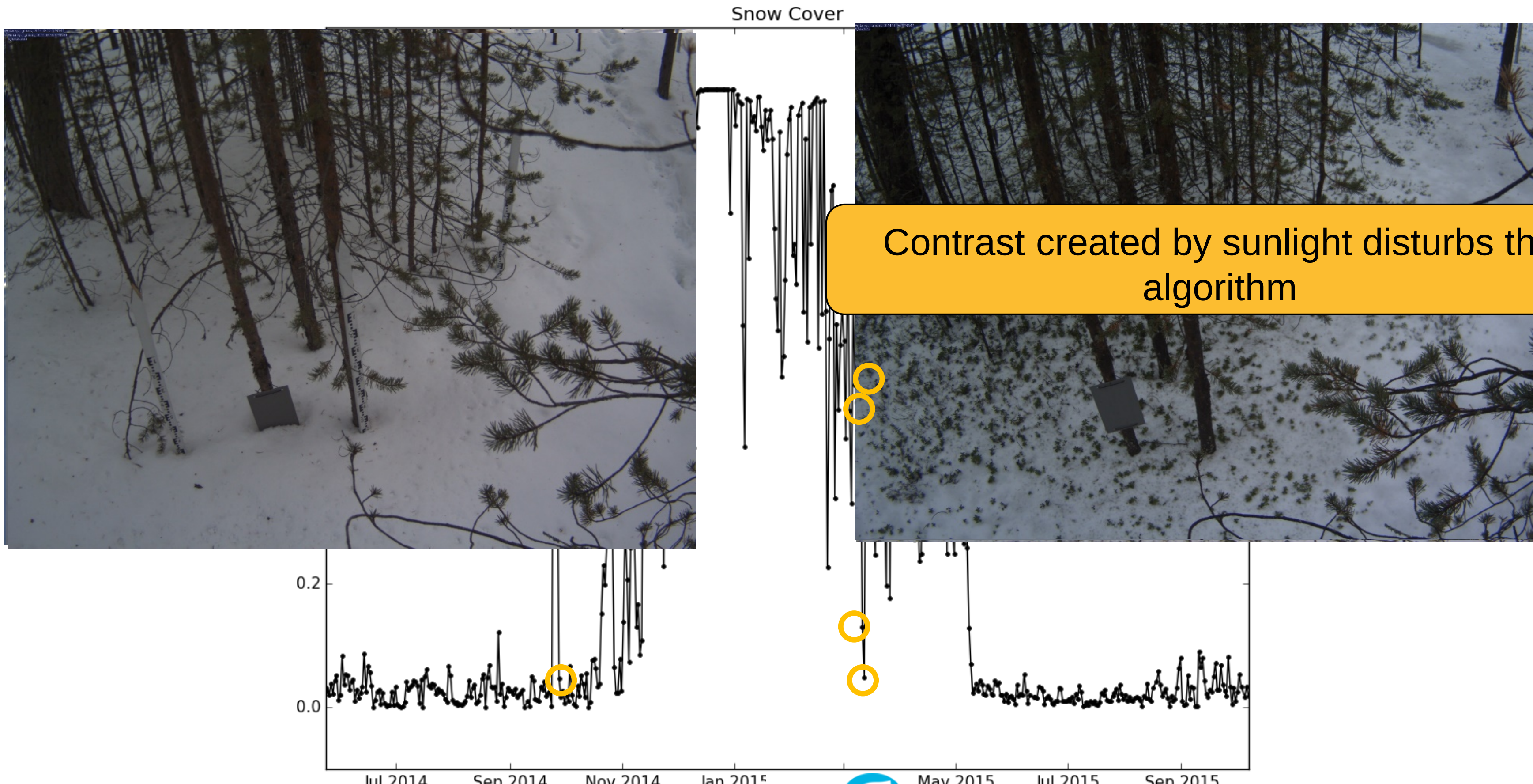
0: No-snow pixel
1: Snow pixel
2: Masked pixel



Snow Detection – Sodankylä Pine Ground Camera

0: No-snow pixel
1: Snow pixel
2: Masked pixel

Snow Cover (No rectification) - Sodankylä Pine Ground Camera



Contrast created by sunlight disturbs the algorithm

Future Work

- Georectification
- 3D Visualization
- Pseudo 4 Channel analyses (Handling IR images with optical images)
- Exception control
- Statistical analyses on results
- GUI Visual Design (e.g. Textures)
- Multiple camera networks

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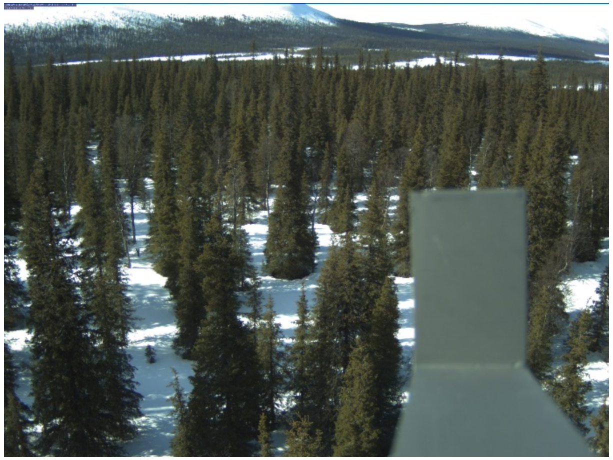
Thank you!



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