



FINNISH METEOROLOGICAL INSTITUTE

# MONIMET Webcam Network, Database and Toolbox for Monitoring Phenology and Snow Cover

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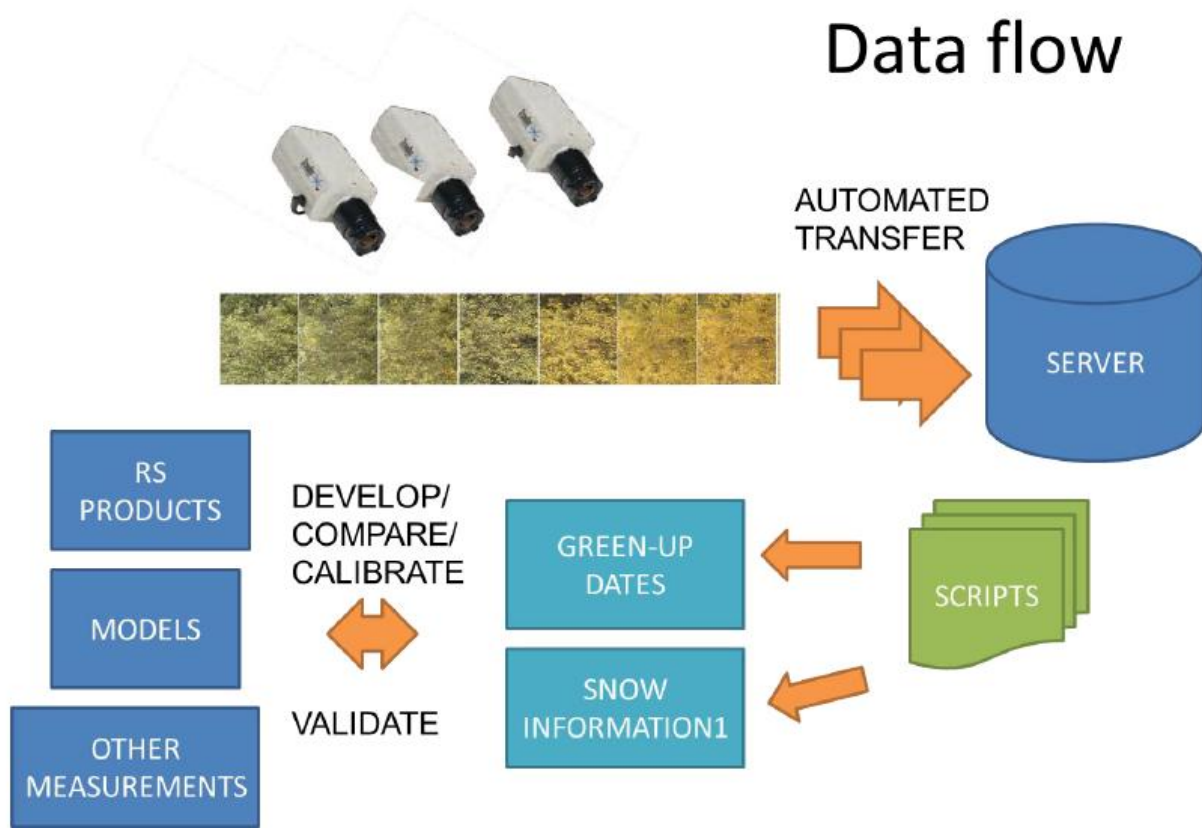
- ❑ EU Life+ MONIMET is an ambitious project spearheaded by scientists in Finland to increase turnover of climate data by implementing a network of webcams in Finland's boreal forest and wetland environments.
- ❑ While climate change is a problem in need of global action, its effects are localized and affect regions in very different ways. Equally, certain areas exert a greater influence on the global climate and carbon balance than others, and it is this dynamic relationship that makes tackling climate change so complex.
- ❑ Over the next century, scientists predict a mean annual temperature increase of 2-6 °C. This change will be particularly important in the boreal forest biome, which is distributed in a band around the northern sub-polar regions of Earth.
- ❑ Boreal forest represents the world's largest terrestrial biome and exerts a pronounced effect on global climate and weather systems.
- ❑ In Finland, the boreal zone is blended with wetland environments that account for one-third of the country's territory. They are important for boreal greenhouse gas balances due to methane emissions.



- ❑ To collect information, data and expertise that is currently spread over several institutes, in order to build a comprehensive platform for analyzing 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 (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**

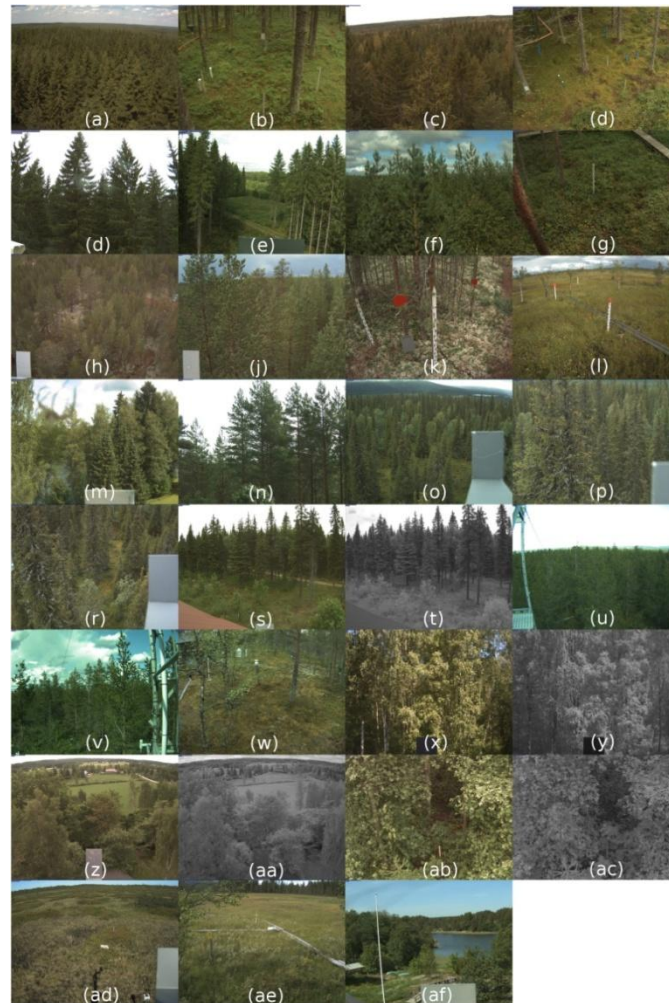
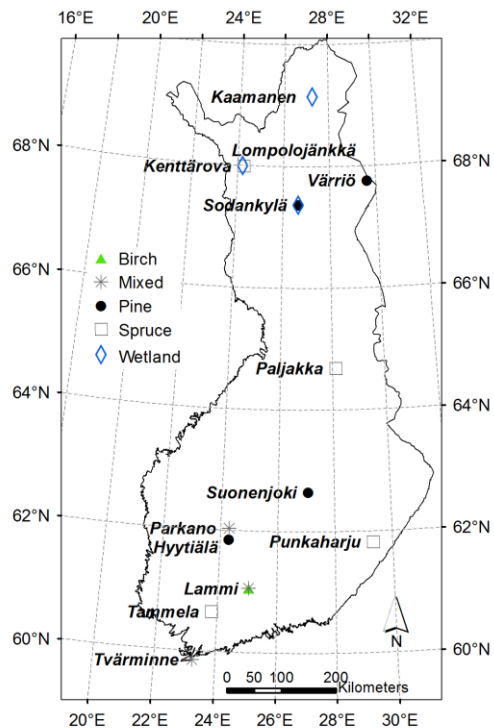


# Data flow





# MONIMET Camera Network





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<https://doi.org/10.5194/essd-2017-62>

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Discussion papers

Abstract

Assets

Discussion

Metrics

10 Aug 2017

### Webcam network and image database for studies of phenological changes of vegetation and snow cover in Finland, image time series from 2014–2016

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#### Review status

This discussion paper is a preprint. It is a manuscript under review for the journal Earth System Science Data (ESSD).

Received: 30 Jun 2017 – Accepted for review: 02 Aug 2017 – Discussion started: 10 Aug 2017



monimet



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File Type

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Pdf (1)

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Keywords

Camera (36)

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View

May 11, 2017 (v3) Technical note Open Access

### Datasheet of ecosystem cameras installed in Finland in Monimet Life+ project

Peltoniemi, Mikko; Aurela, Mika; Böttcher, Kristin; Kolari, Pasi; Linkosalmi, Maiju; Loehr, John; Tanis, Cemal Melih; Arslan, Ali Nadir;

Information datasheet for the phenological cameras installed within the frame of Monimet project. Datasheet includes essential camera information, including preview images and DOI-references to the image data series that are also stored in Zenodo. For questions, contact Mikko Peltoniemi, mikko.pel

Uploaded on June 30, 2017

2 more version(s) exist for this record

View

June 21, 2017 (v1) Dataset Open Access

### Phenological time lapse images from canopy camera MC108 in Sodankylä Pine stand (2014-2016)

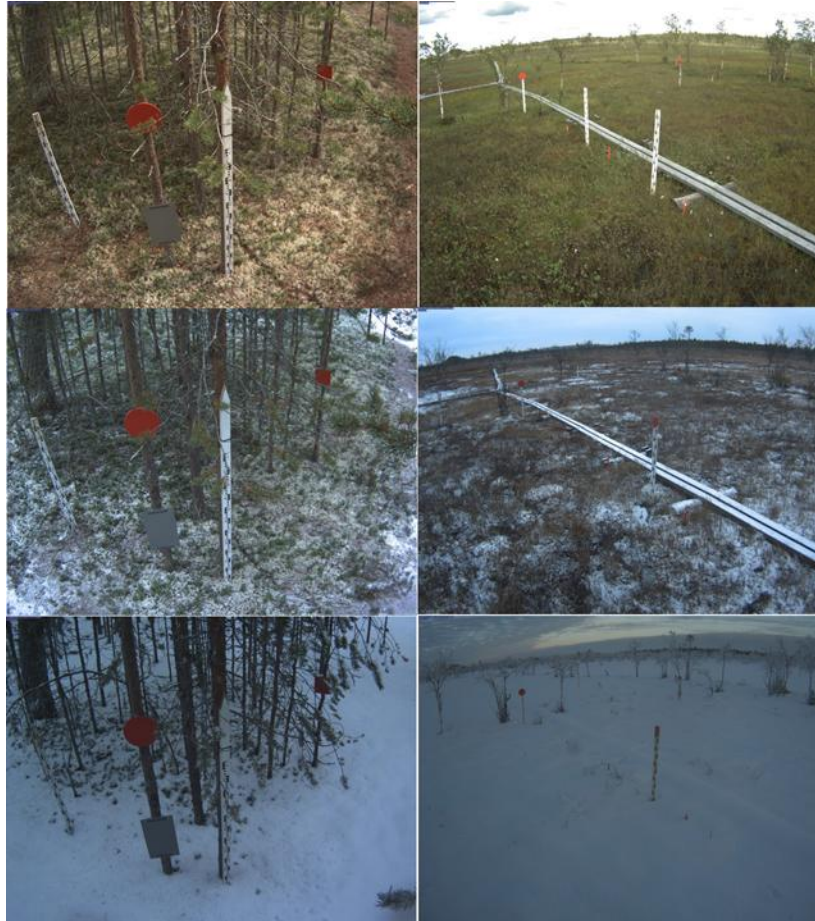
Aurela, Mika; Linkosalmi, Maiju; Tanis, Cemal Melih; Arslan, Ali Nadir; Rainne, Juuso; Kolari, Pasi; Böttcher, Kristin; Peltoniemi, Mikko;

This dataset contains phenological time lapse images from camera Sodankylä Pine stand. Camera was mounted at canopy view level at location 67.3618;26.638167(N;E, WGS84). Images were taken between 22.05.2014–31.12.2016. Cameras were set to fix white balance,



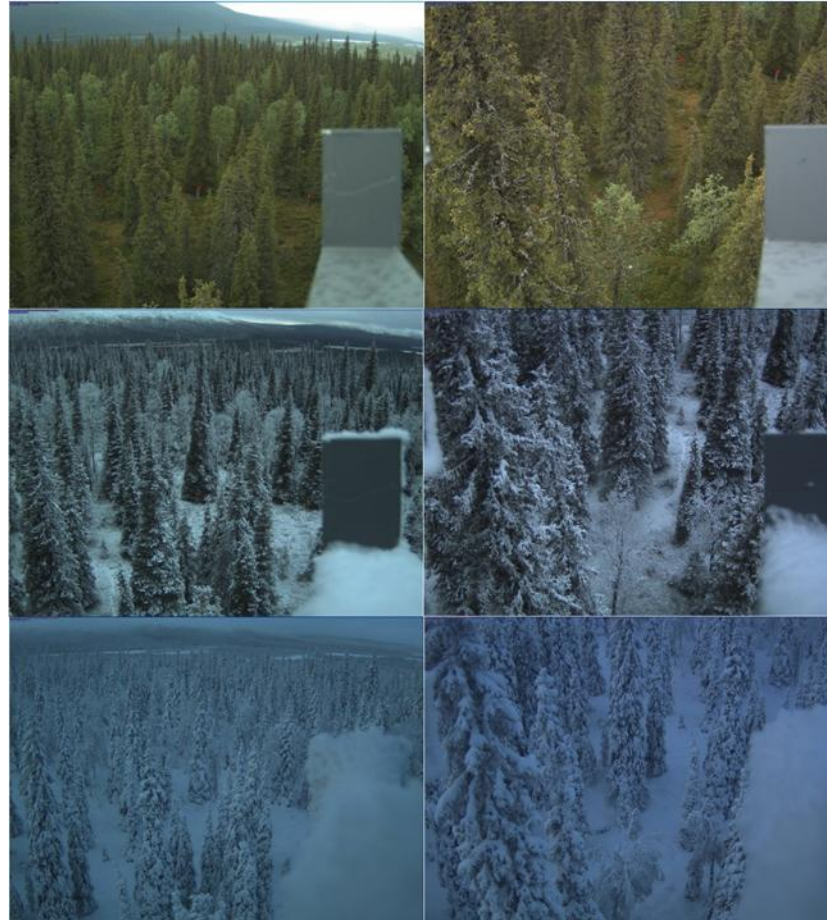


Example images in both summer and winter conditions from ground (left panels) and wetland cameras (right panels) of Sodankylä on 18 June 2016, 12:01 (top), 3 November 2016, 09:31 (center) and 25 November 2016, 11:01 (bottom).





Example images from canopy (left panels) and ground cameras (right panels) of Kenttäröva on 18 June 2016, 12:00 (top), 3 November 2016, 09:30 (center) and 25 November 2016, 11:00 (bottom).





# Finnish Meteorological Institute image PROcessing Toolbox

100% Graphical  
User Interface

Multiple camera  
networks

Automated file  
download

Automated file  
handling

Save/load  
analysis options

Data filtering

Plugin support

Visualization of  
output data

Post-processing

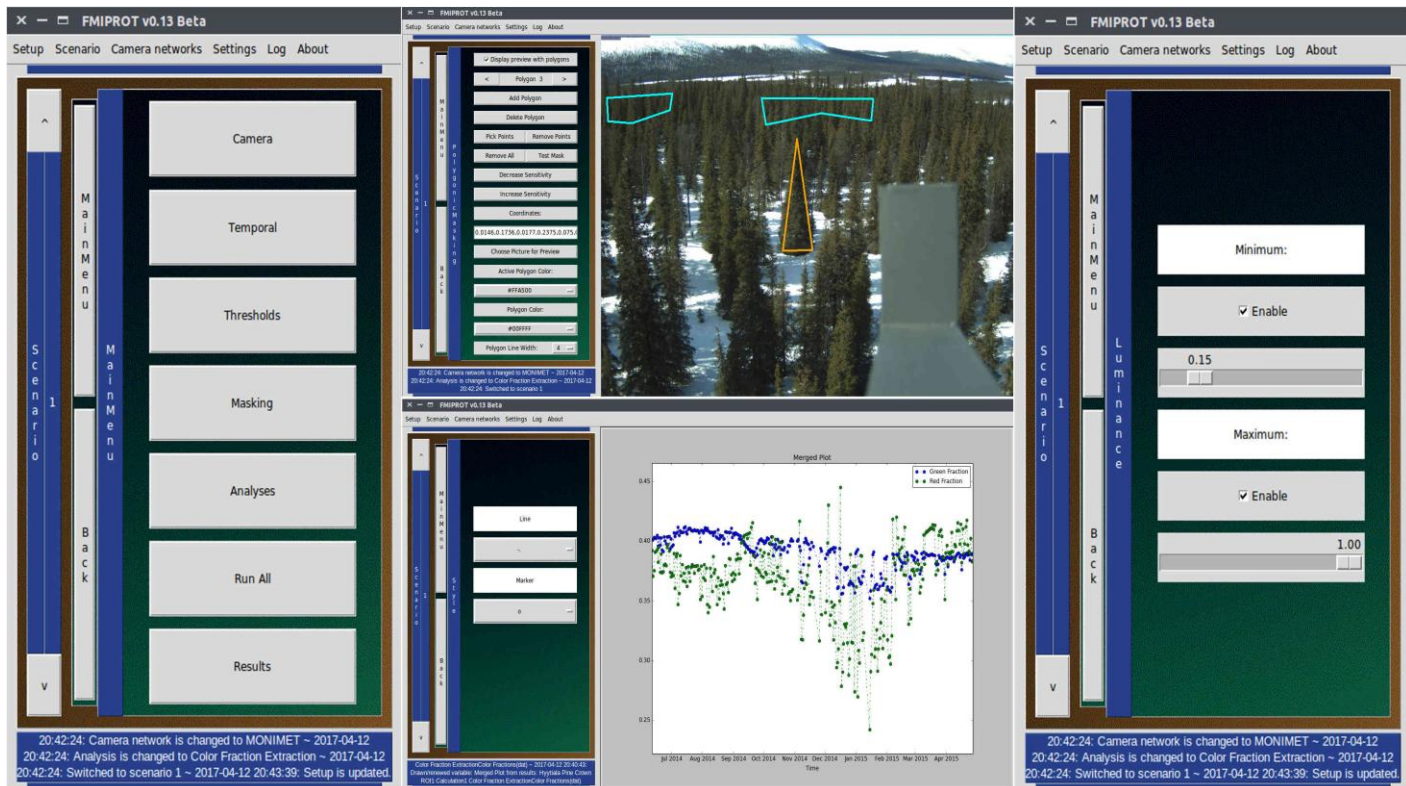
Script  
generation



# Algorithms

- Green color fraction (Green chromatic coordinate)
- Red color fraction (Red chromatic coordinate)
- Blue color fraction (Blue chromatic coordinate)
- Green-Red Vegetation Index
- Green Excess Index
- Snow cover fraction

FMIPROT Graphical User Interface: Main menu (left), threshold selection menu (right), masking menu (middle-top), results menu (middle-bottom).

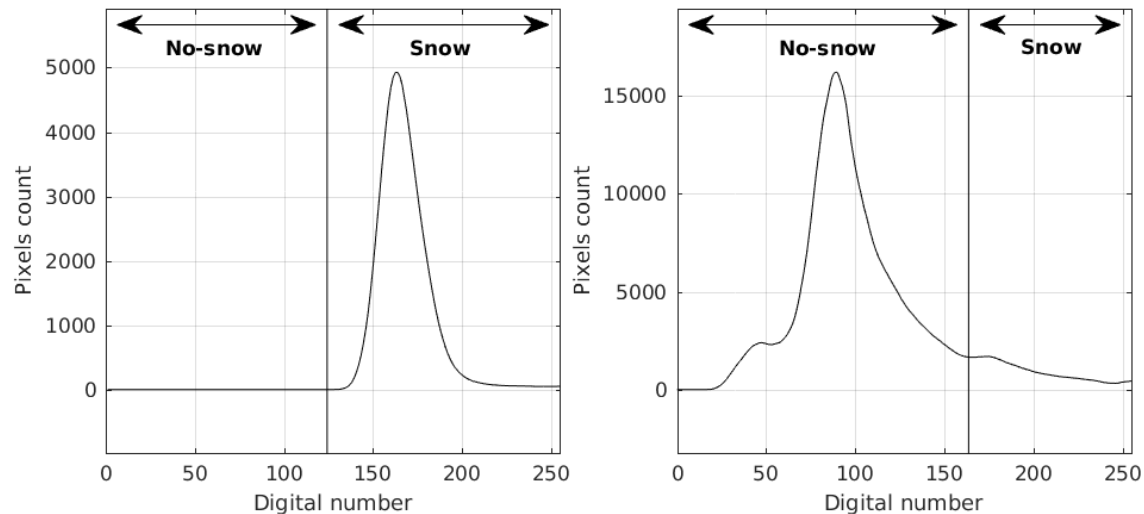


The image displays four screenshots of the FMIPROT v0.13 Beta graphical user interface, arranged in a 2x2 grid. Each screenshot shows a different menu configuration and data visualization.

- Top-Left Screenshot:** Shows the main menu with options: Camera, Temporal, Thresholds, Masking, Analyses, Run All, and Results. The 'Scenario' menu is set to '1'. A status bar at the bottom indicates: "20:42:24: Camera network is changed to MONIMET ~ 2017-04-12", "20:42:24: Analysis is changed to Color Fraction Extraction ~ 2017-04-12", and "20:42:24: Switched to scenario 1 ~ 2017-04-12 20:43:39: Setup is updated."
- Top-Right Screenshot:** Shows the threshold selection menu overlaid on a satellite image of a snowy forest. The menu includes options like "Display preview with polygons", "Add Polygon", "Delete Polygon", "Pick Points", "Remove Points", "Remove All", "Test Mask", "Decrease Sensitivity", "Increase Sensitivity", "Coordinates", "Choose Picture for Preview", "Active Polygon Color", "#FF6600", "Polygon Color", "#0000FF", and "Polygon Line Width". A status bar at the bottom indicates: "20:42:24: Camera network is changed to MONIMET ~ 2017-04-12", "20:42:24: Analysis is changed to Color Fraction Extraction ~ 2017-04-12", and "20:42:24: Switched to scenario 1".
- Bottom-Left Screenshot:** Shows the masking menu with options: "Use", "Marker", and "o". A status bar at the bottom indicates: "20:42:24: Camera network is changed to MONIMET ~ 2017-04-12", "20:42:24: Analysis is changed to Color Fraction Extraction ~ 2017-04-12", and "20:42:24: Switched to scenario 1 ~ 2017-04-12 20:43:39: Setup is updated."
- Bottom-Right Screenshot:** Shows the results menu with options: "Minimum:", "0.15", "Maximum:", "1.00", and "Enable". A status bar at the bottom indicates: "20:42:24: Camera network is changed to MONIMET ~ 2017-04-12", "20:42:24: Analysis is changed to Color Fraction Extraction ~ 2017-04-12", and "20:42:24: Switched to scenario 1 ~ 2017-04-12 20:43:39: Setup is updated."

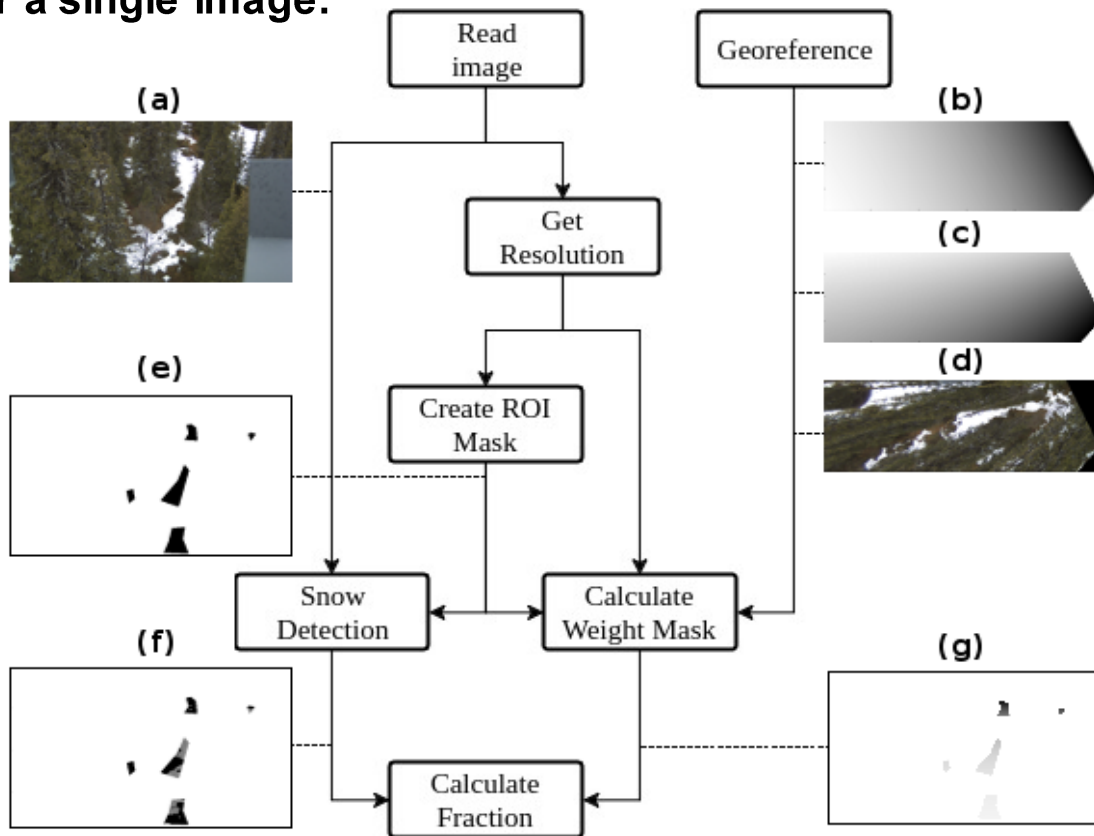


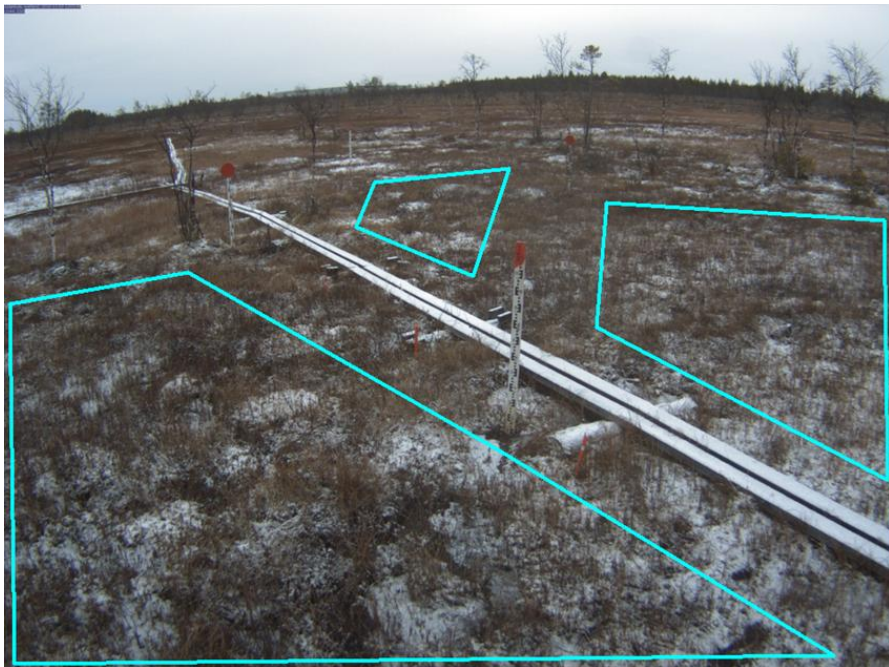
We used an algorithm based on a threshold value, which is defined according to the histogram of an image to classify the pixels in the image as snow-covered or snow-free. In the algorithm, a threshold value for the image is chosen by finding the first local minimum higher than digital number (DN) 127 in the histogram of the blue channel.



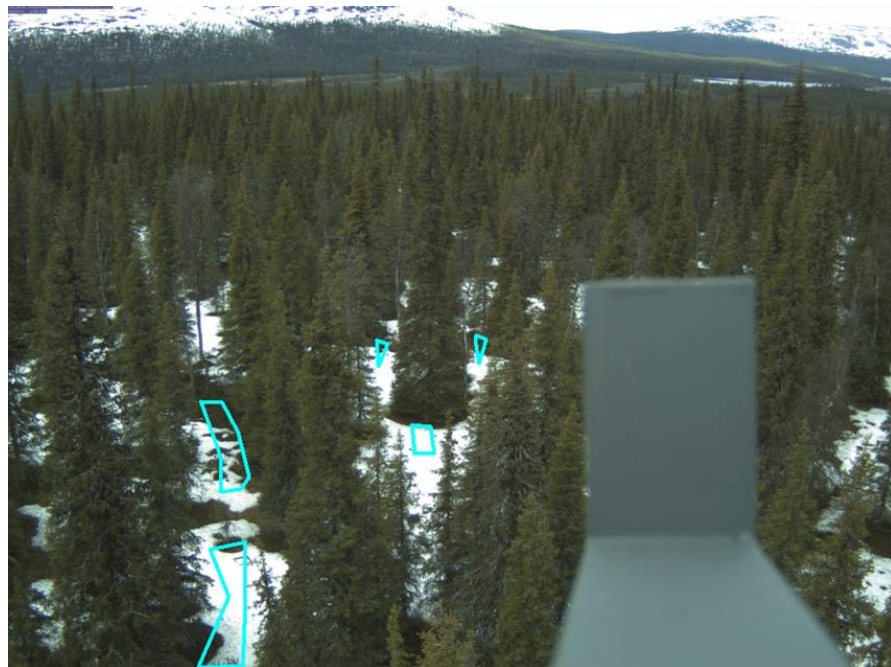
Threshold selection for snow classification for two different types of histogram distributions. The histograms are extracted from real images and smoothed in the same way in the algorithm.

## Main steps of calculating Fractional Snow Cover for a single image:





Sodankylä



Kenttätöva



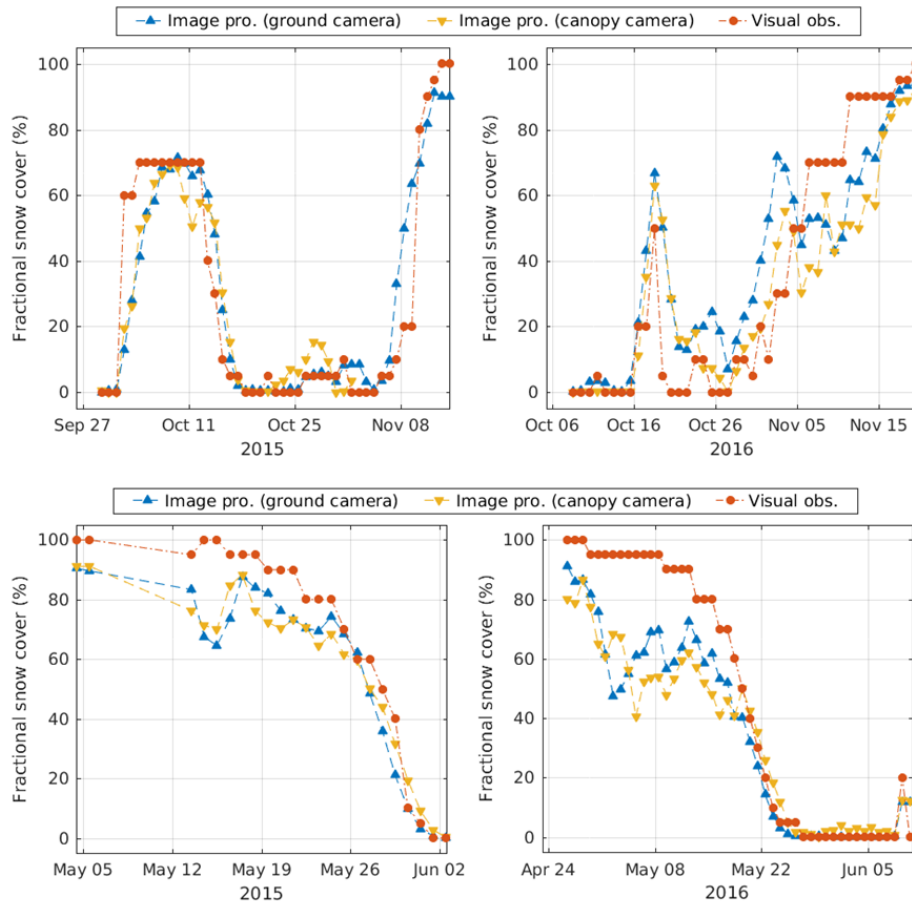


## Definition of Seasons.

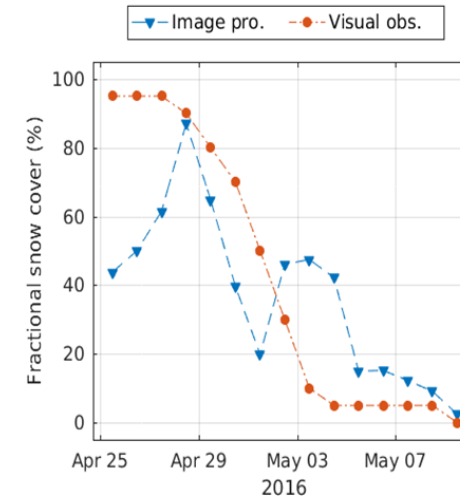
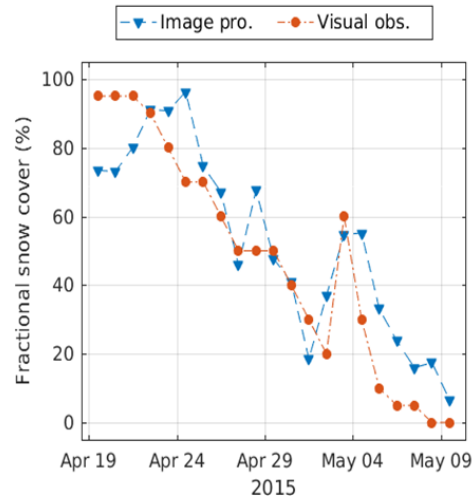
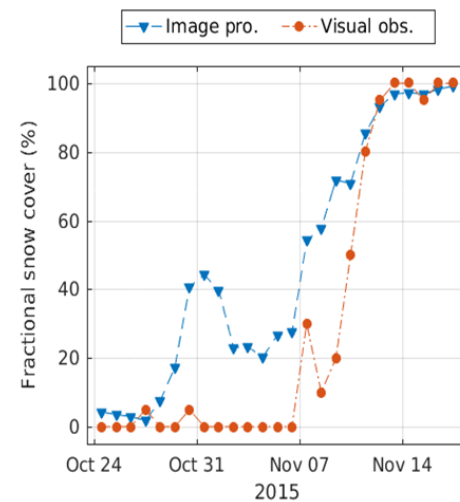
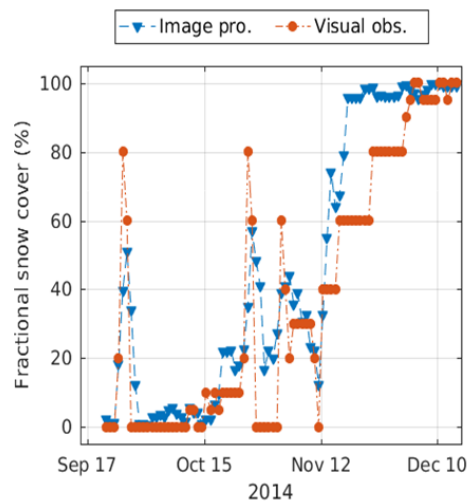
Site/Year	2014	2015	2016
Early Season			
Kenttäröva		29 September–15 November 2015	8 October–21 November 2016
Sodankylä wetland	21 September–6 December 2014	1 October–14 November 2015	14. October–28 November 2016
Sodankylä ground	21 September–15 December 2014	24 October–18 November 2015	14. October–30 October 2016
Melting Season			
Kenttäröva		5 April–3 May 2015	26 April–12 June 2016
Sodankylä wetland		3 May–10 May 2015	27 April–9 May 2016
Sodankylä ground		19 April–10 May 2015	25 April–11 May 2016
Winter Season	Between early season	and melting season	
Summer Season	After melting season		



Kenttäröva ground and canopy cameras early season (top) and melting season (bottom); comparisons of image processing results and visual observations.



Sodankylä ground camera early season (top) and melting season (bottom); comparisons of image processing results and visual observations.





RMSE for the fractional snow cover (FSC) from image processing for all seasons.

Season/Site	Kenttäröva Canopy	Kenttäröva Ground	Sodankylä Ground	Sodankylä Wetland
Early Season	16	17	18	16
Mid-winter	18	12	30	27
Melting Season	20	18	21	24
Summer	1.7	0.45	3.6	0.27
Overall	13	11	19	18
Overall except summer	18	14	26	24



The images for which the fractional snow cover results have large error were further inspected to understand the reasons for the failure.

The factors that cause failures were divided into four groups:

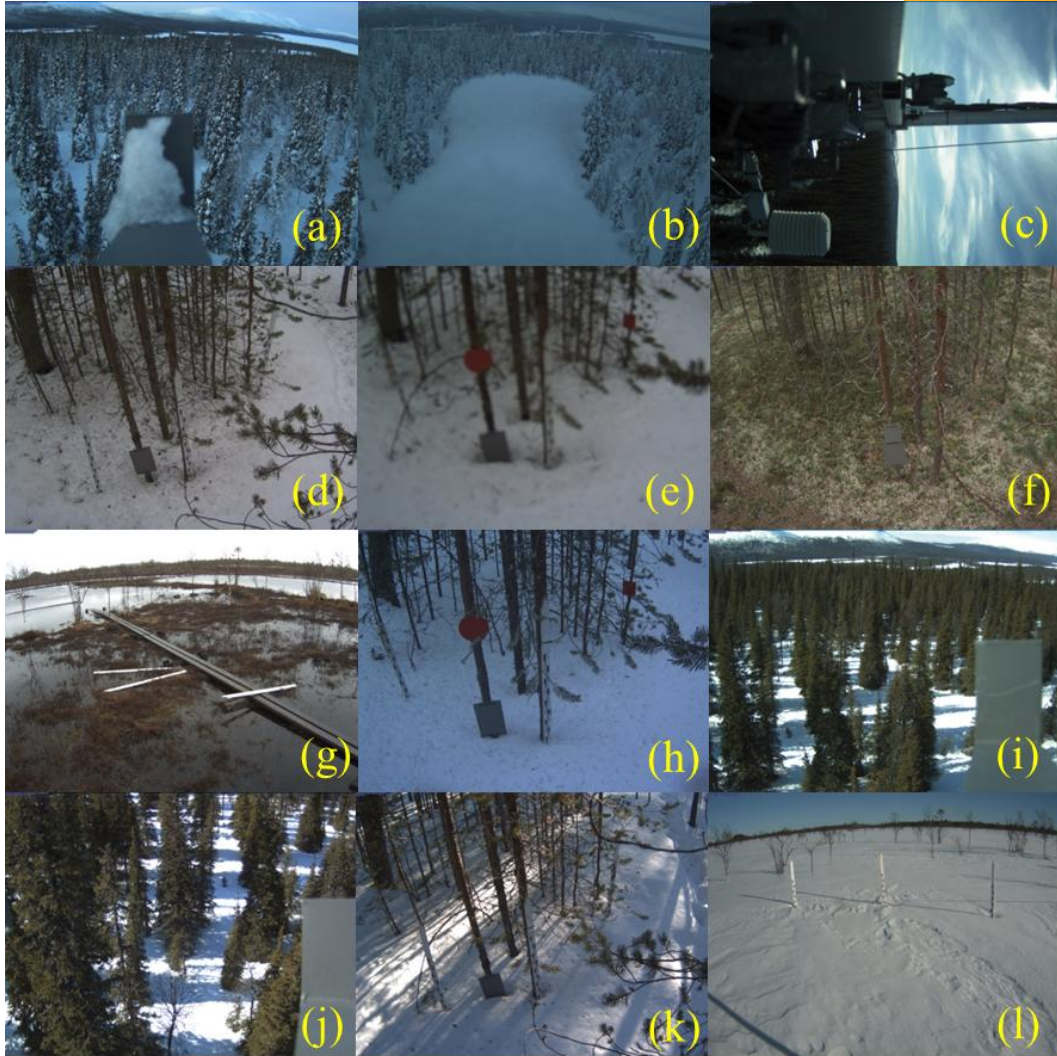
- (1) changes in the camera view,
- (2) environmental components that are classified as snow,
- (3) environmental components that hide the snow cover, and
- (4) phenomena that disturb the histogram.

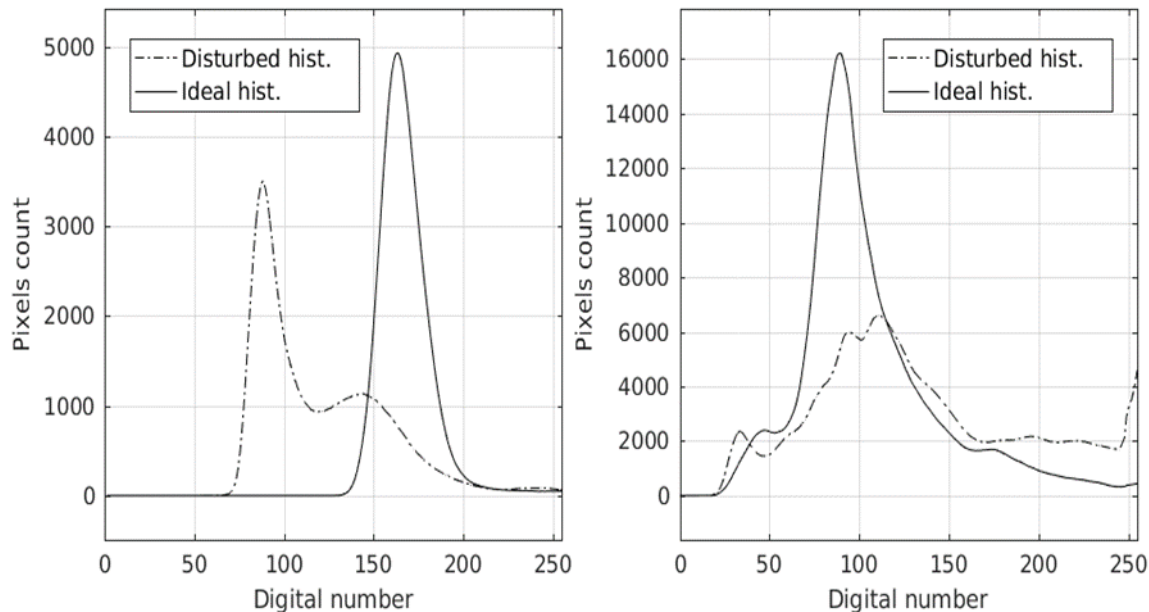
These factors occur in different circumstances, and their effects on the results are different.



Problems in the images that cause failures in detection of fractional snow cover:

- (a) Field of view blocked by the reference plate after the camera movement;
- (b) Field of view blocked by the accumulation of snow on reference plate;
- (c) Field of view loss after the camera movement;
- (d,e) Before and after the minimal camera movement and loss of focus;
- (f) Lichen on the ground;
- (g) Water accumulation which reflects the bright sky and fallen snow sticks;
- (h) Litter and dirt on the ground;
- (i) Shadow of trees in Kenttäröva canopy camera field of view;
- (j) Shadow of trees in Kenttäröva ground camera field of view;
- (k) Shadow by trees and snow sticks in Sodankylä ground camera field of view;
- (l) Shadow by the snow surface irregularities, snow roughness, snow sticks, and camera mast.



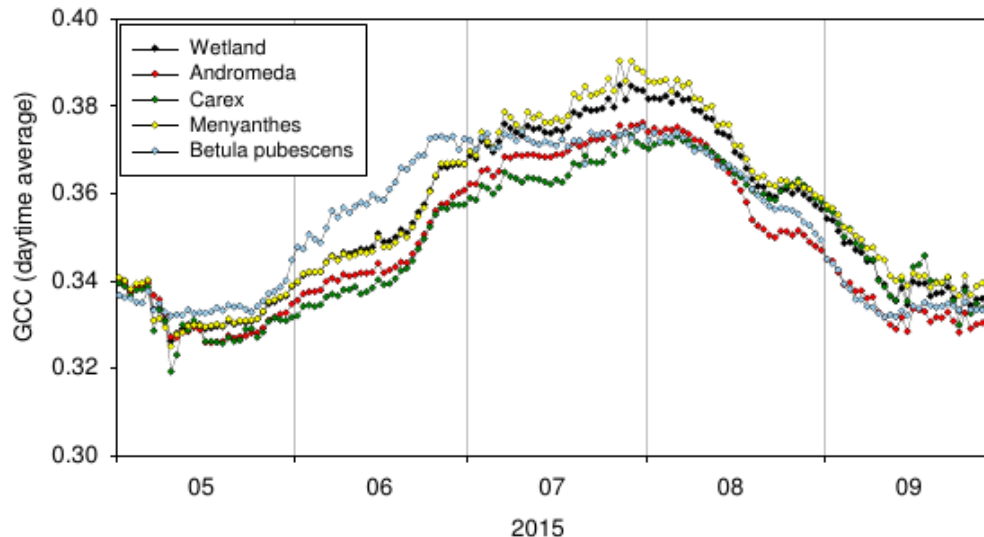


Examples of histogram disturbance by shade. Ideal histogram and disturbed histogram (left) for full snow cover and (right) for partial snow cover.

Histogram disturbing by shade phenomenon is the most significant failure, as it causes the largest errors. The shade phenomenon depends on the cloud cover, environment and sunlight direction, and this may change even within minutes.



# GCC changes by vegetation patch in Sodankylä wetland



Mean daytime GCC of different Regions of Interests (vegetation types) during the period of May 2014 to October 2015 at a wetland in Sodankylä. Wetland refers to a combined ROI covering Andromeda, Carex and Menyanthes communities. (Adapted from Linkosalmi et al. 2016).





- Continue developing FMIPROT
- Camera-based algorithms should be further developed, especially for varying light conditions in the field of view, to obtain better accuracy in FSC retrieval
- Validate Earth-observed FSC

Arslan, A.N.; Tanis, C.M.; Metsämäki, S.; Aurela, M.; Böttcher, K.; Linkosalmi, M.; Peltoniemi, M. Automated Webcam Monitoring of Fractional Snow Cover in Northern Boreal Conditions. *Geosciences* **2017**, *7*, 55.

Linkosalmi, M.; Aurela, M.; Tuovinen, J.-P.; Peltoniemi, M.; Tanis, C.M.; Arslan, A.N.; Kolari, P.; Aalto, T.; Rainne, J.; Laurila, T. Digital photography for assessing vegetation phenology in two contrasting northern ecosystems. *Geosci. Instrum. Methods Data Syst.* 2016, *5*, 417–426.

<http://monimet.fmi.fi>, [zenodo.org](https://zenodo.org) → search:monimet

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# Questions?